# THE IMPACT OF MONETARY POLICY ON THE EXCHANGE RATE: A STUDY USING INTRADAY DATA

Jonathan Kearns and Phil Manners

# Abstract

This paper uses intraday data to estimate the effect of changes in monetary policy on the exchange rate. We use an event study with carefully selected sample periods for four countries (Australia, Canada, New Zealand and the United Kingdom) to ensure that the change in monetary policy is exogenous to the exchange rate. Intraday data allow us to use a short event window, which improves the accuracy of estimates, and demonstrates that the change in policy is rapidly incorporated into the exchange rate. On average, an unanticipated tightening of 25 basis points is found to appreciate the exchange rate by around 0.35 per cent, with estimates for the individual countries ranging from ¼–½ of a per cent. The estimation indicates that monetary policy changes account for only a small part of the observed variability of exchange rates in these countries.

We also find that changes in monetary policy have substantially different effects on the exchange rate depending on how they alter expectations regarding future policy. Surprises that cause expectations of future policy to be revised by the full amount of the surprise are found to have a larger impact on the exchange rate (around 0.4 per cent) than surprises that only bring forward an anticipated change in policy and do not change expectations of future policy (around 0.2 per cent).

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## 1. Introduction

Recent studies have had some success in identifying the response of the exchange rate to macroeconomic variables by using high-frequency data.[1] This paper makes two important contributions to the literature on the response of the exchange rate to monetary policy. First, we use intraday data which allows us to more precisely control for endogeneity and external factors that may influence both exchange rates and interest rates (such as macroeconomic data releases). With intraday data we can also examine the temporal response of the exchange rate. Our second contribution is to consider how changes in the expected path of future monetary policy that result from a monetary surprise influence the response of the exchange rate. Some interest rate changes may surprise with respect to the timing of the change; for example, the rate rise expected next month occurred this month. Others may surprise with respect to the expected path of monetary policy; for example, a surprise rate rise might be taken to indicate that a tightening phase is going to reach a higher maximum than previously anticipated. Because these surprises will have different effects on the expected future path of monetary policy they are unlikely to have equivalent effects on the exchange rate.

A greater understanding of the impact of interest rates on exchange rates is of interest for several reasons. The theory of uncovered interest parity (UIP), which connects expected changes in the exchange rate to interest differentials, is central to almost all international macroeconomic models. Yet empirically, UIP is a resounding failure (Engel 1996). In addition, the response of the exchange rate to monetary policy is also an important monetary transmission channel in small, open economies (see, for example, Grenville 1995; Thiessen 1995).

Our study includes four countries (Australia, Canada, New Zealand and the United Kingdom) that are relatively small, and so changes in their interest rates are

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[1] For example, see Andersen *et al* (2003), Faust, Rogers, Wang and Wright (2003) and Zettelmeyer (2004) and the references therein.

unlikely to affect global interest rates. This is important for isolating the impact of the change in one country's interest rate on the exchange rate. If the country studied was large, such as the United States, then markets might build the likely impact of changes in domestic monetary policy on foreign interest rates into the exchange rate's response. This would contaminate the measured response of the exchange rate. Further, these four countries have highly liquid financial markets, freely floating exchange rates and similar monetary policy regimes.

We use an event study methodology as has become common in the literature on asset prices. An event study is particularly useful because it can abstract from the joint determination of interest rates and exchange rates. The event is a monetary policy decision (either a surprise change in the policy interest rate or no change when a policy announcement was anticipated). We can be confident that we have isolated events in which causality runs in only one direction, from interest rates to exchange rates, for two reasons. Firstly, we use a narrow event window, only examining a short period around the policy change. Secondly, for the countries we study, the institutional structure of monetary policy decision-making means that the decision is made well before the event window we use.

Several papers have recently used high-frequency data to examine the response of asset prices to macroeconomic shocks, including interest rates. This paper most closely follows Zettelmeyer (2004) who examines the response of exchange rates to interest rates using daily data (but not intraday). Unlike Zettelmeyer we restrict our sample to a period in which the central banks we study did not explicitly respond to the exchange rate. We also use a more accurate measure of the monetary surprise (based on 1-month rather than 3-month interest rates) and a larger sample, in part because we include decisions in which monetary policy does not change, that is, 'no-change' surprises. We can include these observations because, under the monetary policy regimes we examine, the timing of the announcement of these no-changes was predetermined. Faust, Rogers, Wang and Wright (2003) use intraday data to examine the response of exchange rates to macroeconomic announcements, including interest rates changes. But they only study surprises in US interest rates, and so the exchange rate responses are potentially clouded by anticipated changes in foreign interest rates. Andersen *et al* (2003) also examine the intraday response of the exchange rate to macroeconomic announcements, but do not consider interest rate shocks. Bernanke and Kuttner (forthcoming), studying the response of equity markets to interest rates using daily data, consider how

the impact differs depending on the changes to the profile of anticipated future monetary policy, as we do in this study. A related literature has attempted to consider the longer-run impact of interest rates on the exchange rate. In an early study using a vector autoregression (VAR), Eichenbaum and Evans (1995) suggest that there exists a delayed overshooting. But by identifying surprise interest rate shocks using daily data, Faust, Rogers, Swanson and Wright (2003) find that this result is not robust to allowing the foreign interest rate to respond. Faust and Rogers (2003) also fail to find evidence of delayed overshooting in a less restricted VAR.

The remainder of the paper is structured as follows. Section 2.1 briefly outlines the application of the event study methodology to monetary policy decisions. In Section 2.2 we review the monetary policy operations of the four countries in the study and discuss how this influences the set of events that we consider. The data are described in more detail in Section 2.3. In Section 3.1 we present the results of the instantaneous impact and the timing of the response of the exchange rate. In Section 3.2 we demonstrate how the response of the exchange rate depends on the effect of the monetary surprise on expectations. We examine the robustness of the results in Section 3.3. Section 4 concludes.

## 2. The Estimation Framework

### 2.1 Event Study Methodology

We use an event study approach, estimating the change in the exchange rate around the announcement of 'monetary policy decisions'. Decisions include both announced changes to monetary policy, and announcements of decisions to not change policy ('no-change' decisions) so long as the market knew for certain that a policy announcement would take place. Further discussion of the events used can be found in Section 2.2. In many cases, monetary policy decisions are widely anticipated by the market and so their impact should already be incorporated into interest rates and exchange rates. In order to identify the impact of a monetary policy decision, we isolate the surprise component of the change in monetary policy by using changes in market interest rates.[2] This technique,

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[2] This does not mean that anticipated changes in monetary policy have no effect on the exchange rate, but that the effect has been incorporated into the exchange rate at the same time as markets came to the conclusion that there would be a change in monetary policy.

developed in Kuttner (2001), is commonly used in the literature. Market interest rates incorporate a risk premium, but the change in the market interest rate is a good proxy for the policy surprise as the risk premium is unlikely to move in the short time periods used in the event study (Piazzesi and Swanson 2004).

