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Starting from a blank page? Semantic similarity in central bank communication and market volatility

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Abstract

Press releases announcing and explaining monetary policy decisions play a critical role in the communication strategy of central banks. Due to their market-moving potential, it is particularly important how they are drafted. Often, central banks start from the previous statement, and update the earlier text at the margin. This makes it straightforward to compare statements and see how the central bank's thinking has evolved; however, more substantial changes, which will eventually be required, might then be harder to understand. Using variation in the drafting process at the Bank of Canada, this paper studies the extent to which similarity in central bank statements matters for the reception of their content in financial markets. It shows that similar press releases generate less market volatility, but that more substantial textual changes after a sequence of very similar statements lead to much larger volatility.

JEL Codes: E43, E52, E58.
Keywords: central bank communication, Bank of Canada, semantic similarity, volatility, ARCH models.

Non-technical summary

Central bank statements that announce and explain monetary policy decisions are closely watched by financial market participants, and have been shown to be important market-movers. In the light of this, central banks put a lot of effort into the drafting of such statements. Often, central banks use the previous statement as their starting point, and modify the text wherever needed. While such an approach has the obvious advantage that new information is easy to grasp, there might also be downsides to such a practice. As the economy evolves, the central bank might be faced with a choice to either keep a similar wording (which might constrain what and how the central bank can communicate) or to update the wording more fundamentally (at which point the new content might be even harder to assess for central bank watchers who are expecting only marginal changes). Not surprisingly, therefore, different approaches have been followed by different central banks, but also over time.

This paper studies to what extent the similarity of central bank statements matters for their reception in financial markets. If, indeed, the information content of similar statements is easier to grasp, there should be less disagreement among central bank watchers about their interpretation and market prices should adjust quickly to their new fundamental value. In contrast, statements that are harder to interpret should imply that prices take longer to adjust. In the context of our analysis, this translates into testing whether the similarity of press releases affects volatility in financial markets, once we have controlled for the content of the communication, the surprise component contained in the monetary policy decision and the degree of uncertainty in financial markets.

We focus on the responsiveness of 1-year government bond yields to 110 Bank of Canada press releases over the time period from 2001 to 2015, but show that our results hold across a large number of financial markets, covering short- to long-term interest rates, exchange rates and stock markets. The key findings are as follows: First, in line with the existing literature, we show that particularly the forward-looking part of communications matters for financial markets. Second, in terms of content, statements about the domestic economy appear to be the most relevant. Third, similarity matters for the reception of the central bank's communication in financial markets. Controlling *inter alia* for the content of communications, we find that less similar press releases are associated with larger volatility, suggesting that market participants find it more difficult to assess their content. This seems to favor a communication approach whereby central banks start from the previous press release rather than from a blank page. However, we also provide evidence that the reaction of market volatility to press releases depends on the content of the previous press releases – volatility increases substantially more if dissimilar press releases follow a sequence of very similar press releases. Our interpretation of this result is that while similar press releases are easier to digest, this comes at a cost when at some point the wording gets adjusted more fundamentally. At that point in time, markets might find it harder to interpret the new wording, having been used to marginal updates of earlier press releases, and presumably expecting another similar press release.

We therefore conclude that both starting from the previous press releases and starting from a blank page are viable communication strategies. While similar press releases appear to be easier to interpret in the short run, this is not necessarily the case over a longer horizon. It is important to stress that other factors need to be considered when choosing a communication strategy. For instance, central banks need to take into account whether similar press releases impose a constraint on what the central bank can communicate. We leave this issue for future research.

1. Introduction

Central bank press releases that announce and explain monetary policy decisions are closely watched by financial market participants and have been shown to be important market movers (for an overview of the relevant literature, see Blinder et al. 2008). When drafting these press releases, central banks often use the previous one as their starting point, modifying the text incrementally so that the new press release is semantically similar to the previous one. This practice has shaped how financial newswire services report about them: Prior to the release, they often re-report key phrases of the previous press release to remind market participants of the starting point. Subsequently, within a minute or two after the release, services like Bloomberg publish side-by-side comparisons that highlight the changes and allow for a direct comparison of the text.

