Daily Effects of Foreign Exchange Intervention: Evidence from Official Bank of Canada Data

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Abstract

This paper analyzes the effects of official, daily Bank of Canada intervention in the CAD/USD exchange rate market over the January 1995 to September 1998 period. Using an event study methodology and different criteria for effectiveness, movements in the CAD/USD exchange rate over the 1 through 10 days surrounding intervention events are investigated. It is shown that Bank of Canada intervention was systematically associated with both a change in the direction and a smoothing of the CAD/USD exchange rate. Bank of Canada intervention did not, however, succeed in reducing the volatility of the CAD/USD exchange rate. Additionally, the paper introduces the issue of currency co-movements to the intervention literature. It is shown that the effects of intervention are weakened when adjusting for general currency co-movements against the USD, suggesting that currency co-movements should be taken into account when addressing the effects of central bank intervention aimed at managing a minor currency vis-à-vis a major currency.

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1. Introduction

The empirical literature on central bank foreign exchange market intervention has been growing rapidly over the recent years, partly due to more official intervention data becoming publicly available.[1] Bank of Canada (BoC) intervention data, however, is not publicly available and only three internal BoC studies (all discussed below) have investigated the effects of intervention in the CAD/USD exchange rate market using the official BoC intervention data. A common feature of these existing BoC intervention studies is the exclusive focus on short-term (intraday or same-day) volatility effects, all within a time-series analysis context. Unlike these studies, this paper investigates direction, smoothing, as well as volatility effects of BoC intervention over several days surrounding the intervention events and it does not employ a time-series framework for doing so.

The analysis presented in this paper uses official, daily data on BoC intervention in the CAD/USD exchange rate market covering the 1 January 1995 to 30 September 1998 period. The data at hand contains unique information on whether intervention operations were discretionary or carried out in accordance with a mechanistic policy framework, thereby allowing for a comparison of effectiveness across the two different types of interventions.

Additionally, the paper takes into account the issue of currency co-movements. Eun and Lai (2004) point out that the issue of currency co-movements has not been given much attention by the academic literature. Not surprisingly, the issue has not been addressed in previous studies of intervention. Currency co-movements, however, are of particular potential importance to this study since the study focuses on the effects of unilateral intervention

conducted by a relatively small central bank aiming to manage a minor currency vis-à-vis a major currency. Therefore, the observed exchange rate movements might be driven by major currency factors rather than minor currency factors such as the unilateral intervention carried out by the smaller central bank.

Due to its non-public nature, only three other studies have examined the official BoC intervention data. The study by Murray, Zelmer, and McManus (1996) constitutes the only existing study that focuses on the daily effects of official BoC intervention. Their analysis was conducted shortly after the new intervention regime was adopted in April 1995 and covers the January 1992 to June 1996 period. They examine the impact of intervention on the (implied) volatility of the CAD/USD exchange rate and do not address issues pertaining to other criteria for effectiveness. They find that intervention did generally not succeed in dampening volatility except in a few cases towards the end of their sample when intervention was allegedly unexpected and unusually large-scale.

The other two papers investigating official BoC intervention data assess intraday effects of intervention. Beattie and Fillion (1999) provide a time-series analysis of the effects of intervention on the (implied) volatility of the CAD/USD exchange rate over the April 1995 to January 1998 period. They find that mechanistic intervention was widely anticipated by the market and had no impact on volatility, and some weaker evidence that discretionary intervention was unanticipated and associated with a short-term intraday decrease in volatility. D'Souza (2002) incorporates both intervention data and data on BoC transactions aimed at replenishing reserves in order to test market microstructure hypotheses. He finds that

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[1] See Dominguez and Frankel (1993), Edison (1993), Humpage (2003), and Sarno and Taylor (2001)

foreign exchange traders treat an intervention operation as any other customer order and suggests that, for intervention to be effective, central banks must be able to forecast overall net customer trades at the time of intervention. [2]

This study follows recent papers by Edison, Cashin and Liang (2003), Fatum (2000), Fatum and Hutchison (2003, 2006), Morel and Teiletche (2004), Pierdzioch and Stadtmann (2003) and others in employing an event study methodology for analyzing the effects of intervention on exchange rates.[3] Specifically, exchange rate movements over the 1 through 10 days surrounding clusters of intervention days are examined. Consistent with Fatum and Hutchison (2006), the effectiveness of intervention is assessed according to three different criteria for what may constitute effectiveness, thus this study is not confining the analysis to focusing on volatility effects.

The results of the analysis suggest that it cannot be rejected that BoC intervention is effective. Instead, evidence that intervention is systematically associated with changes in the direction of the CAD/USD exchange rate and with a smoothing of exchange rate movements in the days following an intervention event is presented. These effects are weakened (but do not disappear altogether) when adjusting for currency co-movements against the USD, suggesting that general market movements, not BoC intervention, are responsible for part of the observed exchange rate movements. Interestingly, the success-to-failure ratios associated

for surveys of the intervention literature.

[2] Rogers and Siklos (2003) use daily changes in the level of BoC reserves as a proxy for BoC intervention. Focusing on exchange rate volatility and kurtosis, they find that intervention had generally no effect. For an earlier study using proxy data, see Philips and Pippenger (1993).

