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Monetary Policy and Covered Interest Parity in the Post GFC Period: Evidence from the Australian Dollar and the NZ Dollar

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Abstract

Unlike the other major currencies, the Australian Dollar and the NZ dollar had lower interest rate than the US dollar on forward contract in the post GFC period. The purpose of this paper is to explore why this happened through estimating the covered interest parity (CIP) 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. The paper first constructs a theoretical model where increased liquidity risk causes deviations from the CIP condition. It then tests this theoretical implication by using daily data of six major currencies. We find that both money market risk measures and policy rates had significant effects on the CIP deviations. The result implies that unique monetary policy feature in Australia and New Zealand made deviations from the CIP condition distinct on the forward contract.

JEL codes: G15, G12, F36

Keywords: covered interest parity, monetary policy, global financial crisis

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1. Introduction

The global financial crisis (GFC) and the following instability in the world economy had enormous impacts on international markets. A number of studies argued that large scale asset purchases by a central bank was effective in mitigating the impacts and helped stabilize financial markets (see, for example, Gertler and Kiyotaki [2010]). However, since each country faced different macroeconomic environments, the degree of monetary expansion was heterogeneous across countries in the post GFC period. The purpose of this paper is to explore how different monetary expansion affected international money market instability in the post GFC period. Specifically, we calculate deviations from covered interest parity (CIP) condition and examine how distinct monetary policy in Australia and New Zealand made their deviations so unique on the forward contract.

Using overnight index swap (OIS) rates as secured shot-term interest rates, Figure 1 depicts daily deviations from CIP condition between the US dollar and each of the five non-US dollar currencies: the Euro, the UK pound, the Japanese yen, the Australian dollar, and the NZ dollar. The sample period is from 2 January 2006 to 29 February 2016. Splitting the sample before and after 1 January 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 $i^{n}_{t} \equiv$ currency n's 3-month OIS rate, $i^{us}_{t} \equiv$ US dollar 3-month OIS rate, $S^{n}_{t} \equiv$ the spot exchange rate between the two currencies, and $F^{n}_{t+1} \equiv$ its 3-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, 2 January 2006 to 31 December 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 early 2009. In particular, there were very large upward deviations when the Lehman shock occurred on 15 September 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, 2 January 2010 to 29 February 2016), significant upward deviations had occurred frequently for the Euro, the UK pound, and the Japanese yen. 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.

In the following analysis, we explore what made the Australian dollar and the NZ dollar so different from the other major currencies in the CIP 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 recovery from deflationary economy. As a result, short-term interest rates hit the zero bound and fell into "liquidity trap" in these advanced economies. In contrast, in Australia and New Zealand where inflation rates were within their target range, short-term interest rates remained significantly positive. Consequently, even if world financial markets were still in turbulence, both Australia and New Zealand became exceptional advanced economies that did not fall into "liquidity trap" after the GFC.

In the following sections, 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 (2016a) explores why the UK pound showed smaller deviations than the Euro after the GFC, while Fukuda (2016b) 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.[1] There are several studies which have examined the effects of central bank liquidity provisions during the global financial crisis. The authors such as Goldberg,

[1] In literature, several studies investigate the interest rate parity conditions in Australia and New Zealand (see, for example, Felmingham and Leong [2005]). But most of them explore the CIP condition before the GFC. Guender (2014) examines the interest rate parity conditions including the post GFC period but only analyzed the uncovered parity condition.

Kennedy, and Miu (2011) and Aizenman and Pasricha (2010) show the contribution of foreign exchange swap lines among central banks to reducing dollar funding pressures and limiting stresses in money markets[2]. But none of them showed that different monetary policy regimes have different impacts on international money markets.

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 difference between unconventional and conventional monetary policies would result in 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 (that is, local safe asset and foreign safe asset) and two monies (that is, local money and foreign money). The local liquid asset and local money are denominated in the local (non-US dollar) currency, while the foreign liquid asset and foreign money are 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:

[2] Engel (2016) provides general survey for the role of macroprudence policy to stabilize international financial markets.

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

where C_{t+j} = real consumption at period t+*j*. 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 and nominal values of local and foreign monies at the end of period *t* by M_t and M^*_t respectively.

For all t, the consumer maximizes (1) subject to the following budget constraint:

(2) $A_t + S_t A^*_t + M_t + S_t M^*_t$

$= (1+i_{t-1}) A_{t-1} + (1+i^*_{t-1}) F_t A^*_{t-1} + M_{t-1} + F_t M^*_{t-1} + P_t(Y_t - L_t) - P_t C_t + T_t$,

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, L_t = real losses from liquidity shocks, and T_t = nominal lump-sum transfer from the government. For all variables, subscript denotes time period.

Because of nominal contract, the consumer cannot hedge inflation risk for the two liquid assets and two monies 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 on liquid assets and monies the consumer holds 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 M_t/P_t. We also assume that the loss from $\theta^*_t L^*$ is decreasing and convex function of A^*_t/P^*_t and M^*_t/P^*_t, where P^*_t is foreign price in period t. The assumption implies that the role of liquid asset and money is currency-specific in the sense that local assets can mitigate only the local liquidity shock and that foreign assets can mitigate only the foreign liquidity shock.

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

$$(3) \quad L_t = \theta_t L(A_t/P_t, M_t/P_t) + (S_t P^*_t / P_t)\ \theta^*_t L^*(A^*_t/P^*_t, M^*_t/P^*_t),$$

where $L_1 \equiv \partial L/\partial(A_t/P_t) < 0$, $L_2 \equiv \partial L/\partial(M_t/P_t) < 0$, $\partial^2 L/\partial(A_t/P_t)^2 \leq 0$, $\partial^2 L/\partial(M_t/P_t)^2 \leq 0$, $L_{12} \equiv \partial^2 L/\partial(A_t/P_t)\partial(M_t/P_t) \leq 0$, $L^*_1 \equiv \partial L^*/\partial(A^*_t/P^*_t) < 0$, $L^*_2 \equiv \partial L^*/\partial(M^*_t/P^*_t) < 0$, $\partial^2 L^*/\partial(A^*_t/P^*_t)^2 \leq 0$, $\partial^2 L^*/\partial(M^*_t/P^*_t)^2 \leq 0$, and $L^*_{12} \equiv \partial^2 L^*/\partial(A^*_t/P^*_t)\partial(M^*_t/P^*_t) \leq 0$. 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

$$(4) \quad u'(C_t) = \beta\,[(1+i_t)/\{1 + \theta_t L_1(A_t/P_t, M_t/P_t)\}]\, E_t\{(P_t/P_{t+1})u'(C_{t+1})\},$$

$$= \beta\,[(1+i^*_t)(F_{t+1}/S_t)/\{1 + \theta^*_t L^*_1(A^*_t/P^*_t, M^*_t/P^*_t)\}]\, E_t\{(P_t/P_{t+1})u'(C_{t+1})\}.$$

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

$$(5)\quad (1+i_t)/\{1 + \theta_t L_1(A_t/P_t, M_t/P_t)\} = (1+i^*_t)(F_{t+1}/S_t)/\{1 + \theta^*_t L^*_1 (A^*_t/P^*_t, M^*_t/P^*_t)\}.$$

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 monies 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 (that is, $\theta_t > 0$ and/or $\theta^*_t > 0$). Taking logarithm of both sides of equation (5), we approximately obtain

$$(6)\quad i_t - (i^*_t + f_{t+1} - s_t) = \theta_t L_1(A_t/P_t, M_t/P_t) - \theta^*_t L^*_1(A^*_t/P^*_t, M^*_t/P^*_t),$$