For each of the events, we measure the movement in the exchange rate around the event using intraday data. We use a short, 70-minute, event window. This reduces the amount of information received by the market in the event window and so the number of events that would have to be discarded due to the exchange rate and interest rate jointly responding to other news, such as a macroeconomic data release. Because the interest rate surprise will be a more dominant piece of information in a short event window, it should also result in more accurate estimates.

One potential source of concern is that exchange rate movements could influence monetary policy decisions. However, this is not likely in this study because in each central bank the main deliberation on policy changes occurs the day before the announcement. Given that changes in exchange rates are not autocorrelated, this means that the event window will not contain exchange rate movements that influenced the policy decision. The daily market interest rates may be affected by other events or an endogenous response to exchange rate movements, but this is minimised by the fact that events occur on days for which monetary policy is likely to be the most important shock to interest rates. Unfortunately, intraday interest rate data are not available for our sample of countries and time.[3] The events that are excluded from our sample for reasons of contamination are outlined in Section 2.2.

## 2.2    Monetary Policy Operations

The monetary policy operations of the four economies used in this study have changed considerably over the past decade (Brown 1997; Archer, Brookes and

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[3]  We investigated using intraday exchange rate forwards to derive a measure of the intraday interest rate shock based on covered interest rate parity. But quotes for exchange rate forwards are not updated frequently and so the length of the period used to measure the shock varied from one event to another, potentially in a way that correlates with the nature of the shock. This measure of the shock was then found to result in larger standard errors, though the point estimates were roughly equivalent.

Reddell 1999; Parent, Munro and Parker 2003; Zettelmeyer 2004). This section briefly outlines the current monetary policy regimes, how they have changed, and how these changes may impact on this study. Using this information, Section 2.3 explains how the set of events used in the analysis were determined.

The four countries currently have very similar monetary policy operations. In particular, they all have:

- fixed announcement dates for monetary policy decisions, albeit with the option to make changes at other times in response to extreme events;

- a short-term interest rate as the policy instrument;

- a preference for not surprising the market; and

- an inflation target.

While all four countries have been inflation targeters for the full sample considered in this paper, institutional aspects of monetary policy operations have changed since the early 1990s in important ways. Some of these changes have been gradual, while others have been more abrupt. In Australia, monetary policy operations have changed progressively since the early 1990s, to resemble the current operational framework by about 1998. Prior to 1998, though the dates of the 11 Board meetings were known (the first Tuesday of every month, with no meeting in January), monetary policy decisions were typically not announced or implemented immediately after a meeting. From 1998 onwards, all changes in monetary policy have been announced the day after a Board meeting. Only since September 2002 has there been a public announcement on the day after the Board meeting in the event that policy was not being changed. However, market commentary in the period 1998 to 2002 suggests that if policy was not changed the day after a Board meeting then no change was anticipated until the subsequent meeting. So for Australia we have included no-change decisions from the beginning of 1998, as well as all changes in monetary policy from mid 1993. Table 1 provides a summary of the sample periods and number of events for each country.

In the other countries, changes in monetary policy operations have been more distinct and in some cases substantial. At the start of 1999, the Reserve Bank of New Zealand (RBNZ) moved from focusing on a monetary conditions index

| | Australia | Canada | NZ | UK |
|---|---|---|---|---|
| **Table 1: The Set of Events** | | | | |
| Sample | 30/07/1993– 02/06/2004 | 28/10/1996– 08/06/2004 | 17/03/1999– 10/06/2004 | 10/07/1997– 10/06/2004 |
| Number of events used | 79 | 33[b] | 42 | 82 |
|   Number of changes | 24 | 23 | 20 | 27 |
|   Number of no-changes | 55 | 10 | 22 | 55 |
| | | | | |
| Regime change | 1998 | December 2000 | March 1999 | June 1997 |
| Old regime | Policy changes included | Policy changes included | None included | None included |
| New regime | Changes and no-changes included | | | |
|   No of meetings per year | 11 | 8 | 8 | 12 |
|   Time of announcement[a] | 9.30 am on the day after the Board meeting | 9 am on fixed announcement days | 9 am on fixed announcement days | 12.30 pm on the second day of the MPC meeting |

Notes: (a) Some events do occur at different times.
(b) Changes after the 11 September 2001 terrorist attacks and in response to the Russian crisis are excluded. Also, eight events that coincide with changes in the Fed funds rate are excluded.

(a combination of the overnight interest rate and the exchange rate) as the main intermediate target of policy to using the overnight cash rate to implement monetary policy. Accordingly, we begin our New Zealand sample in 1999, as prior to this the motivation for interest rate changes were inextricably linked to exchange rate movements.

Like New Zealand, Canada has implemented a system of eight fixed announcement dates (starting December 2000). However, unlike New Zealand, there has been little change in the framework and focus of policy. We therefore include most changes to policy from 1996 onwards, when our intraday exchange rate data for the Canadian dollar begin. Eight changes are excluded, when they are on the day of, or the day after, a change in the Fed funds rate, reflecting the likelihood of contamination of the measure of the surprise in policy. Two further policy changes are excluded, the one following the August 1998 Russian crisis and the one after the 11 September 2001 terrorist attacks, again for reasons of possible contamination.

In the United Kingdom the operational responsibility for monetary policy passed from the Government to the Bank of England in June 1997, ensuring an

independent monetary policy-maker. We exclude monetary policy decisions made prior to this, owing to the large shift in the monetary policy regime and uncertainty about the exact time at which changes were announced prior to 1997.

For each event we searched Bloomberg and other sources to ensure that there was no contaminating information in the event window. Because we use a narrow event window, we did not find cause to exclude any events other than those outlined for Canada.[4] We also record the exact time of the event in order to make them completely comparable.

Given the similarities of the current monetary policy regimes in the four countries, we also present results using a pooled sample. In order to keep the sample as homogenous as possible, only those events that are part of the current regimes, in which monetary policy is implemented according to fixed announcement dates, are included. This is the full sample for New Zealand and the UK, and from 1998 for Australia and the end of 2000 for Canada.

