The Zero Interest Rate Bound and the Covered Interest Parity:

Evidence from the Australian Dollar and the NZ dollar

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Abstract

The global financial crisis (GFC) had enormous impacts on international markets and violated covered interest parity (CIP) condition substantially. In particular, the US dollar tended to have lower interest rate than most of the major currencies even in the post GFC period. However, unlike the other major currencies, the Australian Dollar and the NZ dollar had lower interest rate than the US dollar in the post GFC period. The purpose of this paper is to explore what made the Australian Dollar and the NZ dollar so different in the CPI condition. In the analysis, we focus on a unique feature of Australia and New Zealand where short-term interest rates remained significantly positive even after the GFC. Thee paper first constructs a theoretical model which shows that not only increased liquidity risk but also different policy rates cause deviations from the CIP condition. The paper then tests this theoretical implication by using secured interest rates and exchange rates in six major currencies. We find that both money market risk measures and policy rates had common significant effects on the CIP deviations in the six major currencies. The result supports our hypothesis that unique monetary policy feature in Australia and New Zealand made deviations of their currencies from the CIP condition smaller on the forward contract.

1. Introduction

The global financial crisis (GFC) and the following instability in the world economy 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.

Figure 1 depicts daily deviations from CIP condition between the US dollar and each of the six non-US dollar currencies: the Euro, the Sterling pound, the Japanese yen, the Canadian dollar, the Australian dollar, and the NZ dollar. The sample period is from January 2, 2006 to February 29, 2016. Splitting the sample before and after January 1, 2010, 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.

In the first subsample period (that is, January 2, 2006 to December 31, 2009), deviations had been negligible until the beginning of August 2007. But significant upward deviations had occurred since mid-August 2007 until they were temporarily stabilized in mid-2009. In particular, there were very large upward deviations when the Lehman shock occurred on September 15, 2008. The CIP condition suggests that the US dollar had lower interest rate than any other currency in the crisis. In the global crises, a flight to quality became serious. Consequently, increased demand for the US dollar as international liquidity made its interest rate lower than those of the other major currencies on the forward market.

Even in the second subsample period (that is, January 2, 2010 to February 29, 2016), significant upward deviations had occurred frequently for the Euro, the Sterling pound, the

Japanese yen, and the Canadian dollar. In particular, reflecting the Euro crisis, the Euro frequently showed large upward deviations from 2010 to 2012 and in 2015. However, unlike these currencies, the Australian dollar and the NZ dollar had significant downward deviations in the second subsample period. This implies that unlike the other major currencies, these currencies had lower interest rate than the US dollar on the forward market after the GFC.

The purpose of this paper is to explore what made the Australian dollar and the NZ dollar so different from the other major currencies in the CPI condition after the GFC. In the analysis, we especially focus on a distinct feature of Australia and New Zealand where short-term interest rates remained significantly positive even after the GFC. Figure 2 depicts each central bank's policy rate on daily basis. Soon after the Lehman shock, central banks in the USA, the UK, the Euro zone, and Japan adopted unconventional monetary policy to aid economic recovery. As a result, short-term interest rates hit the zero bound and fell into the liquidity trap in these advanced economies. In contrast, in Australia and New Zealand, short-term interest rates remained significantly positive. Consequently, both Australia and New Zealand became exceptional advanced economies that did not fall into the liquidity trap even after the GFC.

In the following analysis, we explore what made the Australian dollar and the NZ dollar so distinct in the CIP condition on the forward contract. We first construct a representative agent model in a small open economy and examine how international liquidity risk is reflected in the CIP condition. It is shown that increased liquidity risk may widen the CIP deviations but monetary expansion may mitigate the deviations. We then test this theoretical implication by examining the CIP condition in major currencies after the GFC. We find that various risk measures were determinants of deviations from the CIP condition after the GFC. In particular, currency-specific money market risk was critical in explaining the deviations. However, we also find that policy rates set by central banks were another important determinant of deviations from the CIP condition. The latter result supports our hypothesis that the distinct monetary policy feature in Australia and New Zealand made their CIP deviations so unique on the forward contract.

In previous literature, several studies have explored why the CIP condition was violated in the GFC. Baba and Packer (2009a,b) find that CIP deviations 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 the different effects of monetary policies which have not been discussed explicitly in literature.

One important implication of this paper is that the CIP condition is violated not only by liquidity risk in the international money market but also by different monetary policy regimes after the GFC. In the economy where the central bank set its policy rate to be zero, precautionary demand for local liquid assets becomes negligible because the local money market faces little liquidity risk. In contrast, in the country where the central bank's policy rate is far above zero, there still exits significant precautionary demand for local liquid assets. It is thus likely that the different effects between unconventional and conventional monetary policies would lead to different deviations in the CIP condition after the GFC.

2. The Theoretical Model

To see how liquidity risk is reflected in the CIP condition, we consider a representative agent model in a small open economy. In the economy, there are two liquid assets: local safe asset and foreign safe asset. The local liquid asset is denominated in the local (non-US dollar) currency, while the foreign liquid asset is denominated in the international currency (that is, the US dollar). The representative consumer chooses his or her stream of real consumption and asset holdings so as to maximize the following expected utility:

$$(1) \qquad \sum\nolimits_{j=0}^{\infty} \beta^{i} E_t u(C_{t+j}),$$

where β is discount factor such that $0 < \beta < 1$ and E_t is conditional expectation operator based on the information at period t. In the following analysis, we denote nominal values of local and foreign liquid assets at the end of period t by A_t and A^*_t respectively.

The consumer maximizes (1) subject to the following budget constraint:

$$(2) \quad A_t + S_t A^*_t = (1+i_{t-1}) A_{t-1} + (1+i^*_{t-1}) F_t A^*_{t-1} + P_t(Y_t - L_t) - C_t, \quad \text{for all t},$$

where P_t = domestic price, i_{t-1} = nominal interest rate of local liquid asset, i^*_{t-1} = nominal interest rate of foreign liquid asset, S_t = spot exchange rate, F_t = forward exchange rate, Y_t = real domestic output, and L_t = real losses from liquidity shocks. For all variables, subscript denotes time period.