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 $\theta_t L_1(A_t/P_t, M_t/P_t)$ and $\theta^*_t L^*_1(A^*_t/P^*_t, M^*_t/P^*_t)$. From equation (6), it is easy to show that $i_t > i^*_t + f_{t+1} - s_t$ when $\theta^*_t L^*_1(A^*_t/P^*_t, M^*_t/P^*_t) < \theta_t L_1(A_t/P_t, M_t/P_t) \leq 0$ and that $i_t < i^*_t + f_{t+1} - s_t$ when $\theta_t L_1(A_t/P_t, M_t/P_t) < \theta^*_t L^*_1(A^*_t/P^*_t, M^*_t/P^*_t) \leq 0$. In the GFC, shortage of international liquidity increased marginal benefits of holding the US dollar large in many countries. To the extent that θ^*_t rises because of shortage of the US dollar, this implies that the absolute value of $\theta^*_t L^*_1(A^*_t/P^*_t, M^*_t/P^*_t)$ 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 because of its role as credit easing, expansionary monetary which lowers the policy rate might be able to reduce the output losses from the liquidity shocks. If this is the case, each central bank can reduce the liquidity risk through cutting its policy rate and expanding the money. Thus, given A_t/P_t and A^*_t/P^*_t, the difference between $\theta_t L_1(A_t/P_t,$

M_t/P_t) and $\theta^*_t\, L^*_1(A^*_t/P^*_t,\, M^*_t/P^*_t)$ would vary across countries when the degrees of monetary expansion were different.

After the GFC, in the economies such as the Euro zone and Japan, the central bank adopted unconventional monetary policy and kept its local nominal interest rate close to zero. Thus, in these economies, M_t increased dramatically, which might have led to a decline in the absolute value of $\theta_t\, L_1(A_t/P_t,\, M_t/P_t)$. 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. In these countries, the expansion of M_t was limited, so that a decline in the absolute value of $\theta_t\, L_1(A_t/P_t,\, M_t/P_t)$ was likely to be modest. This implies that the absolute value of $\theta_t\, L_1(A_t/P_t,\, M_t/P_t)$ might have been larger in Australia and New Zealand than in the Euro zone 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.

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 UK 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 1 March 2009 to 29 February 2016. There is no consensus on when the GFC ended. But the unprecedented market turbulences in the financial crisis of 2007–2008, known as the GFC, were almost stabilized in early 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 currency *j*'s 3-month OIS rate, i^{us}_t is US dollar 3-month OIS rate, S^j_t is the US dollar spot exchange rate against currency *j*, and F^j_{t+1} is its 3-month forward exchange rate. The unit is basis point. The spot exchange rates and 3-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:

$$(7) \quad Dev_t(j) = const. + \sum_{h=1}^{H} a_h \cdot Dev_{t-h}(j) + b \cdot Risk_t(j) + c \cdot Risk_t(US) + d \cdot Rate_t(j) + e \cdot Rate_t(US) + \sum_{k=1}^{K} f_k \cdot X^k_t,$$

where *j* = the Euro, the UK pound, the Japanese yen, the Canadian dollar, the Australian dollar, and the NZ dollar. $Risk_t(j)$ and $Risk_t(US)$ are money market 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 USA respectively· X^k_t is control variable *k*.

The right hand side of (7) includes 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 the policy rate as explanatory variables is new in literature. However, it is a desirable variable to capture the effect of monetary policy in reducing liquidity risk. After the GFC, 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 maintained their policy rate far above zero. The use of the 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 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 $Dev_t(j)$.

One may argue that either the base money or the money stock is more appropriate than the policy rate to capture the effects of the monetary policy. But since their daily data is not available, we cannot estimate eq. (7) on daily basis by using the base money or the money stock. More importantly, once the policy rate hit the zero bound, the economy falls into "liquidity trap" where an increase in the base money or the money stock might no longer be effective in reducing the absolute value of $\theta_t L_1$ and $\theta^*_t L^*_1$. Thus, to the extent that M_t increases as the policy rate declines only when the policy rate is positive, the policy rate is a more appropriate policy measure to capture the effects on $\theta_t L_1$ and $\theta^*_t L^*_1$ when the policy rate can hit the zero bound.

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 5-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. 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. The data is downloaded from Datastream. 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 UK 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*. In calculating the spread, we use daily data of 3-month LIBOR and 3-month OIS rate for each currency.[4]

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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 affects the spreads.

[4] Taylor and Williams (2009) use the same spreads in measuring money market risk. Fukuda (2012) investigates the role of the money market risk in London and Tokyo markets in the GFC. The spreads may have measurement errors because some panel banks acted strategically when quoting rates to the LIBOR survey during the GFC (see, for example, Mollenkamp and Whitehouse [2008]). However, since our sample period does not include the GFC period, biases from the

Since LIBOR was no longer published for the NZ dollar after 1 March 2013 and for the Australian dollar and the Canadian dollar after 1 June 2013, we use alternative interbank market rate for these currencies when we need to calculate the spread after 2013. The alternative rates are 3-month Bank Bill for the Australian dollar, 3-month Interbank Rate (CIDOR) for the Canadian dollar, and 90-day Bank Bill for the NZ dollar.

All of the data are downloaded from Datastream. Table 1 summarizes yearly-based basic test statistics of these daily money market risk measures from 2 January 2008 to 29 February 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.

Since the GFC originated from the USA and spread out to the London market, the contrast between the period 2008-2009 and the rest of the sample period was especially conspicuous in the US dollar and the UK 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 UK 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, because of the Euro crisis, the spread of the Euro increased to over 40 basis points in 2011.

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

measurement errors would be small.

2008 in the Australian dollar and about 30 basis points in 2009 in the Australian dollar and the NZ dollar. Their mean fell below 20 basis points in the following years. It indicates that Australia and New Zealand faced almost the same degree of money market risk as the other advanced economies. However, they had higher standard deviation than the other advanced countries, implying potential money market volatility in the Australia dollar and the New Zealand dollar in the post-GFC period.

4.2. Policy rate

Policy rates set by central banks are 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 "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 "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 2 January 2009 to 29 February 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 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 1 March 2009 to 30 May 2013 and from 1 March 2009 to 29 February 2016. The unit of each interest rate is basis point. We run GARCH(2,2) 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 throughout the sample periods.

5.1. Currency-specific money market risk

Currency-specific money market risk measures 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 in each currency and that increased market risk made its liquidity tighter and decreased its secured interest rate on the forward contract. In particular, an increase in the US dollar-denominated spread had a significantly positive effect on the deviations in most of the major currencies. Even in the post-GFC period, the US dollar maintained its role as international liquidity in the money market. Thus, global liquidity shortage still made the US dollar interest rate lower on the forward contract when money market risk increases in the US dollar.

Regarding the effects of local currency spread, the Japanese yen was most sensitive to the local money market risk. This may reflect yen's unique feature that local currency spread was suppressed to be low in the post-GFC period. But the Australian dollar and the NZ dollar were also very sensitive to the local money market risk. Unlike in the other major currency, local currency spreads were very volatile in the Australian dollar and the NZ dollar in the post-GFC period. It is likely that the volatile currency-specific market risk increased demand for the Australian dollar and the NZ dollar on forward contract and made their CIP deviations unique.

5.2. Policy rates

The local policy rate was not statistically significant for the Euro and the Japanese yen. This may reflect the fact that under "liquidity trap", the policy rate changed little in the Euro zone and Japan for our sample period. But in the other currencies, 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 achieve recovery from deflationary economy. As a result, their short-term interest rates hit the zero bound and fell into “liquidity trap”. In contrast, in Australia and New Zealand where the inflation rates were within the target range, short-term interest rates remained significantly positive. Consequently, both Australia and New Zealand became exceptional advanced economies that did not fall into “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

Local sovereign CDS, had rather heterogeneous effects across the currencies. They had a significantly negative effect in the Japanese yen, the NZ dollar, and the UK pound. In these currencies, increased demand for local currency lowered local interest rate on forward contract when local sovereign risk rises. In contrast, Germany sovereign CDS had a large positive effect in the Euro. This implies that unlike in the other major currencies, the demand for the US dollar increased on forward contract when sovereign risk rose up in Europe. 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 large positive coefficient of the Germany sovereign CDS might have reflected the environments.