## 2.3 The Data

The two data series used in the event study are interest rates and exchange rates. We use bank bill interest rates (1-month and 3-month) and futures contracts on the 3-month bank bill interest rate. Most of the literature for the US has calculated monetary policy surprises using Fed funds futures contracts (see, for example, Bernanke and Kuttner forthcoming; Faust, Rogers, Swanson and Wright 2003; Kuttner 2001). However, futures contracts over the policy instrument interest rates are not available for the countries we use over our sample period, and so we use bank bill interest rates to calculate monetary policy surprises. One advantage of bank bill rates is that, unlike futures, the horizon of the instrument does not vary from one event to another, thereby simplifying the calculation of the surprise. Piazzesi and Swanson (2004) find that eurodollar interest rate futures provide good measures of interest rate surprises for the US, and are only marginally outperformed by Fed fund futures. The interest rate surprise is calculated as the change in the 1-month or 3-month bank bill interest rate from the close of the day prior, to the close of the day of the monetary surprise. The surprises are measured in percentage points (100 basis points). We use this unit

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[4]  A few events are excluded due to missing intraday exchange rate data.

of measurement because it is a convenient round number and other authors have done likewise, not because it is a plausible magnitude for the surprise. Presently, the central banks in our sample move their policy interest rates in 25 basis point increments, and so this is presumably the maximum surprise. The interest rates we use, and their sources, are described in Appendix A.

The bilateral exchange rates are the US dollar price of the domestic currency, from the Reuters electronic trading system, at 10-minute intervals. At each 10-minute interval, the exchange rate observation is the average of the closest active bid and ask quotes. Goodhart and Payne (1996) and Danielsson and Payne (2002) have found that at 10-minute intervals, quote data are good proxies for actual transaction prices in exchange rate markets.

Table 2 gives a brief summary of the data. The average absolute change in the policy rate, $|\Delta i|$, is based on change and no-change event days in the sample. The average absolute change is typically around twice as large as the average absolute surprise, $|\Delta i^s|$. Exchange rate volatility measured as the average absolute change in the exchange rate over 10 minute intervals, is higher on event days than on non-event days (from 2 hours before to 6 hours after the event), providing some initial evidence that monetary policy has an effect on the exchange rate.

**Table 2: The Data**

|  | Australia | Canada | NZ | UK |
|---|---|---|---|---|
| Number of events used | 79 | 33 | 42 | 82 |
| Average $|\Delta i|$ | 0.13 | 0.21 | 0.15 | 0.09 |
| Average $|\Delta i^s|$ | 0.07 | 0.06 | 0.05 | 0.07 |
| Ratio of event to non-event day exchange rate volatility [a] | 1.34 | 1.17 | 1.33 | 1.13 |
| Average $|\Delta e_{10m}|$ | 0.049 | 0.041 | 0.059 | 0.052 |

Notes:   $|\Delta i|$ is the absolute change in the official interest rate in percentage points. $|\Delta i^s|$ is the absolute change in the 1-month interest rate in percentage points.
(a) The volatility is calculated as the average absolute change in the exchange rate over 10-minute intervals. Averages are taken over a window starting two hours before the event and ending six hours after. The sample of non-event days is constructed by taking the day exactly one week prior to each event.
$|\Delta e_{10m}|$ is the per cent change over 10-minute intervals on event days.

# 3.    Results

## 3.1    The Impact of Monetary Policy Shocks

To quantify the impact of monetary policy on the exchange rate we regress the change in the exchange rate over the event window on the monetary policy surprise, as represented by Equation (1),

$$\Delta e_{[t-10m,t+60m]} = \alpha + \beta \Delta i_t^s + \varepsilon_t \tag{1}$$

where $\Delta e_{[t-10m,t+60m]}$ is the percentage change in the US dollar bilateral exchange rate from 10 minutes before the event to 60 minutes after, and $\Delta i_t^s$ is the surprise move in policy measured by the daily change in market interest rates. We use the exchange rate from 10 minutes before the policy change, rather than at the time of the policy change, in case there are mismatches in the timing of our exchange rate data and policy implementation. We present results using surprises derived from both 1-month and 3-month interest rates.

These regressions suggest that a 100 basis point surprise tightening of monetary policy is estimated to lead to an appreciation of the exchange rate in the range of 1–2 per cent in the hour following the event (Table 3). When we use the sample pooled across countries the estimate is in the middle of this range, just under 1½ per cent.[5] As noted in Section 2.3, the countries used in this study now move their policy rates in 25 basis point increments. A 25 basis point surprise would lead to an appreciation of ¼–½ per cent. The surprise in monetary policy explains only about 10–20 per cent of the movement in the exchange rate over the 70-minute interval. The low proportion of exchange rate movements explained by the interest rate surprise, even in such a short window, is in line with other work on the exchange rate, for example Andersen *et al* (2003) and Faust, Rogers, Wang and Wright (2003).

For all countries and the pooled sample, the coefficient on the interest rate surprise is larger when the surprise is measured using a 3-month interest rate than in the equivalent regression using a 1-month interest rate. Presumably this is because the 3-month rate includes the impact of the decision on expectations of future

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5   The data do not reject the restriction that the coefficient on interest rates is constant across countries.

## Table 3: Impact of a 100 Basis Point Monetary Policy Surprise

| Country | 1-month | 3-month | $\overline{R}^2$ | Observations |
|---|---|---|---|---|
| Australia | 0.96 | | 0.16 | 79 |
| | (0.00) | | | |
| | | 1.88 | 0.32 | 79 |
| | | (0.00) | | |
| Canada | 1.56 | | 0.22 | 33 |
| | (0.00) | | | |
| | | 1.67 | 0.23 | 33 |
| | | (0.00) | | |
| NZ | 1.83 | | 0.11 | 42 |
| | (0.02) | | | |
| | | 1.97 | 0.15 | 42 |
| | | (0.01) | | |
| UK | 1.04 | | 0.11 | 82 |
| | (0.00) | | | |
| | | 1.58 | 0.17 | 82 |
| | | (0.00) | | |
| Pooled sample | 1.45 | | 0.13 | 222 |
| | (0.00) | | | |
| | | 1.77 | 0.17 | 222 |
| | | (0.00) | | |

Notes:     The dependent variable is the change in the exchange rate (relative to the US dollar) from 10 minutes before the event to 60 minutes after. P-values are in parentheses.

monetary policy, at least over the next 3 months, an important issue that we explore in Section 3.2. The point estimates for the 3-month surprises for Australia and Canada are similar to Zettelmeyer's (2004) results using daily data. However, his result for New Zealand is larger, 2.7 per cent, possibly because his sample, being mostly before 1999 when a monetary conditions index was being used, does not contain purely exogenous monetary shocks. The point estimates are also similar in magnitude to the 1.2 for the deutschemark/euro exchange rate response to changes in US interest rates contained in Faust, Rogers, Wang and Wright (2003). However, their estimate for the pound's response to US interest rates of 0.66 is smaller, suggesting that their result may contain some bias in estimating the impact of a change in a large country's interest rate on the bilateral exchange rate with a smaller country.

