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The Impact of Monetary Policy on the Exchange Rate: Evidence from Three Small Open Economies

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The Impact of Monetary Policy on the Exchange Rate: Evidence from Three Small Open Economies

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Abstract

This paper studies the impact effect of monetary policy shocks—identified by the reaction of three month market interest rates to policy announcements—on the exchange rate in Australia, Canada, and New Zealand during the 1990s. The main results are that (i) on average, a 100 basis point contractionary shock will appreciate the exchange rate by 2-3 percent on impact; (ii) seemingly "perverse" reactions of the exchange rate to monetary policy are mainly attributable to reverse causality; (iii) in a few instances, there were true "perverse" reactions of exchange rates to policy—generally, appreciations following expansionary shocks.

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I. INTRODUCTION

The reaction of exchange rates to monetary policy shocks has been the subject of a large body of—mostly VAR-based—empirical research since the early 1990s.[2] There are essentially three motives that drive this literature. First, to evaluate economic models of exchange rate dynamics—for example, by testing the prediction that exchange rates "overshoot" on impact in response to nominal shocks, or as a means of testing UIP directly.[3] Second, to understand the effects of monetary policy, either because the exchange rate reaction to monetary policy is in itself viewed as important for monetary transmission, or because estimating this reaction (along with that of other variables) helps to discriminate between alternative models of the business cycle, which may have different implications about how monetary policy should be conducted.[4] Third, more recently, the Asia crisis has ignited a debate on the role of monetary policy in stabilizing exchange rates both during and in the aftermath of a currency crisis. Specifically, to what extent is tight money successful in offsetting, or mitigating, pressure on the exchange rate, as conventional open economy models would predict? Are there circumstances when it could have the opposite effect—for example, by exacerbating the decline in economic activity to the point where any increase in potential return via higher interest rates is offset by higher default risk and/or lower future expected exchange rates?[5]

This paper presents evidence from three small open economies—Australia, Canada, and New Zealand—that sheds light on the impact effect of monetary policy shocks on exchange rates, using an empirical approach that does not rely on VAR-based identification of monetary policy shocks. In essence, the strategy will be to focus on the immediate response of the exchange rate to shocks associated with particular policy actions, both during "normal" times and at times of pressure on the exchange rate. The cost of this approach is that it restricts attention to the *impact* reaction of policy shocks, and thus forgoes studying the dynamics of exchange rate adjustment after the initial reaction. The benefit, however, is that the

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[2] Sims (1992), Racette and Raynauld (1992), Eichenbaum and Evans (1995), Skinner and Zettelmeyer (1995b), Grilli and Roubini (1995, 1996), Clarida and Gertler (1997), Cushman and Zha (1997), Fung and Gupta (1997), Faust and Rogers (1998), Bagliano and Favero (1999), in addition to the papers on monetary policy after a currency crisis cited below.

[3] See Eichenbaum and Evans (1995), Grilli and Roubini (1996) and Faust and Rogers (1998).

[4] The latter point is emphasized by Christiano, Eichenbaum and Evans (1998).

[5] This is argued by Furman and Stiglitz (1998); for two models that can rationalize their argument (under specific assumptions), see Aghion, Bacchetta and Banerjee (2000) and Lahiri and Végh (2000b). For theoretical papers on the related issue whether high interest rates are effective in defending exchange rate *pegs* see Drazen (1999), Lahiri and Végh (2000a) and Flood and Jeanne (2000). Empirical papers on the subject are referenced below.

assumptions used to identify policy shocks are much weaker than those commonly used—minimizing, in particular, the risk of reverse causality. This means that the approach taken in this paper is justified provided that (i) an important subset of the debate concerns the direction and size of the direct effect of monetary policy on the exchange rate, rather than its path; (ii) the results in the existing empirical literature seem sensitive to the identification assumptions made, and reverse causality is generally a problem. Except for the U.S., where the finding that a monetary contraction appreciates the exchange rate is very robust, and most of the debate concentrates on whether exchange rate overshooting is "delayed" or not, this is arguably the case:

- in countries other than the U.S., the direction and significance of the exchange rate response is often *not* robust to alternative VAR-based identification assumptions. As shown by Grilli and Roubini (1995) for the G7, and by Sims (1992) for a G7 subset, when monetary policy shocks are identified with shocks to short interest rates in the context of a standard recursive identification scheme (which in particular assumes that interest setting is independent of contemporaneous values of money, the exchange rate, and foreign interest rates), exchange rates mostly appear to *depreciate* rather than appreciate in response to a monetary contraction (except in the case of the U.S). In contrast, Cushman and Zha (1997), Kim and Roubini (1995)[6], and Clarida and Gertler (1997),[7] identify shocks assuming a structural model among the contemporaneous variables, and report an appreciation on impact, which is usually significant. Based on these papers, one would conjecture that the original "exchange rate puzzle" was spurious, and resulted from the failure to control for the endogeneity of monetary policy to contemporaneous exchange rate movements and/or foreign interest rate changes—which may be innocuous for the case of the U.S. but not for smaller countries. The methodology presented in this paper provides an opportunity to confirm this conjecture using an unrelated identification approach, which does not require assuming a structural model.

- the debate on the direction of the impact of tight money on the exchange rate in times of turbulence is wide open. Using a large sample that includes both industrial and developing countries, Goldfajn and Gupta (1999) present evidence supporting the view that tight monetary policy generally mitigates the collapse of the exchange rate after a currency crisis. Based on similar countries, however, Kraay (1999) finds that the level of interest rates is irrelevant to whether or not an exchange rate peg is likely to succumb to a speculative attack. Focusing on emerging market economies during crisis periods, Furman and Stiglitz (1998) find that tighter monetary policy (measured be the level of interest rates, and excepting high inflation cases) is associated with *larger* exchange rate collapses. Goldfajn and Baig (1998) and Tanner (1999, using NDA as the policy measure) find the opposite, while several papers (Goldfajn and Baig (1998), Gould and

[6] The results of this paper are reported in Grilli and Roubini (1996).

[7] For Canada, the G7, and Germany, respectively.

Kamin (2000) and Ohno, Shirono and Sisli (1999), all using high-frequency data) fail to detect any significant influence of interest rate policy on exchange rates during the Asia crisis. However, since most of these papers do not attempt to instrument their policy proxies and/or to identify monetary policy shocks,[8] some of the divergence in findings may be attributable to the fact that the policy measures used mix policy shocks with endogenous policy responses or even market-driven changes. Depending on which policy variable is used, this could bias results either in favor or against the conventional view about the relationship between monetary policy and the exchange rate.[9]

While the present study obviously does not speak directly to the debate about monetary policy during the Asia crisis, the sample period includes several large bouts of exchange rate market turbulence which affected the three countries in our sample. Two of these—Canada and New Zealand—attempted to tighten their monetary policies to lean against exchange rate pressure during one or several of these episodes. Thus, the paper does provide some evidence on the effect of monetary policy on exchange rates in times of turbulence, although this applies only to industrialized economies at the periphery of the crises of the 1990s, rather than emerging market economies at its center.

Methodologically, this paper is related to Romer and Romer (1989) and Cook and Hahn (1989) in examining the effects of actual (historic) monetary policy *actions*. The basic motivation for doing this is the same as in Romer and Romer, and Cook and Hahn: by focusing on the effects of policy actions, one can avoid the endogeneity of variables otherwise used to proxy or identify policy (money, NDA, or interest rates) to non-policy economic shocks—except, of course, to the extent that such shocks influence policy actions themselves. Following an approach first used by Skinner and Zettelmeyer (1995a), the paper then goes beyond Cook and Hahn and Romer and Romer in two respects. First, it attempts to measure the effect of policy *shocks*, rather than the actions themselves, i.e. to disentangle the unanticipated and anticipated components of policy actions. This is achieved by using the reaction of a market interest rate (such as the 3 month T-Bill rate) on the day of a policy announcement as a measure of the "surprise" associated with a given announcement. Second, it attempts to identify instances, through a careful reading of press reports and central bank statements accompanying policy announcements, in which a policy action may have been a

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[8] The main exceptions are Kraay (1999) and Gould and Kamin (2000).

[9] In general, studies that use interest rates as the policy variable are faced with a potential bias *against* finding a stabilizing effect of high interest rates on exchange rates, as partial accomodation of exchange market pressure by the monetary authorities would lead to both higher interest rates and a more depreciated exchange rate. In contrast, studies that use net domestic assets of the central bank as the policy variable are exposed to a potential bias *in favor* of finding a stabilizing effect of tight money on exchange rates, since partly accomodating a capital outflow would lead to both higher contemporaneous NDA and a more depreciated exchange rate.

within-day reaction to economic news. These episodes are excluded from the main regressions (though they are included in the descriptive parts of the paper), to avoid an endogeneity problem via the policy reaction function.

The main results are as follows. On average—i.e. lumping all non-endogenous policy actions for each country into one sample—there is a significant response of the exchange rate to policy shocks in the direction traditionally assumed by economists (a contraction leads to an appreciation). Moreover, monetary policy shocks appear to affect the exchange rate in this direction even in times of turbulence. However, we also observe that in most cases in which monetary policy was tightened in response to exchange rate pressure on the same day, the initial depreciation to which the monetary authorities were reacting was *not fully offset* by a recovery by the end of the trading day. Thus, although monetary policy appears capable of stabilizing the exchange rate even at times of turbulence, central banks often end up partly accommodating exchange market pressure. This may reflect the interest rate "cost" of a full defense. It also implies that correlations between daily exchange rate and interest rate changes which include episodes of exchange rate pressure, even when restricted to days on which policy announcements occurred, can easily give the false impression that interest rate hikes lead to exchange rate depreciation. Finally, is worth noting a few intriguing cases in which the exchange rate seems to have reacted "perversely" (i.e. appreciated) after unexpected policy *easings*.

In the first section that follows, the methodology used is justified in some detail. Next, we present the policy actions and data for the three countries studied, and discuss some features of their monetary policy regimes for the period under consideration. We subsequently present results, beginning with graphical summaries, and followed by regressions over the whole sample and subsamples, robustness checks, and a discussion of major outliers.

II. Method

The approach taken in this paper is to study the immediate—i.e. same day—response of exchange rates to specific monetary policy actions, such as changes in official interest rates or the overnight rate target, where the reaction of the 3-month T-Bill or similar market determined rate is used as a measure of the unanticipated content of the action. In other words, the proposal is to run:

$$\Delta e_t = \alpha + \beta \Delta i_{3m,t} + \varepsilon_t$$

where $\Delta i_{3m,t}$ is the change in the three month interest rate on the day of a policy announcement and Δe_t is the change in the exchange rate on the same day (defined such that an increase denotes an appreciation). Thus, the regression proposed does *not* use the full time series of daily changes in the exchange and interest rates, but only changes on the days

of policy events. The constant α is included to capture any trend depreciation (as we shall see, it will generally be insignificant).[10]

Based on this regression, one can then go on to test $H_0 : \beta \leq 0$. A rejection of this hypothesis would be interpreted as evidence in favor of the conventional view of the relationship between monetary policy and exchange rates. In what follows, we justify (1) the focus on a narrow time window around the policy announcement, between market closing on the market day of the announcement and market closing on the previous day, and (2) the use of the change in the three month treasury bill interest rate (or similar rate of maturity between, say, one and twelve months) during this time interval as a measure of the unanticipated content of a policy action.

Using daily data—the highest frequency data that is readily obtained for both interest rates and exchange rates in all three countries and time periods in which we are interested—is justified by the fact that both the left and right hand side variables in regression (1) are asset prices in liquid markets. Consequently, *if* exchange rates and interest rates move at all in response to a monetary policy announcement, they should do so instantaneously.[11] Thus, it is sufficient to restrict attention to the day of the policy announcement for the purposes of studying the short-run effect of monetary policy on the exchange rate, i.e., the reaction of exchange rates before the price level and real economic variables have begun to adjust. On the other hand, the use of a short time interval around the policy announcement offers a huge benefit from the perspective of avoiding the endogeneity problem that plagues much of the existing empirical literature on the subject. Depending on the institutional setup of the central bank, it may be possible to argue that the actions of the central bank are unlikely to be based on economic information that becomes available *on the same day* of the policy action, or at least that this is sufficiently unusual so that exceptions can be identified based on press reports (see below). In contrast, with lower frequency data (say, the month or quarter in

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[10] This approach follows the literature on the effects of monetary policy on market (and in particular, longer term) interest rates. See Cook and Hahn (1989), Skinner and Zettelmeyer (1995a) and Hardy (1998), amongst others.

[11] This is supported by a set of recent studies that examine the relationship between financial market volatility and scheduled news announcements using intra-day data, which find that "the price adjustment is largely completed within one minute, with volatility remaining significantly higher for 10-15 minutes after the release" (see Beattie and Fillion (1999), p. 11, and references therein). Specifically, Beattie and Fillion (1999) find that changes in the Bank of Canada operating band (its main policy target) did not increase market volatility beyond the first 20 minutes after the information is released.

which the policy target was changed), the policy decision itself would generally be endogenous to contemporaneous (i.e., within-period) economic news.[12]

The reaction of the three month interest rate in response to a policy announcement is a plausible measure of the surprise content of the announcement for two reasons. First, given the widely documented and accepted fact that central banks can control very short interest rates, most economists would agree that the three-month T-bill rate is *sufficiently short* that it will react to unanticipated monetary policy actions such as surprise changes in the overnight rate target. On the other hand, the three-month T-bill rate is *sufficiently long* that it will, to a first approximation, react to monetary actions *only to the extent that they are unanticipated.* Any anticipation would have been "discounted", in the sense that it would have been reflected in the closing rate on the day preceding the policy action. Of course, the same arguments apply to money market rates of somewhat shorter or longer maturity, and the results will be checked for robustness using several alternative interest rates as right hand side measures of the policy surprise.[13]

This said, two potential problems need to be addressed.