Because of nominal contract, the consumer cannot hedge domestic inflation risk for the two liquid assets under the budget constraint (2). However, since F_t is forward exchange rate contracted in period t-1, the consumer covers the foreign asset's exchange risk by the forward contract. Thus, even if the spot exchange rate is volatile, the consumer faces no uncertainty on the one-period nominal return from holding the foreign liquid asset.

In our economy, both local and international liquidity shocks, that is, $\theta_t L$ and $\theta^*_t L^*$, hit the economy and deteriorate the domestic output Y_t at the beginning of each period. The size of the production losses, however, depends not only on liquid assets the consumer holds in period t but also on monetary policy in period t. Following a shopping time model in literature, we assume that $\theta_t L$ is decreasing and convex function of A_t/P_t and that the loss from $\theta^*_t L^*$ is decreasing and convex function of A^*_t/P^*_t, where P^*_t is foreign price in period t. We also assume that $\theta_t L$ is increasing in R_t and $\theta^*_t L^*$ is increasing in R^*_t, where R_t and R^*_t are the policy rate set by domestic and foreign central banks in period t respectively. The latter assumption reflects the fact that each central bank can reduce the liquidity risk through cutting its policy rate.

More specifically, the following analysis denotes the total output losses from the liquidity shocks as follows

(3) $$L_t = \theta_t L(A_t/P_t;\, R_t) + (S_t P^*_t /P_t)\ \theta^*_t L^*(A^*_t/P^*_t;\, R^*_t),$$

where $L' \equiv \partial L/\partial(A_t/P_t) < 0$, $\partial^2 L/\partial(A_t/P_t)^2 \leq 0$, $L^{*\prime} \equiv \partial L^*/\partial(A^*_t/P^*_t) < 0$, and $\partial^2 L^*/\partial(A^*_t/P^*_t)^2 \leq 0$. Since the loss from the international liquidity shock is denominated in the international currency, $\theta^*_t L^*$ is multiplied by $(S_t P^*_t /P_t)$ to adjust the real exchange rate.

The representative consumer chooses A_t and A^*_t so as to maximize (1) subject to (2) and (3). The first-order conditions of the constrained maximization lead to

(4) $$u'(C_t) = \beta\,[(1+i_t)/\{1 + \theta_t L'(A_t/P_t;\, R_t)\}]\, E_t\{(P_t/P_{t+1})u'(C_{t+1})\},$$

$$= \beta\,[(1+i^*_t)(F_{t+1}/S_t)/\{1 + \theta^*_t\, L^{*'}(A^*_t/P^*_t;\, R^*_t)\}]\; E_t\{(P_t/P_{t+1})u'(C_{t+1})\}.$$

Rearranging the second equality of the first-order conditions, we obtain the following modified CIP condition:

$$(5) \quad (1+i_t)/\{1 + \theta_t\, L'(A_t/P_t;\, R_t)\} = (1+i^*_t)(F_{t+1}/S_t)/\{1 + \theta^*_t L^{*'}(A^*_t/P^*_t;\, R^*_t)\}.$$

Since no liquidity shock implies $\theta_t = \theta^*_t = 0$, equation (5) is degenerated into the standard CIP condition when there is no liquidity shock. However, to the extent that the two liquid assets and two policy rates have different marginal contributions in mitigating the liquidity shocks, the condition (5) implies that the standard CIP condition does not hold when there are liquidity shocks. Taking logarithm of both sides of equation (5), we approximately obtain

$$(6) \quad i_t - (i^*_t + f_{t+1} - s_t) = \theta_t\, L'(A_t/P_t;\, R_t) - \theta^*_t\, L^{*'}(A^*_t/P^*_t;\, R^*_t),$$

where $f_{t+1} \equiv log(F_{t+1})$ and $s_t \equiv log(S_t)$.

Equation (6) indicates that the deviations from the CIP condition depend on the difference between $\theta_t\, L'(A_t/P_t;\, R_t)$ and $\theta^*_t\, L^{*'}(A^*_t/P^*_t;\, R^*_t)$. From equation (6), it is easy to see that $i_t > i^*_t + f_{t+1} - s_t$ when $\theta^*_t\, L^{*'}(A^*_t/P^*_t;\, R^*_t) < \theta_t\, L'(A_t/P_t;\, R_t) \leq 0$ and that $i_t < i^*_t + f_{t+1} - s_t$ when $\theta_t\, L'(A_t/P_t;\, R_t) < \theta^*_t\, L^{*'}(A^*_t/P^*_t;\, R^*_t) \leq 0$. In the GFC, shortage of international liquidity increased marginal benefits of holding the US dollar large in many countries. To the extent that A^*_t is foreign liquid assets denominated in the US dollar, this implies that the absolute value of $\theta^*_t\, L^{*'}(A^*_t/P^*_t;\, R^*_t)$ became large during the crisis. The condition (6) thus explains why the US dollar interest rate became lower on the forward market in the GFC.

However, we need to note that the output losses from the liquidity shocks $\theta_t L'(A_t/P_t; R_t)$ and $\theta^*_t L^{*'}(A^*_t/P^*_t; R^*_t)$ were also different across countries when the policy rates were different. For example, in the economies such as the USA, EU, and Japan, the central bank adopted unconventional monetary policy and kept its local nominal interest rate close to zero after the GFC. In contrast, in the countries such as Australia and New Zealand, the central bank kept its local nominal interest rate positive even after the GFC. Noting that the unconventional monetary policy is much more effective in reducing local liquidity risk than the conventional policy, this implies that $\theta_t L'(A_t/P_t; R_t)$ may have been larger in Australia and New Zealand than in EU and Japan after the GFC. Comparing deviations from the CIP condition in Australia and New Zealand with those in EU and Japan, the following sections explore the validity of this conjecture.[1]

3. Empirical Specification

The purpose of the following sections is to examine why the CIP condition of several major currencies, which had shown similar deviations in the GFC, showed asymmetric deviations after the GFC. Using the US dollar as the benchmark currency, the following analysis investigates what determined the CIP deviations between the US dollar and each of six currencies: the Euro, the Sterling pound, the Japanese yen, the Canadian dollar, the Australian dollar, and the NZ dollar. We chose these currencies because they are currencies in advanced economies which imposed no capital control but adopted different monetary policies after the GFC.