[3] An event study is a very general test of a specific hypothesis and does not rely on a structural model of exchange rate determination. This is a desirable feature given the lack of consensus over what is the

with mechanistic events are very similar to those associated with discretionary events, suggesting that discretionary BoC interventions are not more effective than mechanistic BoC interventions. Consistent with Murray, Zelmer and McManus (1996), this study does not find significant effects on the volatility of the CAD/USD exchange rate. In particular, the results suggest that the BoC interventions did not succeed in reducing the (realized) CAD/USD exchange rate volatility.

The rest of the paper is organized as follows. The next section presents the data. Section 3 discusses the event-study methodology, the criteria for assessing effectiveness, and the issue of currency co-movement in the context of an intervention study. Section 4 presents the results and section 5 concludes the paper.

2. Data

This paper uses official daily BoC intervention data, provided by the BoC. The time-period under study, 2 January 1995 to 30 September 1998, spans over two distinctly different BoC intervention regimes. During the first of these regimes all BoC interventions were carried out as a mechanistic response (in terms of both timing and intervention volume) whenever the CAD/USD exchange rate breached a daily pre-set non-intervention band. This intervention regime ended on April 11, 1995. The second regime began on April 12, 1995 and lasted until the end of the sample period.[4] During this revised regime, interventions were either

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appropriate structural exchange rate model, but the drawback is that the particular channel of transmission (if intervention is effective) is not identified.

[4] The BoC has not intervened in the CAD/USD market since 17 September 1998, which is also the last intervention day in the sample under study.

mechanistic as before or carried out in a standard discretionary fashion in terms of both the timing and the intervention volume.[5]

Table 1 shows that during the full sample period, 2 January 1995 to 30 September 1998, the BoC intervened on a total of 151 days. The BoC intervened on 67 days in 1995, on 13 days in 1996, on 37 days in 1997, and on 34 days in 1998.[6] Using the mechanistic versus discretionary classification provided by the BoC, Table 1 shows that all the intervention days in 1995 were carried out in accordance with the mechanistic intervention framework while all intervention days in 1998 were carried out in accordance with the discretionary intervention framework. Additionally, the table provides an overview of the average intervention amounts separated into year, intervention classification and USD purchases or sales, respectively. It is shown that the average intervention amounts range from USD 51,000 (discretionary purchase of USD in 1998) to USD 274,788 (discretionary sales of USD in 1998).[7]

The analysis employs both daily and intraday data on the CAD/USD, DEM/USD, GBP/USD and JPY/USD exchange rates. The daily exchange rate data contains quotes recorded at noon (EST) obtained from the Board of Governors of the Federal Reserve. The intraday exchange rate data is purchased from Olsen and Associates and is utilized for

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[5] Chiu (2003), D'Souza (2002), and Murray, Zelmer, and McManus (1996) provide detailed descriptions of the institutional BoC intervention framework and of the two intervention regimes.

[6] A total of 40 intervention days occurred during the intervention program that ended on 11 April 1995.

[7] Since the intervention data set is not publicly available, the paper is not displaying or describing this data in great detail. Table 1 provides an overview of the BoC intervention data that conforms to what is shown in Beattie and Fillion (1999).

analyzing exchange rate volatilities. The intraday data provides the spot rate at the end of every 5-minute interval over a 24-hour period for each of the aforementioned exchange rates.[8]

3.   Methodology

The starting point for an event study is to define the event of interest and to identify the periods over which the security price is examined (the "event windows").[9] In this context, the event is defined as an episode of intervention days and the event windows are the pre- and post-event days during which the CAD/USD exchange rate movements are analyzed.

Specifically, an event is defined as a period of days with official intervention in the CAD/USD exchange rate in one direction (in terms of purchases or sales), interspaced by a fixed maximum number of consecutive business days of no intervention (the "tranquility" period that can be allowed for while still considering the surrounding days of intervention to be part of one and the same event). Given the structure of the daily intervention data at hand and to be consistent with Fatum (2000) and Fatum and Hutchison (2003, 2006), this study employs a "tranquility" period of 5 days for the baseline analysis (and vary this number in the robustness checks). Changes in the CAD/USD exchange rate are analyzed during pre- and post-event windows ranging in length from 1 to 10 business days.[10]

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[8] The bid and offer rates are provided for intervals where an actual trade takes place, while a representative quote is used for other periods. There is little time-variation in the bid-ask spreads and the analysis focuses the volatility analysis on the bid rates.

[9] See Fatum (2000) for a detailed description of the event study methodology applied to the analysis of daily data on foreign exchange market intervention.

[10] In order to limit the instances when pre- and post-event windows overlap, the window lengths are not expanded beyond 10 days. A small number of events, however, are interspaced such that an event in one direction (e.g. USD sales) is immediately followed by an event in the opposite direction (e.g. USD purchases), thereby leading to overlaps (regardless of the window length) as well as pre- and post-event windows "contaminated" by the preceding or succeeding event. In order to ensure that none

As noted by, for example, Dominguez (2003) there is no convention on what constitutes successful intervention. This study follows Fatum and Hutchison (2006) and applies three alternative criteria of success. The first criterion of success is simply whether the direction of the movement in the exchange rate over the post-event window is the same as the direction in which the BoC was intervening, e.g. does the value of the CAD relative to the USD increase after CAD are purchased? This measure of successfulness is referred to as the "direction" criterion and is formally expressed as follows: An event is a success if either

$$\{E_i > 0 \text{ and } \Delta s_{i+} > 0\} \text{ or } \{E_i < 0 \text{ and } \Delta s_{i+} < 0\}$$

where E_i is the total amount of central bank intervention (positive values represent purchases of USD, negative values represent sales of USD) during event i and Δs_{i+} is the CAD/USD exchange rate change (in %) during the associated post-event window.