The timing of the impact of a monetary policy surprise on the exchange rate can be determined by estimating Equation (2) for $k$ ranging from 2 hours before the event to 6 hours after (at 10 minute intervals).

$$\Delta e_{[t,t+k]} = \alpha + \beta \Delta i_t^s + \varepsilon_t \qquad (2)$$

The results are shown in Figures 1 to 4 where the surprise is measured using the 1-month interest rate. In all 4 countries there is a sharp spike in the impact in the 10 minutes following the event, demonstrating that monetary policy announcements have a rapid impact on the exchange rate. The relative stability of the coefficients over the six hours after the event indicate that the surprise has little additional influence after its immediate impact. The standard errors, the dashed lines in the graphs, widen further from the event as the policy change becomes a smaller proportion of the information incorporated into the exchange rate. As a result, the statical significance using daily data will be substantially weaker.

For Australia and Canada there is significant movement in the exchange rate prior to the event in the same direction as the response following the event. Given this is gradual for Canada it is suggestive of late changes in market expectations of the policy announcement, perhaps as participants' expectations coalesce around a particular policy announcement. Such changes in market expectations would presumably also be reflected in intraday interest rate data were they available. For Australia the sharp jump that occurs 10 minutes before the event most likely reflects slight differences between the timing of the announcement and the exchange rate data. The significance of this change immediately prior to the event is not unduly influenced by any particular observations and so the result does not appear to be the result of leaked information.[6] It is because of this possible timing mismeasurement that we base our main results on the exchange rate starting 10 minutes before the event.

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[6] This result is not sensitive to the exclusion of the only two events for Australia in which there is any suggestion of some participants seemingly having early access to the policy outcome: one in which the monetary policy decision was mistakenly released to some market participants six minutes early (2 February 2000) and the other in which Bloomberg mistakenly released a report about one minute early even though it did not yet know the outcome (3 July 2002). Note that these do not affect our main results because we use the exchange rate from 10 minutes before the policy change.

**Figure 1: Australian Dollar**

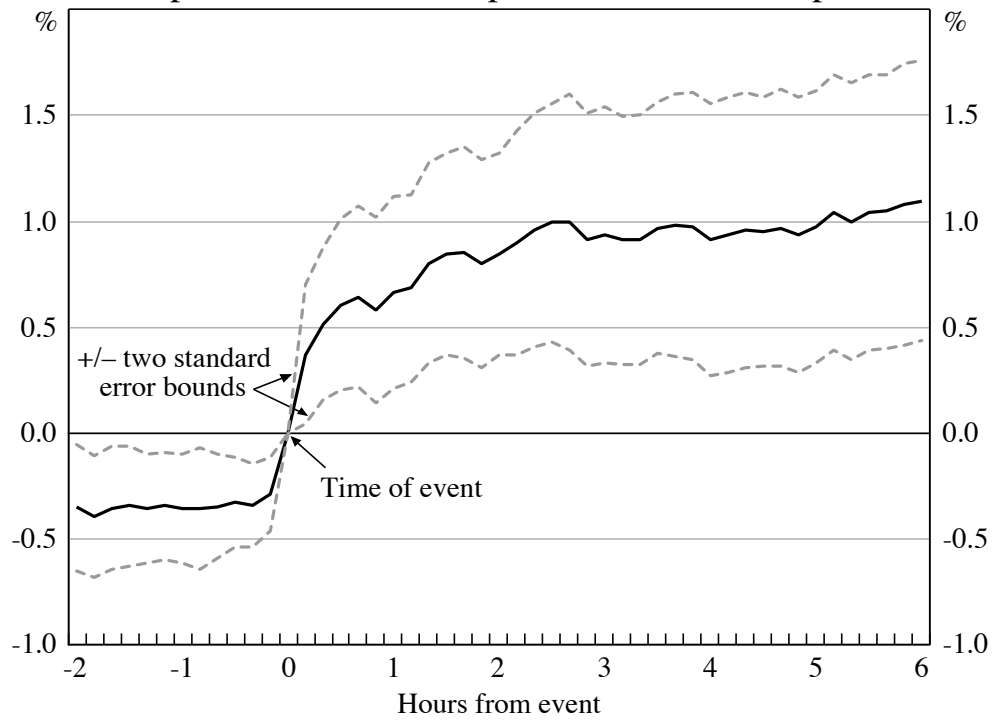Response to a 100 basis point interest rate surprise

%

%

1.5

1.5

1.0

1.0

0.5

0.5

+/– two standard
error bounds

0.0

0.0

Time of event

-0.5

-0.5

-1.0

-1.0

-2    -1    0    1    2    3    4    5    6

Hours from event

**Figure 2: Canadian Dollar**

Response to a 100 basis point interest rate surprise

%

%

3

3

2

2

1

1

0

0

Time of event

-1

-1

-2

-2

-2    -1    0    1    2    3    4    5    6
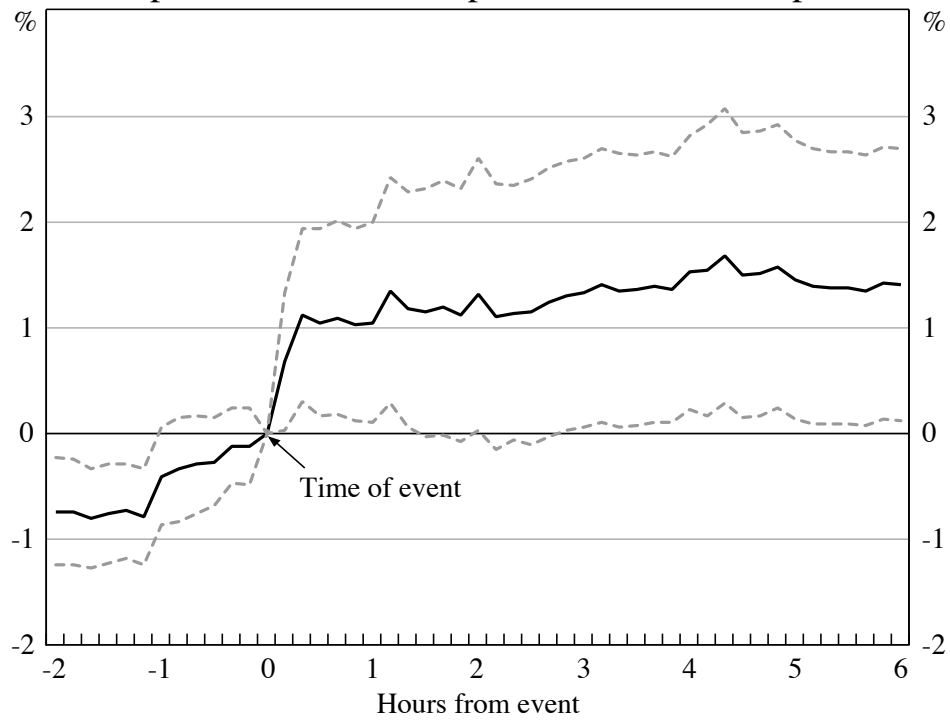
Hours from event