The total sample period is from January 2, 2009 to February 29, 2016. There is no consensus

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1 One may argue that the policy rate (R_t or R^*_t) also affects the interest rate of liquid asset (i_t or i^*_t). Although it is true, a change of the policy rate is neutral for the CIP condition when $\theta_t L'$ and $\theta^*_t L^{*'}$ are given. For example, given $\theta_t L'$, $\theta^*_t L^{*'}$, and R^*_t, a change of R_t is neutral for the CIP condition because R_t has the same impact on i_t and f_{t+1}-s_t. Similarly, given $\theta_t L'$, $\theta^*_t L^{*'}$, and R_t, a change of R^*_t is neutral for the CIP condition, $i_t - (i^*_t+f_{t+1}-s_t)$.

on when the GFC ended. But the market turbulences after the financial crisis of 2007–2008, known as the GFC, were almost stabilized in mid-2009 in most of the advanced countries. Defining the deviation from the CIP condition between the US dollar and currency j in period t by $Dev_t(j)$, the following analysis examines what factors explain $Dev_t(j)$ after the GFC. We calculate $Dev_t(j)$ by $Dev_t(j) \equiv (1+i^j_t) - (1+i^{us}_t)(F^j_{t+1}/S^j_t)$, where i^j_t is the three-month currency j's OIS rate, i^{us}_t is the three-month US dollar OIS rate, S^j_t is the US dollar spot exchange rate against currency j, and F^j_{t+1} is its three-month forward exchange rate. 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.

By using daily data, we estimate the following equation:

$$(7) \quad Dev_t(j) = const. + \sum_h a_h \cdot Dev_{t-h}(j) + b \cdot Risk_t(j) + c \cdot Risk_t(US) + d \cdot Rate_t(j) + e \cdot Rate_t(US) + \sum_k f_k \cdot X^k_t,$$

where j = the Euro, the Sterling pound, the Japanese yen, the Canadian dollar, the Australian dollar, and the NZ dollar. $Risk^k_t(j)$ and $Risk^k_t(US)$ are k type risk measure in currency j and the US dollar respectively, while $Rate_t(j)$ and $Rate_t(US)$ are the policy rate in currency j and the US dollar respectively· X^k_t is control variable k.

The right hand side of (7) includes the constant term, lagged dependent variables, money market risk measures, policy rates, and control variables as explanatory variables. The use of money market risk measures as explanatory variables is standard in literature. 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, money market risk measures may capture financial market tightness in each currency.

In contrast, the use of policy rates as explanatory variables is new in literature. However, after the GFC, several advanced countries adopted different monetary policies. One group of countries adopted unconventional monetary policy and set their policy rate to be almost zero. The other group of countries adopted conventional monetary policy and kept their policy rate far above zero. The use of policy rates thus can test whether the different monetary policies had different impacts on the CIP deviations. To the extent that lowering the policy rate reduces liquidity risk in the local money market, we can expect that the policy rate of currency *j* has a negative effect on $Dev_t(j)$, while the policy rate of the US dollar has a positive effect on $Dev_t(j)$.

In addition to these key variables, we also include two types of control variables. One is a credit risk measure in country in period *t*. To measure the country-specific credit risk, the following analysis uses the credit default swap (CDS) prices for country *q* (*q* = the United States, UK, Germany, Japan, Canada, Australia, and New Zealand). We use the daily time series of the five-year sovereign CDS. The data is downloaded from Datastream, which is based on Thomson Reuters CDS. After the GFC, soared sovereign risk hit mainly Euro member countries because of the Euro crisis. This suggests that credit risk had country-specific features after the GFC. We explore whether different country risk had different impacts in the sample period.

The other control variable is a global market risk measure in period *t*. To measure the global market risk 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.[2] 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

[2] The data was downloaded from Datastream.

next 30-day period. We explore whether the global market risk had different impacts in the two subsample periods.

4. Key Explanatory Variables and Their Basic Statistics

4.1. Currency-specific money market risk

To measure the currency-specific money market risk, the following analysis uses the spread between LIBOR and OIS rate in currency *h* (*h* = the US dollar, the Euro, the Sterling pound, the Japanese yen, the Canadian dollar, the Australian dollar, and the NZ dollar). 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.[3] LIBOR, which were published by the British Bankers' Association after 11:00 a.m. each day (Greenwich Mean Time), is based on the interest rates at which banks borrow unsecured funds from other banks in each currency. Each spread thus reflects a counterparty credit risk in currency *h*.[4] In calculating the spread, we use daily data of three-month LIBOR and three-month OIS rate for each currency.

Since LIBOR is no longer published for the NZ dollar after March 1, 2013 and for the Australian dollar and the Canadian dollar after June 1, 2013, we use alternative interbank market rate for these currencies when we need to calculate the spread after 2013. The alternative rates are three-month Bank Bill for the Australian dollar, three-month Interbank Rate (CIDOR) for the Canadian dollar, and 90-day Bank Bill for the NZ dollar.

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3 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.

4 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.

All of the data were downloaded from Datastream. Table 1 summarizes yearly-based basic test statistics of these daily money market risk measures from January 2, 2008 to February 29, 2016. All spreads had larger mean, median, standard deviation, and skewness in 2008-2009 than in the rest of the sample period. Regardless of the currency denomination, turbulence in the short-term money markets remained serious soon after the GFC than in the other post GFC period.

The contrast between 2008-2009 and the rest of the sample period was especially conspicuous in the US dollar and the Sterling pound. The mean of the spreads in the US dollar which was about 100 basis points in 2008 and about 50 basis points in 2009 dropped below 20 basis points in 2010 and remained low in the following years. The mean in the Sterling pound which exceeded 100 basis points in 2008 and was about 75 basis points in 2009 dropped to around 20 basis points in 2010 and remained low in the following years. The sharply increased money market credit risk in the two currencies was relatively stabilized in the post GFC period. The mean of the Euro-denominated spreads which was close to 90 basis points also dropped significantly in 2010. However, the spread of the Euro increased to over 40 basis points in 2011 because of the Euro crisis.

In contrast, the Australia dollar and the NZ dollar were a relatively safe currency in the international money market in the GFC. The mean of the spreads was about 50 basis points in 2008 in the Australian dollar and about 30 basis points in 2009 in the Australian dollar and the NZ dollar. Their mean of the spreads remained low in the following years.