The stated motivation for BoC intervention is to maintain orderly markets. It may be the case, therefore, that intervention operations are carried out for the purpose of smoothing exchange rate movements or reducing exchange rate volatility, rather than for affecting the direction of exchange rate movements. The next two criteria address this issue.

The second criterion defines a successful event as one where intervention is associated with a smoothing of the exchange rate movement. This criterion is formally expressed as follows: An event is a success according to the "smoothing" criterion if either

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of these occurrences impact the results, the analysis was redone after dropping these potentially

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{the event is a success according to the "direction" criterion} or

$\{E_i > 0 \text{ and } \Delta s_{i+} > \Delta s_{i-}\}$ or $\{E_i < 0 \text{ and } \Delta s_{i+} < \Delta s_{i-}\}$

where Δs_{i-} is the CAD/USD exchange rate change (in %) during the associated pre-event window.

The third criterion of success compares the (realized) variance of the CAD/USD exchange rate preceding and succeeding each event, respectively, and associates reduced volatility after relative to before the event with success. This criterion is formally expressed as follows: An event is a success according to the "volatility" criterion if

$$\{\sigma^2_{i+} < \sigma^2_{i-}\}$$

where σ^2_{i+} (σ^2_{i-}) denotes the realized post-event variance (pre-event variance) of the CAD/USD exchange rate. In order to get a sufficient amount of data points for the volatility measures to be meaningful and, in turn, facilitate the comparison of volatility patterns around each of the events, the 5-minute high-frequency exchange rate data is used for calculating the variance of the CAD/USD exchange rate over the 1 through 10 business days preceding and succeeding each event.

Two statistical tests are employed. The main test is the non-parametric sign test for the median. This test verifies whether the observed number of successes based on the "direction" (appreciation or depreciation), the "smoothing" (appreciation/smaller depreciation

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problematic events and the results were unchanged.

or depreciation/smaller appreciation), and the "volatility" (decreased or not) criteria are random or systematic.

With reference to the "direction" criterion for success, the null-hypothesis is that the probability of observing a positive value ("success") is the same as that of observing a negative value ("no-success"), hence the underlying probability parameter is 0.50. In other words, the random variable X (equal to the number of positive values or "successes") among n sample observations has a binomial distribution with $\mu = 0.50$. A significant sign test indicates that the observed number of successes is not a random finding attributable to the equal probability of appreciation or depreciation. For details on this test in event studies, see MacKinlay (1997).[11]

It should be noted that the BoC interventions are always leaning against the wind (e.g. the BoC purchases USD in response to a USD depreciation) thus the true probability of observing a reversal of the exchange rate movement around periods of intervention (under the assumption that intervention has no effect) is likely to be less than 0.5. Therefore, a probability parameter choice of 0.50 (0.75) when assessing effectiveness according to the "direction" ("smoothing") criterion constitutes a conservative parameter value that tends to bias the results towards not finding significant effects of intervention or, put differently, it literally raises the bar with respect to the number of successes necessary for rejecting randomness.

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[11] See Fatum (2000) for a discussion of the choice of probability parameters associated with the "direction" and the "smoothing" criteria for success and Fatum and Hutchison (2006) regarding the "volatility" criterion probability parameter.

In addition, the matched sample (difference-in-means) test is employed. The matched sample test is only associated with the "smoothing" criterion as it indicates, at the minimum, smaller post-event CAD depreciation or appreciation. Since this additional test confirms the results based on the sign test, only sign test results are reported for brevity.[12]

3.1   Currency Co-Movements

Eun and Lai (2004) document systematic co-movement patterns across several currencies, in particular vis-à-vis the USD and to a lesser extent vis-à-vis the EUR. They find evidence that currency co-movement is significantly driven by "the competitive influence" of major currencies on minor ones.[13] The issue of currency co-movement is of potential importance to the analysis of effectiveness of intervention, in particular when focusing on unilateral intervention conducted by a minor central bank and aimed at managing a minor currency vis-à-vis a major currency. To illustrate this point, suppose an appreciation of the CAD against the USD follows a BoC intervention event characterized by CAD purchases. The event will then appear effective according to the "direction" criterion described above. However, if the USD is depreciating against not just the CAD but against other currencies in general, there is little reason to believe that the USD depreciation should be ascribed to the unilateral BoC interventions.

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[12] See, for example, Ben-Horim and Levy (1984, p. 458) for details on the matched sample test and Fatum (2000) and Fatum and Hutchison (2003) for applications.

[13] As noted by Eun and Lai (2004), despite the vast research in co-movement of other asset prices such as bonds and stocks, the potentially highly important issue of currency co-movement has not been given much attention in the academic literature.

In order to make an attempt at addressing this concern, the analysis of effectiveness is carried out on a "filtered" CAD/USD exchange rate as well as on the readily observable or "raw" CAD/USD rate. The "filtered" exchange rate measure is calculated as the difference between the % change in the ("raw") CAD/USD rate and a weighted average of the % change in the GBP/USD, DEM/USD and JPY/USD exchange rates.[14,15]

4.   The Results of the Daily Data Event Study

Using the baseline event definition that allows for a maximum of 5 consecutive days of no intervention while still considering the surrounding intervention days to be part of one and the same event, 58 separate BoC intervention events are identified (27 of these events lasted for multiple days).