The US sovereign CDS had a significantly positive effect in the Australian dollar, the NZ dollar, and the UK pound. 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 a significantly negative effect in the Euro. In international money markets, the Euro is a potential substitute for the US dollar. Thus, it is likely that the demand for the Euro increased when the US sovereign risk rose up.

VIX had a significantly positive except in the Australian dollar. Due to the role of the US dollar as international liquidity, the global market risk was likely to increase the demand for the US dollar and to lower the US interest rate. But the effect of VIX was mixed in the Australian dollar. Resource rich countries such as Australia might have faced different global risk in the post-GFC period.

6. Why Did the Australian Dollar and the NZ Dollar Have Downward Deviations?

Until the last sections, we explored determinants of the CIP deviations in the six major currencies and found that the determinants were common across the major currencies. In particular, we found that both money market risk measures and policy rates had very similar effects on the CIP deviations. The purpose of this section is to examine how well the similar significant effects could explain very different CIP deviations in the six major currencies. Specifically, using the estimated coefficients in Table 3 and realized values of explanatory variables, we calculate the theoretical value of the CIP deviations as follows.

$$(8) \quad \widehat{Dev_t}(j) = \frac{\hat{b}}{1-\sum_h \widehat{a_h}} Risk_t(j) + \frac{\hat{c}}{1-\sum_h \widehat{a_h}} Risk_t(US) + \frac{\hat{d}}{1-\sum_h \widehat{a_h}} Rate_t(j) + \frac{\hat{e}}{1-\sum_h \widehat{a_h}} Rate_t(US)$$

$$+ \frac{\widehat{f_1}}{1-\sum_h \widehat{a_h}} CDS_t(j) + \frac{\widehat{f_2}}{1-\sum_h \widehat{a_h}} CDS_t(US) + \frac{\widehat{f_3}}{1-\sum_h \widehat{a_h}} VIX_t,$$

where $\widehat{a_h}$, $\hat{b}$, $\hat{c}$, $\hat{d}$, $\hat{e}$, $\hat{f}_1$, $\hat{f}_2$, and $\hat{f}_3$ are the estimated coefficients in Table 3. Since our main interest is to calculate the steady-state value of the CIP deviations, equation (8) is formulated so as to obtain the long-run value of $\widehat{Dev_t}(j)$ after adjusting the lagged effects.

For currency j, we investigate contributions of each of the seven explanatory variables to $\widehat{Dev_t}(j)$ in each year. Table 4 reports the contributions of each explanatory variable in 2009, 2010, 2011, 2012, 2013, 2014, and 2015. It also reports the theoretical and realized values of $Dev_t(j)$ in each year. Comparing the sum of the contributions $\widehat{Dev_t}(j)$ with the realized value of $Dev_t(j)$, $\widehat{Dev_t}(j)$ tracks essential features of $Dev_t(j)$ in most of the currencies. Both $\widehat{Dev_t}(j)$ and $Dev_t(j)$ took the same sign in all of the seven years in the Euro and the NZ dollar, in six years in the Australian dollar and the Canadian dollar, and in five years in the UK pounds. In particular, they show similar yearly fluctuations. In case of the Japanese yen, $\widehat{Dev_t}(j)$ and $Dev_t(j)$ took the opposite sign in most of the years. But even in the Japanese yen, their yearly fluctuations are similar.

When we compare contributions of the seven explanatory variables, the US dollar spread had a large positive effect in the Australian dollar, the Japanese yen, the NZ dollar, and the UK pound in 2009. Soon after the GFC, money market risk in the US dollar increased the demand for the US dollar and lowered the US interest rate on forward contract. However, the contributions of the US dollar spread declined significantly after 2010. In contrast, because the Euro crisis, the local sovereign risk, the US dollar sovereign risk, and VIX had large contributions in the Euro throughout the sample period.

The most noteworthy feature is that the local policy rate had the largest contributions in the Australian dollar and the NZ dollar. In the post-GFC period, the CIP condition showed downward deviations in the Australian dollar and the NZ dollar but upward deviations in the other major currencies. This indicates that the policy rates could explain the different CIP deviations among the six major currencies.

Figure 3 depicts contributions of the seven explanatory variables to $\widehat{Dev_t}(j)$ in the Australian dollar and the NZ dollar in 2009, 2010, 2011, 2012, 2013, 2014, and 2015. In the figure, upward deviations contribute to lowering the US interest rate, while downward deviations contribute to lowering the local interest rate on forward contract. In both of the currencies, the local policy rate was the dominant source of downward deviations throughout the period. In contrast, reflecting relatively sound economic conditions in Australia and New Zealand, local money market spread had limited contributions to their downward deviations. Counterfactual simulation in the figure thus suggests that the Australian Dollar and the NZ dollar would have had equally significant upward CIP deviations as the other major currencies if their policy rate was lowered to the zero bound in the post GFC period.

7. Robustness

The purpose of this section is to explore robustness of our empirical results. In checking the robustness, we allow two additional effects on the CIP deviations in the regressions. One is the effects of unconventional monetary policies. In previous sections, we used the policy rates to capture the effects of monetary policy. They are desirable variables in the post-GFC period because additional monetary expansion might no longer be effective once the policy rate hit its zero bound. However, even if the policy rate hit its zero bound, some unconventional monetary policies could have been effective in reducing liquidity risk. In reaction to the GFC, several central banks implemented quantitative easing (QE) by buying financial assets from commercial banks and other financial institutions. We thus investigate how our empirical results will change when we allow these QE policies.

The other is the effects of commodity prices. Australia and New Zealand are resource rich countries whose local financial markets may be susceptible to turbulence in global commodity markets. Global commodity markets experienced substantial price fluctuations in the post-GFC period. For example, Figure 4 depicts daily data of Diapason Commodities Index and their sub-indices (Agriculture, Energy, and Metals) from 1 January 2007 to 31 March 2016. All of the indices, which were downloaded from Datastream, had a temporary spike in summer of 2008 but declined substantially after the Lehman shock. They started to recover at the beginning of 2009 and remained high from February 2011 to April 2014. However, their crash occurred in June 2014 after which the indices experienced persistent declines. We examine whether our empirical results in Australia and New Zealand will remain robust even if we allow the effects of these volatile commodity price changes.

To check the robustness, we included four US QE policy dummies in all of the regressions, seven UK QE policy dummies in the UK pound regression, and four Japan's QE policy dummies in the Japanese yen regressions. For the Australia dollar and the NZ dollar, we also included the logged differenced Diapason Commodities Metal Index and Diapason Commodities Index respectively.

Each of the QE policy dummies takes one for each of alternative QE policy regimes and zero otherwise. The four US alternative QE policy regimes are classified by QE1 (from 25 Nov. 2008 to 31 March 2010), QE2 (from 3 Nov. 2010 to 30 June 2011), QE3 (from 13 Sep. 2012 to 29 Oct. 2014), and Tapering (from 18 Dec. 2013 to 29 Oct. 2014). The seven UK alternative QE policy regimes are classified depending on the amounts purchased by Asset Purchase Facility (APF) of the Bank of England[5], while four Japan's alternative QE policy regimes are classified by "Comprehensive Monetary Easing" (from 5 Oct. 2010 to 3 April 2013), "Quantitative and Qualitative Monetary Easing (QQE)" (from 4 April 2013 to 30 Oct. 2014), "Expansion of QQE" (from 31 Oct. 2014 to 28 Jan. 2016), and "QQE with a Negative interest Rate" (from 29 Jan.