4.2. Policy rate

Policy rates set by central banks are also key variables in our estimations. Soon after the Lehman shock, central banks in the USA, the UK, the Euro zone, and Japan adopted unconventional monetary policy to aid economic recovery. As a result, short-term interest rates hit the zero bound and fell into the liquidity trap in these advanced economies. In contrast, in Australia and New Zealand, short-term interest rates remained significantly positive. Consequently, both Australia and New Zealand became exceptional advanced economies that did not fall into the liquidity trap even after the GFC.

For the policy rates, the following analysis uses RBA New Cash Rate Target for Australia, Overnight Money Market Financing Rate for Canada, Uncollateral Overnight Call Rate for Japan, RBNZ Official Cash Rate (OCR) for New Zealand, Clearing Banks Base Rate for the UK, Federal Fund Effective Rate for the USA, and Main refinancing operations for ECB. Table 2 summarizes yearly-based basic test statistics of these daily policy rate from January 2, 2009 to February 29, 2016. In 2008, the policy rate was still far above zero in all of the currencies except the Japanese yen. But in 2009, the policy rate became close to zero in all of the currencies except the Australian dollar and the NZ dollar. In 2009, the policy rate also dropped significantly in the Australian dollar and the NZ dollar. But their policy rate was still significantly above zero in 2009 and the following years.

5. Estimation Results

This section reports our empirical results. In each regression we use daily data for each of the two alternative periods: from January 2, 2009 to May 30, 2013 and from January 2, 2009 to February 29, 2016. The unit of each interest rate is basis point. We run OLS regressions for equation (7) with six lagged dependent variables. Since the dependent variable is the value at 4pm in London time, we choose the explanatory variables which are the latest values before 4pm in London time. The estimated results are summarized in Table 3. It shows that both money market risk measures and policy rates had significant effects on the CIP deviations. In particular, many of them had the same signs for most of the major currencies. This implies that the determinants of the CIP deviations were common across the major currencies. The result is noteworthy because the CIP condition showed downward deviations in the Australian dollar and the NZ dollar but upward deviations in the other major currencies.

5.1. Currency-specific money market risk

Regarding currency-specific money market risk measures, they were not statistically significant for the Euro. This may have happened because the Euro crisis increased serious sovereign risk but did not increase money market risk in the Euro zone. But except for the Euro, the spread denominated in the currency *j* had a significantly negative effect on the deviations, while the US dollar-denominated spread had a significantly positive effect on the deviations. The symmetric results indicate that the foreign exchange forward markets were very sensitive to a liquidity shortage and that an increase in currency-specific market risk made liquidity of the currency tighter and decreased the secured interest rate on the forward contract. In particular, the US dollar-denominated spread had a significantly positive effect on the deviations. After the Lehman shock, coordinated monetary policies by central banks contributed to reducing liquidity risk in the international money market. But, due to the role of the US dollar as international liquidity, global liquidity shortage still made the US dollar interest rate lower on the forward contract in most of the major currencies in the post-GFC period.

Among the major currencies, the Japanese yen and the Sterling Pound were sensitive to the currency-specific money market risk measures. But the Australian dollar and the NZ dollar were also very sensitive to the currency-specific money market risk measures. This implies that relatively larger currency-specific market risk in the post GFC period increased demand for the local currency and made the CIP deviations unique in the Australian dollar and the NZ dollar.

5.2. Policy rates

Both the local and US policy rates were not statistically significant for the Japanese yen. This may reflect the fact because both Japan and the USA were under liquidity trap in most of the sample period. But except for the Yen, the policy rate in the currency j had a significantly negative effect on the deviations, while the US policy rate had a significantly positive effect on the deviations. The symmetric results indicate that less expansionary monetary policy made liquidity of the currency tighter and decreased the secured interest rate on the forward contract.

The result has especially important implication for the CIP deviations in the Australian dollar and the NZ dollar. Soon after the Lehman shock, central banks in the USA, the UK, the Euro zone, and Japan adopted unconventional monetary policy to aid economic recovery. As a result, short-term interest rates hit the zero bound and fell into the liquidity trap in these advanced economies. In contrast, in Australia and New Zealand, short-term interest rates remained significantly positive. Consequently, both Australia and New Zealand became exceptional advanced economies that did not fall into the liquidity trap even after the GFC. Thus, relatively larger policy rate in the post GFC period increased demand for the local currency and made the CIP deviations unique in the Australian dollar and the NZ dollar.

5.3. Other variables

Regarding local sovereign CDS, the effects were rather heterogeneous across the currencies. The local sovereign CDS had a significantly negative effect in the Yen, the Euro, and the NZ dollar. In particular, Germany sovereign CDS had a large negative effect. 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 coefficient of the Germany sovereign CDS might have reflected the environments. In contrast, the local sovereign CDS had a significantly positive effect in the Australian dollar and the Sterling pound. The financial markets were relatively sound in Australia and the United Kingdom when the Euro crisis occurred. The distinct feature may have reflected the environments.

The US sovereign CDS had a significantly positive effect in the Australian dollar, the Canadian dollar, and the New Zealand dollar. These currencies might be more vulnerable to sovereign shocks in the United States and might have a flight to quality might when the US sovereign risk increased. But the US sovereign CDS had no significant effect in the Euro, the Yen, and the Sterling pound. In contrast, VIX had a significantly positive in the Euro and the Yen. This suggests that the global market risk had a significant impact on the deviations in the Euro and the Yen. But the effect of VIX was mixed in the Australian dollar and the New Zealand.

6. Concluding Remarks

To be addressed.

References

Baba, N., and F. Packer, (2009a) Interpreting Deviations from Covered Interest Parity During the Financial Market Turmoil of 2007-08, *Journal of Banking and Finance* 33(11), 1953-62.

——— (2009b) From Turmoil to Crisis: Dislocations in the FX Swap Market Before and After the Failure of Lehman Brothers, *Journal of International Money and Finance* 28(8), 1350-74.

Coffey, N., W. B. Hrung, and A. Sarkar, (2009), Capital Constraints, Counterparty Risk, and Deviations from Covered Interest Rate Parity, Federal Reserve Bank of New York Staff Report no. 393.