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[12] One could attempt to integrate the identification approach used in this paper with a VAR analysis by simply using the sum of the shocks on the dates of policy actions in each month as an exogenous input (see Skinner and Zettelmeyer 1995b). However, this assumes that the dates at which we measure policy shocks are the only instances on which such shocks occur during a given month. Thus, when policy events are anticipated either because of the publication of relevant economic news prior to the action or because of statements by officials, this may not be a good measure, as it misses surprises that occur as relevant information becomes public *prior* to the actual policy event.

[13] A conceptually attractive alternative that cannot be used in this paper for lack of data, but gives very similar results for the U.S. as the approach proposed, is to measure the policy surprise associated with a new target announcement as the difference between the new target and the one-month ahead overnight interest futures rate at t-1, along the lines of the monthly measure proposed by Rudebusch (1998). Alternatively, one could also *estimate* a daily measure of interest rate expectations using market data (Hardy (1998) and Bagliano and Favero (1998, 1999)). We do not take this route for two reasons. First, it adds a technically complex step to the overall method. Second, just like the approach proposed, estimation-based techniques obviously do not get the underlying monetary policy shock exactly right. Unlike the technique proposed, however, any remaining "measurement error" problem cannot be dealt with by using changes in the underlying policy target as an instrument (see discussion below), since this variable has already been used for the purposes of constructing the estimates of the shock.

- One drawback of using a market interest rate as a measure of the policy shock is that changes in this variable may obviously reflect other shocks—say, news about domestic activity, or external finance premia—that coincidentally occur on the day of a policy announcement. In other words, the change in the three month rate on the day of a policy announcement may contain some "noise", in addition to carrying a "signal" about the policy decision. In general, this will bias the estimate of the direct effect of the policy shock on exchange rates. Fortunately, there is a straightforward remedy, which is to use the underlying change in the monetary policy target (or, for the case of New Zealand, a dummy variable capturing the direction of the policy change; see below) as an instrument in regression (1). This instrument is correlated with the change in the three month rate on the day of the policy announcement. However—provided the policy action was not endogenous to same-day economic news, see below—it is uncorrelated, by definition, with any non-policy noise that might affect the three month rate on the day of the announcement. Note that this method will work regardless of whether additional shocks that might be present on the day of policy announcement affect only interest rates or both interest rates and the exchange rate (in the event that they *only* affect the exchange rate, there was no problem to begin with since this is captured by the error term in equation (1)).

- A more severe problem is the potential endogeneity of policy actions to news that occur on the same day. This is a strong possibility in cases in which policy decisions are made public outside a predetermined schedule, as occurred frequently in the United States prior to 1994 and in our sample is often true for both Canada and New Zealand (but not for Australia). It becomes even more likely in situations in which the currency is under pressure, when central banks may well decide to take a policy action based on their observation of exchange rate developments in the early hours of trading, or overnight trading. To deal with this possibility, it is essential to not just compile the data set mechanically, by matching all days of policy events with reactions of the three-month rate and the exchange rate, but to understand the background of each policy event—based on both central bank press releases and financial press commentary—and to rule out (for the purpose of the main regressions) observations when policy may have reacted to news becoming public on the same day.

Finally, note that the method proposed assumes that financial markets react to central bank announcements because of what these announcements imply about the authorities' policy actions, rather than because they reveal private information about the state of the economy. A sufficient condition for this is that, on the eve of the policy announcement, financial markets know the realization of all economic variables believed to enter the central bank reaction function. This may seem too strong, particularly if major economic releases are known to monetary authorities some time ahead of publication, as may well be the case. However, this lead period is likely to be short, and to the extent that it results in the announcement of a relevant news release and a monetary policy action on the same day, the procedure proposed would exclude the event on the grounds of possible within-day endogeneity. Note also that the method proposed is far less susceptible to the private information problem than the VAR-based literature: while we must assume that the monetary authority generally has no more

information than financial markets—institutions that spend large resources in gathering all available information that might possibly be relevant to central bank decision making—VAR-based identification procedures require the much stronger assumption that the information set of the central bank be fully described by the variables contained *in the VAR*.

III. Monetary Policy Actions in Australia, Canada and New Zealand

For the period studied in this paper—essentially, the 1990s—the three countries studied share a number of important characteristics: a high degree of openness both in terms of trade and vis à vis international capital flows; floating exchange rate regimes in the sense that no particular level of the exchange rate was targeted by policy-makers, and finally, the use of formal inflation targets over most of the period (since 1990 in the case of New Zealand, 1991 in the case of Canada, and 1993 in the case of Australia).[14] However, there are differences in the way in which the three countries implemented monetary policy during most of the 1990s, which have consequences for defining the monetary policy event set on which the proposed methodology is based, and for the interpretation of the results. In addition, some aspects of central bank policies during this period—in particular, the use of a "Monetary Conditions Index" in New Zealand, and direct foreign exchange intervention in Canada and Australia—may complicate the application of the methodology proposed. These issues are discussed in turn.

At the risk of oversimplifying, one can put the differences in monetary policy procedures in terms of a spectrum with Australia at one end and New Zealand at the other, and with Canada sharing some features with both. Australian monetary policy procedures in the 1990s (including in the period before the adoption of formal inflation targeting) closely resemble the United States in that the main operational instrument of monetary policy is the overnight ("cash") interest rate, and changes in policy are signaled by publicly announced changes in the targeted cash rate. The decision to change the cash rate target is taken by the Board of the Reserve Bank of Australia (RBA), which meets on a publicly known schedule—generally, on the first Tuesday of the month. About half of the policy decisions taken during the 1990s were announced on the following day at 9:30 in the morning;[15] in the remaining cases, a longer time interval (usually 1-2 weeks) elapsed between the board meeting and the public announcement. Target changes were infrequent (only 26 between January 1990 until February 2000) and received extensive public attention and press coverage (first page

[14] The Australian, Canadian, and New Zealand monetary policy frameworks and experiences from the late eighties to the mid-1990s are compared in Debelle (1996) and (for the last two countries) Ammer and Freeman (1995) and Mishkin and Posen (1997).

[15] Campbell and Lewis (1998).

headlines in the financial press). Consequently, they constitute a natural set of "policy events" for the purposes of this study.[16]

New Zealand, in contrast, adopted publicly announced overnight interest rate targets (or "official cash rates", as they are known in New Zealand) only in early 1999. Prior to that, the main instrument of monetary policy was, in principle, the "cash target", a daily target for the level of (voluntarily held) reserves of commercial banks at the Reserve Bank of New Zealand (RBNZ). This, in turn, could be controlled through open market operations.[17] However, changes in the cash target were extremely infrequent (only four in ten years). Rather than changes in the target itself, the main policy instrument, in practice, became publicly announced *warnings* that the available operational instruments would be used, a practice sometimes referred to as "open mouth operations".[18] To the extent that these threats were credible, the desired degree of tightness was subsequently implemented by the markets themselves.

A further notable characteristic of the New Zealand approach throughout the 1990s was the notion of a trade-off between nominal interest rates and the nominal exchange rate in determining "monetary conditions", in the sense that a depreciation of the exchange rate required an offsetting increase in interest rates if overall monetary conditions—viewed as the key indicator of future inflation—were to stay unchanged. The precise nature of this trade-off was left open until December of 1996, when Donald Brash, the RBNZ governor, stated that a two percent appreciation of the trade-weighted exchange rate was viewed as equivalent to a one percentage point rise in the 90-day interest rate in terms of its impact on monetary conditions. Shortly thereafter, the Bank began using a "monetary conditions index" (MCI), defined as the two-to-one weighted average of the exchange rate and the 90-day interest rate, as a loose target for monetary policy (loose both in the sense that a "tolerance level" around that target was defined, and that the MCI frequently broke outside that target range). This system was maintained until February 1999, when the Bank switched to an official cash rate target (OCR), along the lines of the Australian or U.S. overnight interest rate targets.

The Canadian approach to policy implementation, finally, combined both the use of an overnight interest rate target (since mid-1994), and a monetary conditions index as an

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[16] For a summary of the RBA's approach to inflation targeting, see "Monetary Policy and Inflation Targeting, Reserve Bank of Australia Bulletin, October 1997, pp. 14-19. For details on RBA operating procedures, see "The Reserve Bank's Domestic Money Market Operations," Reserve Bank of Australia Bulletin, December 1990, pp. 8-15.

[17] This description is based on Bonato, St. Clair and Winkelmann (1999). See Huxford and Redell (1996) for more details.

[18] See Bonato, St. Clair and Winkelmann and references therein.

indicator of the policy stance. [19] However, the MCI was never used as a policy target. Changes in the overnight target occurred somewhat more often in Canada than in Australia—in part, because Canadian monetary authorities took a more active role in leaning against exchange rate movements than in Australia, see below—but remained relatively infrequent (about 40 changes from mid 1994 to late 1999). Another difference with respect to Australia, and similarity with New Zealand (prior to 1999), is that policy decisions were not taken on a pre-announced schedule, in the sense that the Governing Council of the Bank met on a daily basis and policy decisions could be taken at any time.

Tables 1 through 3 show Australian, Canadian and New Zealand monetary policy actions for the 1990s, as well as changes in exchange rates and interest rates on the day of these changes.[20] Exchange rates are defined such that a positive change means an appreciation. For Australia and Canada, the dataset comprises all changes in the overnight or ("cash") target during the 1990s. In Australia, the starting date is determined by the decision to publicly announce target changes, beginning in January 1990. The Canadian sample starts with the first "publicly recognized" change in the overnight rate target after the Bank of Canada switched to the use of such targets in mid-1994.[21] The sample for New Zealand is based on a comprehensive set of New Zealand policy events compiled by Bonato, St. Clair and Winkelmann (1999) for the period 1990 to March 1998, and updated for the remainder of 1999 using the record of RBNZ news releases contained on the RBNZ website.[22] It begins

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[19] For a discussion of monetary policy operating procedures before and after the switch to overnight interest rate targets, see Noël (1995), Clinton (1991), Kasman (1992), Gonzalez-Hermosillo and Ito (1997) and, for further references, Bank of Canada (1996a,b).

[20] Generally, these are closing rates on the day on which the policy change was perceived by financial markets, minus closing rates on the previous day. In some cases in which there were major news after market closing on the previous day but prior to market opening on the day of the policy news, opening rates on the day of the policy news were used if available.

[21] While there was no formal announcement of the overnight target until February 1996 (see *Bank of Canada Review*, Summer 1996, p. 21), shifts in the overnight band were "communicated to the market as quickly and clearly as possible", through money market operations at the new level of interest rates, since about the Fall of 1994. However, "initially, a change in the bank was signaled ... only when overnight rates threatened to trade outside the boundaries of the new band." Noël (1995), p. 99-100. This may explain why it took until September 1994 for the Toronto *Financial Post* to pick up the changes.

[22] For the period 1990-March 1998, this event-set is identical to the one described in Bonato, St. Clair and Winkelmann except that two "technical" RBNZ announcements (September 3 and 30, 1992), of which I found no mention in the press, were excluded. For the period March 1998-February 1999, I added all RBNZ announcements of the type compiled by Bonato, St. Clair and Winkelmann for the preceding period, i.e. comments on monetary conditions. For March 1999 until January 2000 all official cash rate (OCR) reviews were

(continued...)

with the first "open mouth operation" after the signing of the first policy target agreement between the RBNZ and the government in March 1990.

Table 1: Australian Monetary Policy Actions and Market Reactions, 1990-2000

Date perceived	Target midpoint	Motivation 1/	Other news referred to in money market reports on the same day?	"Exogeneity Class" 2/	ΔER(t) (USc/AU$)	ΔAU3m(t) (points)
01/23/90	17.00	O	no	1a	-1.33	-0.71
02/15/90	16.50	O	no	1a	-0.02	0.05
04/04/90	15.00	O	no	1a	0.51	0.01
08/02/90	14.00	O	Kuwait invasion (afternoon)	1b	-1.30	-0.69
10/15/90	13.00	O	no	1a	-2.06	-0.64
12/18/90	12.00	O	no	1a	0.37	-0.27
04/04/91	11.50	O	no	1a	0.30	-0.13
05/16/91	10.50	O	no	1a	0.06	-0.39
09/03/91	9.50	O	no	1a	-0.61	-0.58
11/06/91	8.50	O	no	1a	0.15	-0.06
01/08/92	7.50	O	unexpectedly weak housing figures	2	-0.20	-0.08
05/06/92	6.50	O	no	1a	-0.04	-0.11
07/08/92	5.75	O	comments on fiscal policy	1b	0.02	0.08
03/23/93	5.25	O	no	1a	-0.90	0.07
07/30/93	4.75	O	EMS crisis (safe haven buying)	1b	0.80	-0.16
08/17/94	5.50	O	Fed tightens	3	0.20	-0.06
10/24/94	6.50	O	no	1a	0.47	0.22
12/14/94	7.50	O	no	1a	0.20	0.37
07/31/96	7.00	O	no	1a	-1.35	-0.43
11/06/96	6.50	O	US Republican party victory buoys bonds	1b	0.54	-0.05
12/11/96	6.00	O	no	1a	-1.04	-0.55
05/23/97	5.50	O	no	1a	-1.29	-0.48
07/30/97	5.00	O	stronger commodity prices	1b	0.91	-0.13
12/02/98	4.75	O	strong growth figures	1b	0.63	-0.08
11/03/99	5.00	O	stronger than expected retail sales	2	0.45	-0.04
02/02/00	5.50	O	no (precedes Fed action)	1a	0.65	0.19

1/ "Ed": attempt to reverse, lean against, or offset impact of exchange rate depreciation.
"Ea": attempt to reverse, lean against, or offset impact of exchange rate appreciation
"O": any other motivation (generally to initiate policy easing or tightening, or "technical").