Table 2 provides details on these 58 events and the associated exchange rate movements over 2-day pre- and post-event windows. For each event, the table shows the event number and the direction of the intervention in terms of purchases or sales of USD. The final four columns provide details on the behavior of the CAD/USD in terms of average daily % change and volatility during the pre- and post-event windows. By comparing the direction of each intervention event (column 2) with the associated post-event exchange rate (column 4), success according to the "direction" criterion is assessed. Similarly, a comparison of the direction of each intervention event with the average daily % change in the CAD/USD before

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[14] As a robustness check, the weights used when calculating the "filtered" exchange rate are varied. The findings are very robust to this and only the results based on equal weights are reported.

[15] In a related study, Beine (2004) analyses US Fed, Bank of Japan and Bundesbank/ECB intervention and finds that coordinated intervention is associated with the time-varying conditional covariances between the major currencies.

(column 3) and after each event (column 4), respectively, addresses the issue of success according to the "smoothing" criterion. Finally, success according to the "volatility" criterion is assessed by comparing pre-event volatility (column 5) to post-event volatility (column 6).

Table 2 shows that the direction of the change in the exchange rate during the post-event window was consistent with the direction of the associated intervention in 28 events and, accordingly, inconsistent in 30 events, thus 28 of the 58 events were successful according to the "direction" criterion. Furthermore, 54 of the 58 events were successful according to the "smoothing" criterion. Comparing the 2-day pre-event volatility to the 2-day post-event volatility, it follows that 26 events were associated with decreased post-event volatility, while 32 events were associated with increased post-event volatility.

4.1   Direction Results

Figure 1 displays the results from the sign test based on the "direction" criterion with the underlying probability parameter of 0.50 across all window lengths (1 through 10 business days). The sign test result that follows from the aforementioned 2-day post-event windows is captured by the second bar displayed in Figure 1.

For all figures 1(a)-1(f), the horizontal line shows the number of successes necessary for rejecting a random outcome at the 95 % significance level.[16] Figure 1(a) summarizes the findings based on all 58 events for the "raw" CAD/USD exchange rate, while figure 1(d) summarizes the findings based on the same 58 events for the "filtered" CAD/USD rate that

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[16] For ease of exposition, only the horizontal bar associated with the 95 % significance level is shown. Given the limited number of events, effectiveness assessed according to the 90 % significance level instead does not increase the described support for effectiveness dramatically.

controls for currency co-movements against the USD. Figure 1(a) shows evidence in support of effectiveness at window lengths of 3 through 7 days and again at 9 days, as the associated bars reach (or exceed) the horizontal line (at 36 successes out of 58). Figure 1(d) shows evidence in support of effectiveness at window lengths of 3, 4 and 8 days. Interestingly, adjusting for the co-movements of major currencies against the USD weakens the results in support of effectiveness, yet the null hypothesis that the observed number of successes is random cannot be accepted (separately) across all window lengths.

As pointed out earlier, the sample period under study is of particular interest as it comprises two intervention regimes, the first characterized by mechanistic intervention (until mid-April 1995) and the second characterized by both mechanistic and discretionary intervention (from mid-April 1995 and onwards).

In order to investigate whether mechanistic and discretionary intervention events affect the market differently, the analysis is redone separately on the sub-sample of events associated with mechanistic intervention and on the sub-sample of events associated with discretionary intervention.[17] Due to the nature of the daily data analysis of this paper only relatively few events (58) are identified. The analysis of separate sub-samples of mechanistic and discretionary events relies on even fewer events (and this is a particular concern when analyzing the sub-sample of only 15 discretionary events), of course, thus precluding any strong conclusions regarding whether different intervention regimes are associated with different effects on exchange rates.

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[17] Two events contain both mechanistic and discretionary intervention transactions and these are classified as discretionary for convenience. Alternatively, dropping these "mixed" events from the analysis does not affect the results.

Figures 1(b) and 1(e) show the results of the analysis of the 43 mechanistic intervention events using the "raw" and the "filtered" CAD/USD exchange rate, respectively. Based on the "raw" CAD/USD rate, 5 of the bars displayed in figure 3(b) reach (or exceed) the horizontal line (at 28 successes out of 43) suggesting that intervention is systematically associated with success according to the "direction" criterion. Focusing instead on figure 1(e) and the "filtered" rate, significance at the 95 % level is only found at the 4-day window length.

Turning to the analysis of the 15 discretionary events, figures 1(c) and 1(f) show that none of the bars reach the horizontal line (at 12 successes out of 15), thus there is no significant evidence in support of effectiveness when analyzing discretionary intervention events. It is noteworthy, however, that 67% or more of the discretionary events are successful at window lengths of 4 and 5 days and at window lengths of 3 through 10 days, respectively, thus the success-to-failure ratio is very similar to what is the case for the mechanistic events. Therefore, the seemingly surprising and counterintuitive finding when comparing the effects of mechanistic versus discretionary intervention events should be taken with much caution due to the much smaller number of discretionary events and the associated lower degrees of freedom of the sign test.