Fong, W.-M., G. Valente, and J. K. W. Fung, (2010), "Covered Interest Arbitrage Profits: the Role of Liquidity and Credit risk," *Journal of Banking and Finance*, 34, 1098–1107.

Fukuda, S., (2012), Market-specific and Currency-specific Risk during the Global Financial Crisis: Evidence from the Interbank Markets in Tokyo and London, *Journal of Banking and Finance*, 36 (12), 3185-3196.

Fukuda, S., (2011), Regional Liquidity Risk and Covered Interest Parity during the Global Financial Crisis: Evidence from Tokyo, London, and New York, paper presented at 24th Australasian Finance & Banking Conference held at Sydney, Australia on December 14-16, 2011.

Grioli, T. M., and A. Ranaldo, (2010) Limits to Arbitrage during the Crisis: Funding Liquidity Constraints and Covered Interest Parity, Swiss National Bank.

Moessner, R., and W. A. Allen, (2013), Central Bank Swap Line Effectiveness during the Euro Area Sovereign Debt Crisis, *Journal of International Money and Finance*, 35, 167-178.

Mollenkamp, C., and J. Whitehouse, (2008), Bankers cast doubt on key rate amid crisis, *The Wall Street Journal*, April 15, 2008.

Taylor, J., and J. Williams, (2009), A Black Swan in the Money Market. *American Economic Journal: Macroeconomics*, 1(1): 58--83.

Table 1. Basic Test Statistics of Money Market Risk Measures

(1) Australia

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mean	0.51	0.30	0.24	0.28	0.25	0.12	0.19	0.23	0.35
Median	0.46	0.27	0.22	0.24	0.25	0.12	0.18	0.22	0.35
Maximum	1.43	0.80	0.52	0.63	0.49	0.23	0.33	0.41	0.40
Minimum	0.19	0.05	0.05	0.08	0.01	0.01	0.10	0.06	0.32
Std. Dev.	0.19	0.14	0.09	0.14	0.09	0.04	0.05	0.06	0.02
Skewness	1.21	0.95	0.53	0.67	0.22	−0.11	0.79	0.86	0.58
Kurtosis	4.83	3.47	3.29	2.32	2.89	3.25	2.98	3.44	4.34
Observations	262	261	261	260	261	261	261	261	47

(2) Canada

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mean	0.68	0.22	0.22	0.29	0.29	0.27	0.27	0.31	0.44
Median	0.67	0.18	0.22	0.28	0.29	0.28	0.27	0.31	0.41
Maximum	1.21	0.70	0.35	0.35	0.33	0.29	0.29	0.41	0.50
Minimum	0.33	0.17	0.16	0.24	0.25	0.25	0.27	0.26	0.39
Std. Dev.	0.22	0.09	0.03	0.03	0.02	0.01	0.00	0.04	0.04
Skewness	0.84	3.41	0.22	0.54	−0.18	−0.71	1.77	0.47	0.30
Kurtosis	3.17	16.81	2.36	2.20	3.27	3.02	6.50	2.39	1.32
Observations	85	261	261	260	261	261	261	261	47

(3) Euro

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mean	0.88	0.54	0.25	0.43	0.29	0.05	0.11	0.10	0.13
Median	0.72	0.47	0.24	0.25	0.30	0.05	0.11	0.11	0.13
Maximum	1.95	1.16	0.37	0.93	0.89	0.11	0.20	0.17	0.18
Minimum	0.29	0.21	0.13	0.09	0.04	0.01	0.03	0.06	0.11
Std. Dev.	0.44	0.27	0.05	0.28	0.23	0.02	0.03	0.02	0.01
Skewness	1.03	0.62	0.29	0.51	0.96	1.66	0.56	0.63	1.50
Kurtosis	2.77	2.08	2.74	1.56	3.07	8.13	3.28	5.57	6.37
Observations	262	261	261	260	261	261	261	261	46

(4) Japan

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mean	0.47	0.37	0.14	0.12	0.12	0.08	0.06	0.03	0.04
Median	0.41	0.35	0.15	0.12	0.12	0.08	0.07	0.03	0.05
Maximum	0.81	0.73	0.18	0.14	0.13	0.10	0.08	0.09	0.08
Minimum	0.37	0.18	0.09	0.09	0.10	0.07	0.04	0.01	−0.02
Std. Dev.	0.11	0.14	0.02	0.01	0.01	0.01	0.01	0.01	0.02
Skewness	1.30	0.40	−1.17	−1.03	−0.33	1.16	−0.81	0.38	−0.14
Kurtosis	3.44	2.17	3.26	2.82	2.27	3.28	2.31	3.78	1.52
Observations	262	261	261	260	261	261	261	261	46

(5) New Zealand

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mean	NA	0.28	0.22	0.20	0.20	0.14	0.17	0.17	0.22
Median	NA	0.28	0.19	0.19	0.20	0.14	0.17	0.16	0.21
Maximum	NA	0.40	0.65	0.49	0.29	0.20	0.24	0.33	0.32
Minimum	NA	0.22	0.07	−0.37	0.10	0.11	0.09	0.08	0.15
Std. Dev.	NA	0.04	0.13	0.12	0.04	0.02	0.02	0.05	0.05
Skewness	NA	0.66	2.22	−1.93	−0.10	0.70	−0.09	0.88	0.20
Kurtosis	NA	3.20	6.79	12.59	2.29	3.29	3.63	3.16	1.43
Observations	NA	162	261	260	261	261	261	261	47

(6) United Kingdom

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mean	1.07	0.74	0.21	0.34	0.39	0.10	0.11	0.12	0.13
Median	0.80	0.75	0.23	0.30	0.46	0.10	0.10	0.12	0.13
Maximum	3.00	1.66	0.26	0.59	0.60	0.14	0.13	0.13	0.14
Minimum	0.26	0.15	0.15	0.17	0.11	0.09	0.08	0.10	0.12
Std. Dev.	0.62	0.50	0.03	0.11	0.18	0.01	0.01	0.01	0.00
Skewness	0.98	0.31	−0.54	0.60	−0.37	2.04	0.06	0.09	0.15
Kurtosis	2.68	1.63	1.56	2.24	1.49	9.07	2.05	2.52	3.95
Observations	262	261	261	260	261	261	261	261	46