2/ "1a": no other news reported as relevant to money market developments on that day
"1b": other news reported as relevant to money markets, but could not have influenced policy action
"2": other relevant news reported, but unclear whether monetary policy reacted to them
"3": documented reaction to relevant news on same day

added that either changed the level of the OCR or went along with a comment on monetary conditions and the likelihood of future changes in the OCR.

Table 2: Canadian Monetary Policy Actions and Market Reactions, 1994-1999

Date perceived	Target midpoint	Motivation 1/	Other news referred to in money market reports on the same day?	"Exogeneity Class" 1/	ΔER(t) (USc/CD$)	ΔCN3m (points)
09/21/94	5.00	Ea	no	1a	-0.03	-0.08
11/16/94	5.25	Ed	no	1a	-0.05	0.02
12/08/94	5.50	Ed	no	1a	0.04	0.09
01/10/95	6.00	Ed	pressure on exchange rate	3	-0.07	0.36
01/12/95	6.50	Ed	pressure on exchange rate	3	-0.34	0.44
01/17/95	7.00	Ed	pressure on exchange rate	3	-0.44	0.47
02/01/95	7.50	Ed	Fed hike	3	-0.03	0.13
02/16/95	8.00	Ed	Moody's warns of downgrade	3	-0.47	0.45
05/08/95	7.75	O	no	1a	-0.24	-0.07
06/02/95	7.50	O	large decline in US earnings data	3	-0.23	-0.21
06/13/95	7.25	O	weaker than expected US retail sales	3	-0.22	-0.23
07/06/95	7.00	O	Fed easing	3	0.15	-0.10
07/10/95	6.75	O	C$ surge in European markets	3	0.34	-0.18
08/09/95	6.50	O	no	2	-0.08	-0.12
08/28/95	6.25	O	no	1a	0.33	-0.08
10/31/95	6.00	O	fiscal consequences of Quebec referendum	1b	-0.28	-0.28
12/19/95	5.75	O	Fed easing	3	0.21	-0.14
01/25/96	5.50	O	US budget standoff	2	-0.43	-0.19
01/31/96	5.25	O	Fed easing	3	0.22	-0.02
03/21/96	5.00	O	no	1a	-0.12	-0.03
04/18/96	4.75	O	no	1a	-0.35	-0.17
07/19/96	4.50	O	CPI news	3	-0.04	-0.18
08/09/96	4.25	O	weak jobs data, low US CPI	3	0.05	-0.03
08/22/96	4.00	O	no	1a	0.24	-0.04
10/02/96	3.75	Ea	no	1a	0.03	-0.19
10/16/96	3.50	Ea	weak manufact. data, low US CPI	2	-0.01	0.00
10/28/96	3.25	Ea	US inflation concerns	1b	0.03	-0.01
11/08/96	3.00	Ea	bad unemployment & housing news	2	-0.11	-0.01
06/26/97	3.25	Ed	no	1a	0.65	0.31
10/01/97	3.50	O	no	1a	0.18	0.01
11/25/97	3.75	Ed	no	1a	0.20	0.12
12/12/97	4.25	Ed	no	1a	0.35	0.21
01/30/98	4.75	Ed	slowing economy	1b	0.45	0.30
08/27/98	5.75	Ed	C$ under pressure after Russia crisis	2	-0.57	0.85
09/29/98	5.50	O	Fed easing	3	0.00	0.03
10/16/98	5.25	O	no	1a	-0.29	-0.10
11/18/98	5.00	O	no	1a	-0.21	-0.05
03/31/99	4.75	O	disappointing January output growth	2	0.13	-0.12
05/04/99	4.50	O	no	1a	-0.30	-0.14
11/17/99	4.75	O	no	1a	-0.31	-0.07

1/ See notes to Table 1

Table 3: New Zealand Monetary Policy Actions and Market Reactions, 1990-2000

Date perceived	BSW classification 1/		Motivation 2/	Other news referred to in money market reports on the same day?	"Exogeneity Class" 2/	ΔER(t) (US¢/NZ$)	ΔNZ3m (points)
	Direction	Type					
08/01/90	1	P	Ed	no	1a	0.35	0.10
08/03/90	1	P	Ed	Kuweit invasion	1b	0.05	0.25
10/17/90	1	W	Ed	no	1a	0.00	0.00
10/18/90	1	P	Ed	pressure on exchange rate	1a	0.75	0.40
01/11/91	1	W	O	no	1a	0.45	0.50
02/22/91	0	T	O	Brash comments	1b	-0.07	0.02
05/15/91	1	W	O	unexpectedly low Australian inflatio	1b	0.17	0.01
08/13/91	-1	T	O	no	1a	0.15	0.14
08/21/91	0	T	O	no	1a	0.07	-0.05
08/22/91	0	T	O	lower cash rate from preceding actio	2	0.00	-0.02
09/25/91	-1	P	O	no	1a	-1.12	-0.64
12/18/91	0	T	O	no	1a	-0.43	-0.22
12/24/91	0	T	O	no	1a	0.25	-0.05
01/06/92	1	W	Ed	no	1a	0.71	-0.06
09/09/92	1	W	Ed	no	1a	0.36	0.00
12/15/92	1	P	Ed	pressure on exchange rate	3	-0.26	0.19
12/24/92	1	P	Ed	no	1a	0.20	0.15
01/06/93	1	P	Ed	pressure on exchange rate	3	-0.55	1.70
01/08/93	-1	P	Ea	pressure on exchange rate subsides	3	0.08	-0.65
01/18/93	-1	P	Ea	pressure on exchange rate	2	0.15	-0.18
02/03/93	-1	P	Ea	exchange rate appreciation	3	0.01	-0.22
07/10/95	-1	W	Ea	no	1a	-0.31	-0.18
07/12/95	0	W	Ed	no	1a	0.06	-0.02
07/28/95	1	W	Ed	pressure on exchange rate	3	-0.23	0.17
08/11/95	1	P	Ed	pressure on exchange rate	2	0.02	0.06
08/25/95	1	P	Ed	pressure on exchange rate	3	0.22	0.07
10/17/95	-1	W	O	rise in market interest rates	2	-0.30	-0.07
10/30/95	0	W	O	decline in market interest rates	3	0.07	-0.02
11/01/95	1	W	O	Goldman reports NZ$ overvalued	1b	-0.34	0.13
10/16/96	1	W	O	decline in market interest rates	3	-0.03	0.03
10/24/96	-1	W	Ea	no	1a	-0.97	-0.33
12/17/96	-1	W	O	no	1a	0.71	0.06
03/13/97	-1	W	Ea	no	1a	-0.50	-0.22
05/12/97	1	W	Ed	pressure on exchange rate	2	0.64	0.26
06/27/97	-1	W	O	no	1a	-0.54	-0.10
07/03/97	1	W	Ed	pressure on exchange rate	3	-0.30	0.66
07/11/97	-1	W	Ed	BoP news/pressure on NZ$	3	0.17	0.14
08/18/97	1	W	Ed	no	1a	0.23	0.07
09/18/97	0	W	O	no	1a	-0.35	-0.09
12/05/97	1	W	Ed	pressure on exchange rate	2	-0.29	0.33
12/16/97	0	W	O	RBNZ current account projection	3	-1.97	0.45
02/23/98	1	W	Ed	strengthening of US$	3	-0.58	0.21
03/18/98	-1	W	O	no	1a	-1.28	0.25
03/27/98	1	W	Ed	unexpectedly large CA deficit	3	0.02	0.21
03/30/98	0	W	O	release of GDP data	2	-0.42	0.13
05/26/98	-1	W	O	no	1a	0.07	-0.22
06/10/98	1	W	Ed	weakening of $A	1b	-1.22	0.63
08/20/98	-1	W	O	no	1a	-0.37	-0.54
08/26/98	1	W	Ed	weakening of $A	1b	-0.15	0.09
10/07/98	1	W	O	strengthening of $A and Yen	1b	0.48	0.15
11/18/98	0	W	O	no	1a	-0.42	-0.43
02/08/99	0	T	O	no	1a	0.66	0.15
03/17/99	0	P	O	weakening of $A	1b	-0.47	0.18
05/19/99	0	P	O	Fed indicates tightening bias	1b	-1.00	-0.04
08/18/99	1	P	O	no	1a	0.17	0.02
11/17/99	1	P	O	Fed tightens less than expected	2	-0.38	-0.01
01/19/00	1	P	O	unexpectedly low inflation	2	-0.14	0.05

1/ Follows Bonato, St. Clair and Winkelmann (1999). "P" stands for policy change (announcement accompanied by change in liquidity of money market); "W" stands for "Conditional Warning" (i.e. announcement that is not immediately backed up by an action that affects market liquidity); "T" for "Technical Change. "Direction" refers to whether announcement was indended to induce a tightening in monetary conditions (1), a loosening in monetary conditions (-1) or to be neutral. Note the actual impact of the announcment may have been different.

2/ See notes to Table 1.

Along with the events themselves and financial market reactions, Tables 1-3 contain two sets of qualitative information:

First, policy events are classified in terms of their presumed exogeneity to same-day economic news. Class 1 means that no major other economic news to which the central bank might have reacted were reported in the money/currency market reports on the same day. Within this class, we make a distinction between events where *no* other news were mentioned in market reports, and events were other news were reported but—generally for timing reasons—the monetary authorities could not possibly have reacted to them. Class 3 is at the other end of the spectrum; this comprises dates on which other news were reported *and* the fact that monetary authorities were reacting to them can be documented, either by statements of the authorities themselves, or in accompanying financial press reporting. Finally, class 2 is essentially a residual category: this refers to cases in which other economic news were reported on the same day, but it is not clear whether the Bank reacted to them or not.

Second, events are also classified in terms of whether they were motivated in terms of leaning against an appreciation ("Ea"), leaning against a depreciation ("Ed") or neither of the two ("O" for "other", e.g. a decision to loosen because of low inflation news or low growth numbers). These distinctions are taken in order to test whether the impact of monetary policy on exchange rates is any different in situations when stabilizing the exchange rate is the main objective of the central bank. Because the three central banks which we deal with in this paper go to great lengths to explain the rationale for their actions, making these classifications is typically straightforward. The setting in which an event was classified "Ed" (or "Ea") is generally one where the central banks argue for the need to offset a market driven loosening (or tightening) of monetary conditions, *and* it is clear either directly from the wording of the statement or from financial market behavior prior to the statement that this perceived loosening/tightening was attributable to exchange rate movements. On some occasions (mainly, January/February of 1995 and August of 1998) the Bank of Canada also argued that leaning against pressure on the C$ was necessary to prevent a disorderly depreciation, i.e. to reduce market volatility. Tables 1-3 show that the relevance of the exchange rate as a motive for monetary policy is very different across countries (very prevalent in New Zealand before 1999, not at all prevalent in Australia), in line with the differences in importance attached to the "monetary conditions index" discussed earlier.

Before presenting results, we briefly address two potential complications, for the purposes of applying the method proposed in the previous section, which arise from the practical conduct of monetary policy in New Zealand, Canada and Australia during the sample period. First, the use of the MCI as a policy target in New Zealand during 1996-1998 raises the question to what extent policy announcements from this period are appropriate events to measure the *market-determined* impact of interest rate policy on exchange rates. Specifically, suppose the authorities are successful in targeting a given MCI level, i.e. in fixing a specific trade-off between 90-day interest rates and exchange rates, and restricting any movement of interest rates and exchange rates to be a movement along this trade-off. Then, trying to measure the relationship between changes in interest rates and exchange rates would amount to

"rediscovering" the ratio set by authorities in their definition of the MCI—a policy parameter—rather than a market-determined behavioral relationship.

However, this does not pose a problem for the purposes of this paper, which seeks to measure the relationship between interest rate movements and exchange rate movements *on the day of policy announcement*, because movements on these days by definition did not constitute movements along the MCI-determined trade-off. As long as interest rates and exchange rates moved along this trade-off, one would not have observed any policy announcements since monetary conditions would have been to the RBNZ's satisfaction. Announcements only occurred when the Bank either attempted to bring the MCI back on target after interest rates and exchange rates had moved off the target corridor, or when it decided to change the target itself. As the RBNZ often pointed out, the relative reactions of interest rates and exchange rates to these announcements were market determined, and not something the Bank could, or tried to, control.[23] Moreover, the logic of "open mouth operations" implies that the direction of causality on these days should generally be the same as in the case of policy actions in Australia and Canada, i.e. from interest rates to exchange rates: in a regime that consistently abstains from direct foreign exchange market intervention, the channel through which the central bank can be expected to enforce a warning is overnight market liquidity and short interest rates. Consequently, we include all policy announcements of the RBNZ in our policy event set, including those during 1996-1998.