Using the previous press release as the starting point has the obvious advantage of making new content easy to identify and interpret. Market participants know exactly what to look for in new releases or have access to financial newswire services that provide them relevant cues. At the same time, there might also be downsides. Central bank watchers learn to expect only marginal changes, making more substantive revisions to the text surprising and possibly harder to assess. The central bank might face a situation where it wants to update content of the press release more fundamentally but feels obligated to produce a press release similar to the previous one. Not surprisingly, therefore, different approaches have been followed not only by different central banks but also by the same central bank over time. Bank of Canada Governor Stephen S. Poloz, for instance, announced that he prefers starting each press release from a blank page, changing the previous practice where certain parts of the statements were only marginally changed over time.[1]

This paper studies the impact of the similarity of press releases announcing central bank monetary policy decisions on financial markets. If similar statements are easy for markets to digest, prices should adjust quickly because market participants find it easier to agree about their new fundamental values. In the context of our analysis, this translates into testing whether the similarity of press releases affects volatility in financial markets after we control for the surprise component contained in the monetary policy decision itself, the tone of the press release, and uncertainty in financial markets.

The paper uses the Bank of Canada as its testing case for two reasons. First, unlike most other advanced-economy central banks, the Bank of Canada was mainly using conventional monetary policy in the aftermath of the global financial crisis (the only exception being a short period where it employed forward guidance). Accordingly, the content of its monetary policy communications has been relatively stable over a long time period: Our sample covers 110 press releases from November 2001 to July 2015. Second, while the monetary policy tools and the content of the press releases remained relatively stable over time, the drafting of the press releases has undergone substantial changes. For some time, certain parts of each press release were virtually identical to the previous one, with minor changes made to reflect new developments. More recently, the press releases have become less similar, reflecting the current governor's preference for starting from a blank page. The Bank of Canada's communications do therefore provide an ideal testing ground for our hypotheses, as they contain useful variation in the drafting while keeping the content relatively stable.

[1] Comment made during the press conference on 17 July 2013; see also http://blogs.wsj.com/canadarealtime/2014/03/05/poloz-brings-change-to-the-bank-and-its-statements/.

We focus on the responsiveness of 1-year government bond yields to monetary policy press releases but we extend our results to a range of financial markets including short- to long-term interest rates, stock markets and exchange rates. The key findings are as follows: First, in line with the existing literature, we show that the forward-looking part of communications matters more to financial markets than the backward-looking part. Second, in terms of topic, content about the domestic economy appears to be the most relevant. Third, semantic similarity matters for the reception of the central bank's communication in financial markets.

Controlling *inter alia* for the content of communications, we find that more similar press releases are associated with lower volatility, suggesting that market participants find it easier to assess their content. This seems to favor a communication approach in which central banks start from the previous press release rather than from a blank page. However, we also provide evidence that market volatility depends on the similarity of previous press releases. Volatility is substantially larger when a dissimilar press release follows a sequence of very similar press releases. Our interpretation of this result is that while similar press releases are generally easier for markets to digest, they lull markets into expectations of similarity so that at some point when the wording needs to be adjusted more fundamentally, markets find it harder to interpret the new wording, having become accustomed to receiving only marginal updates of earlier press releases.

We therefore conclude that both starting from the previous press releases and starting from a blank page are viable communication strategies. While similar press releases appear to be easier to interpret in the short run, this is not necessarily the case over a longer horizon. When choosing a communication strategy, central banks need to take other considerations into account, such as whether similar press releases impose a constraint on what the central bank can communicate, an issue that is beyond the scope of this paper.