(7) United States

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mean	1.08	0.49	0.16	0.23	0.29	0.15	0.14	0.14	0.23
Median	0.76	0.36	0.11	0.17	0.30	0.15	0.14	0.14	0.23
Maximum	3.64	1.24	0.34	0.50	0.51	0.17	0.16	0.23	0.25
Minimum	0.31	0.07	0.06	0.12	0.16	0.13	0.12	0.09	0.22
Std. Dev.	0.72	0.38	0.09	0.11	0.09	0.01	0.01	0.02	0.01
Skewness	1.71	0.44	1.12	1.18	0.29	−0.19	0.13	2.21	0.13
Kurtosis	5.25	1.53	2.60	3.11	2.76	2.41	2.35	9.22	2.63
Observations	262	261	261	260	261	261	261	261	46

Table 2. Basic Test Statistics of Policy Rates

(1) Australia

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mean	6.67	3.28	4.35	4.69	3.69	2.73	2.50	2.11	2.00
Median	7.00	3.25	4.50	4.75	3.50	2.75	2.50	2.00	2.00
Maximum	7.25	4.25	4.75	4.75	4.25	3.00	2.50	2.50	2.00
Minimum	4.25	3.00	3.75	4.25	3.00	2.50	2.50	2.00	2.00
Std. Dev.	0.92	0.39	0.33	0.14	0.43	0.22	0.00	0.16	0.00
Skewness	−1.64	1.46	−0.77	−2.30	0.20	0.12	NA	1.23	NA
Kurtosis	4.39	4.06	2.28	7.00	1.65	1.35	NA	3.30	NA
Observations	262	261	261	260	261	261	261	261	59

(2) Canada

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mean	3.04	0.43	0.59	1.00	1.00	1.00	1.00	0.65	0.50
Median	3.00	0.25	0.50	1.00	1.00	1.00	1.00	0.75	0.50
Maximum	4.25	1.50	1.00	1.00	1.00	1.00	1.00	1.00	0.50
Minimum	1.50	0.25	0.25	1.00	1.00	1.00	1.00	0.50	0.50
Std. Dev.	0.68	0.34	0.33	0.00	0.00	0.00	0.00	0.15	0.00
Skewness	−0.28	1.92	0.17	NA	NA	NA	NA	0.44	NA
Kurtosis	2.98	5.59	1.31	NA	NA	NA	NA	2.32	NA
Observations	262	261	261	260	257	261	261	261	60

(3) Euro

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mean	3.90	1.28	1.00	1.25	0.88	0.55	0.16	0.05	0.05
Median	4.00	1.00	1.00	1.25	1.00	0.50	0.15	0.05	0.05
Maximum	4.25	2.50	1.00	1.50	1.00	0.75	0.25	0.05	0.05
Minimum	2.50	1.00	1.00	1.00	0.75	0.25	0.05	0.05	0.00
Std. Dev.	0.44	0.45	0.00	0.20	0.13	0.17	0.09	0.00	0.01
Skewness	−2.10	1.49	NA	0.00	−0.10	−0.26	−0.25	NA	−7.48
Kurtosis	6.85	3.89	NA	1.53	1.01	2.23	1.41	NA	57.02
Observations	262	261	261	260	261	261	261	261	59

(4) Japan

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mean	0.46	0.11	0.09	0.08	0.08	0.08	0.07	0.07	0.04
Median	0.50	0.10	0.09	0.08	0.08	0.07	0.07	0.08	0.06
Maximum	0.64	0.13	0.11	0.11	0.11	0.11	0.09	0.09	0.08
Minimum	0.10	0.09	0.08	0.06	0.07	0.06	0.03	0.01	−0.01
Std. Dev.	0.10	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.04
Skewness	−1.99	1.09	0.48	0.38	0.13	1.34	−0.60	−3.88	−0.12
Kurtosis	6.10	5.22	3.95	3.08	3.51	5.83	11.18	24.96	1.07
Observations	262	261	261	260	261	261	261	261	59

(5) New Zealand

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mean	7.68	2.87	2.75	2.59	2.50	2.50	3.13	3.15	2.45
Median	8.25	2.50	2.75	2.50	2.50	2.50	3.25	3.25	2.50
Maximum	8.25	5.00	3.00	3.00	2.50	2.50	3.50	3.50	2.50
Minimum	5.00	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.25
Std. Dev.	0.95	0.70	0.23	0.19	0.00	0.00	0.40	0.35	0.10
Skewness	−1.80	2.14	0.00	1.66	NA	NA	−0.48	−0.37	−1.61
Kurtosis	5.14	6.71	1.15	3.75	NA	NA	1.63	1.59	3.59
Observations	262	261	261	260	261	261	261	261	59

(6) United Kingdom

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mean	4.67	0.64	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Median	5.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Maximum	5.50	2.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Minimum	2.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Std. Dev.	0.97	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Skewness	−1.87	2.38	NA	NA	NA	NA	NA	NA	NA
Kurtosis	5.15	7.70	NA	NA	NA	NA	NA	NA	NA
Observations	262	261	261	260	261	261	261	261	59

(7) United States

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mean	1.93	0.16	0.18	0.10	0.14	0.11	0.09	0.13	0.36
Median	2.01	0.16	0.19	0.09	0.15	0.09	0.09	0.13	0.37
Maximum	4.27	0.25	0.22	0.19	0.19	0.17	0.13	0.37	0.38
Minimum	0.09	0.05	0.05	0.04	0.04	0.06	0.06	0.06	0.20
Std. Dev.	1.04	0.04	0.03	0.03	0.03	0.03	0.01	0.05	0.03
Skewness	−0.01	0.32	−1.27	0.98	−1.04	0.57	0.76	3.93	−4.31
Kurtosis	2.81	2.58	3.97	2.72	3.34	1.79	4.23	19.35	24.09
Observations	262	261	261	260	261	261	261	261	59