A second potential complication arises from the presence of direct foreign exchange market intervention by the RBA and the Bank of Canada during the sample period (but not by the RBNZ, which has not engaged in direct foreign exchange market intervention since the late

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[23] In the words of Reserve Bank Monetary Policy Implementation Manager Michael Reddell, in a March 30, 1998 speech: "Both interest rates and the exchange rate influence inflation. Monetary policy can alter these two in combination, but whether one goes up and the other goes down, or vice versa, is beyond the control of the Reserve Bank. Rather, it is the result of trading in the financial markets, reflecting decisions taken by many thousands of people, both here and abroad." Nevertheless, there were a few occasions when the authorities tried to separately indicate "appropriate" levels for the exchange rate and market interest rates, or at least were interpreted as doing that by the markets. However, these attempts were rare and, to my knowledge, never successful. An example is the December 17, 1996 presentation of the Bank's monetary policy statement, whose main purpose appears to have been to endorse somewhat easier monetary conditions that had evolved over the preceding months, but which in addition mentioned specific "preferred" exchange rate and interest rate levels. "At the presentation of the bank's six-monthly monetary policy statement, the governor, Dr. Don Brash, endorsed the recent market-led easing of monetary conditions but said a combination of the 90-day yield at 8.5 percent and the trade weighted exchange rate index at 66.5 would be consistent with overall conditions. With the 90-day yield at 7.88 percent and the index at 67.4, that pointed to a wish for higher interest rates and a lower dollar. But dealers said that higher interest rates meant a higher kiwi, so the kiwi's value was sharply boosted."

1980s). In Australia, there was occasional, discretionary intervention in both spot and options markets during the 1990s, mainly to lean against sharp swings in the exchange rate. While data on intervention is not publicly available, the fact that none of the policy events of Table 1 were motivated by exchange rate developments (and in particular, none was a response to direct pressure on the exchange rate), implies that instances of direct intervention in Australia are very unlikely to coincide with the set of policy events chosen. Indeed, with one exception—when the RBA stepped in to mitigate the depreciation of the $A *in reaction* to an interest rate easing[24] —no foreign exchange market intervention during days of monetary policy announcements was noted in financial press reports. Thus, RBA intervention is unlikely to be a confounding factor for the purposes of our analysis.

The Bank of Canada regularly intervened in the foreign exchange market until August 1998 (since September 1998, there has been no intervention, although the Bank has not ruled out the possibility, and maintains a link on its website that is supposed to indicate when intervention occurs). Intervention was either automatic, following to a rule designed to resist large swings in the exchange rate on any given day, or discretionary.[25] While its precise timing and volume was (and still is) a secret, there are two excellent studies by Bank of Canada researchers (Murray, Zelmer and McManus, 1996, and Beattie and Fillion, 1999) which give a sense of the frequency and size of intervention, and attempt to estimate its effectiveness. The gist of these studies is that automatic intervention was ineffective—in the sense that it had no significant impact on Canadian dollar volatility—but that discretionary intervention after April 1995, when a change in rules in gave the authorities greater flexibility to choose the timing and volume of intervention, might have had significant effects, presumably because it was both unanticipated and heavy when it occurred. Thus, we have to worry about the coincidence of monetary policy actions in Canada with discretionary intervention, particularly after April 1995. On request, the Bank of Canada kindly supplied me with information which showed that policy announcements coincided with discretionary intervention on 8 days in the sample, 4 of which correspond to the time after April 1995. Of these 8 instances, however, 5 are already being excluded from our main regressions on the grounds of documented or suspected within-day endogeneity. This leaves three observations in the main Canadian sample which could be "contaminated" by the presence of discretionary intervention. The approach will be to test the robustness of our results by running the regressions both with and without these observations.

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[24] See *Australian Financial Review*, January 9, 1992. The effect of the intervention on the $A closing rate seems to have been moderate. The *AFR* reports a decline of the $A from US 75.9 to US75.5c in reaction to a 100 basis point easing of the cash rate target in the morning. Intervention briefly "helped hoist [the $A] to about US76c", but "the dollar later drifted back to a close of US75.7c." It makes little difference to our results whether the initial depreciation of 0.4 cents of the depreciation of 0.2 cent over the whole day is used.

[25] See Murray, Zelmer and McManus (1996) for details.

IV. RESULTS

A. Scatterplots and Basic Regressions

Figures 1 through 3 plot changes in three-month interest rates against changes in the bilateral exchange rate with the U.S. dollar on the days of domestic monetary policy announcements for Australia, Canada, and New Zealand, using the data contained in Tables 1–3. Each of the figures comprises four panels, labeled A through D, which reflect the classification by the presumed degree of "exogeneity" of monetary policy made in the tables. The points shown reflect (A) the full event set, (B) the set of policy events excluding *documented* within-day responses of policy to economic news (C) the event set excluding *both documented and suspected* within-day responses policy events, and (D) the event set excluding days where *any other kind* of news were mentioned in financial market reports. Thus, C is the set of all policy actions that are presumed exogenous with respect to same-day information, while D is the set of policy actions that not only are presumed exogenous, but in addition do not coincide with major other news.[26] Thus, moving from top left to bottom right, we have an increasing degree of confidence that the points shown reflect the reaction of market interest rates and exchange rates *to* monetary policy announcements, as opposed to the mere co-movement between exchange rates and interest rates on the day of policy announcements, which might capture either reverse causality, or the influence of shocks unrelated to policy, or both.

The three figures have two main features in common. First, in all plots showing the full sample of exchange rate and interest rate changes to monetary policy events, a substantial subset of points is located in the upper left and bottom right quadrant of each graph. That is, there are a number of observations that seem to lend prima-facie support to the idea that exchange rates (sometimes) react "perversely" to monetary policy shocks (relative to the conventional prediction). The more prominent examples have been labeled by their dates; in the next section, we will take a look at what was "going on" on some of those dates. Second, by the time we get to the bottom right quadrant, the number of points in the top right and bottom left quadrant is much reduced, and a clear positive correlation emerges in all three figures. Thus, the scatterplots suggest that a large part of the observed "perverse" correlations observed in the full samples may have been attributable to either reverse causality or the coincidence of monetary policy with other economic news, and that by and large exchange rates did in fact respond to monetary easing or tightening in the direction that conventional wisdom would suggest.

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[26] In terms of the "exogeneity classification" of Tables 1–3, A is the union of sets 1a, 1b, 2 and 3 (the full set); B is the union of sets 1a,1b and 2; C is the union of sets 1a and 1b, and D is just set 1a.

Figure 1. Australia: Changes in USc/$A Versus Changes in 90-Day Bank Bill Rate on Policy Days

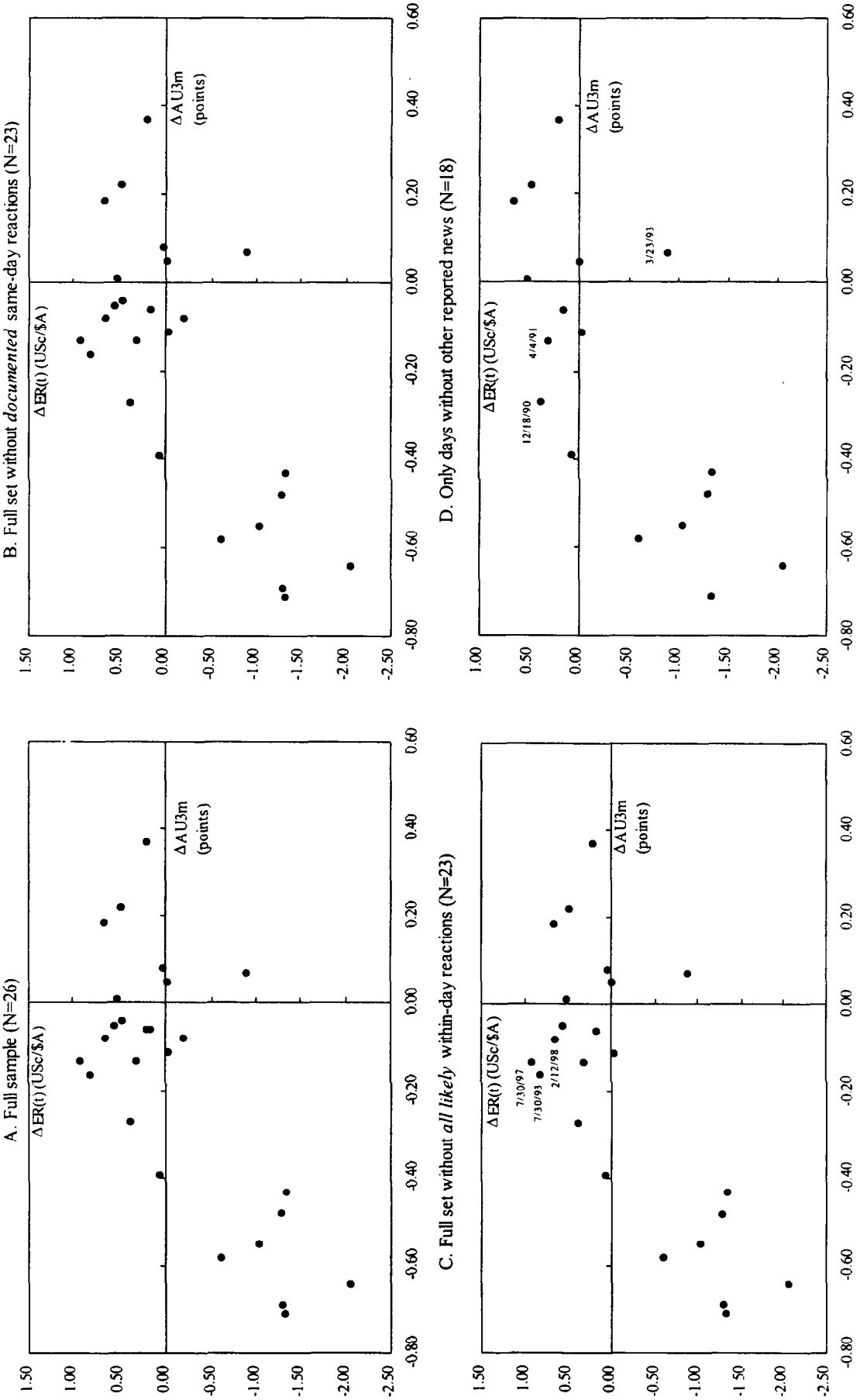


Figure 2. Canada: Changes in USc/C$ Versus Changes in 3-Month T-Bill Rate on Policy Days