The remainder of this paper is organized as follows. A review of the most relevant related literature is provided in section 2. The third section discusses the data and methodology used in the analysis. Section 4 provides some insights into the content of the Bank of Canada press releases and its evolution over time, and section 5 presents the empirical findings and reports the results of robustness tests. A discussion of the conclusions and implications follows in section 6.

2. Related Literature

This paper relates to the extensive literature on the effect of macroeconomic announcements on asset prices. Early contributions have studied the release of macroeconomic data and have documented the responsiveness of stock prices (McQueen and Roley 1993), money and bond markets (Fleming and Remolona 1999; Thornton 1998), and exchange rates (Andersen et al. 2003; Faust et al. 2007). This early evidence has been refined in subsequent work in various ways, in particular with regard to identifying which data releases are most important and why (see, e.g., Gilbert et al. 2016).

A related literature (surveyed in Blinder et al. 2008) has focused on news releases by central banks and how they are received in financial markets. Central bank communications have been found to be among the most important market movers, not only for interest rates (Guthrie and Wright 2000; Kohn and Sack 2004; Andersson et al. 2006; Ehrmann and Fratzscher 2007a) but also for exchange rates via the regular monetary policy communications (Sager and Taylor 2004; Melvin et al. 2009; Conrad

and Lamla 2010) as well as through communications about the exchange rate, i.e., via "oral exchange rate interventions" (Jansen and de Haan 2005; Fratzscher 2006; Dewachter et al. 2014).

Among the many types of communications by central banks, those on behalf of the entire policy-making committee are particularly strong market movers (Reinhart and Sack 2006; Reeves and Sawicki 2007). The most important component of central bank communication on behalf of the entire committee is clearly the announcement of policy decisions and the surrounding communication. Gürkaynak et al. (2005) show that both monetary policy actions and statements by the Federal Reserve have important but differing effects on asset prices, with statements having a much greater impact on longer-term Treasury yields, a finding that is confirmed by Brand et al. (2010) for the European Central Bank (ECB).

A few papers have studied Bank of Canada communications in particular. Macklem (2005) provides an overview of how the Bank of Canada has become more transparent over time, in line with the overall trend among central banks. Hendry (2012) shows how the Bank of Canada's press releases on its fixed announcement dates (i.e., when it announces its monetary policy decisions) affect volatility in short-term interest rates. Hayo and Neuenkirch (2012a) use a GARCH model—as we do here—to study the effects of central bank communication and macroeconomic news on Canadian bond, stock and foreign exchange market returns and their volatility. They show that communication by the Bank of Canada is more relevant than communication by the U.S. Federal Reserve, whereas U.S. macro news exerts larger effects than Canadian news—findings that are in line with the earlier results reported in Gravelle and Moessner (2002). Hayo and Neuenkirch (2012b) differentiate between the original communication by the Bank of Canada and newswire reports, showing that bond markets react more to the original communication, while newswire reports are more relevant for the stock market. Finally, Fay and Gravelle (2010) show that, with the inclusion of forward-looking statements about monetary policy in the Bank's press releases, markets focus less on the discussion of the economic outlook and therefore respond less than before to new macroeconomic data releases.

The focus of our current paper is the similarity of central bank statements, an area covered by very few earlier papers. Jansen and de Haan (2010) test the extent to which ECB communication has used consistent language over time and find consistency overall, even though the ECB's communication has been flexible enough to adapt to changing circumstances. Acosta and Meade (2015) study the similarity of subsequent FOMC post-meeting statements and demonstrate that these have become substantially more similar over time and especially so since the global financial crisis. However, they also show that it is important to measure the semantic content of the statements appropriately, since their semantic content is less similar and more variable than what a comparison of the raw language would suggest. Interestingly, while FOMC statements have become more similar since the crisis, they have also become more complex, as shown by Hernández-Murillo and Shell (2014). This is important because more complex statements are associated with higher volatility in financial markets, a point that is demonstrated by Jansen (2011) for the Humphrey-Hawkins testimonies by the Chairperson of the FOMC.[2] A closely related paper is Amaya and Filbien (2015), which looks at the case of the ECB

[2] For international comparisons of the complexity of central bank communication and their determinants, see Bulíř et al. (2013a) and Bulíř et al. (2013b).

and finds that similarity has been increasing over time, helping stock markets digest the information more easily.