Table 3. Estimation Results

(1) Australia

		2009-2013	2009-2016
	Constant term	0.583	−2.166
		(0.46)	(−4.00)***
Lagged dependent var.	Dependent var. (-1)	0.434	0.467
		(14.88)***	(20.38)***
	Dependent var. (-2)	0.120	0.126
		(4.01)***	(5.34)***
	Dependent var. (-3)	0.050	0.063
		(1.67)*	(2.67)***
	Dependent var. (-4)	−0.007	−0.004
		(−0.23)	(−0.17)
	Dependent var. (-5)	0.391	0.408
		(13.21)***	(17.35)***
	Dependent var. (-6)	−0.160	−0.169
		(−5.59)***	(−7.45)***
Measure of currency-specific credit risk	Local LIBOR spread	−0.106	−0.091
		(−6.33)***	(−5.52)***
	Dollar LIBOR spread	0.120	0.037
		(5.14)***	(2.59)***
Policy rates	Local policy rate	−0.014	−0.001
		(−4.26)***	(−0.89)
	US policy rate	0.117	0.038
		(2.85) ***	(1.94)*
Measure of country-specific credit risk	Local CDS/100	0.034	−0.001
		(1.91)*	(−0.08)
	US CDS/100	0.060	0.057
		(2.60)***	(3.24)***
Market risk	VIX	−0.064	0.029
		(−2.23)**	(1.23)
	Adjusted R-squared	0.86	0.88
	Observation number	1145	1847

(2) Canada

		2009-2013	2009-2016
	Constant term	−0.728	1.273
		(−1.63)	(3.67)***
Lagged dependent var.	Dependent var. (-1)	0.761	0.766
		(25.57)***	(32.95)***
	Dependent var. (-2)	0.077	0.070
		(2.08)**	(2.40)**
	Dependent var. (-3)	0.002	0.008
		(0.05)	(0.28)
	Dependent var. (-4)	−0.046	−0.025
		(−1.22)	(−0.88)
	Dependent var. (-5)	0.085	0.139
		(2.29)**	(4.82)***
	Dependent var. (-6)	−0.001	−0.057
		(−0.05)	(−2.50)**
Measure of currency-specific credit risk	Local LIBOR spread	−0.013	−0.040
		(−0.98)	(−3.64)***
	Dollar LIBOR spread	0.031	0.047
		(2.33)**	(4.71)***
Policy rates	Local policy rate	−0.014	−0.010
		(−4.75)***	(−3.73)***
	US policy rate	0.053	0.020
		(3.12) ***	(1.99)**
Measure of country-specific credit risk	Local CDS/100	0.005	−0.008
		(0.85)	(−2.24)**
	US CDS/100	0.031	0.020
		(3.14)***	(2.56)**
Market risk	VIX	0.017	0.006
		(1.25)	(0.58)
	Adjusted R-squared	0.97	0.97
	Observation number	1148	1850

(3) Euro

		2009-2013	2009-2016
	Constant term	−2.164	−3.186
		(−1.17)	(−2.53)**
Lagged dependent var.	Dependent var. (-1)	0.238	0.194
		(8.00)***	(8.38)***
	Dependent var. (-2)	0.163	0.057
		(5.35)***	(2.43)**
	Dependent var. (-3)	0.156	0.143
		(5.10)***	(6.14)***
	Dependent var. (-4)	0.075	0.098
		(2.44)**	(4.19)***
	Dependent var. (-5)	0.071	0.103
		(2.35)**	(4.41)***
	Dependent var. (-6)	0.065	0.084
		(2.23)**	(3.63)***
Measure of currency-specific credit risk	Local LIBOR spread	0.009	0.035
		(0.38)	(1.12)
	Dollar LIBOR spread	0.004	0.014
		(0.15)	(0.43)
Policy rates	Local policy rate	−0.046	−0.040
		(−2.55)**	(−3.23)***
	US policy rate	0.172	0.280
		(2.28)**	(4.42)***
Measure of country-specific credit risk	Local CDS/100	0.129	0.168
		(6.63)***	(6.99)***
	US CDS/100	−0.048	−0.084
		(−1.19)	(−1.58)
Market risk	VIX	0.259	0.228
		(4.09)***	(3.07)***
	Adjusted R-squared	0.74	0.55
	Observation number	1145	1861

(4) Japan

		2009-2013	2009-2016
	Constant term	5.121	5.047
		(0.86)	(1.77)*
Lagged dependent var.	Dependent var. (-1)	0.135	0.129
		(4.52)***	(5.56)***
	Dependent var. (-2)	0.093	0.075
		(3.11)***	(3.22)***
	Dependent var. (-3)	0.136	0.159
		(4.55)***	(6.89)***
	Dependent var. (-4)	0.074	0.107
		(2.49)**	(4.60)***
	Dependent var. (-5)	0.096	0.110
		(3.21)***	(4.72)***
	Dependent var. (-6)	0.076	0.110
		(2.57)**	(4.31)***
Measure of currency-specific credit risk	Local LIBOR spread	−0.839	−0.619
		(−4.69)***	(−5.62)***
	Dollar LIBOR spread	0.346	0.251
		(4.55)***	(4.72)***
Policy rates	Local policy rate	0.512	−0.309
		(0.87)	(−0.82)
	US policy rate	−0.106	0.122
		(−0.73)	(1.61)
Measure of country-specific credit risk	Local CDS/100	−0.097	−0.067
		(−2.10)**	(−3.17)***
	US CDS/100	0.046	0.044
		(0.76)	(0.75)
Market risk	VIX	0.696	0.606
		(6.00)***	(6.55)***
	Adjusted R-squared	0.50	0.48
	Observation number	1145	1861