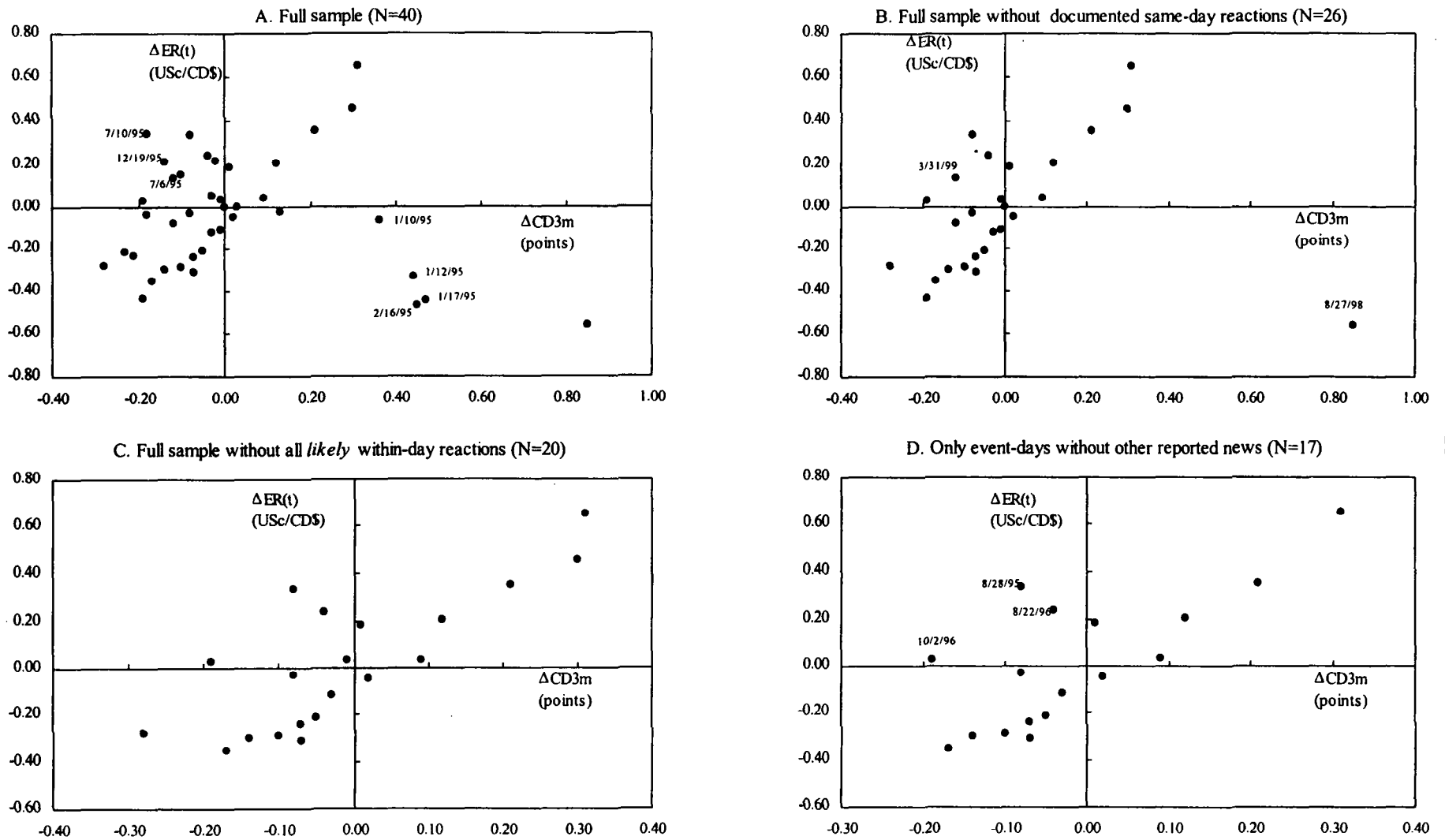
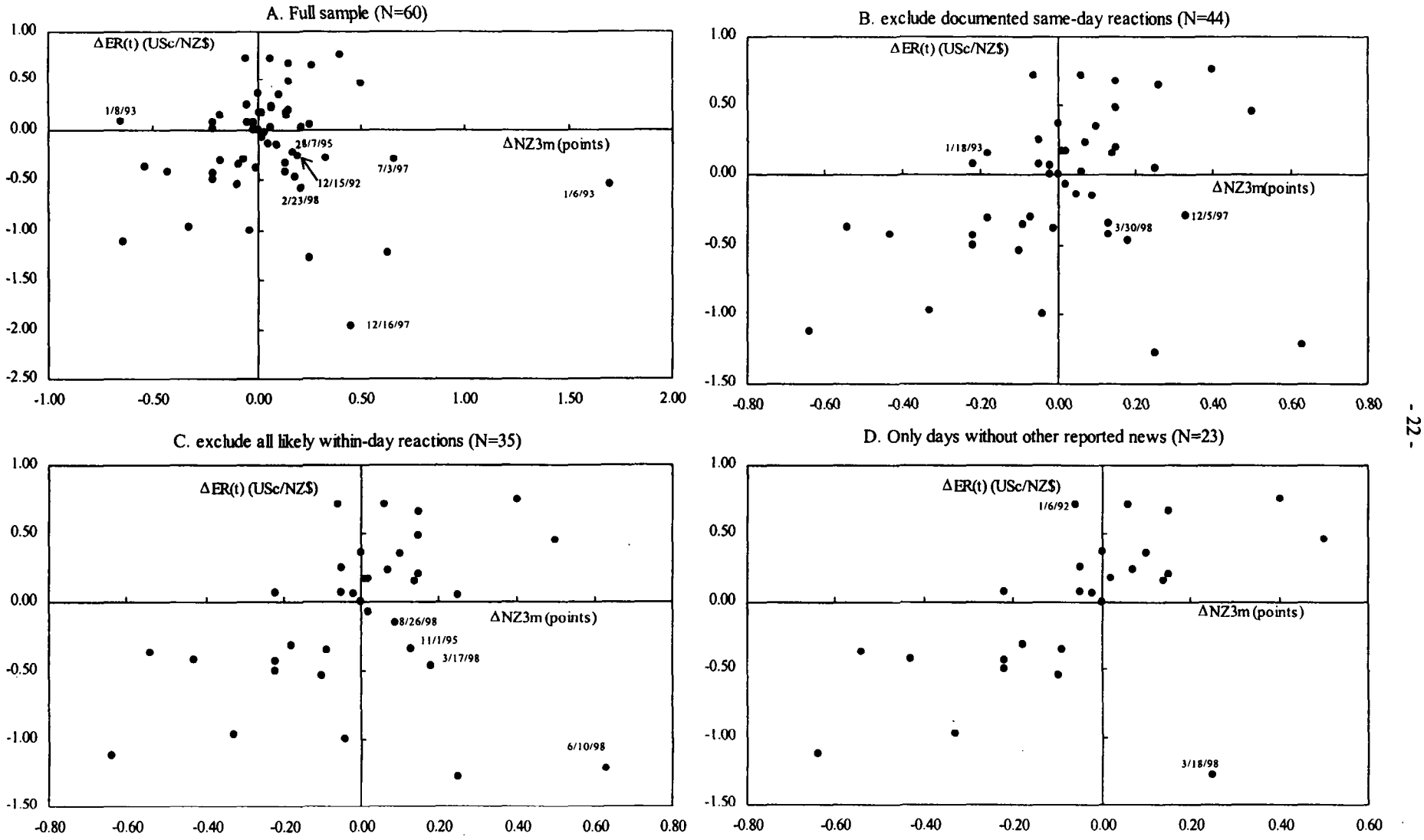


Figure 3. New Zealand: Changes in USc/$NZ Versus Changes in 90-Day bank Bill Rate on Policy Days



There are also some noteworthy differences across the three figures. Most strikingly, whether or not policy actions are excluded that were either endogenous to or coincided with other reported news does not matter much for Australia, where the scatterplot shows a clear positive correlation even in the full sample, but it makes a large difference for New Zealand, where this correlation only emerges in the bottom right quadrant. Canada comes out in-between. This reflects the fact that much fewer Australian policy actions were endogenous to within-day news than for Canada and New Zealand, and that many more policy actions in New Zealand coincided with other news acknowledged in financial market reports than in both Australia and Canada. There are several reasons for these differences. First, the desire to lean against an exchange rate depreciation or appreciation played a much more prominent role in monetary policy in Canada and New Zealand than in Australia (see tables 1-3); as we shall see below, this constitutes one of the main sources of within-day policy endogeneity. Second, unlike in Canada and New Zealand, decisions in Australia were generally taken during board meetings scheduled well in advance, and announced at least one day later; as a result, they were much less likely to be responses to economic information becoming public on the day of the announcement. Finally, in both Australia and Canada policy decisions were taken relatively rarely, so that they were less likely to share the limelight with other news than in the case of New Zealand.

The information embodied in the scatterplots can be summarized by running some simple regressions (Table 4). The results reported in the upper panel of the table are the OLS regression counterparts of each of the panels of Figures 1 through 3. Regressions A and B should be interpreted only as a summary of the corresponding data, i.e. fitting a line through the corresponding scatterplot. As an estimate of the reaction of exchange rates to monetary policy they *cannot* be taken seriously since they suffer from an actual—or at least potential, in the case of B—endogeneity problem. Regressions on sets C and D, however, are valid except for the possible presence of "noise" in the interest rate variable. As argued previously, this can be addressed by estimating the equation using instrumental variables, using the underlying policy target changes—or in the case of New Zealand, Bonato, St. Clair and Winkelmann's (1999) dummy variable describing the direction of the policy change—as an instrument. The trade-off between equations on set C and D is that the former is based on more data, but is also likely to contain more noise as it includes some datapoints which we know were influenced by news unrelated to monetary policy. The main results are as follows:

- Once potentially endogenous observations are eliminated—i.e. based on sets C and D—a strong significant relationship between monetary policy shocks and exchange rate movements emerges for all three countries, in the direction conventionally assumed. In the OLS regressions using New Zealand data, this is true only for regression D, but not C (as one would expect from the corresponding scatterplot, see Figure 3). However, the instrumental variables regressions on set C shows that this is just an artifact of the high noise embodied in changes in the New Zealand three month rate, which biases the coefficient toward zero. For the other countries, the IV results are not significantly different from the OLS results (see line "Hausman p", which gives the threshold significance levels at which a Hausman specification test would reject the null hypothesis of no misspecification).

Table 4. Coefficient Estimates in Basic Regressions
(dependent variable: percentage changes in the US/domestic exchange rate, t-values in italics)

	Australia, 1990-2000				Canada, 1994-1999				New Zealand, 1990-2000			
Variable	Set A	Set B	Set C	Set D	Set A	Set B	Set C	Set D	Set A	Set B	Set C	Set D
					OLS regressions							
Constant	0.30	0.29	0.28	0.05	-0.05	-0.05	0.05	0.04	-0.22	-0.19	-0.18	0.05
	1.70	*1.60*	*1.42*	*0.24*	*-0.88*	*-0.55*	*0.80*	*0.57*	*-1.81*	*-1.39*	*-1.10*	*0.32*
Δi 3m	2.58	2.57	2.55	2.38	-0.23	0.23	2.09	2.25	-0.19	0.83	0.89	2.07
	4.95	*4.82*	*4.60*	*4.25*	*-0.88*	*0.62*	*5.45*	*4.32*	*-0.53*	*1.50*	*1.41*	*3.48*
R^2	0.51	0.50	0.50	0.55	0.02	0.02	0.62	0.55	0.01	0.05	0.06	0.34
N	26	25	23	17	40	26	20	17	57	44	35	26
					IV regressions 1/							
Constant			0.15	-0.12			0.04	0.03			-0.18	0.16
			0.58	*-0.42*			*0.74*	*0.47*			*-1.02*	*0.79*
Δi 3m			1.85	1.56			1.86	1.85			2.72	4.27
			1.92	*1.60*			*3.83*	*2.68*			*2.16*	*2.94*
Hausman *p*			0.36	0.26			0.45	0.37			0.05	0.02
N			23	17			20	17			35	26

Definitions: Set A: Full event set
Set B: Full event set exluding documented policy reactions to same-day economic news
Set C: Full event set exluding documented and possible policy reactions to same-day economic news
Set D: Only events in which no other economic news were mentioned in market reports

1/ Instrument: either change in cash rate target (AU, CN) or dummy variable for direction of policy change (NZ).

- The magnitude of the coefficients in regressions C and D for Australia and Canada, and C for New Zealand (once measurement error is corrected) are remarkably similar, namely between about 2.1 and 2.7.[27] Indeed, tests show that the OLS coefficients for Australia and Canada using sets C and the OLS coefficients for Australia, Canada and New Zealand, using sets C and D, respectively, are not significantly different from each other.[28] Only the coefficient for New Zealand in the IV version of regression D stands out

[27] This statement is based on the rule that, for reasons of precision, one should use the OLS estimates as long as the null hypothesis of no misspecification cannot be rejected based on the comparison of the IV and OLS results (i.e. using a Hausman test). In the above, the null is rejected only in the regressions for New Zealand (at the 5 percent level).

[28] More precisely, a Chow test for structural breaks did not reject the null hypothesis of no structural break between the Australian and Canadian subsamples and a union of sets C for both countries ($p = 0.85$). Similarly, one cannot reject the null hypothesis of no structural

(continued...)

above this range. The regression results thus imply that, on average, a contractionary monetary shock that increases the three month interest rate by 100 basis points leads to an appreciation of the currency by about 2–3 percent.

B. Robustness

We now check the robustness of the results of the previous section along three dimensions: First, with respect to the choice of variable used to measure the magnitude of the monetary policy shock, second, and with respect to the exchange rate measure used, and third, with respect to the inclusion of additional controls in the basic regression. For each country, we use the largest dataset for which one can assume with some confidence that within-day endogenous reactions have been excluded (sets C in the terminology of the previous section).[29]

Table 5 is based on the same simple regression as Table 4 except that the variable used to proxy the "shock" associated with the monetary policy actions is now either the change in a money market rate of somewhat longer maturity (six months or one year) or the underlying change in the policy target itself (for New Zealand, where policy actions usually did not involve any change in a policy target, the Bonato, St. Clair and Winckelmann (1999) dummy variable for the direction of the policy change was used). Using a longer money market rate to measure the shock content of the policy action clearly makes very little difference: in each of the three country panels of Table 5, the coefficients in the first two columns are both economically and statistically very close to their counterparts for the regressions on "Set C" in Table 4. As before, measurement error is not an issue for Australia and Canada (see the line describing the p-values from applying a Hausman test), but it is for New Zealand, and thus the IV estimates should be used in that case.

The last column in each of the three panels shows that the main qualitative finding of the previous section—contractionary monetary policy significantly appreciates the exchange rate on impact, and vise versa for expansions—survives in two out of three cases even if the policy target change (or in the case of New Zealand, a dummy representing the direction of the action) is directly used in the regression. Thus, our results seem to be driven primarily by the fact that within-day policy reactions are excluded from the sample, and not by the way in

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break between the Australian, Canadian, and New Zealand subsamples and a union of sets C for Australia and Canada and set D for New Zealand (at high p-values).

[29] In the regressions shown in Table 5, one additional observation—the easing of monetary policy on October 31, 1995 prompted by the favorable outcome of the Quebec referendum—had to be excluded for Canada. When using the change in the three month interest rate as a policy measure, it is possible to discriminate between the effect of the referendum and the effect of the policy action because the immediate post-referendum interest rate is quoted in the newspapers. This, unfortunately, is not the case for the two longer rates.