4.2   Smoothing Results

Figure 2 displays the results based on the "smoothing" criterion where the sign test is based on an underlying probability parameter of 0.75 across all window lengths. Figures 2(a) and 2(d) summarize the findings based on all 58 events for the "raw" and the "filtered" CAD/USD rate, respectively. Figure 2(a) shows that the observed number of successes is

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statistically significant at the 95 % level (at 50 or more successes out of 58) for window lengths of 1, 2 3, 6, and 9 days. When analyzing the "filtered" rate, the observed number of successes is not significant at any window length, further suggesting that currency co-movements against the USD matter.

Figures 2(b) and 2(e) display the results based on the 43 mechanistic events, while figures 2(c) and 2(f) display the results based on the 15 discretionary events. The sub-sample results are similar to those based on the full sample, showing some support for success according to "smoothing" when using the "raw" CAD/USD rate while no support for success is found when using the "filtered" CAD/USD rate.

4.3   Volatility Results

Figure 3 displays the results based on the comparison of pre-event versus post-event volatility for window lengths ranging from 1 to 10 days. In this context, the sign test results indicate whether the observed number of events associated with decreased CAD/USD volatility appears random or systematically associated with intervention events. Since the test has an underlying probability parameter of 0.50, the horizontal 95 % significance bars for all figures 3(a)-3(f) are (pair wise) identical to the significance bars for the sign test results based on the "direction" criterion as displayed in figures 1(a)-1(f).

Figures 3(a) through 3(f) all show that the number of events associated with decreased post-event volatility is too small to question randomness, implying that volatility patterns within the 10 days around the described events are not systematically affected by intervention. In particular, none of the bars displayed in these figures reaches the 95% significance line, regardless of window length and regardless of whether the analysis is

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carried out separately on mechanistic or separately on discretionary intervention events. As shown in figures 3(d)-3(f), netting out the impact of currency co-movements against the USD does not change this conclusion. This clear rejection of any impact of intervention on volatility is especially interesting considering that a primary objective of BoC intervention was to maintain an orderly market for the CAD/USD by smoothing the movements or dampening the volatility of the exchange rate.

Given that the observed number of events associated with decreased post-event volatility is consistently smaller than the number of events associated with increased post-event volatility across all window lengths and, furthermore, some studies find that intervention is systematically associated with increased volatility (see Beine, Laurent and Lecourt, 2003, and Humpage, 2003, for recent discussions), the possibility that BoC intervention leads to increased CAD/USD volatility needs to be addressed as well (results not shown for brevity).

Only when analyzing the full sample and the "raw" CAD/USD rate, however, is there some evidence in support of increased volatility, and only for window lengths of 1 and 5 days. For all other window lengths, the results support acceptance of the null hypothesis that the observed number of events associated with increased post-event volatility is random. When the CAD/USD rate is adjusted for currency co-movements against the USD, the findings only reject the null hypothesis at the 1-day window length. Additionally, when analyzing the sub-samples of mechanistic and discretionary intervention events separately, the existence of a systematic link between intervention and increased volatility for all window lengths except one is strongly rejected.

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In sum, these findings confirm that the observed volatility patterns do not appear to be systematically affected by intervention.

4.4 Monetary Policy Changes and Intervention by Other Central Banks

As mentioned by Fatum and Hutchison (2006) and others, the event-study methodology assumes that intervention defines the event and is not systematically related to other relevant economic news such as monetary policy changes or USD intervention by other central banks. In principle, this is a concern in all event studies but it is of particular concern in this context where several intervention events last for several days.

In order to address this concern, the analysis described in sections 4.1 through 4.3 is redone on sub-samples of events that do not occur on days coinciding with monetary policy changes in either Canada or the United States.[18] Although the power of the tests is reduced due to the smaller number of events, the daily data results described in sections 4.1 through 4.3 are robust to the exclusion of these 13 events.

Intervention in the DEM/USD or the JPY/USD by other major central banks coincides with 4 days of BoC intervention. Dropping the associated 4 events from the analysis does not impact the results.

As a methodological robustness check, the baseline event definition is changed and, again, the analysis described in sections 4.1 through 4.3 redone. Specifically, an event is redefined as a period of days with intervention in one direction, interspaced by at most 3

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[18] Table 3 shows there are only 13 days in the sample where BoC intervention coincided with a change in the target for the Canadian overnight interest rate. No intervention day coincided with a change in US monetary policy.

(instead of 5) consecutive days of no intervention. Use of this slightly altered event definition affects only 5 events and does not change the results.

5.   Conclusion

This paper investigates the daily effects of sterilized intervention in the CAD/USD exchange rate from 1995 to 1998 using official BoC intervention data. Within the context of an event study framework, the paper introduces the issue of currency co-movements to the intervention literature. Specifically, the analysis is carried out using the readily observable or "raw" CAD/USD exchange rate as well as using the "filtered" currency co-movement adjusted CAD/USD exchange rate.

The findings suggest that BoC intervention was systematically associated with both a change in the direction and a smoothing of the CAD/USD exchange rate. In particular, the "raw" CAD/USD rate moved in a direction consistent with the preceding intervention event over periods of 3 to 9 business days following the event while intervention was associated with exchange rate smoothing over periods of 1 to 3 business days around the event.

The described findings are weakened (but do not disappear altogether) when adjusting for currency co-movements against the USD. This suggests that general market movements are responsible for part of the observed exchange rate movements and, furthermore, that controlling for currency co-movements might be of importance when assessing the effectiveness of intervention.