A common theme across all papers in the central bank communication literature is the preparation of the raw text for econometric analysis. In the current paper, we need to explore this in two ways. First, we measure the content and the tone of the communication, as these will be important control variables; second, we measure the similarity of two subsequent press releases. With regard to the first dimension—the measurement of the tone and the content of central bank communications—there are mainly two different approaches in the previous literature. On the one hand, several studies have used human coding, arguing that automated language processing is not suitable to pick up subtle nuances in language—especially given the complex language often used by central banks (Ehrmann and Fratzscher 2007a; Conrad and Lamla 2010; Neuenkirch 2013). On the other hand, a number of recent papers have used automated procedures, highlighting in particular that this approach guarantees consistency and replicability of results, as well as less subjectivity (Lucca and Trebbi 2009; Hansen and McMahon 2015; Schmeling and Wagner 2016). In this paper, we position ourselves in the middle of this debate. We use human coding to measure the tone and content of communication and also because we are interested in differentiating forward-looking from backward-looking statements, which, to our knowledge, has not yet been done in an automated fashion. At the same time, we apply an automated approach to measure the similarity of consecutive press releases and to their (human-coded) subcategories. In doing so, we follow the approach of Acosta and Meade (2015), which lends itself naturally to automation.

3. Data and Empirical Methodology

In this section, we outline our estimation methodology and the data we use for our empirical analysis.

3.1 Data

Measuring the tone of the press releases

With regard to the Bank of Canada's communications, we focus on the press releases that accompany the announcement of interest rate decisions. As discussed previously, these arguably constitute the most important piece of monetary policy communication on behalf of the entire policy-making committee. There are eight such releases each year. Currently, for four of them, the Bank of Canada simultaneously releases its *Monetary Policy Report* (MPR), and the Governor and Senior Deputy Governor subsequently hold a press conference. It is important to note, however, that until the end of 2012 (i.e., for the largest part of our sample period), the MPR was released on a different date than the press release. For simplicity, we will therefore abstract from the content of the MPR and accompanying press conference in our analysis and focus exclusively on the press release. We will, however, test to what extent the release of the MPR influences the effect of press releases. We also abstract from other Bank of Canada communications, such as

speeches, since these do not occur on the same day or even in the week before the press release, given that the Bank adheres to a blackout period.[3]

As mentioned above, we rely on human coding to measure the tone of the press releases. In a nutshell, we break a press release into blocks of words, code the tone of these and then aggregate the blocks of words into an overall indicator.[4] This procedure involves four steps.

In step 1, we categorize blocks of words in each press release into one of the following four topics, which were included in the press releases in a relatively consistent manner throughout the sample period: domestic economy, the global economy, inflation and foreign exchange. If required, we split sentences into different parts to reflect that these belong to a different category. Following are a few examples (for a more comprehensive list, please refer to Table A1 in the appendix): A statement about the domestic economy would be "The Canadian economy continued to expand in the first quarter of 2003, reflecting firmness in domestic demand." A statement about the global economy is "Strong growth in the United States is expected to resume in the second quarter of 2015." One on inflation is "Canadian consumer price data for January show core inflation at 1.8 per cent and total CPI inflation at 1.3 per cent," and a statement related to the exchange rate is "The Canadian dollar has traded in a higher range against the U.S. dollar and other major currencies."

In step 2, we differentiate the blocks of words into statements that talk about the past, i.e., provide a backward-looking assessment of the state of the economy or of monetary policy, and statements that talk about the future, i.e., provide a forward-looking assessment. The global economy statement above is an example for a forward-looking statement ("is expected to resume"); the domestic economy statement is a backward-looking statement ("continued to expand").