**Figure 3: New Zealand Dollar**

Response to a 100 basis point interest rate surprise
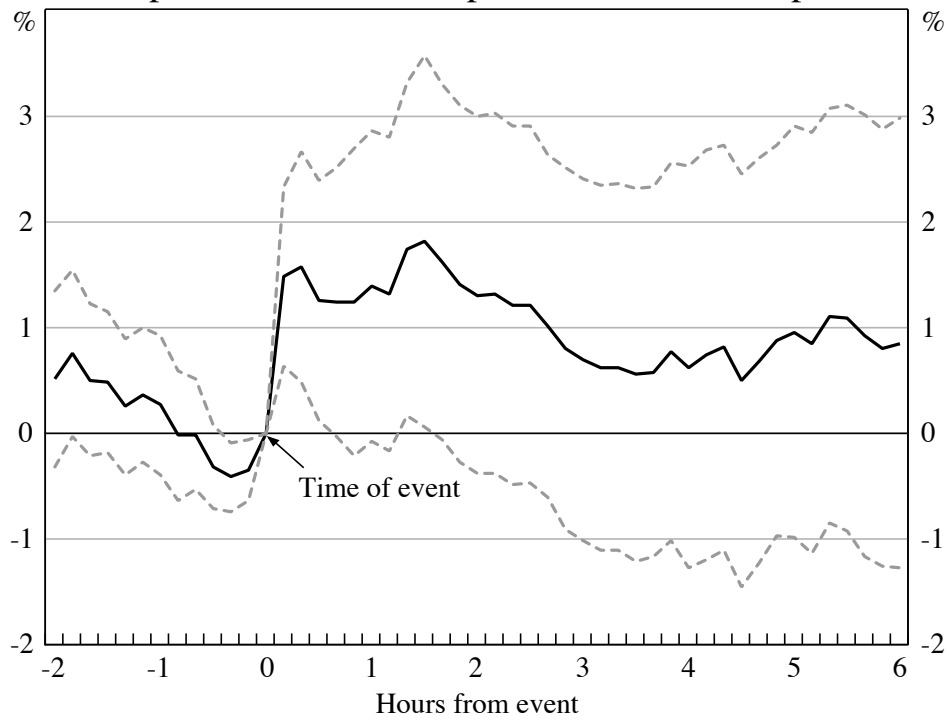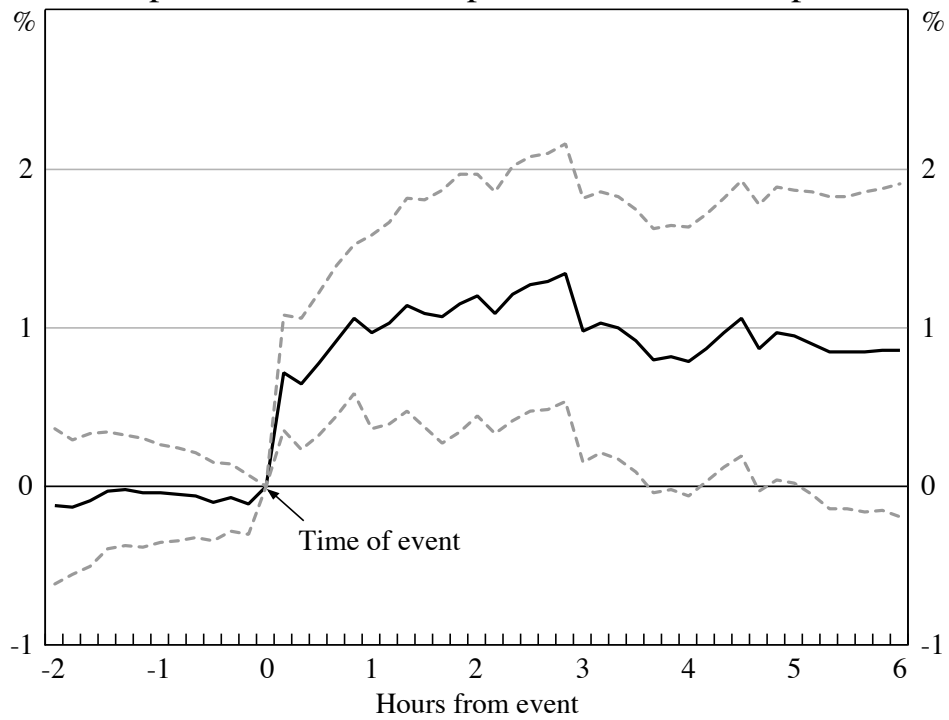


Hours from event

**Figure 4: British Pound**

Response to a 100 basis point interest rate surprise



Hours from event

Given the importance for New Zealand of financial linkages with Australia, and New Zealand's smaller relative size, it is also interesting to examine the impact of monetary policy surprises in New Zealand on the New Zealand dollar/Australian dollar bilateral exchange rate. Figure 5 demonstrates that the response is more precisely estimated, and larger, than for the response of the New Zealand dollar/ US dollar exchange rate shown in Figure 3.