Although the small number of discretionary events precludes the analysis from reaching strong conclusions when comparing effectiveness of BoC intervention across sub-samples of mechanistic and discretionary events, it is noted that the success-to-failure ratios

associated with mechanistic events are very similar to those associated with discretionary events. This suggests that discretionary BoC interventions are not more effective than mechanistic BoC interventions.

When focusing on the volatility of the CAD/USD exchange rate, the analysis does not find any significant effects of BoC intervention. This is the case regardless of whether the volatility effectiveness criterion is associated with a reduction or an increase in volatility.

In sum, the presented findings show that BoC intervention appears moderately effective in moving the CAD/USD exchange rate over a number of days following the intervention events while it appears ineffective in reducing exchange rate volatility.

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Table 1   Bank of Canada Intervention, Jan 1995 to Sep 1998[a]

	Number of Intervention Days: All	Number of Intervention Days: Sell USD	Number of intervention Days: Buy USD	Average Daily Absolute Amount (in USD): Buy USD	Average Daily Absolute Amount (in USD): Sell USD
Year: 1995	67				
Mechanistic	67	26	41	213,692	126,032
Discretionary	0	0	0	0	0
Year: 1996	13				
Mechanistic	9	5	4	109,000	56,250
Discretionary	4	4	0	174,000	0
Year: 1997	37				
Mechanistic	17	10	7	213,850	237,857
Discretionary	20	20	0	159,355	0
Year: 1998	34				
Mechanistic	0	0	0	0	0
Discretionary	34	33	1	274,788	51,000

a) Official Bank of Canada intervention data as well as the classification of intervention carried out in accordance with either the mechanistic or the discretionary intervention framework provided by the Bank of Canada.

Table 2 (part 1)   Intervention Events, Jan 1995 to Sep 1998

(1) Event	(2) Direction: Purchase (P) or Sale (S) of USD	(3) Avg. daily % change in CAD/USD over preceding 2 days (a)	(4) Avg. daily % change in CAD/USD over subsequent 2 days (a)	(5) Volatility in CAD/UAD over preceding 2 days (b)	(6) Volatility in CAD/USD over subsequent 2 days (b)
1	S	0.1956	-0.3181	0.000061	0.000140
2	P	-0.3181	-0.1254	0.000199	0.000247
3	S	0.3723	-0.2143	0.000202	0.000083
4	P	-0.2143	0.0000	0.000162	0.000306
5	S	0.0000	-0.2937	0.000294	0.000369
6	P	-0.3230	0.2788	0.000308	0.000105
7	S	0.0705	-0.5635	0.000258	0.000055
8	P	-0.2023	-0.0918	0.000055	0.000267
9	P	-0.3877	0.1399	0.000232	0.000081
10	S	0.2649	0.0110	0.000103	0.000219
11	P	-0.2620	0.2174	0.000224	0.000148
12	P	-0.2310	0.1365	0.000167	0.000274
13	S	0.1876	-0.1143	0.000274	0.000196
14	S	0.3176	-0.4606	0.000029	0.000254
15	P	-0.4606	-0.0294	0.000247	0.000226
16	P	-0.4606	-0.1196	0.000220	0.000262
17	S	0.1601	-0.2127	0.000054	0.000257
18	P	-0.1860	0.2621	0.000223	0.000260
19	S	0.4037	-0.0732	0.000232	0.000448
20	P	-0.1468	0.3219	0.000166	0.000248
21	S	0.4158	-0.1106	0.000242	0.000337
22	S	0.3562	0.0653	0.000272	0.000242
23	P	-0.5507	-0.0699	0.000265	0.000218
24	P	-0.1031	-0.1329	0.000142	0.000276
25	S	0.2107	-0.1706	0.000231	0.000088
26	P	-0.4134	0.2113	0.000264	0.000243
27	S	0.2212	0.1122	0.000275	0.000276
28	S	0.1469	0.0330	0.000233	0.000238
29	S	0.0219	-0.0036	0.000216	0.000264
30	S	0.2668	0.0438	0.000210	0.000101
31	P	-0.1426	-0.0073	0.000244	0.000192
32	P	-0.0675	-0.0300	0.000121	0.000245
33	S	0.1744	-0.0958	0.000162	0.000087

Table 2 (part 2)   Intervention Events, Jan 1995 to Sep 1998

(1) Event	(2) Direction: Purchase (P) or Sale (S) of USD	(3) Avg. daily % change in CAD/USD over preceding 2 days (a)	(4) Avg. daily % change in CAD/USD over subsequent 2 days (a)	(5) Volatility in CAD/USD over preceding 2 days (b)	(6) Volatility in CAD/USD over subsequent 2 days (b)
34	P	-0.6338	-0.0821	0.000196	0.000305
35	S	0.1193	0.0967	0.000269	0.000198
36	S	0.1355	0.0365	0.000260	0.000259
37	S	0.2227	0.3481	0.000114	0.000268
38	S	0.0792	0.0108	0.000240	0.000178
39	P	-0.3022	-0.2969	0.000196	0.000190
40	P	-0.2574	-0.1202	0.000210	0.000320
41	S	0.2604	-0.0217	0.000155	0.000276
42	S	0.2890	0.0793	0.000242	0.000065
43	S	0.1009	-0.4813	0.000234	0.000413
44	S	0.1720	0.0143	0.000192	0.000199
45	S	0.3076	-0.0355	0.000083	0.000190
46	S	0.3193	-0.0178	0.000240	0.000086
47	S	0.1228	-0.2292	0.000255	0.000210
48	S	0.0597	-0.3849	0.000183	0.000230
49	S	0.1922	0.0245	0.000194	0.000267
50	P	-0.1473	0.3725	0.000267	0.000037
51	S	0.0243	-0.1723	0.000215	0.000097
52	S	0.2584	0.2605	0.000117	0.000239
53	S	0.3911	0.2068	0.000231	0.000230
54	S	0.1821	0.0240	0.000122	0.000207
55	S	0.2624	0.0782	0.000214	0.000185
56	S	0.2154	0.1176	0.000179	0.000219
57	S	0.2415	-1.1700	0.000243	0.000711
58	S	-0.4189	0.0393	0.000414	0.000352