In step 3, we further differentiate the blocks of words according to tone, differentiating positive, negative and neutral statements. We code indications that economic growth—both domestically and globally—is picking up (slowing down) and that inflation edges higher (lower) as positive (negative) to indicate that such developments would imply higher (lower) interest rates going forward. For example, the statement "Inflation has risen by more than expected" is coded as positive; "The Canadian economy has been growing broadly in line with the Bank's expectations" as neutral; and "Temporary supply chain disruptions are expected to restrain growth sharply in the current quarter" as negative.

With regard to the exchange rate, we code a currency appreciation (depreciation) as positive (negative), with the underlying idea that an appreciating Canadian dollar is a reflection of a stronger economy. This is in line with the high correlation of the Canadian dollar with commodity prices and the fact that Canada is a large commodity exporter. This coding might be controversial, since an appreciating currency would tend to lower exports and import prices (and thus it could imply a negative outlook for interest rates). We have tested for the robustness of our results to the coding of exchange rate statements in two ways: by reversing the coding and by excluding the exchange rate statements entirely (when we study the effect of statements about other topics in isolation). We find our results to be robust.

[3] See http://www.bankofcanada.ca/core-functions/monetary-policy/key-interest-rate/blackout-guidelines/.
[4] We look at the entire press release, but exclude common "operational" phrases such as the introductory paragraph, which announces the interest rate decision itself, or an often-used final paragraph, which underscores the Bank's mandate to keep inflation close to its target.

Following these 3 steps, we now have word blocks that are differentiated according to topic, tense and tone. With 4 topics, 2 tenses and 3 tones, there are 24 different categories.

In step 4, we count the number of words in each category and aggregate them to our variable of interest, the balance of words for each press release. This is defined as

$$tone_{i,\tau} = \frac{wc_{i,positive,\tau} - wc_{i,negative,\tau}}{wc_{i,positive,\tau} + wc_{i,neutral,\tau} + wc_{i,negative,\tau}}, \quad (1)$$

where *wc* denotes the word counts, i is the category and τ is the press release. Note that we scale these balances by the total number of words in the category to allow for different length in press releases over time. We construct such tone variables for the entire press release (where we aggregate over all topics and both tenses), for the forward-looking part and for the backward-looking part (where we aggregate over all topics, but separately for each tense) and for each topic (where we aggregate over both tenses for each topic). These variables give an indication of the tone of a given press release with respect to the specific topic or tense, or overall.

Measuring the similarity across different press releases

Our second measure of the content of press releases relates to the similarity of subsequent press releases, following the approach proposed by Acosta and Meade (2015). This approach involves calculating the cosine similarity (distance) between fixed-length vector representations of pairs of press releases (bag of words model). First, we subject the raw text to several preprocessing steps: (i) We remove the introductory paragraph announcing the interest rate decision because it is contained in every press release using virtually the same language, which would bias the similarity measure upward. (ii) We convert the text into lowercase and remove punctuation, dates, numbers and stop words (common words with no meaningful interpretation such as articles and pronouns).[5] (iii) We concatenate a few words that have special meaning when appearing together (such as "bank of canada" to "bankofcanada") because leaving them separated might bias the similarity measure upward.[6] (iv) We split the remaining text into individual words through a process called "tokenization," and "stem" each word down to its root.[7] (v) We tabulate the list of unique words used in the body of the press releases and record how often each word appears in each press release. (vi) We multiply each unique word by a scaling factor $ln(n/n_w)$, where n is the total number of press releases and n_w is the number of press releases where word w appears.[8] This assigns higher weights to words that appear rarely and lower weights to words that appear frequently in the corpus, thus allowing us to emphasize subtle differences in language. A robustness tests shows that our results are not sensitive to this weighting.