[5] The classified amounts purchased by APF are £50bn (19 Jan. to 4 March in 2009), £75bn (5 March to 6 May in 2009), £125bn (7 May to 5 Aug. in 2009), £175 (6 Aug. to 4 Nov. in 2009), £200bn (5 Nov. in 2009 to 5 Oct. in 2011), £275bn (6 Oct. in 2011 to 8 Feb. in 2012), £325bn (9 Feb. to 5 July in 2012).

2016).

Including these additional variables, we estimated equation (7) for the Australian dollar, the NZ dollar, the Japanese yen, and the UK pound. Except that we included additional variables, the estimation methods, that is, GARCH(2,2) regressions, are the same as those in previous sections. Table 5 summarizes the estimation results for two alternative sample periods. Except for the Japanese yen, most of the additional variables had significant effects on the CIP deviations. The QE policy dummies had significant effects on the CIP deviations especially in the NZ dollar and the UK pound. In particular, four US QE policy dummies tended to have positive effects on the CIP deviations, suggesting that the demand for the US dollar might have increased on forward contract during the QE period.[6] A rise of the commodity price index had positive effects on the CIP deviations in the Australian dollar and the NZ dollar, suggesting that the demand for the Australian dollar and the NZ dollar increased when commodity prices increased.

However, it is worthwhile to note that even if we allow these additional effects, our main results in previous sections remained robust. That is, the local currency spread had a significantly negative effect on the deviations, while the US dollar spread had a significantly positive effect on the deviations. More importantly, the local policy rate had a significantly negative effect on the deviations, while the US policy rate had a significantly positive effect on the deviations. The estimated effects of the local policy rate became rather larger in the Australian dollar and the NZ dollar when we allow these additional effects. This confirms our view that the policy rates in the Australian dollar and the NZ dollar could explain their unique CIP deviations in the post-GFC period.

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[6] The demand for the US dollar might have increased during the QE period because the QE policy did not benefit non-US financial institutions. See Kleymenova, Rose, and Wieladek (2016) for supportive evidence.

8. Concluding Remarks

The purpose of this paper was to explore what made the Australian Dollar and the NZ dollar so different in the CIP condition. In the analysis, we focused on a unique feature of Australia and New Zealand where short-term interest rates remained significantly positive even after the GFC. The paper first constructed a theoretical model where not only increased liquidity risk but also different monetary policies may cause deviations from the CIP condition. The paper then tested this theoretical implication by using money market risk measures and policy rates in six major currencies. We found that both money market risk measures and policy rates had similar effects on the CIP deviations in the six major currencies. The result supported our hypothesis that unique monetary policy in Australia and New Zealand made deviations from the CIP condition distinct on the forward contract.

In general, the monetary policy has two goals: price stability and financial stability. When the financial market becomes unstable in a deflationary economy, monetary expansion lowering the policy rate is effective to achieve the tow goals. However, when the financial market becomes unstable in an inflationary economy, the central bank faces a conflict because it cannot achieve both of the goals at the same time. After the GFC, the central bank in Australia and New Zealand faced such a conflict. Unlike the other advanced economies, Australia and New Zealand had inflation rates which were almost within the target range. As a result, even if the world financial market was still unstable, the policy rate remained significantly different from zero in Australia and New Zealand. Our empirical results supported the view that this caused unique feature on forward contract in Australia and New Zealand.

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Table 1. Basic Test Statistics of Money Market Risk Measures

(1) Australia

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mean	50.71	30.27	23.50	28.01	25.37	12.46	18.80	23.08	34.95
Median	46.20	27.30	22.45	23.79	24.80	12.25	17.80	21.70	35.00
Maximum	142.75	79.80	51.58	62.50	48.95	23.25	32.70	40.50	40.20
Minimum	18.75	5.25	5.00	7.78	1.00	0.95	9.50	5.50	31.50
Std. Dev.	18.79	13.82	8.58	13.90	9.18	3.87	4.97	6.22	1.57
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	67.80	22.27	22.40	29.02	29.21	27.39	27.39	30.98	43.50
Median	66.65	18.45	22.07	27.87	29.16	27.50	27.30	31.05	41.30
Maximum	121.44	70.05	34.61	35.13	33.33	29.13	29.43	40.70	50.10
Minimum	33.08	16.84	15.84	24.35	24.56	24.90	26.80	25.60	39.00
Std. Dev.	22.17	8.54	3.34	2.55	1.70	0.95	0.46	3.77	3.92
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	87.53	54.34	24.55	43.32	28.67	5.23	10.73	10.47	12.74
Median	72.12	47.15	24.35	25.23	30.21	5.00	10.79	10.59	12.53
Maximum	195.33	116.18	36.83	93.19	89.26	11.44	19.97	16.71	18.47
Minimum	28.58	21.19	13.41	9.21	4.03	1.13	3.44	6.13	10.53
Std. Dev.	43.67	27.23	5.01	28.11	23.15	1.51	3.04	1.64	1.49
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	47.35	36.70	14.10	12.03	11.91	8.21	6.47	2.71	3.83
Median	41.00	34.50	15.00	12.42	12.07	7.93	6.87	2.89	4.75
Maximum	80.50	73.25	18.25	13.95	13.32	10.36	7.79	8.93	7.51
Minimum	36.75	17.94	8.63	8.88	9.96	7.21	4.46	0.50	−1.61
Std. Dev.	11.38	14.09	2.22	1.25	0.75	0.75	0.83	1.31	2.49
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

Table 1. Basic Test Statistics of Money Market Risk Measures (continued)

(5) New Zealand

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mean	NA	28.35	22.40	19.50	19.65	14.43	16.79	17.17	22.34
Median	NA	27.75	19.00	18.69	19.50	14.25	16.75	16.00	20.50
Maximum	NA	39.50	64.50	49.00	29.12	19.50	24.00	32.50	32.25
Minimum	NA	21.50	7.00	−37.00	10.00	11.25	8.60	7.75	14.50
Std. Dev.	NA	3.81	12.62	11.66	4.21	1.62	2.23	4.54	5.45
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	106.87	73.78	21.21	33.50	38.66	9.93	10.68	11.69	12.92
Median	80.29	75.45	22.87	29.56	45.65	9.83	10.44	11.65	13.01
Maximum	300.33	165.90	25.55	58.56	60.23	13.74	12.60	13.09	14.35
Minimum	26.15	15.11	15.38	16.68	10.95	8.81	8.31	9.91	12.06
Std. Dev.	61.67	50.11	2.95	11.37	18.23	0.76	1.04	0.62	0.45
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	108.30	49.45	15.53	22.98	29.20	15.47	14.00	14.00	23.35
Median	75.94	36.45	11.14	17.13	29.91	15.41	14.06	13.66	23.20
Maximum	364.38	124.13	34.06	50.23	50.90	17.10	16.39	23.41	24.65
Minimum	30.88	7.44	5.56	12.08	15.55	12.66	11.91	9.46	21.76
Std. Dev.	72.19	37.69	8.90	10.81	9.10	0.85	1.01	2.34	0.65
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

Notes 1) Unit = basis points.

2) Since LIBOR was not published for the NZ dollar, the Australian dollar, and the Canadian dollar after mid-2013, we use 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.

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

Table 2. Basic Test Statistics of Policy Rates (continued)

(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

Notes 1) Unit = percent.