(5) New Zealand

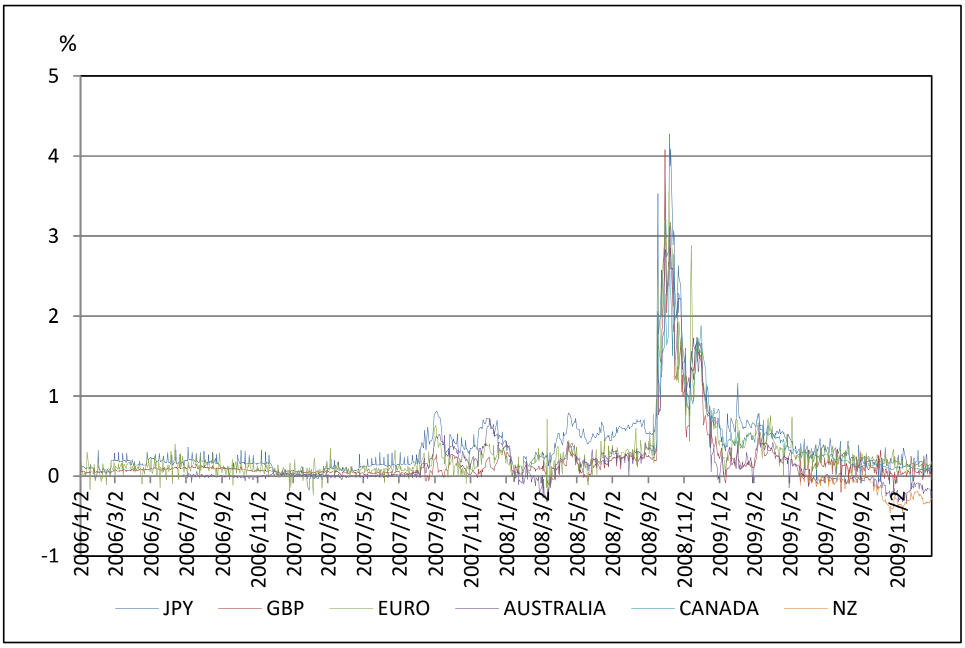
		2009-2013	2009-2016
	Constant term	8.725	3.393
		(2.43)**	(2.31)**
Lagged dependent var.	Dependent var. (-1)	0.309	0.364
		(10.39)***	(15.93)***
	Dependent var. (-2)	0.120	0.105
		(3.81)***	(4.36)***
	Dependent var. (-3)	0.028	0.021
		(0.87)	(0.86)
	Dependent var. (-4)	0.005	0.000
		(0.17)	(−0.01)
	Dependent var. (-5)	0.200	0.269
		(6.37)***	(11.29)***
	Dependent var. (-6)	0.001	−0.088
		(0.04)	(−3.95)***
Measure of currency-specific credit risk	Local LIBOR spread	−0.599	−0.432
		(−21.75)***	(−22.42)***
	Dollar LIBOR spread	0.319	0.128
		(10.08)***	(5.94)***
Policy rates	Local policy rate	−0.014	−0.025
		(−1.13)	(−5.71)***
	US policy rate	0.531	0.097
		(6.83)***	(4.55)***
Measure of country-specific credit risk	Local CDS/100	−0.023	−0.039
		(−1.18)	(−2.79)***
	US CDS/100	0.050	0.095
		(1.11)	(3.90)***
Market risk	VIX	−0.183	0.127
		(−5.08)***	(4.61)***
	Adjusted R-squared	0.75	0.74
	Observation number	737	1498

(6) United Kingdom

		2009-2013	2009-2016
	Constant term	−4.413	−0.790
		(−2.60)***	(−0.55)
Lagged dependent var.	Dependent var. (-1)	0.144	0.100
		(4.89)***	(4.33)***
	Dependent var. (-2)	0.087	0.074
		(2.91)***	(3.19)***
	Dependent var. (-3)	0.036	0.049
		(1.22)	(2.14)**
	Dependent var. (-4)	0.141	0.105
		(4.76)***	(4.52)***
	Dependent var. (-5)	0.042	0.045
		(1.41)	(1.92)*
	Dependent var. (-6)	0.073	0.113
		(2.48)**	(4.91)***
Measure of currency-specific credit risk	Local LIBOR spread	−0.188	−0.167
		(−5.42)***	(−4.70)***
	Dollar LIBOR spread	0.309	0.302
		(6.05)***	(6.11)***
Policy rates	Local policy rate	−0.063	−0.066
		(−2.61)***	(−2.37)**
	US policy rate	0.461	0.298
		(5.88)	(5.70)***
Measure of country-specific credit risk	Local CDS/100	0.069	0.039
		(2.76)***	(1.95)*
	US CDS/100	−0.041	−0.038
		(−0.98)	(−0.83)
Market risk	VIX	0.027	0.057
		(0.47)	(0.99)
	Adjusted R-squared	0.38	0.25
	Observation number	1145	1854

Figure 1. The CIP deviations when the US dollar is a benchmark currency

(1) January 2, 2006 to December 31, 2009



(2) January 2, 2010 to February 29, 2016

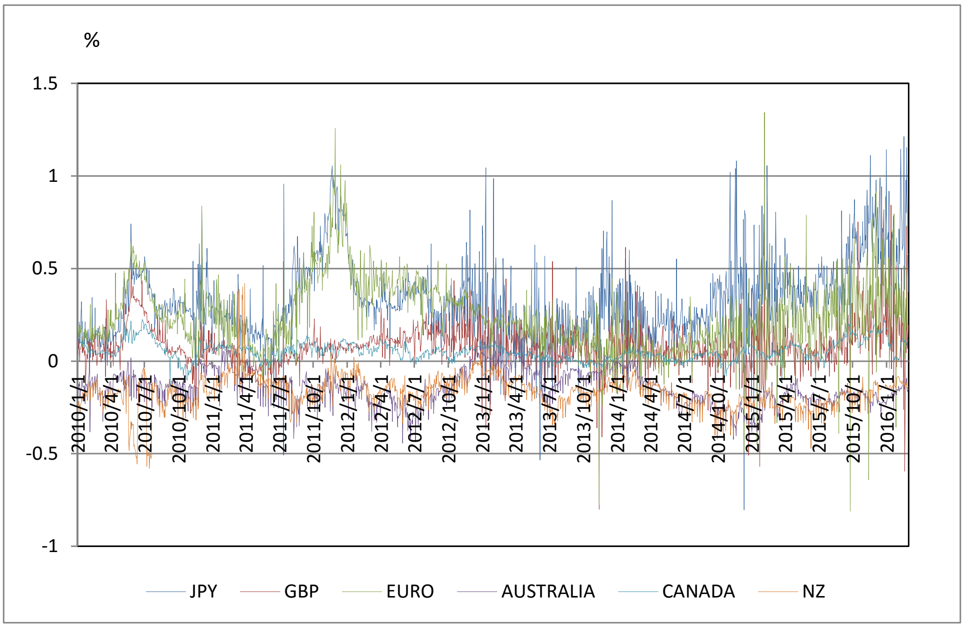


Figure 2. Central bank's policy rates