**Figure 5: New Zealand Dollar/Australian Dollar Bilateral Rate**

Response to a 100 basis point interest rate surprise
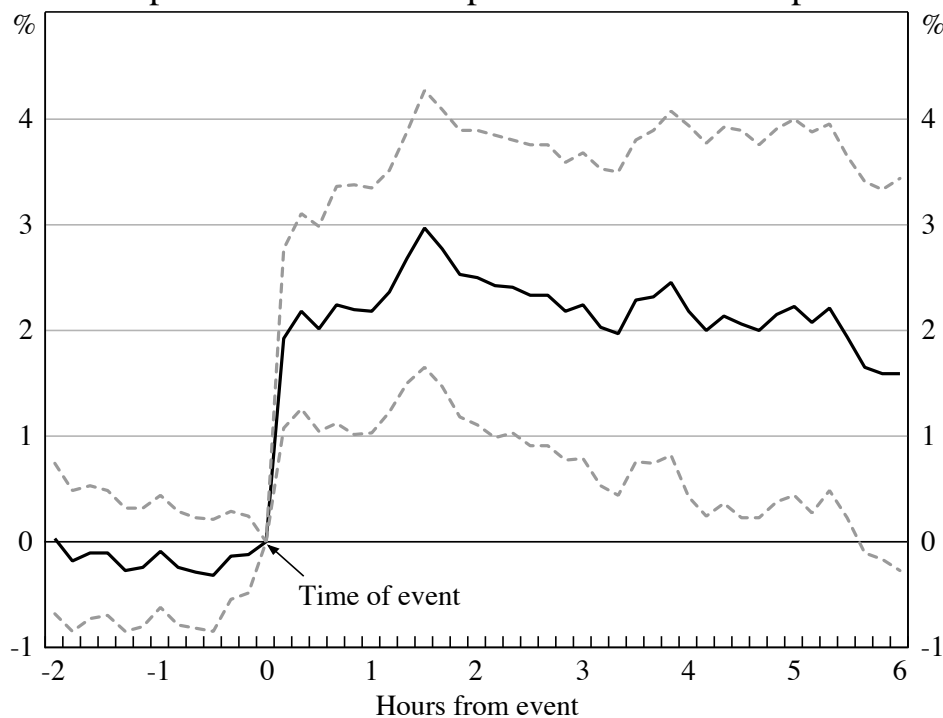


## 3.2    The Importance of Expectations

The impact of a policy decision on expectations of future policy may be important in determining the exchange rate's response. This is apparent from the different results obtained when measuring the monetary policy surprise using 1-month and 3-month interest rates. A monetary policy decision might simply surprise the market in its timing (a 'timing' surprise), or it might be a surprise that shifts policy expectations at all horizons (a 'level' surprise). A change in current monetary policy could even shift expectations of future policy by more than the impact on 1-month interest rates if market participants believe that it indicates that future changes in the same direction are likely.

To test whether expectations are important we examine changes in 3-month interest rate futures (details of these contracts are in Appendix A). These are not perfect measures of policy expectations, but changes in these interest rates have been shown to be a reasonable guide to changes in policy expectations (Piazzesi and Swanson 2004). Typically, about eight futures contracts trade at any one time, giving a horizon of about two years in total. What is termed the 'first' interest rate futures contract expires sometime in the next 3 months, and is settled on the 3-month interest rate prevailing on that expiration date. The 'second' futures contract is settled on the 3-month interest rate prevailing 3 months after the expiration of the first contract, and so on. Because the futures contracts expire at fixed points in time 3 months apart, but monetary policy events can happen at any time in a 3-month period, the horizon until the contract expiration can differ from 1 event to another. While not ideal, this is unavoidable given that 1-month futures contracts are not available for these countries over the relevant sample and the time between the fixed announcement dates can vary in Canada and New Zealand. We consider the sensitivity to this measurement issue in Section 3.3.

Figure 6 shows a scatterplot of the change in the 1-month interest rate against the change in the second futures contract, on days with a monetary policy event, for all four countries. We use the second futures contract as it has the advantage that it does not expire until after at least two complete monetary policy decision cycles.

Given that monetary policy changes are not quickly reversed, surprises that lead to a positive (negative) change in the 1-month interest rate are unlikely to also lead to a negative (positive) change in the futures rate. This suggests that there should be very few points in Quadrants I and III. It would seem likely that most surprises would be somewhere between a level and timing surprise. Changes in the futures rate should then be of the same sign as, but smaller in magnitude than, the change in the 1-month rate. In this case, most observations would lie in the shaded area in Figure 6. The data broadly fit this pattern, especially for large monetary surprises, although there are still quite a number of points outside the shaded area. If all surprises had the same effect on expectations of future policy then they would lie on a straight line. The scatterplot shows that this is clearly not the case, and regressions for each country indicate that the change in the 1-month interest rate explains only about half of the change in the second futures rate. It thus appears that there is sufficient heterogeneity to test whether the effect that a monetary

**Figure 6: Change in Spot Interest Rate vs Change in Futures Rate**
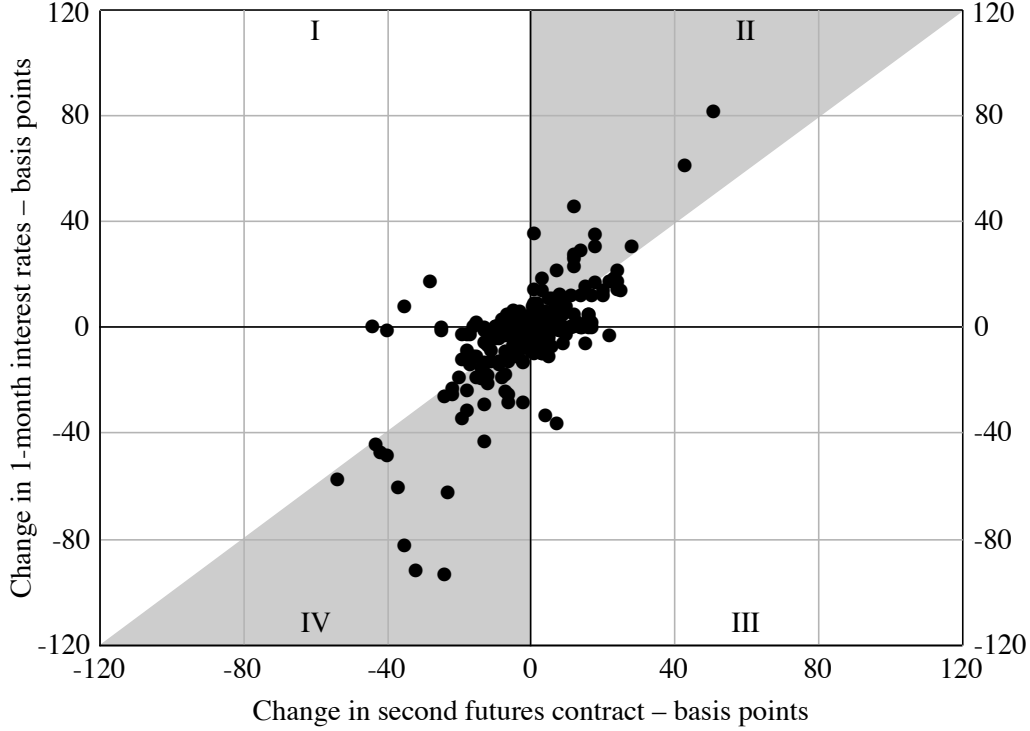


policy decision has on expectations of future policy is important in determining the decision's impact on the exchange rate.