2) For the policy rates, we use 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 3. Estimation Results

		The Euro		The UK pound		Japanese yen	
		2009-2013	2009-2016	2009-2013	2009-2016	2009-2013	2009-2016
	Constant term	0.178	-2.513	-0.250	2.359	5.948	3.210
		(0.12)	(-2.94)***	(-0.17)	(1.89)*	(1.94)*	(2.11)**
Lagged	Dependent var. (-1)	0.263	0.238	0.251	0.237	0.331	0.275
dependent		(6.94)***	(9.67)***	(6.45)***	(9.64)***	(8.79)***	(10.22)***
var.	Dependent var. (-2)	0.135	0.111	0.133	0.079	0.125	0.121
		(4.29)***	(4.19)***	(3.64)***	(3.11)***	(3.61)***	(4.95)***
	Dependent var. (-3)	0.169	0.113	0.103	0.061	0.138	0.156
		(4.90)***	(4.38)***	(2.46)**	(1.98)**	(4.02)***	(6.08)***
	Dependent var. (-4)	0.106	0.141	0.112	0.101	0.045	0.058
		(3.35)***	(5.62)	(2.58)**	(3.92)***	(1.52)	(2.51)**
	Dependent var. (-5)	0.084	0.117	0.036	0.085	0.125	0.121
		(2.56)**	(4.17)***	(0.99)	(3.82)***	(4.01)***	(5.09)***
	Dependent var. (-6)	0.105	0.120	0.106	0.117	0.094	0.091
		(3.26)***	(4.37)***	(2.78)***	(4.93)***	(3.40)***	(3.87)***
Measure of	Local LIBOR spread	-0.019	-0.021	-0.040	-0.053	-0.357	-0.365
currency-		(-0.91)	(-1.00)	(-1.87)*	(-2.53)**	(-4.73)***	(-6.45)***
specific money	Dollar LIBOR spread	-0.024	0.002	0.110	0.147	0.125	0.125
market risk		(-1.00)	(0.08)	(3.40)***	(4.80)***	(3.34)***	(4.03)***
Policy rates	Local policy rate	-0.016	0.001	-0.104	-0.131	-0.318	-0.265
		(-0.88)	(0.08)	(-4.35)***	(-5.03)***	(-0.99)	(-1.24)
	US policy rate	0.145	0.193	0.299	0.301	0.037	0.086
		(2.71)***	(3.71)***	(5.91)***	(6.86)***	(0.49)	(1.82)*
Measure of	Local CDS	0.080	0.089	0.080	0.057	-0.056	-0.038
country-		(4.51)***	(5.22)***	(5.08)***	(4.91)***	(-2.56)**	(-3.02)***
specific	US CDS	-0.095	-0.092	-0.184	-0.205	-0.012	0.001
credit risk		(-2.69)***	(-2.81)***	(-8.47)***	(-10.33)***	(-0.41)	(0.03)
Global market	VIX	0.133	0.129	0.074	0.122	0.360	0.393
risk		(2.33)**	(2.41)**	(1.83)*	(3.19)***	(6.12)***	(8.44)***
	Constant term	1.790	1.680	1.210	0.879	1.140	1.680
		(4.82)***	(6.57)***	(6.55)***	(7.22)***	(3.69)***	(4.55)***
	RESID(-1)^2	0.243	0.089	0.176	0.184578	0.476	0.315
Variance		(5.75)***	(10.57)***	(7.89)***	(11.76)***	(7.96)***	(8.49)***
equation	RESID(-2)^2	-0.131	0.091	0.052	0.021	-0.392	-0.226
		(-2.77)***	(11.42)***	(2.08)**	(1.80)*	(-7.02)***	(-5.92)***
	GARCH(-1)	0.493	-0.045	0.051	0.022	0.988	0.876
		(3.79)***	(-0.57)	(0.78)	(1.32)	(13.38)***	(9.89)***
	GARCH(-2)	0.375	0.871	0.736	0.804	-0.065	0.035
		(3.27)***	(11.89)***	(11.94)***	(50.41)***	(-1.03)	(0.45)
	Adjusted R-squared	0.74	0.59	0.47	0.25	0.62	0.55

Table 3. Estimation Results (continued)

		Canadian dollar		Australian dollar		NZ dollar	
		2009-2013	2009-2016	2009-2013	2009-2016	2009-2013	2009-2016
	Constant term	-0.618	-0.036	2.866	-1.339	4.108	0.619
		(-1.68)*	(-0.118)	(2.21)**	(-3.15)***	(2.01)*	(0.57)
Lagged	Dependent var. (-1)	0.746	0.729	0.390	0.495	0.482	0.484
dependent		(21.84)***	(25.78)***	(10.22)***	(17.25)***	(13.72)***	(17.34)***
var.	Dependent var. (-2)	0.077	0.086	0.119	0.104	0.095	0.063
		(1.88)*	(2.90)***	(3.47)***	(3.69)***	(2.57)**	(2.22)**
	Dependent var. (-3)	0.013	-0.001	0.068	0.074	0.059	0.063
		(0.37)	(-0.02)	(2.09)**	(2.72)***	(1.43)	(2.08)**
	Dependent var. (-4)	0.009	-0.015	0.014	0.001	0.017	0.018
		(0.24)	(-0.56)	(0.48)	(0.02)	(0.43)	(0.68)
	Dependent var. (-5)	0.208	0.305	0.450	0.478	0.437	0.477
		(6.65)***	(13.12)***	(20.06)***	(26.45)***	(12.40)***	(23.30)***
	Dependent var. (-6)	-0.121	-0.168	-0.196	-0.231	-0.208	-0.239
		(-4.97)***	(-7.65)***	(-7.12)***	(-10.69)***	(-6.01)***	(-9.33)***
Measure of	Local LIBOR spread	-0.007	0.027	-0.110	-0.066	-0.090	-0.150
currency-		(-0.77)	(3.29)***	(-7.10)***	(-4.80)***	(-6.53)***	(-11.06)***
specific money	Dollar LIBOR spread	0.010	0.015	0.072	0.014	0.104	0.082
market risk		(1.10)	(2.07)**	(3.47)***	(0.95)	(4.38)***	(4.79)***
Policy rates	Local policy rate	-0.004	-0.010	-0.017	-0.005	-0.024	-0.011
		(-2.23)**	(-4.83)***	(-5.39)***	(-3.49)***	(-3.02)***	(-3.32)***
	US policy rate	0.045	0.007	0.112	0.044	0.158	0.029
		(3.95)***	(1.10)	(3.08)***	(2.82)***	(4.29)***	(1.70)*
Measure of	Local CDS	0.005	-0.001	0.074	0.012	-0.051	-0.032
country-		(1.14)	(-0.56)	(3.50)***	(1.01)	(-3.70)***	(-2.99)***
specific	US CDS	0.000	0.001	0.022	0.067	0.060	0.056
credit risk		(0.02)	(0.23)	(0.77)	(3.69)***	(2.55)**	(3.26)***
Global market	VIX	0.020	0.008	-0.087	0.003	0.046	0.074
risk		(2.07)**	(0.97)	(-3.69)***	(0.15)	(1.74)*	(3.56)***
	Constant term	0.060	0.081	0.473	0.020	0.123	0.649
		(5.23)***	(4.66)***	(2.45)**	(2.82)***	(3.24)***	(2.83)***
	RESID(-1)^2	0.315	0.363	0.119	0.141	0.093	0.152
Variance		(9.67)***	(11.89)***	(5.88)***	(6.90)***	(4.72)***	(5.00)***
equation	RESID(-2)^2	-0.256	-0.299	-0.107	-0.127	-0.071	-0.038
		(-7.16)***	(-8.98)***	(-5.22)***	(-6.27)***	(-2.98)***	(-0.71)
	GARCH(-1)	0.801	0.869	1.019	0.994	1.731	0.631
		(8.28)***	(16.75)***	(6.13)***	(11.05)***	(45.18)***	(1.66)*
	GARCH(-2)	0.119	0.042	-0.053	-0.010	-0.755	0.226
		(1.37)	(0.98)	(-0.33)	(-0.11)	(-23.82)***	(0.68)
	Adjusted R-squared	0.96	0.96	0.86	0.87	0.68	0.72