a) Average daily % change in the daily CAD/USD over the two business days prior to (after) first (last) day of the event.
b) Volatility of the % change in the high-frequency CAD/USD over the two business days prior to (after) the first (last) day of the event.

Table 3:   Intervention and Bank of Canada Monetary Policy Changes[a]

Date	Direction: Purchase (P) or Sale (S) of USD	Change in overnight rate target	Overnight rate target after change
10-Jan-95	S	0.50	6.00
12-Jan-95	S	0.50	6.50
17-Jan-95	S	0.50	7.00
16-Feb-95	S	0.50	8.00
10-Jul-95	P	-0.25	6.75
28-Aug-95	P	-0.25	6.25
31-Oct-95	P	-0.25	6.00
25-Jan-96	S	-0.25	5.50
18-Apr-96	S	-0.25	4.75
12-Dec-97	S	0.50	4.25
30-Jan-98	S	0.50	4.75
27-Aug-98	S	1.00	5.75

a) No intervention day coincided with a change in US monetary policy.

Figure 1:   Success of Intervention Based on the "Direction" Criterion

This figure displays the results of the sign test based on the "direction" criterion with the underlying probability parameter of 0.50. Each column represents the number of successes based on a different window length, ranging from 1 to 10 business days. For all figures, the horizontal line shows the number of successes necessary for rejecting randomness at the 95 % significance level.
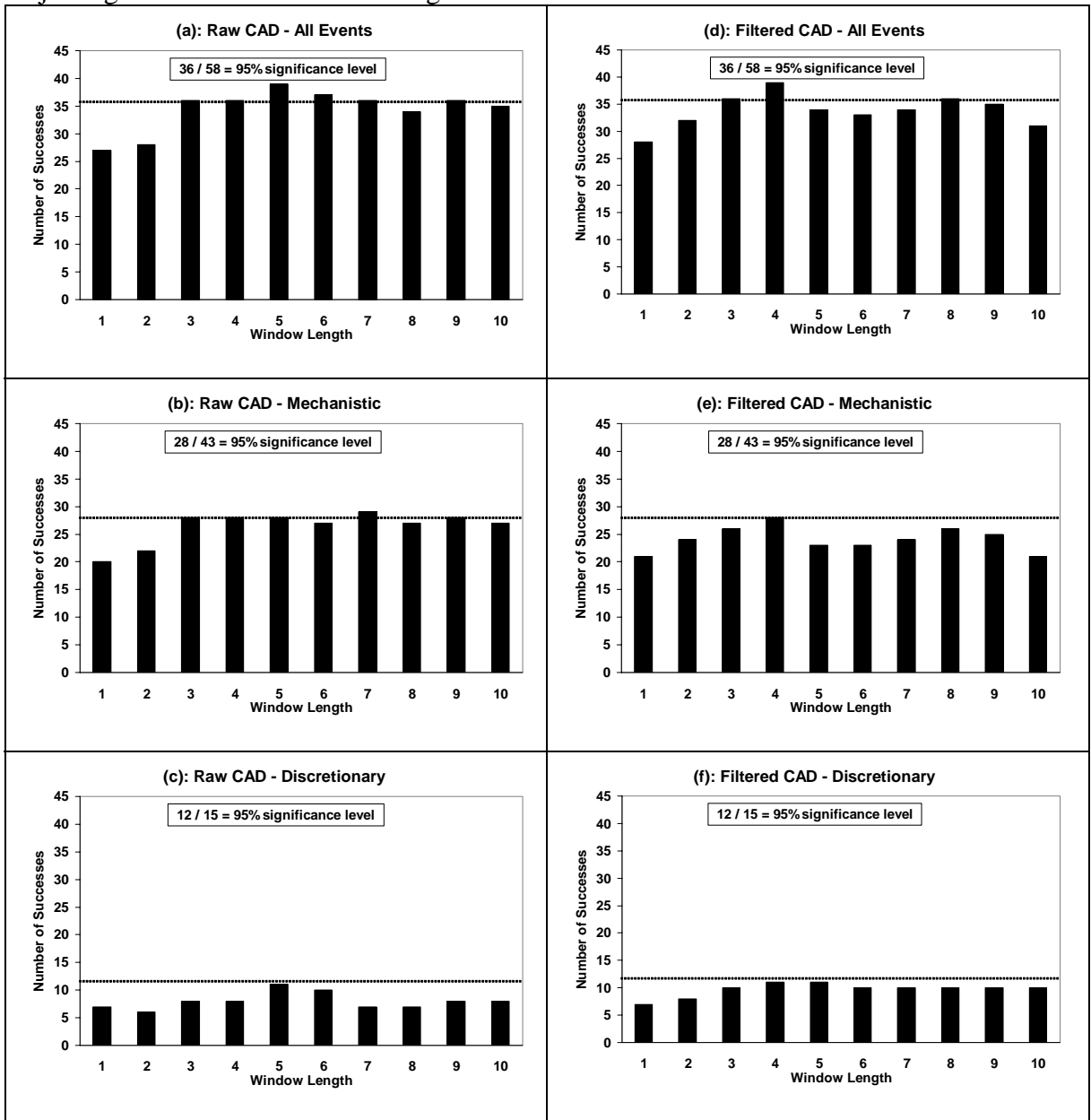
Figure 2:   Success of Intervention Based on the "Smoothing" Criterion