We incorporate information on the change in the futures contract in Equation (3).

$$\Delta e_{[t-10m,t+60m]} = \alpha + \beta \Delta i_t^s + \gamma \Delta i_t^{s,f} + \varepsilon_t \tag{3}$$

A 'timing' surprise – a surprise that does not change expectations of the level of future policy – is captured by $\beta$, since there is no change in the futures interest rate (that is, $\Delta i_t^{s,f} = 0$). A 'level' surprise – a surprise that changes expectations of future interest rates by as much as the surprise in current policy, i.e., $\Delta i_t^s = \Delta i_t^{s,f}$ – is measured by $\beta + \gamma$. The results are presented in Table 4.

These results confirm that a surprise in the level of policy leads to a greater change in the exchange rate than does a surprise in the timing of policy. Estimates of the impact of a 100 basis point surprise in timing, $\beta$, for the individual countries are imprecisely estimated, but range from being negative to around 1 per cent. However, in the larger pooled sample, the estimate is very precisely estimated to be 0.87. A 100 basis point surprise increase in the level of the (current and future) policy instrument is estimated to lead to a 1.3 to 2.2 per cent appreciation in the

**Table 4: Timing and Level Surprises**

| | Timing surprise $\beta$ | $\gamma$ | Level surprise $\beta + \gamma^{(a)}$ | $\overline{R}^2$ | Observations |
|---|---|---|---|---|---|
| Australia | 0.46 | 0.80 | 1.26 | 0.21 | 79 |
| | (0.14) | (0.02) | (0.00) | | |
| Canada | 0.84 | 0.85 | 1.69 | 0.23 | 33 |
| | (0.26) | (0.20) | (0.00) | | |
| NZ | 1.06 | 0.74 | 1.80 | 0.11 | 42 |
| | (0.35) | (0.35) | (0.02) | | |
| UK | −0.21 | 2.44 | 2.22 | 0.29 | 82 |
| | (0.59) | (0.00) | (0.00) | | |
| | | | | | |
| Pooled sample | 0.87 | 0.81 | 1.68 | 0.17 | 222 |
| | (0.00) | (0.00) | (0.00) | | |

Notes: P-values are in parentheses.
(a) The p-value for $\beta + \gamma$ is calculated using a Wald test.

exchange rate, as seen by the estimates of $\beta + \gamma$. The pooled sample produces an estimate in the middle of this range, 1.68. These estimates of the impact of a level surprise are highly significant for all of the countries and the pooled sample. This indicates that a 25 basis point timing (level) surprise would appreciate the exchange rate by around 0.2 per cent (0.4 per cent). Clearly a level surprise has a much larger impact on the exchange rate than a timing surprise.

It is interesting to benchmark these results to what the theory of UIP might suggest. To calculate the jump in the exchange rate that would be implied by a surprise change in monetary policy, we need to know both how long the change in monetary policy will be sustained and the level that the exchange rate is expected to return to after the change in the interest differential is undone. Using our estimates that separate the timing from the level effects we can attempt to control for the first of these issues. But without knowing what caused the monetary surprise, and what impact that news had on the equilibrium value of the exchange rate, we cannot determine the level to which the exchange rate is expected to return. For the purpose of this calculation we assume that the monetary surprise did not change the long-run expected value of the exchange rate. If the monetary decision is a pure timing surprise, the interest rate given by the futures contract that expires in 3–6 months does not change. Assuming that the surprise lasts

4½ months (that is, the midpoint of 3 and 6 months), UIP suggests that a 100 basis point surprise increase would lead to an immediate appreciation of less than half a per cent (0.375 per cent).[7] In contrast we estimate the response to a 100 basis point timing surprise to be over twice as large, 0.87 per cent. Of course, this interpretation is subject to the important caveat that we do not know how the long-run equilibrium level of the exchange rate has changed.

## 3.3 Robustness

To test the robustness of our findings we include a range of other variables in the regressions. For brevity we only report results using the pooled sample. The equivalent regressions for the individual countries produce similar results, though understandably with larger standard errors. Table 5 reports specifications using surprises based on 1-month bank bill interest rates, while Table 6 repeats the regressions using surprises based on 3-month bank bill rates. The coefficients on monetary policy surprises are found to be robust and maintain their statistical significance across a range of specifications. Specifications I and II repeat the pooled results from Tables 3 and 4. The estimates using the 3-month interest rate surprise are slightly larger, reflecting their less precise separation of timing and level surprises. Using the third rather than second futures contract, Specification III, does not change the results appreciably.

One surprising result is that the coefficient on the expected change (the change in monetary policy less the unexpected change) is always about $-0.2$ per cent and marginally significant (Specifications IV–VII). This runs counter to our priors that only unexpected changes in monetary policy should affect the exchange rate. This result owes a lot to one particular event in New Zealand, 17 May 2000. The tightening in monetary policy on this day was almost completely anticipated. But the particularly hawkish Monetary Policy Statement released with the decision seemingly led to concerns about the impact of the indicated course of policy on the growth of the economy and a sharp *depreciation* of the exchange rate. Excluding this observation, the expected change in policy does not have a statistically significant impact on the exchange rate.

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[7]  This assumes that the foreign interest rate remains constant.

**Table 5: Pooled Results – 1-month Surprise**

| Model | Surprise change $\beta$ | Futures contract $\gamma$ 2nd | Futures contract $\gamma$ 3rd | Expected change | Maturity[a] | Change dummy with: Surprise change | Change dummy with: 2nd future | $\overline{R}^2$ |
|---|---|---|---|---|---|---|---|---|
| I | 1.45 (0.00) | | | | | | | 0.13 |
| II | 0.87 (0.00) | 0.81 (0.00) | | | | | | 0.17 |
| III | 0.95 (0.00) | | 0.74 (0.00) | | | | | 0.17 |
| IV | 0.89 (0.00) | 0.83 (0.00) | | −0.21 (0.00) | | | | 0.18 |
| V | 0.94 (0.00) | 0.76 (0.01) | | −0.21 (0.09) | 0.00 (0.61) | | | 0.17 |
| VI | 0.61 (0.16) | 0.72 (0.01) | | −0.25 (0.06) | 0.00 (0.61) | 0.58 (0.26) | | 0.17 |
| VII | 0.74 (0.10) | 0.47 (0.19) | | −0.24 (0.06) | −0.01 (0.46) | 0.15 (0.82) | 0.63 (0.26) | 0.18 |

Notes: The dependent variable is the change in the exchange rate (relative to the US dollar) from 10 minutes before the event to 60 minutes after. P-values are in parentheses. There are 222 observations in all regressions.
(a) The maturity variable is: (the change in the futures contract) × (the difference between the days to maturity and the average days to maturity).