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

Table 4. Contribution of Each Explanatory Variable

(1) Australia

		2009	2010	2011	2012	2013	2014	2015
	local spread	−21.6	−16.8	−20.0	−18.1	−8.9	−13.4	−16.5
contribution	US spread	23.1	7.3	10.7	13.6	7.2	6.5	6.5
of each	local rate	−37.1	−49.3	−53.1	−41.8	−31.0	−28.3	−23.9
explanatory	US rate	11.6	12.8	7.4	10.3	7.8	6.5	9.8
variable	local CDS	34.7	22.6	30.9	31.4	21.1	17.7	17.2
	US CDS	5.4	3.8	4.9	4.1	3.1	2.2	2.0
	VIX	−17.8	−12.8	−13.6	−10.1	−8.1	−8.0	−9.5
total (theoretical value)		−1.8	−32.3	−32.8	−10.6	−8.6	−16.8	−14.3
realized value		3.0	−13.0	−12.1	−17.8	−5.6	−19.0	−21.0

(2) Canada

		2009	2010	2011	2012	2013	2014	2015
	local spread	−2.3	−2.4	−3.1	−3.1	−2.9	−2.9	−3.3
contribution	US spread	7.5	2.3	3.5	4.4	2.3	2.1	2.1
of each	local rate	−2.8	−3.9	−6.6	−6.6	−6.6	−6.6	−4.2
explanatory	US rate	10.6	11.7	6.7	9.4	7.1	5.9	8.9
variable	local CDS	10.0	4.0	5.2	6.4	4.1	2.4	2.4
	US CDS	0.1	0.0	0.1	0.1	0.0	0.0	0.0
	VIX	9.4	6.7	7.2	5.3	4.2	4.2	5.0
total (theoretical value)		32.3	18.6	13.0	16.0	8.4	5.2	11.0
realized value		27.8	6.9	5.9	5.4	2.3	2.6	8.3

(3) Euro

		2009	2010	2011	2012	2013	2014	2015
	local spread	−7.6	−3.4	−6.1	−4.0	−0.7	−1.5	−1.5
contribution	US spread	−8.5	−2.7	−3.9	−5.0	−2.6	−2.4	−2.4
of each	local rate	−15.2	−11.9	−14.9	−10.5	−6.6	−1.9	−0.6
explanatory	US rate	16.7	18.5	10.6	14.8	11.3	9.3	14.1
variable	local CDS	21.8	23.1	38.1	39.8	17.8	12.1	8.2
	US CDS	−26.3	−18.6	−23.9	−19.7	−15.2	−10.8	−9.8
	VIX	30.4	21.7	23.2	17.2	13.7	13.6	16.1
total (theoretical value)		11.2	26.6	23.1	32.6	17.6	18.4	24.1
realized value		28.1	26.3	31.4	38.2	14.4	7.5	25.1

Table 4. Contribution of Each Explanatory Variable (continued)

(4) Japan

		2009	2010	2011	2012	2013	2014	2015
contribution of each explanatory variable	local spread	−91.7	−35.3	−30.1	−29.8	−20.5	−16.2	−6.8
	US spread	43.4	13.6	20.2	25.6	13.6	12.3	12.3
	local rate	−23.4	−20.8	−17.3	−18.4	−16.7	−15.1	−16.2
	US rate	4.1	4.5	2.6	3.6	2.8	2.3	3.5
	local CDS	−23.3	−28.3	−39.3	−37.7	−26.0	−18.1	−16.6
	US CDS	−3.2	−2.3	−2.9	−2.4	−1.9	−1.3	−1.2
	VIX	79.4	56.8	60.8	44.9	35.9	35.6	42.1
total (theoretical value)		−14.9	−11.7	−6.2	−14.1	−12.9	−0.5	17.1
realized value		35.0	27.6	38.0	32.7	21.5	25.7	48.4

(5) New Zealand

		2009	2010	2011	2012	2013	2014	2015
contribution of each explanatory variable	local spread	−21.8	−17.2	−15.0	−15.1	−11.1	−12.9	−13.2
	US spread	43.8	13.7	20.3	25.8	13.7	12.4	12.4
	local rate	−58.7	−56.2	−52.9	−51.1	−51.1	−63.8	−64.4
	US rate	21.5	23.8	13.7	19.1	14.5	12.0	18.2
	local CDS	−38.0	−25.5	−33.1	−33.3	−19.8	−16.0	−15.2
	US CDS	19.7	13.9	17.9	14.7	11.3	8.1	7.3
	VIX	12.5	8.9	9.6	7.1	5.6	5.6	6.6
total (theoretical value)		−21.0	−38.5	−39.5	−32.7	−36.8	−54.7	−48.3
realized value		−15.4	−20.9	−11.2	−13.4	−15.4	−19.4	−21.3

(6) United Kingdom

		2009	2010	2011	2012	2013	2014	2015
contribution of each explanatory variable	local spread	−11.5	−3.3	−5.2	−6.0	−1.5	−1.7	−1.8
	US spread	21.1	6.6	9.8	12.4	6.6	6.0	6.0
	local rate	−25.8	−20.1	−20.1	−20.1	−20.1	−20.1	−20.1
	US rate	18.5	20.4	11.8	16.4	12.5	10.3	15.6
	local CDS	12.0	26.2	22.5	22.3	18.2	12.4	6.8
	US CDS	−11.3	−27.2	−19.3	−24.7	−20.4	−15.7	−11.2
	VIX	9.3	9.0	6.4	6.9	5.1	4.1	4.0
total (theoretical value)		12.2	11.7	6.0	7.2	0.4	−4.7	−0.7
realized value		13.5	10.9	2.5	12.4	6.1	4.3	9.9

Table 5. Estimation Results with Additional variables

		Japan		UK	
		2009-2013	2009-2016	2009-2013	2009-2016
Measure of currency-specific money market risk	Local LIBOR spread	-0.210	-0.311	-0.138	-0.113
		(-2.05)**	(-3.10)***	(-3.07)***	(-2.75)***
	Dollar LIBOR spread	0.075	0.126	0.195	0.246
		(1.83)*	(3.00)***	(3.29)***	(5.27)***
Policy rates	Local policy rate	-0.105	-0.338	0.085	0.031
		(-0.28)	(-1.15)	(2.73)***	(0.72)
	US policy rate	0.085	-0.019001	0.0848	0.456
		(1.12)	(-0.27)	(1.39)	(8.88)***
Measure of country-specific credit risk	Local CDS	-0.027	-0.053	0.142	0.152
		(-1.07)	(-2.26)**	(4.71)***	(6.27)**
	US CDS	-0.042	-0.044	-0.044	-0.176
		(-1.45)	(-0.21)	(-0.05)	(-6.06)***
Global market risk	VIX	0.004	0.004	-0.001	0.002
		(6.03)***	(7.83)***	(-2.33)**	(3.74)***
US QE Dummies	USQE1(-1)	-0.003	-0.010	-0.034	0.006
		(-0.22)	(-0.76)	(-3.72)***	(0.63)***
	USQE2(-1)	0.017	0.008	-0.037	0.003
		(2.63)***	(1.06)	(-5.45)***	(0.62)
	USQE3(-1)		0.003		-0.010
			(0.33)		(-1.27)
	USTAPER(-1)		-0.010		0.021
			(-0.70)		(3.03)***
Local QE Dummies	Local dummty 1	0.013	0.008	-0.062	-0.192
		(1.56)	(0.79)	(-1.18)	(-3.71)***
	Local QE dummy 2	0.018	-0.016	0.029	-0.107
		(0.85)	(-0.79)	(1.05)	(-3.63)***
	Local QE dummy 3		0.015	0.051	-0.065
			(0.75)	(2.60)***	(-3.08)***
	Local QE dummy 4		0.052	0.054	-0.037
			(1.26)	(3.44)***	(-2.44)**
	Local QE dummy 5			-0.014	-0.065
				(-1.56)	(-7.63)***
	Local QE dummy 6			-0.067	-0.087
				(-4.92)***	(-6.45)***
	Local QE dummy 7			-0.010	-0.038
				(-0.85)***	(-3.33)***
	Adjusted R-squared	0.617	0.555	0.493	0.254