This figure displays the results of the sign test based on the "smoothing" criterion with the underlying probability parameter of 0.75. Each column represents the number of successes based on a different window length, ranging from 1 to 10 business days. For all figures, the horizontal line shows the number of successes necessary for rejecting randomness at the 95 % significance level.
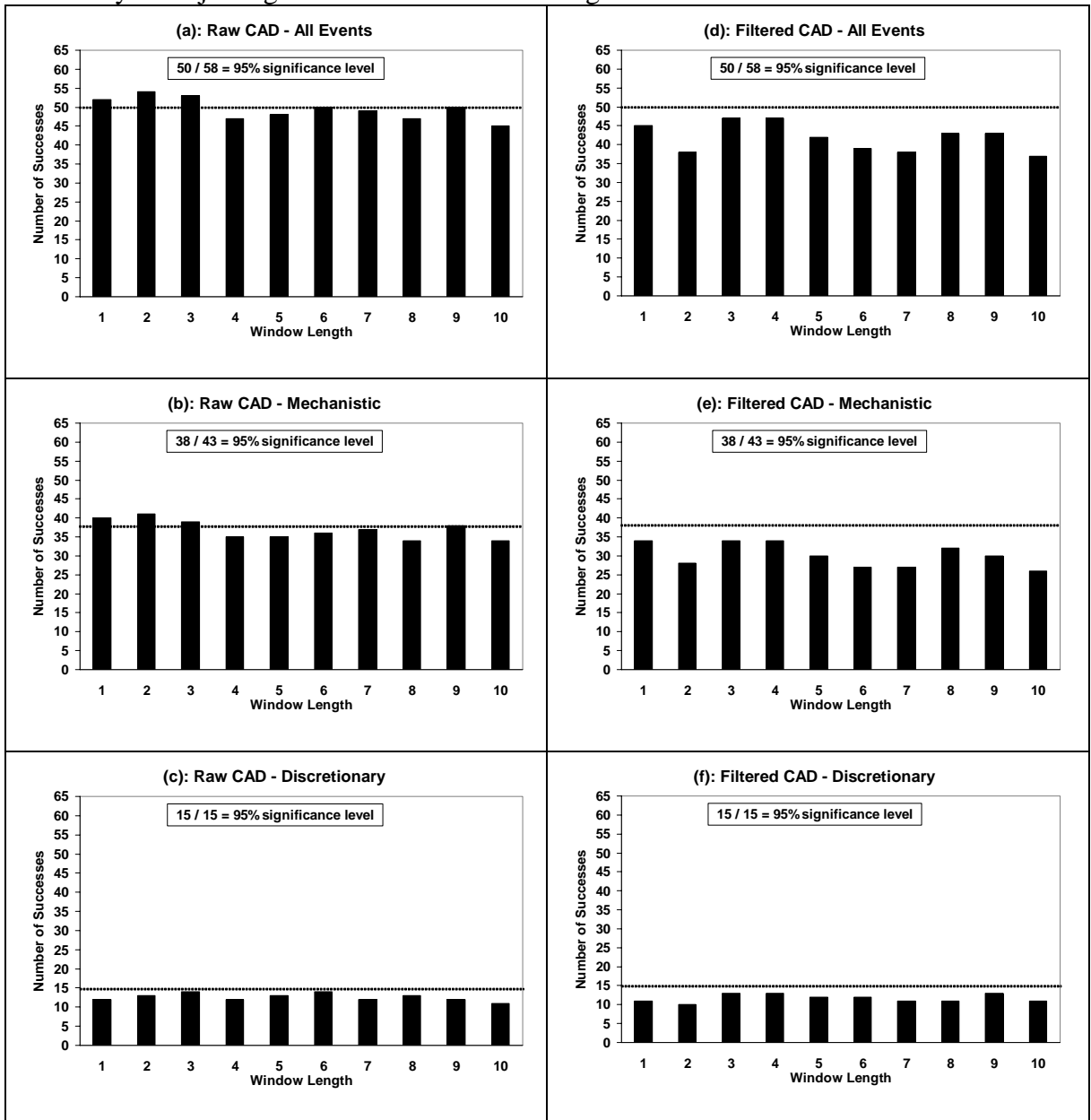
Figure 3:   Success of Intervention Based on the "Volatility" Criterion

This figure displays the results for the sign test based on the "volatility" criterion with the underlying probability parameter of 0.50. Each column represents the number of successes based on a different window length, ranging from 1 to 10 business days. For all figures, the horizontal line shows the number of successes necessary for rejecting randomness at the 95 % significance level.