A variable that controls for the changing number of days until maturity of futures contracts, used in Specifications V–VII, is always economically and statistically insignificant. This suggests that our conclusions about the timing and level surprises are not unduly influenced by the fact the horizon of interest rate futures is not constant across events.

The coefficient on a dummy for whether the decision was a change in monetary policy, multiplied by the monetary policy surprise, is always positive though not significant (Specifications VI and VII). This suggests that there may be a slightly greater effect on the exchange rate when the surprise monetary decision is a change in the policy interest rate. Alternatively, this could simply reflect the fact that the proportion of the interest rate change that is caused by monetary policy is likely to be higher when the surprise is larger, which typically occurs when monetary policy is changing.

**Table 6: Pooled Results – 3-month Surprise**

| Model | Surprise change $\beta$ | Futures contract $\gamma$ | | Expected change | Maturity[a] | Change dummy with: Surprise change | Change dummy with: 2nd future | $\overline{R}^2$ |
|---|---|---|---|---|---|---|---|---|
| | | 2nd | 3rd | | | | | |
| I | 1.77 | | | | | | | 0.17 |
| | (0.00) | | | | | | | |
| II | 1.27 | 0.52 | | | | | | 0.18 |
| | (0.00) | (0.08) | | | | | | |
| III | 1.32 | | 0.48 | | | | | 0.18 |
| | (0.00) | | (0.07) | | | | | |
| IV | 1.32 | 0.51 | | −0.21 | | | | 0.19 |
| | (0.00) | (0.08) | | (0.08) | | | | |
| V | 1.42 | 0.41 | | −0.20 | −0.01 | | | 0.18 |
| | (0.00) | (0.22) | | (0.10) | (0.49) | | | |
| VI | 0.94 | 0.39 | | −0.23 | −0.01 | 0.72 | | 0.19 |
| | (0.08) | (0.24) | | (0.06) | (0.48) | (0.20) | | |
| VII | 1.01 | 0.30 | | −0.23 | −0.01 | 0.49 | 0.25 | 0.18 |
| | (0.08) | (0.45) | | (0.06) | (0.45) | (0.54) | (0.71) | |

Notes: The dependent variable is the change in the exchange rate (relative to the US dollar) from 10 minutes before the event to 60 minutes after. P-values are in parentheses. There are 222 observations in all regressions.
(a) The maturity variable is: (the change in the futures contract) $\times$ (the difference between the days to maturity and the average days to maturity).

## 4. Conclusions

In this paper we use an event study to isolate the impact of changes in monetary policy on the exchange rate. Two important aspects of our study enable us to abstract from endogeneity and the influence of other exogenous news. First, we use a sample period for four countries (Australia, Canada, New Zealand and the United Kingdom) in which monetary policy does not focus on the exchange rate and the decision is predetermined when it is implemented. Second, we use intraday data with a narrow event window. The results indicate that the exchange rate appreciates on average by around 1½ per cent in response to an unanticipated 100 basis point increase in the policy interest rate. The estimates for individual countries range from 1.0–1.8 per cent. For a 25 basis point surprise this equates to an average appreciation of 0.35 per cent (¼–½ of a per cent for individual countries). These results are slightly smaller than those in Zettelmeyer (2004) but mostly marginally larger than those in Faust, Rogers, Wang and Wright (2003).

The impact of monetary policy changes on the exchange rate is found to occur virtually instantaneously. If we use an event window that ends well after the monetary policy decision, the estimates do not change, indicating that the news is rapidly incorporated into exchange rates, although the standard errors widen. Despite using a narrow event window in which no other identifiable events occurred, the monetary shock explains only 10–20 per cent of the variation in the exchange rate in that short window. In general, the results suggest that monetary policy can account for only a small part of the observed volatility in the exchange rate. The small proportion explained by such high-profile news indicates that there is still much to learn in explaining exchange rate movements.

In the second part of the paper we present new evidence that not all monetary surprises will have the same effect on the exchange rate. Those that cause a revision to expectations of future policy are found to have a much larger impact than surprises in the timing of a change in monetary policy. A 100 basis point (25 basis point) increase in current and future policy interest rates is found to appreciate the exchange rate by around 1.7 per cent (0.4 per cent). Estimates for individual countries range from 1.3–2.2 per cent. In contrast, a monetary surprise that only brings forward an anticipated change in policy is found to appreciate the exchange rate by just 0.9 per cent (0.2 per cent). A rough calculation, subject to the caveat of not knowing the change in the long-run equilibrium exchange rate, suggests that this immediate jump in the exchange rate is over twice as large as uncovered interest parity would suggest, adding to the puzzle of its empirical failure.

# Appendix A: Data Description and Sources

| | Australia | Canada | NZ | UK |
|---|---|---|---|---|
| **Table A1: Data** | | | | |
| **Interest rates** | | | | |
| 1-month interest rate | 30-day bank bills (RBA) | 1-month bankers acceptances (BoC) | 1-month wholesale bill (RBNZ) | 1-month LIBOR (Datastream: LDNIB1M) |
| 3-month interest rate | 90-day bank bills (RBA) | 3-month bankers acceptances (BoC) | 3-month wholesale bill (RBNZ) | 3-month LIBOR (Datastream: LDNIB3M) |
| **Futures** | | | | |
| Contracts | 90-day bank bills (Bloomberg: IR1 comdty) | 3-month bankers acceptances (Bloomberg: BA1 comdty) | 3-month bank bills (Bloomberg: ZB1 comdty) | 3-month LIBOR (Bloomberg: L 1 comdty) |
| Futures exchange | Sydney Futures Exchange | Montreal Exchange | Sydney Futures Exchange | London International Financial Futures Exchange |
| Settlement months | March, June, September and December for all countries | | | |
| Expiration day | 2$^{nd}$ Friday | 3$^{rd}$ Tuesday | Thursday after first Wednesday after 9$^{th}$ of month | 3$^{rd}$ Thursday |
| **Exchange rates** | RBA/Reuters, 10-minute intervals, midpoint of 2 closest quotes | | | |

Note: RBA is the Reserve Bank of Australia, BoC is the Bank of Canada, and RBNZ is the Reserve Bank of New Zealand.

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