Table 5. Estimation Results with Additional variables (continued)

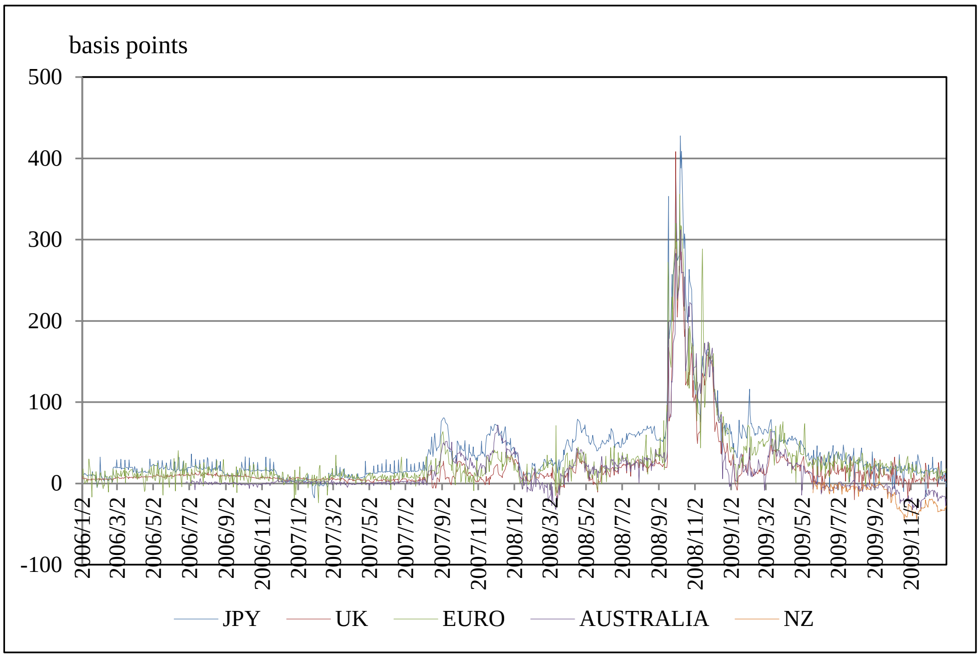
		Australia		New Zealand	
		2009-2013	2009-2016	2009-2013	2009-2016
Measure of currency-specific money market risk	Local LIBOR spread	-0.117	-0.056	-0.405	-0.166
		(-7.41)***	(-3.82)***	(-24.22)***	(-11.28)***
	Dollar LIBOR spread	0.086	0.019	0.271	0.106
		(4.04)***	(1.24)	(10.68)***	(6.07)***
Policy rates	Local policy rate	-0.023	-0.005	-0.028	-0.009
		(-5.00)***	(-3.50)***	(-3.18)***	(-2.33)**
	US policy rate	0.111	0.047	0.472	0.047
		(2.97)***	(2.65)***	(12.24)***	(2.50)**
Measure of country-specific credit risk	Local CDS	0.100	0.010	-0.039	-0.029
		(3.01)***	(0.79)	(-2.38)***	(-2.63)***
	US CDS	0.000	0.066	0.011	0.044
		(0.85)	(3.47)***	(0.42)	(2.49)**
Global market risk	VIX	0.000	0.000	0.000	0.001
		(-1.67)***	(0.60)	(0.26)	(3.50)***
US QE Dummies	US-QE1(-1)	-0.009	0.004	0.074	0.008
		(-1.61)	(1.05)	(13.66)***	(2.76)***
	US-QE2(-1)	0.006	0.008	0.009	0.014
		(1.01)	(1.82)*	(2.18)**	(3.53)***
	US-QE3(-1)		0.007		0.003
			(2.20)**		(1.03)
	US-TAPER(-1)		-0.002		0.006
			(-0.67)		(1.75)*
	Commodity Price	-0.013	0.164	0.219	0.175
		(-0.11)	(1.90)*	(2.16)**	(0.26)**
	Adjusted R-squared	0.859	0.875	0.725	0.727

Notes 1): t-value is in the parenthesis. *** = 1% significance level, ** = 5% significance level, * = 10% significance level.

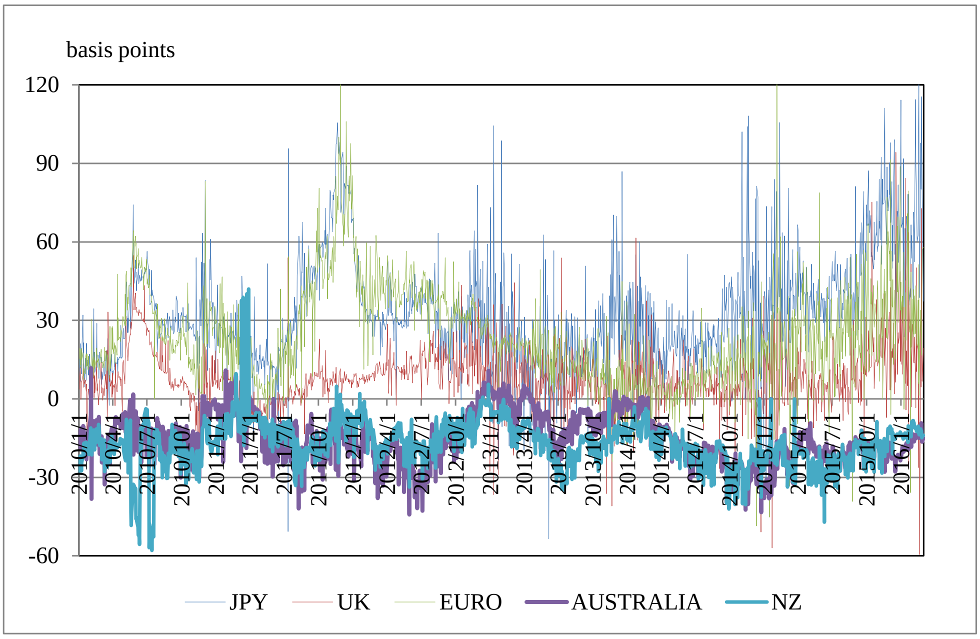
2): To save space, the table does not show the estimation results of the constant term, lag dependent variables, and variance equation.