Table 5. Coefficient Estimates using Alternative Policy Measures 1/
(dependent variable: percentage changes in the US/domestic exchange rate, t-values in italics)

	Australia, 1990-2000			Canada, 1994-1999			New Zealand, 1990-2000		
	using as policy measure ...			using as policy measure ...			using as policy measure ...		
Variable	Δi 6m	Δi 1y	index 2/	Δi 6m	Δi 1y	index 2/	Δi 6m	Δi 1y	index 2/
				OLS regressions					
Constant	0.06	0.03	0.09	0.03	0.01	0.05	-0.18	-0.16	-0.24
	0.31	*0.14*	*0.29*	*0.44*	*0.08*	*0.63*	*-1.09*	*-1.00*	*-1.58*
RHS policy measur	2.12	2.01	0.55	2.24	2.27	0.75	0.99	1.14	0.47
	3.40	*3.63*	*1.48*	*3.42*	*3.28*	*2.66*	*1.29*	*1.47*	*2.58*
R^2	0.36	0.39	0.09	0.41	0.39	0.29	0.05	0.06	0.17
N	23	23	23	19	19	19	35	35	35
				IV regressions 3/					
Constant	0.10	0.12	...	0.03	0.00	...	-0.18	-0.13	...
	0.38	*0.44*	...	*0.43*	*0.00*	...	*-0.94*	*-0.73*	...
RHS policy measur	2.39	2.81	...	2.42	2.65	...	3.78	3.41	...
	1.75	*1.71*	...	*2.90*	*2.83*	...	*2.04*	*2.17*	...
Hausman *p*	0.83	0.60	...	0.74	0.56	...	0.04	0.05	...

1/ Using datasets C (see Table 4).
2/ Either change in cash rate target (AU, CN) or dummy variable for direction of policy change (NZ).
3/ Instrument: either change in cash rate target (AU, CN) or dummy variable for direction of policy change

which policy shocks are measured. The exception is the coefficient estimate for Australia, which is positive but not significant, and smaller in size than the estimate for Canada, which reflects comparable units. One interpretation might be that policy actions in Australia, unlike New Zealand or Canada, occurred on pre-announced dates, and may thus have embodied a smaller surprise element. This would imply that any given change in the policy target prompted a smaller reaction of the exchange rate, and also—to the extent that the degree to which actions were anticipated varied across actions—that extracting the precise magnitude of the surprise may be more important in this case than for New Zealand or Canada, where most actions were, to a first approximation, unanticipated.

Next, we confirm that previous results go through if an effective (trade-weighted) exchange rate index is used on the left hand side in lieu of bilateral exchange rates vis à vis the US$. While the latter generally gets more attention in the financial press (which is why it was used in our regressions so far), the former is arguably more relevant for the purposes of transmitting policy shocks—as implicitly acknowledged by the monetary authorities in New Zealand and Canada, who used the effective exchange rate in their definition of "monetary conditions". In any event, Table 6 shows that the results are robust to the choice of exchange rate (see the columns corresponding to datasets C in Table 4 for comparison). For Australia,

the coefficients are almost unchanged, for Canada, they are slightly higher, and for New Zealand, slightly lower. The main finding that a contractionary 100 basis point shock leads to an exchange rate appreciation of about 2-3 percent continues to apply.

Table 6. Coefficient Estimates using Alternate Exchange Rate Measure 1/
(dep. variable: percentage changes in the effective exchange rate, t-values in italics)

	Australia		Canada		New Zealand	
Variable	OLS	IV 2/	OLS	IV 2/	OLS	IV 2/
Constant	0.22	0.05	0.09	0.09	-0.23	-0.24
	1.05	*0.17*	*1.18*	*1.13*	*-1.67*	*-1.58*
Δi 3m	2.43	1.53	3.37	3.14	0.93	2.18
	4.17	*1.50*	*6.35*	*4.69*	*1.72*	*2.10*
R^2	0.45	...	0.69	...	0.08	...
N	23		20		35	
Hausman *p*	0.26		0.58		0.12	

1/ Using datasets C (see Table 4).
2/ Instrument: either change in cash rate target (AU, CN) or dummy variable for direction of policy change (NZ).

Consider next Table 7, where we go back to both the original left hand side variable and right hand side policy measure (i.e., bilateral exchange rates and the three-month money market rate, respectively), and explore the consequences of adding changes in the US three-month T-bill rate and/or daily commodity prices to the basic regression model.[30] Given the way the sample has been constructed—comprising only days when changes in monetary policy occurred, excluding those that constituted reactions to same-day economic news—one would expect these extra variables to matter only in the sense that they add explanatory power to the regression, but *not* in the sense that they modify the previous results (to the extent that omitted terms of trade or US interest rate changes are correlated with domestic interest rate changes, this would have been dealt with by our IV regressions). This is generally confirmed by the results. In most cases, there is a moderate improvement in the fit of the regression. For two out of three countries, however—Canada and New Zealand—the additional variables

[30] To economize on presentation, only either OLS or IV results are shown, depending on whether the Hausman test rejected or not (see line "Hausman p"). The commodity price data consists of changes in the daily commodity futures price index compiled by The Bridge/Commodities Research Bureau and its subcomponents for grains, livestock and meats, and precious metals (Source: Datastream; see http://www.crbindex.com on information about how this index is compiled).

Table 7. Coefficient Estimates using Additional Controls 1/
(dependent variable: percentage changes in the US/domestic exchange rate, t-values in italics)

Variable	Australia, 1990-2000				Canada, 1994-1999				New Zealand, 1990-2000		
	OLS regressions								IV regressions 2/		
Constant	0.37	0.43	0.34	0.32	0.05	0.05	0.04	0.05	-0.20	-0.12	-0.21
	1.92	*2.47*	*1.81*	*1.59*	*0.87*	*0.84*	*0.69*	*0.82*	*-1.11*	*-0.67*	*-1.15*
Δi 3m	3.09	3.23	3.00	3.02	2.09	2.12	2.09	2.03	2.78	2.56	2.62
	5.28	*6.05*	*5.16*	*5.02*	*5.42*	*4.57*	*5.40*	*4.73*	*2.18*	*2.14*	*2.34*
Δi US3m 3/	-9.77	-8.83	-9.71	-9.05	0.41	0.42	0.54	0.41	-3.97	-4.20	-3.61
	-1.99	*-1.98*	*-2.01*	*-1.79*	*0.86*	*0.83*	*1.08*	*0.84*	*-1.00*	*-1.10*	*-0.91*
ΔComall 3/		0.38				0.01				0.25	
		2.32				*0.11*				*1.39*	
ΔCommetal 3/			0.06				0.03				
			1.30				*0.89*				
ΔComlivestock 3/				0.04							-0.03
				0.73							*-0.35*
ΔComgrain 3/								-0.01			
								-0.33			
Hausman *p*	0.32	0.84	0.37	0.30	0.45	0.46	0.51	0.44	0.05	0.08	0.03
R^2	0.58	0.68	0.62	0.60	0.64	0.54	0.66	0.52	...	...	...
N	23	23	23	23	20	20	20	20	35	35	35

1/ Using datasets C (see Table 4).
2/ Instrument: dummy variable for direction of policy change.
3/ Changes in the US 3-mont T-Bill rate, the CRB commodity futures price index, and the CRB futures price indices for precious metals, livestock and meats, and grain, respectively.

have statistically insignificant effects, and the coefficients on the domestic policy measure are virtually unchanged (about 2.1 and 2.7, respectively). Only for Australia does the extension of the model seem to matter, in the sense that the coefficients on the US interest rate variable and the main commodity price index are significantly different from zero with the expected signs, and that the coefficient on the main policy variable increases by about half a percentage point (around 3.1 instead of 2.6). Thus, for Australia, the previous coefficients would appear slightly biased downward by the fact that commodity and US interest rate changes were excluded from the model, but not in any economically significant way.

For Canada, the regression was also run on an extended sample of 28 observations which included policy events that were classified as endogenous reactions to *US* news (on the logic that including US interest rate changes amounts to controlling for the influence of such events). This lowered the estimated coefficient on the change in the Canadian3-month T-Bill rate, to about 1.85 with a standard error of about 0.35 (not shown in Table). Finally, we reran both sets of regressions after excluding the three event-days that coincided with

discretionary intervention (see end of Section III). This lowered the coefficient on the change in the Canadian T-Bill rate slightly (from 2.09 to 2.01 if the regression excludes events classified endogenous to US news, and from 1.85 to 1.71 if it includes them; with a t-value of about 3.8 in both cases). Thus, the reaction of exchange rates to higher interest rates observed on these three days is higher than average, consistent with the view that discretionary intervention added to the strong reaction of the exchange rate on these occasions. However, the results so far are clearly not sensitive to the exclusion of these points.

C. Effect Modifications by Type of Policy Action

The main lesson from the last two sections is that, after excluding observations which are contaminated by reverse causality, exchange rates appear respond significantly to monetary policy shocks in the direction conventionally predicted by economists. What is not clear at this point, however, is whether this finding can be interpreted as an answer to the question how the exchange rate responds to tighter monetary policy during times of exchange market pressure. Two concerns need to be addressed. The first, which will be taken up in detail in the next section, relates to potential sample selection bias: many instances of policy changes in response to heavy pressure on the currency were removed from the sample because they occurred on the same day as the exchange rate movement to which they were reacting. The second concerns the possibility of a structural break even *within* the main regression samples chosen so far. In particular, could the strength of our average results be driven mainly by events in which the exchange rate was *not* the main policy concern? Put differently, does the main result holds to the same degree for events in which the central bank was *trying* to influence exchange rates—and in particular, leaning against depreciations—as it does on the whole sample? In what follows, we attempt to answer this question. and at the same time check whether there are significant differences between the reaction of the exchange rate depending on whether the authorities wanted an appreciation or a depreciation, and in the way the exchange rate responded to contractionary and expansionary actions more generally.

Tentative evidence is shown in Table 8, which shows regressions based on a sample of 69 observations from the pooling of sets C for Australia and Canada and Set D for New Zealand.[31] The justification for working with pooled data is that it is impossible to slice the individual country datasets any further without ending up with very small numbers of observations; moreover, we saw earlier that the coefficients in the main regressions are insignificantly different from each other across the three datasets that are being pooled. Two

[31] For New Zealand, Set C contains a number of very noisy data points, and the relatively small sample sizes in the exercise that follows precludes the use of IV to deal with this noise. Comparing the OLS coefficients on the three-month interest rates across the three countries in Table 4, along with the Chow test results mentioned earlier, suggests that Sets C for Australia and Canada and Set D for New Zealand are good choices for the purposes of pooling.

sets of regressions are shown, which differ only in whether the three outliers apparent in panel D of Figures 1 and 3 are included (left panel) or not (right panel).

Table 8. Coefficient Estimates on Subsamples

(Dependent Variable: Percentage change in US cents per domestic currency; t values in italics)

	Basic Sample 1/					Basic Sample w/o 3 Outliers 2/				
	All	Ed and Ea 3/	Ed events	All Contr.	All Expans.	All	Ed and Ea events	Ed events	All Contr.	All Expans.
Constant	0.11	0.14	0.34	0.31	0.06	0.18	0.06	0.13	0.17	0.34
	1.27	*1.43*	*2.28*	*2.45*	*0.37*	*2.66*	*0.92*	*1.33*	*1.63*	*2.69*
Δi 3m	2.22	2.59	1.35	1.21	2.15	2.48	2.79	2.31	1.74	2.98
	7.16	*5.07*	*1.66*	*2.10*	*4.17*	*10.21*	*8.41*	*4.54*	*3.75*	*7.31*
R^2	0.43	0.59	0.19	0.20	0.30	0.62	0.81	0.65	0.45	0.58
N	69	20	14	20	42	60	19	13	19	40
Chow *p*		0.98	0.90	0.87			0.83	0.97	0.35	

1/ Union of sets C for Australia and Canada and set D for New Zealand (see Table 1).

2/ Namely, 3/23/93 (Australia), 3/18/98 (New Zealand) and 1/6/92 (New Zealand). See Figures 1 and 3, respectively.

3/ "Ea" refers to policy actions that attempt to lean against an appreciation, "Ed" refers to actions that attempt to lean against a depreciation.

There are two noteworthy results:

(i) Whether or not one runs the regression on the whole sample or the subsample that includes only policy actions that were responses to exchange rate depreciations ("Ed events") or appreciations ("Ea events") makes very little difference to the estimated coefficient on the change in the three-month interest rate. The *p* value corresponding to an F-Test for structural breaks (last line) indicates that there is no trace of such a break. Thus, the results from the basic regressions would seem to extend to instances in which the authorities were attempting to influence the exchange rate. However, this remains subject to the basic caveat mentioned at the beginning of the section, in that all results are based on a sample which excludes most instances of interest rate defenses against heavy speculative attacks.

(ii) Judging from the relative magnitudes of the coefficients, we do observe a slight asymmetry in the response of exchange rates to policy on occasions when the trigger was a depreciation of the exchange rate (and the authorities attempted to tighten) and occasions when the trigger was an appreciation (and the authorities tried to loosen). In general, the former seem to generate less of an exchange rate response than the latter. In other words, it seems to be somewhat easier to "lean against the wind" when the wind is blowing from below (i.e. the triggering event is an appreciation of the currency) than when the wind is blowing from above. A similar finding holds for contractions and expansions more generally,

with the coefficient on the three-month interest rate larger in the event of expansions. However, none of these differences are statistically significant, as shown by the Chow test p-values in the last line of the table.[32]

D. A Closer Look at Some Outliers

Using contemporaneous press reports, we now present additional qualitative information on observations which exhibit large movements between exchange rates and interest rates in the opposite direction (where for the exchanged rate "up" is defined as an appreciation), i.e. points in the top-left and bottom-right quadrants in the scatterplots of Figures 1-3. There are two motivations for doing this. First and foremost, there is the possibility of sample selection bias raised in the previous section. While the results so far support the "conventional" view of how monetary policy impacts the exchange rate, it is clear from the scatterplots and Table 1 that this would not generally be true if suspected endogenous reactions had not been excluded from the dataset. These exclusions were made for good reason—one cannot draw conclusions from a regression that includes endogenous reactions because of the reverse causality problem. However, if the true reaction of exchange rates to interest rate hikes is in fact systematically weaker—or even of the opposite sign—during speculative attacks against the currency, then the regressions based on samples C and D would overstate the impact of monetary policy on exchange rates, as days of speculative attacks are more likely to precipitate same-day policy reactions than normal days and thus more likely to be excluded from the data. Only intra-day information on how the exchange rate reacted *following* the policy announcement—even if this is just qualitative information—can help us decide whether this is likely to be the case. Second, to the extent that large "outliers" remain in the sample even *after* excluding actions which constituted within-day reactions or coincided with other economic news, one would be curious to know what was "going on" during those days, and in particular whether these observations support the notion that tight money might be counterproductive from the point of view of stabilizing the exchange rate in some circumstances.