Figure 1. CIP Deviations when the US Dollar is a Benchmark Currency

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

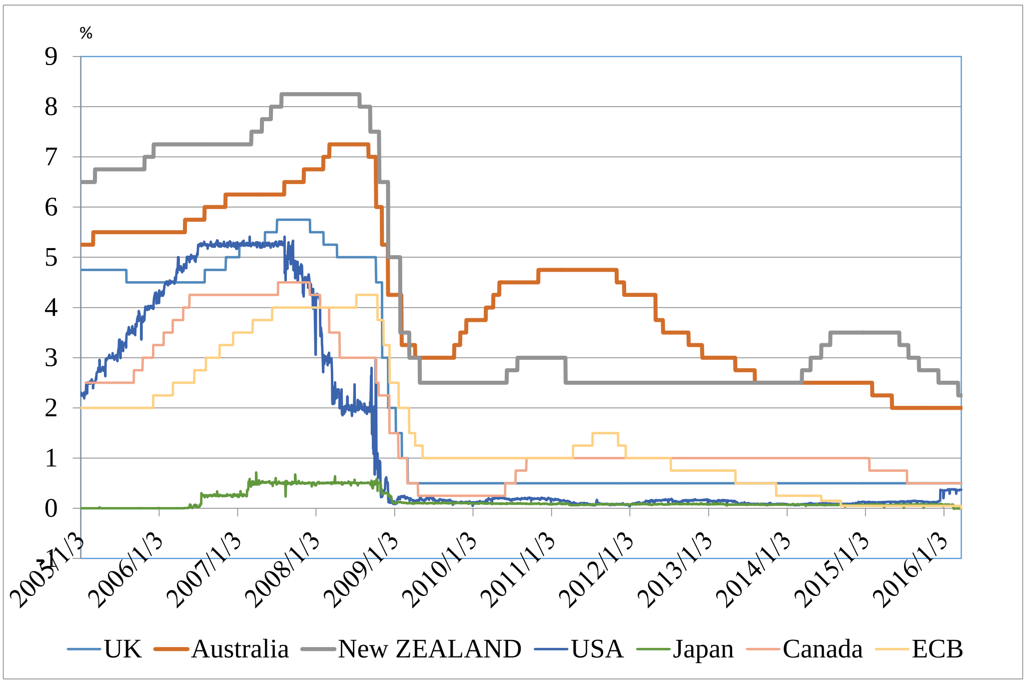


(2) January 2, 2010 to February 29, 2016



Source: Authors' calculation based on Datastream.

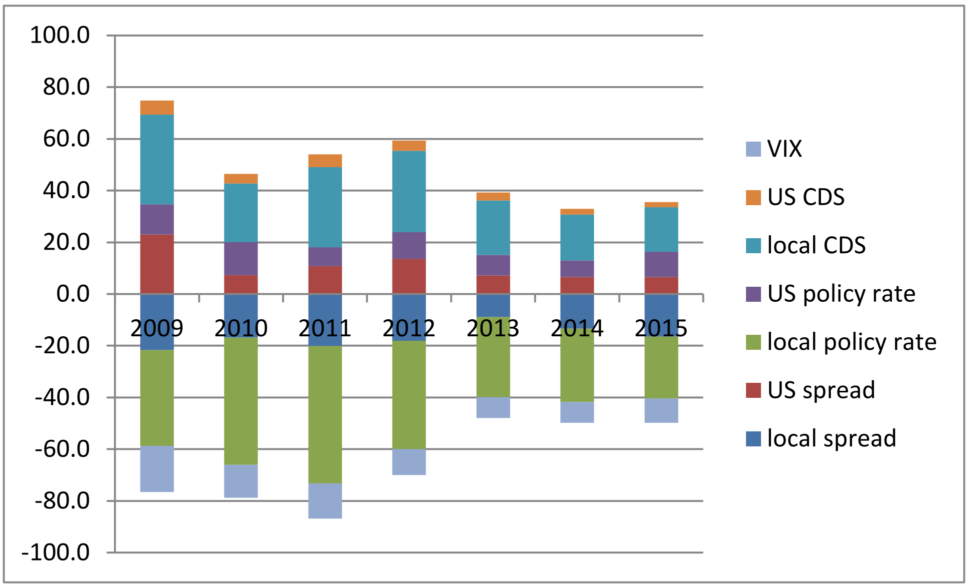
Figure 2. Central Bank's Policy Rates



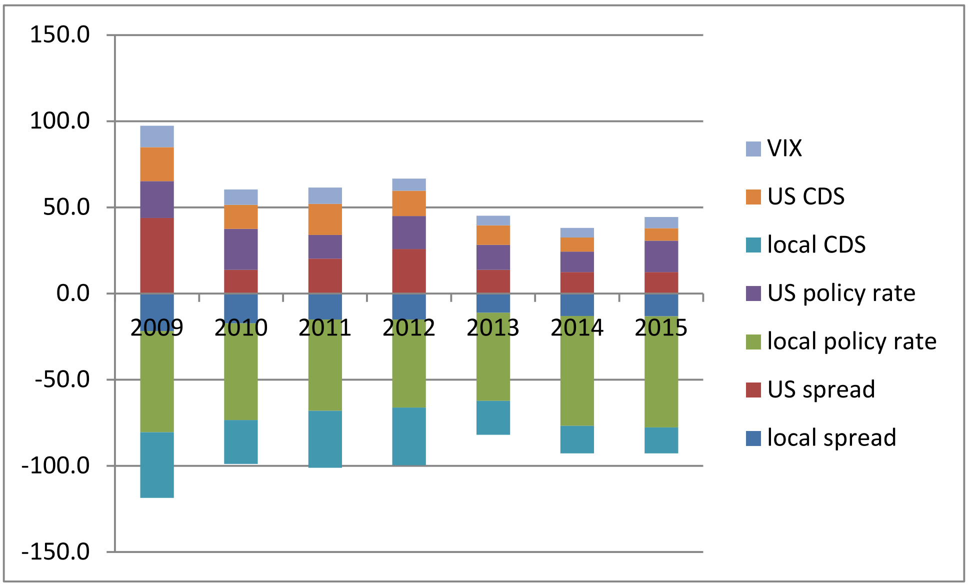
Sources: Each central bank's website.

Figure 3. Contributions of the Seven Explanatory Variables

(1) Australia

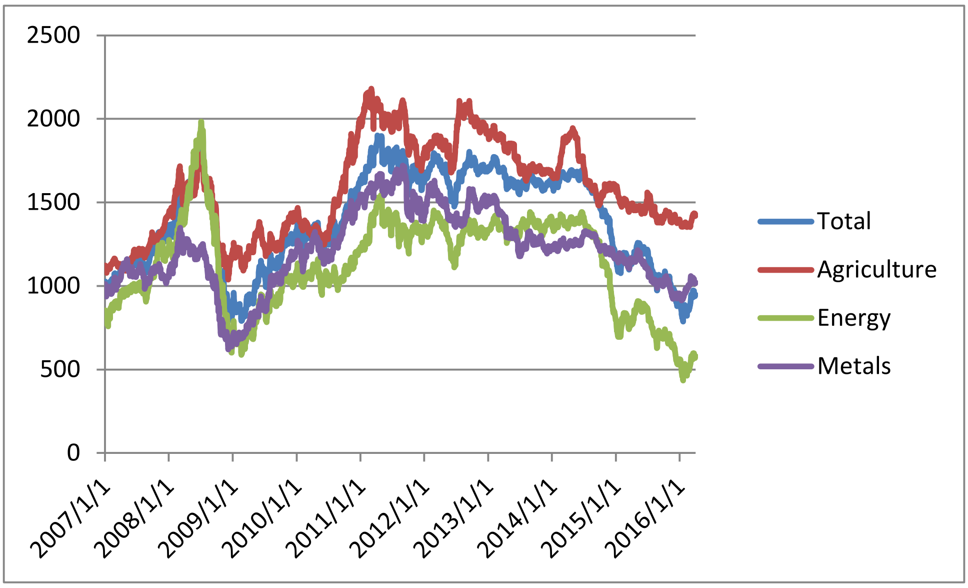


(2) New Zealand



Source: Authors' calibration.

Figure 4. Commodities Indices in the Post-GFC period



Note: The indices are those of Diapason Commodities Index.

Source: Datastream.