An event-by-event description of the interpretation which the main outliers were given in the financial press is presented in the appendix. In the following, we summarize the main findings for the purposes of addressing the points raised in the previous paragraph.

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[32] The Chow tests mostly refer to testing for a break between the particular subsample associated with each column and the whole sample (including outliers in the case of the left set of columns, and excluding them in the case of the right set of columns). The only exception is the Chow p-value given for the "contractions" and "expansions" columns, which refers to a structural break test comparing these subsets and the sample comprised of the union of the two subsets. Testing for breaks vis-à-vis the whole sample would have made little difference to the results (it would have led to slightly higher p-values).

Endogenous responses

Table 9 gives the total number of bottom-right and top-left observations that were associated with endogenous reactions of policy to economic news on the day of the policy event. The main outliers of this class, which have been labeled by their dates in panels A and B of Figure 1 through 3, are characterized along two dimensions: (1) whether or not policy was reacting to an appreciation or depreciation on the same day, and (2) how the exchange rate reacted to the policy announcement (to the extent that this is documented in press reports).

Table 9. Classification of Outliers Associated with Within-Day Policy Reactions to News

	Total	Australia	Canada	New Zealand	
"Bottom-right" observations classified as within-day reactions	16	–	6	10	
of which : **major outliers** (labeled by dates in panels A and B)	**13**	–	**5**	**8**	
of which : action preceded by depreciation on same day	11	–	4	7	
action resulted in appreciation (documented)	8	–	3	5	
action resulted in depreciation (documented)	1	–	0	1	1/
reaction to action not documented	4	–	2	2	
"Top-left" observations classified as within-day reactions	12	2	6	4	
of which : **major outliers** (labeled by dates in panels A and B)	**6**	–	**4**	**2**	
of which : action preceded by appreciation or Fed easing	4	–	3	1	
action resulted in appreciation (documented)	3	–	2	1	2/
action resulted in depreciation (documented)	2	–	2	0	
reaction to action not documented	1	–	0	1	

1/ Depreciation was reaction to currenct account projections that were announced together with Monetary Policy Statement.
2/ Action was attempt to tighten (see appendix).

Consider first the upper panel of the table, which refers to observations when interest rate hikes were associated with exchange rate depreciations. The main lesson is that among the 13 major outliers that were classified as endogenous to within day reactions, and consequently excluded from the main regressions (on sets C and D), there is only one instance in which one can document a depreciation of the exchange *in reaction to* the policy announcement. Moreover, this turns out to be an unusual case in which the exchange rate was in fact reacting to an unexpectedly pessimistic current account projection by the Reserve Bank of New Zealand that was announced in connection with the monetary policy statement, rather than the statement itself (see appendix). In contrast, there are 8 cases where the opposite reaction can be documented, i.e. an appreciation following the interest rate hike, as would conventionally be expected. This does not show in the daily data because it was insufficient to fully reverse the depreciation of the exchange rate *preceding* the policy event on the same day. Thus, by excluding within day reactions we do not appear to be suppressing information that would support a reaction of exchange rates to monetary tightening in the *opposite*

direction of that described by the results from regressions C and D. This said, it remains possible—but impossible to confirm, for lack of historic intra-day data—that the *size* of the response to policy tightening was smaller, on average, on the days excluded.

Things are less clear-cut for the observations where interest rate declines were associated with exchange rate appreciations is observed in the daily data ("top-left" outliers, lower panel of Table 9). This time, an appreciation *following* the policy announcement, rather than just prior to it, can be documented in 3 out of the 6 major outliers shown in the figures. One of those three cases actually involves an attempt to tighten, so here the puzzle is why the *interest rate* registered a (small) decline, rather than an increase. The other two instances truly describe appreciations following attempted easings. Both refer to Canadian observations. In one instance (3/31/99), the market report simply states that the dollar rose after the rate cut, without attempting any explanation. In the other one (12/19/95), however, the report suggests that the easing, which came on the heels of a US interest rate cut, might have helped the C$ because of its stimulating effect on the Canadian economy: "The C$ closed slightly higher after the Bank of Canada dropped its overnight call-loan rate by 25 points in line with a similar cut by the US Federal Reserve ... Although currency traders and analysts fully expected the Bank of Canada to follow any easing move by the Fed, the cut by the US central bank enables its Canadian counterpart to get some stimulation into the dreary Canadian economy through lower interest rates rather than a lower currency."

Remaining outliers (Panels D of Figures 1-3)

After excluding endogenous policy reactions and event-days that coincide with major news other than monetary policy, there are still a few remaining outliers, which are labeled in Panel D of Figures 1-3. Interestingly, most of them are in the top-left quadrant, i.e. appreciations associated with easings (3 observations for Canada, 2 for Australia and one for New Zealand). In contrast, only two outliers remain in the bottom-right quadrant (one each for Australia and New Zealand).

Taking the latter first, it turns out that both of these points, which would suggest an exchange rate depreciation following a contractionary monetary policy shock, actually correspond to attempted *easings*. Underlying the 3/23/93 event for Australia is a 50 basis point reduction in the cash rate target which "prompted the $A to tumble" by US 0.9c, but disappointed bond markets: "Traders ... had factored in closer to a 75 basis point rate cut and when, at 9.30 AEST yesterday morning the RBA announced just a 50 point cut they realized they were overbought." No explanation is given for the different reaction in the bond and currency markets. The 3/18/98 outlier for New Zealand, on the other hand, is a peculiar event in which the announcement of easier monetary conditions caused both the $NZ and, initially, the 90-day bank bill yield to fall, until bond market participants supposedly realized that the combined drop in the exchange rate and bank bill yields had gone too far relative to the new MCI target, and bank bill yields rose back to close higher (but the $NZ still closed lower, see appendix for details). This is one of the few documented cases where the presence of an MCI target as opposed to an overnight rate target might have made a difference to the way in which money markets reacted.

Finally, consider the six instances of exchange rate appreciations associated with a decline in the three-month interest rate. One of these cases (New Zealand, 1/6/92) correspond to an attempted tightening to which the NZ$ reacted as expected, and the puzzle, which market reports do not discuss, is why the 90 day bill did not (the one-year bond rate did in fact rise slightly). In another case (Australia, December 18, 1990), market reports state that the $A actually fell after the RBA announcement, but then recovered and continued to rise for unspecified reasons during the rest of the day. The remaining four cases are more interesting in that they constituted attempts to ease *and* an appreciation of the currency is clearly attributed to this attempted easing, with two distinct interpretations suggested in the financial press reports:

- In case of the 4/4/91 (Australia) and 8/22/96 (Canada) event-days, the appreciation in the dollar is attributed to the fact that market participants believe that the Central Banks' easing signals *higher* interest rates in the future, either because the reduction was smaller than expected, or because "the bank has now finished cutting interest rates" (Toronto *Financial Post* report on 8/22/96 easing by Bank of Canada). As noted before, this immediately raises the question why this signal did not lead to a corresponding movement in the three month rate (i.e. up rather than down). One possibility is that the three month rate may not be sufficiently long to capture what may have a been perceived as a signal about the level of interest rates beyond the weeks immediately ahead.

- In contrast, the story suggested in explanation of the 8/28/95 and 10/02/96 exchange rate appreciations (both for Canada) is that lower interest rates will lead to a stronger economy, as was the case of the 12/19/95 outlier for Canada discussed in the previous subsection (see appendix for details). Thus, these three event-days do indeed suggest the presence of an "output channel" through which interest rate declines might appreciate the currency during a recession because of their impact on expected *future* exchange rates. However, note that these reactions occurred in an exceptionally favorable external environment: in the first two cases, on the heels of a major C$ appreciation, and in the latter, on the same day as a Fed easing.

V. CONCLUSIONS

This paper studied the impact response of exchange rates to monetary policy shocks in floating regimes, both during normal times and during times of pressure on the currency. Its main findings are as follows:

1. Excluding events when monetary policy was an endogenous response to economic news (and in particular exchange rate pressure) on the same day, a regression of changes in the exchange rate on changes in the three-month interest rate on the day of policy actions shows a significant relationship between exchange rates and monetary policy in the direction commonly predicted. Coefficient estimates for Australia, Canada and New Zealand imply that a monetary policy shock leading to a 1 percentage point increase in the three-month interest rate will appreciate the exchange rate by 2–3 percent.

2. Instances in which the exchange rate reacted "perversely" to a policy action were very rare. In only 5 cases (out of a total of 126) was this documentably the case. All are cases of appreciations after attempted easings. Three out of these five cases occurred in the context of a depressed economy as well as a favorable external environment, either on the heels of a major appreciation prior to the policy action, or on the same day as a U.S. Federal Reserve easing.

3. Based on financial market reports, we could not find a single example in which raising interest rates to stabilize the exchange rate in times of turbulence backfired in the sense of leading to a further depreciation. However, on days when the policy action was prompted by pressure on the exchange rate on the same day, whatever stabilization or recovery of the exchange rate ensued as a result of the action was often (in 6 out of 11 cases for New Zealand, and 6 out of 6 for Canada, see Tables 2 and 3) insufficient to make up for ground lost prior to the policy announcement. As a result, interest rate hikes prompted by exchange rate weakness frequently go together with exchange rate depreciations when both are measured over the entire day. Based on such observations, it is possible to mistakenly conclude that higher interest rates led to more depreciated exchange rates.

4. While the same *direction* of the relationship between tighter monetary policy and exchange rates appears to hold regardless of whether or not the policy action was taken in response to financial turmoil, the results are not conclusive on whether the *magnitude* of the response is smaller in times of turbulence. Regression results suggest that the exchange rate reaction to policy shocks when the monetary authorities wanted to lean against a depreciation is no different from the average reaction; however this is based on a sample which excluded most cases of heavy turbulence since these often trigger policy reaction on the same day, and thus were excluded from the sample.

In sum, the evidence presented in this paper supports the conventional view about the direction of the impact of interest rates on exchange rates during both normal times and times of turbulence. At the same time, the results suggest that the interest rate "costs" of resisting exchange rate pressure could be high: even assuming that the same coefficients apply to normal and turbulent times, offsetting a 10 percent depreciation would require an interest rate shock of about 500 basis points. The fact that interest rate hikes in response to exchange rate pressure usually did not fully offset the initial depreciation—in other words, that the overall result was a partial accommodation of the depreciation triggering the policy response—may be a reflection of that cost.

APPENDIX I

A DISCUSSION OF THE OUTLIERS IN FIGURES 1-3

What follows is an account of financial press interpretations of the outliers labeled by their dates in Figures 1 - 3. The convention adopted in panels A B and C was to label all points showing a large negative co-movement between exchange rate and interest rates that where dropped when moving to the next panel. For example, points labeled in Panel A are all outliers that do not show up in Panel B as well, i.e. that were removed on the grounds of documented within-day endogeneity. The Panel D labels the remaining outliers that were neither associated with endogenous reactions nor reflected unrelated news.

Australia

The Australian dataset is unique in that, with only one exception, all outliers are bunched in the upper-left quadrant, i.e. they correspond to easings accompanied by exchange rate *appreciations*. Of these, three appear to be driven by the coincidence of the monetary policy announcement with other news which strengthened the $A (see Table1). This leaves only two events of interest in the upper left quadrant: December 18, 1990, April 4, 1991. In the former case, the market reports state that the $A actually fell after the RBA announcement, but then recovered and continued to rise for unspecified reasons during the rest of the day. In contrast, the argument that is given for April 4, 1991 is that the $A rose because the RBA's easing was unexpectedly modest: "Markets were surprise the RBA did not deliver a full 1 percent easing, as it has done six times since the last tight policy was first relaxed in January last year. This surprise disappointed money markets but buoyed currency traders, who regard the smaller cut as confirming a high yielding $A for the near term." The real puzzle is thus why the supposed "disappointment" of money markets did not manifest itself in higher yields for the 90 day bank bill rate but merely in a smaller drop in yields than might otherwise have occurred (only 13 basis point). This is an issue which we will re-encounter on several occasions below.

Finally, consider the point labeled March 23, 1993, the only bottom-right outlier of the Australian sample. As Table 1 shows, this point actually corresponds to an RBA *easing*—specifically, a reduction in the cash target rate—which "prompted the $A to tumble" by US 0.9c, but disappointed bond markets: "Traders had expected a bigger cut and were now pushing out any further easing until after the Budget." ... "Many of them had factored in closer to a 75 basis point rate cut and when, at 9.30 AEST yesterday morning the RBA announced just a 50 point cut they realized they were overbought." No explanation is given for the different reaction in the bond and currency markets.

Canada

Consider first the four documented within-day policy reactions in the "bottom-right" quadrant of panel A, Figure 2. As Table 1 shows, these are part of a string of five same-day reactions to sharp pressure on the C$ during January and February of 1995, a time of global exchange rate turbulence prompted by the Mexican peso collapse of December 1994, in addition to fears about Canada's worsening fiscal situation. A typical Toronto *Financial Post*

headline during these days is that of Wednesday, January 11: "Central bank forced to raise rates as C$ wilts". Notably, in three of these five instances (namely, January 10, January 12, and February 1) the Financial Post reports that the C$ *recovered* following the Bank's action. Only in one case (February 1), however, was the recovery strong enough to offset the initial depreciation to which the Bank was reacting. Except for this case, the net result over the course of the day is thus a depreciation of the currency accompanied by a sharp hike in interest rates.

A particularly interesting event-day is the February 16, 1995, when the Bank reacted to a C$ sell-off that was in turn prompted by a Moody's Investor Service announcement saying that it had put Canada's foreign-currency debt ratings under review for a possible downgrade. "The announcement sent the C$ skidding and prompted the Bank of Canada to hoist interest rates half a percentage point" (*Financial Post*, February 17th front page article). Since the Moody's announcement prompted the sell-off mainly by exacerbating fiscal worries—a downgrade would have raised risk premia on Canada's public debt made it even more difficult to finance the budget—this event could be viewed as a test-case for the notion that higher interest rates can have perverse effects on the exchange rate. Indeed, *Financial Post* reports during this time show that at least some market participants were keenly aware about the possibility of such a perverse effect. In its report on the January 17th interest rate hike, the *Post* writes: "The market turmoil [preceding the interest rate hike] resulted from renewed warnings about Canada's financial predicament, the prime minister's hint of higher taxes and expectations of rising US interest rates. Analysts said rising rates may be creating a vicious circle, further threatening Ottawa's deficit targets and accentuating the very concerns that push up rates." Yet, neither here nor in the case of the February 16 tightening is there any hint in the market reports that the Bank's action prompted a *further* depreciation of the exchange. However, it is also interesting that the two event-days during January/February 1995 in which exchange rate market turbulence seems to be triggered by fiscal worries are precisely those in which *no recovery* of the exchange rate is reported after the Bank of Canada hike.

Turn now to the bottom right outlier in panel B of Figure 2. August 27, 1998 was the day of global financial meltdown following the Russia crisis. While the *Financial Post* report on that day does not explicitly state that a C$ sell-off preceded the Bank of Canada's 100 basis point hike on that day, this is nevertheless strongly suggested by the report: "Fears of a global recession took hold yesterday as the world's stock markets crashed and the C$ tumbled despite the best efforts of the Bank of Canada ... In an effort to boost confidence in the C$, the Bank of Canada hiked the bank rate by 100 basis points, increasing its official lending rate to banks to 6% from 5%. The strategy failed. After a brief rebound in trading the C$ sank more than half a cent against the US$ to close at another record low of US63.31c." Note that the impact effect of the Bank of Canada move again seems to be an appreciation of the currency, although it is not sustained.

Finally, consider outliers in the top right quadrant, i.e. the seven cases labeled in Figure 2 in which the exchange rate *appreciated* noticeably during days on which the Bank *eased* monetary policy. On closer inspection, there is nothing puzzling about the two July 1995

events (panel A). The July 10 event is analogous to the January 1995 policy actions. As in these cases, the Bank's action is triggered by developments in the exchange rate—this time, a surge, giving the Bank room to stimulate the depressed Canadian economy. The impact of this action is reported to go the way one would conventionally expect, but apparently not enough to offset the initial surge on that day: "The latest cut came early in the trading day in North America after the value of the C$ was bid up in late trading on European markets. A C$ rally to a nine-month high to US74.27c was reversed by the bank's cut in the overnight funds, or call, rate." The July 6 easing, on the other hand, is a reaction to a Fed easing on the same day. The impact of looser US monetary policy happens to dominate the impact of the corresponding Canadian loosening, as witnessed by the fact that the interest rate differential widens (see Table 1), i.e. that US money market rates fall by more than Canadian money market rates. Thus, the exchange rate reacts in line with the conventional view.

The remaining four cases are more interesting in that the *Financial Post* reports an appreciation of the exchange rate *after* the interest rate easing. In one instance (3/31/99), no suspected reasons for this appreciation are given, and there is no suggestion that the appreciation was "caused" by the easing. In contrast, in the remaining instances the direction of causation from lower interest rates to a more appreciated currency is clearly suggested by the report, with two distinct interpretations.

(1) For the 8/22/96 event-day, the appreciation in the dollar is attributed to the fact that market participants believe that the Bank's next move will be to raise interest rates: "The C$ strengthened after the Bank of Canada lowered its target band for overnight rates 1/4 point to 3.75 to 4.25%. Most traders believe the bank has now finished cutting interest rates ... There is a perception that the Bank of Canada won't be easing any more unless there's evidence of the economy showing renewed weakness". As noted before in the discussion of Australian "top left" outliers, this interpretation is at odds with the fact that the three month interest rate did in fact decline (by a small amount) in response to the announcement.

(2) In contrast, the story suggested in explanation of the 8/28/95, 12/19/95 and 1/31/96 exchange rate appreciations is that lower interest rates will lead to a stronger economy: "the C$ gained one-third of a cent against its US counterpart on the heels of a round of interest rate cuts yesterday ... The C$ value jumped by 33 basis points ... following an even stronger upward move of 51 basis points on Friday. A rising currency value has made it easy for the Bank of Canada to guide rates lower and economists universally prescribe rate cuts as an antidote to a slowdown that is occurring this year." (*Financial Post*, August 29, 1998). Similarly, on December 20, 1995 the Post reports (under the headline: "Easing helps C$ close stronger"): "the C$ closed slightly higher after the Bank of Canada dropped its overnight call-loan rate by 25 points in line with a similar cut by the US Federal Reserve ... Although currency traders and analysts fully expected the Bank of Canada to follow any easing move by the Fed, the cut by the US central bank enables its Canadian counterpart to get some stimulation into the dreary Canadian economy through lower interest rates rather than a lower currency." Finally, on February 1, 1996 the *Post* writes: "The Bank of Canada has adopted a much more aggressive stance in cutting interest rates as economic statistics

describe a faltering economy. ... the C$ actually rose yesterday against is US counterpart, closing up US0.25c at US72.81c."

New Zealand

In contrast to the Australian sample, New Zealand outliers are concentrated in the bottom right quadrant, with only two exceptions, which are labeled 1/8/93 and 1/6/92 in panels A and D, respectively. The former is a classic case of reverse causality. The RBNZ eased in response to an appreciation of the $NZ after it had tightened policy only two days earlier: "The NZ dollar moved further into the Reserve Bank's comfort zone yesterday, allowing wholesale interest rates to ease for a second day. The Reserve Bank relaxed its monetary stance slightly after the trade-weighted index reached 53.5 late in the afternoon" (*NZH*, January 9, 1993). The small net appreciation apparent in Figure 3 reflects the combined effect of the morning appreciation and the reaction to the Reserve Bank move. The appreciation on 1/6/92, on the other hand, occurred after "the Bank noted that it would be concerned if there were further weakening in the exchange rate, because at then current levels inflation outcomes for 1992 and 1993 were now expected to be towards the top end of the target ranges." (RBNZ Bulletin Vol 56, No 2., p. 101). Thus, the exchange rate responded in the direction one would expect following a monetary tightening. As noted before, the puzzle in this case is why the 3-month interest rate did not increase—but then, the decline it registered was very small (six basis points).

Consider now the eight cases of within-day endogeneity shown in the bottom-right quadrants of scatter plots A and B. Of these, five—12/15/92, 1/6/93, 28/7/95, 7/3/97 and 2/23/98—involve actions that were taken in direct response to pressures on the NZ$ on the same day (or, in one case, in overnight US and European trading after previous market closing), and two others—12/5/97 and 3/30/98—are also likely to have been within-day responses to a weakening currency, although this not directly implied by the language of the market report. In two cases (1/6/93 and 3/30/98), money market reports do not state the NZ$ reaction to the RBNZ governor's announcement, but in the five other cases they do, and all are described as appreciations: "The dollar had already fallen ... early this month, prompting a statement from the bank that it was unhappy with the inflation consequences of such a fall. That was reiterated in the latest Monetary Policy Statement released yesterday morning. However, it appear that one major local bank decided to test the Reserve Bank's resolve to defend the currency, pushing the dollar briefly below 53 on the trade weighted index. Short term interest rates rose slightly and the dollar rose quickly to around 53.2 on the TWI." (The [Christchurch] *Press*, December 16, 1992). "In overseas trading, on Thursday night the New Zealand dollar dropped from the local finish of 67.28 USc to a low of 66.6 as a US investment bank continued to sell. The kiwi opened here at 67c yesterday but soon weakened to 66.76c. The Reserve Bank statement perked it back up to finish at 67.05c." (*NZH* July 29, 1995). "The kiwi sold off in the morning after United States selling overnight.'With Dr. Brash's comments [in the early afternoon] there was some frenzied buying back up to 67.85 Usc' a dealer said. 'It was looking a bit ugly really. I was looking like it was going to come off a hell of a lot. Then the statement brought it back up.' " (*NZH*, July 4, 1997 market report). "The Reserve Banked yanked the financial market's leash yesterday with a warning

that monetary conditions had loosened too far. Both the dollar and the wholesale interest rates rose in response to the bank's statement, which caught the market unawares." (*NZH*, December 6, 1997). "The Reserve Bank fired a warning shot across the financial markets yesterday, saying that monetary conditions had eased too far over recent days. Earlier, the MCI, which reflects both exchange rates and 90-day interest rates, had dropped to 517--133 points below the bank's official desired level of 650. It had been pulled lower largely by a fall in the exchange rate against the United States dollar, which was more a case of appreciation of the American currency stemming from disappointment at the bland outcome of a G7 meeting over the weekend. The market obediently pushed the MCI back to 541 immediately after the Reserve Bank's statement, with the dollar recovering 20 points to 57.65 USc, but by the end of the day it had slipped back to 536." (*NZH* February 23, 1998).

A highly unusual event that triggered large reactions of interest rates and exchange rates in opposing directions was the monetary policy announcement on December 16, 1997, the largest "bottom right" outlier in the sample. The announcement carried three pieces of information: First, an "endorsement" of the easier monetary conditions that had developed in recent weeks with the depreciation of the $NZ; second, a much worse than expected current account projection, and third, the statement that "the Reserve Bank is not looking for any further easing in actual conditions at this time." Market reactions focused on the last two elements, which were taken to imply that the Bank would seek a higher level of interest rates in order to offset the depreciation associated with the projected current account deterioration. The December 17, 1997 *New Zealand Herald* headline ran: "Big risk interest rates will rise, warns Brash". "The Reserve Bank governor, Don Brash, warned yesterday of a 'significant risk' the dollar would fall and interest rates rise because of a ballooning external deficit. As if to illustrate his point, the dollar fell sharply, loosing 2c against the United States dollar within 24 hours, while 90 day interest rates jumped nearly half a percentage point [...] The bank expects the current account deficit to blow out to 7.7 per cent of GDP by March next year. That raises the prospect that the New Zealand dollar will continue to be sold off, which in turn would require interest rates to rise to keep the overall level of inflation resistance in monetary conditions the same." The December 16 event was thus equivalent to the simultaneous announcement of adverse BoP news and of a contractionary reaction of monetary policy to these news, and was thus excluded as endogenous to information that became public on the same day.

Turning to the lower half of Figure 3, panel C shows four cases in which the dollar closed lower on days of contractionary policy actions because of unrelated news that drove its value down (in three cases, sharp declines of the Australian dollar, and in one case, an unfavorable report by Goldman Sachs). That leaves just one bottom-right outlier in panel D: March 18, 1998. Just like in the case of the analogous outlier for Australia discussed previously (Figure 3, 3/23/93 event in panel D), this turns out to reflect an *easing* by the Reserve Bank, and the puzzle is why interest rates closed higher, although the announcement clearly came as a surprise. The *New Zealand Herald's* reporting suggests that yields initially fell, but backtracked after the perceived overshooting of the exchange rate: "The Governor of the Reserve Bank, Dr. Don Brash, astonished the financial markets yesterday by easing monetary policy about as aggressively as they thought he should ... Market analysts had expected

Dr. Brash to cut the bank's desired level for the monetary conditions index by 75 or 100 points ... but he eased 150 points to 500 and amplified the message by projecting further easings ..." (Money market report): "The kiwi immediately reacted by dropping over 1 USc to 57 USc The 90 day bill yields initially dropped 15 basis points before dealers realized the kiwi was absorbing what was initially seen as a "huge" easing. ... The debt market reacted by hiking 90-day bill yields up 25 basis points. A bill dealer said the market 'bulled up' after the statement but selling quickly began as the kiwi went into free-fall." This leaves the question why, in this particular instance, markets channeled the surprise easing disproportionally through the exchange rate in the first place. One story that is consistent with the wording of the report is that Governor Brash's announcement may have been interpreted to suggest "further easing" of monetary policy beyond the horizon relevant for the 90-day interest rate.

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