Following these steps, we calculate the cosine similarity for each consecutive pair of press releases. The cosine similarity between any two press releases τ and τ^* is

[5] We use the publicly available list of English stop words in the Natural Language Toolkit for Python 2.7.
[6] We concatenate or abbreviate the following eight phrases: "monetary policy report update" to "mpru," "monetary policy report" to"mpr," "bank of canada" to "bankofcanada," "federal reserve" to "federalreserve," "federal funds rate" to "fedfundsrate," "united states" to "unitedstates," " u.s." to "unitedstates," and "per cent" to "percent."
[7] Stemming involves removing suffixes and inflections from the end of words so that all the derivatives of a word stem have the same form, e.g., "increase," "increases," "increasing," and "increasingly" are all stemmed down to "increas."
[8] This is often referred to as a TF-IDF (term frequency-inverse document frequency) weighting scheme.

$$s_{\tau,\tau^*} = \frac{\sum_{w=1}^{W} fr_{w,\tau} fr_{w,\tau^*}}{\left(\sqrt{\sum_{w=1}^{W} fr_{w,\tau}^2}\right)\left(\sqrt{\sum_{w=1}^{W} fr_{w,\tau^*}^2}\right)}, \quad (2)$$

where W is the total number of unique words that ever appeared in one of the press releases (i.e., the entire corpus of text), and $fr_{w,\tau}$ and $fr_{w,\tau*}$ are the frequencies of word w in press releases τ and τ^*. Two press releases with the exact same set of words and frequencies have $s_{\tau,\tau^*} = 1$ and are perfectly similar; two press releases that use none of the same words are orthogonal—or perfectly dissimilar—with $s_{\tau,\tau^*} = 0$. Importantly, this measure does not depend on the order of the words in the text.

As we did for the *tone* measures, we calculate semantic similarities for entire press releases as well as separately for the forward-looking and the backward-looking parts and for each topic. In addition, we calculate the semantic similarity for the last paragraph of each press release only, given that the last paragraph is particularly important in communicating the Bank's outlook for monetary policy.[9]

Financial market data

Regarding the dependent variable, we focus our analysis on the 1-year government bond yields, sourced from Bloomberg, since this is the maturity that has been shown to be most affected by announcement effects (Fleming and Remolona 1999) and is among the most liquid. We collect the data at the daily frequency and use the first differences as our dependent variable. We consider a daily frequency to be an appropriate frequency for our type of analysis. As is common in the announcement literature, our identification assumption is that the central bank news (i.e., the monetary policy decision and the surrounding communication) dominate all other news during the time window that we analyze, i.e., that any change in market prices occurs as a reaction to this news (see, e.g., Rigobon and Sack 2004). The higher the frequency, the more plausible this assumption. However, whereas intra-day data would allow a more precise measurement of the announcement effects (since fewer other events and news may introduce noise into the analysis), daily data allow us to account for potential overshooting effects in the very short run.

For testing the effect on other maturities and other markets, we also collected data from Bloomberg, namely for government bond yields at the 3-month, 6-month, 2-year, 5-year, 10-year and 30-year maturity; money market rates at the 3-month, 6-month and 1-year maturity; the TSX and the MSCI stock indices for Canada and the USD-CAD exchange rate. We also include a measure of the Canadian effective exchange rate provided by the Bank of Canada.[10] We use first differences for the interest rates and daily growth rates for stock indices and exchange rates as our dependent variables. Table A2 in the appendix provides summary statistics for the various financial market variables.

To estimate the effect of the Bank of Canada's communication on financial markets, it is crucial to control for the surprise component contained in the announced monetary policy decision. For that purpose, we follow the vast announcement literature (e.g., Ehrmann

[9] If a subcategory appears in a press release but does not appear in the subsequent press release, the similarity is equal to 0 (since the current press release is perfectly dissimilar to the preceding one). Press releases that follow this release that have no content from the subcategory have similarities of 1 (since they are perfectly similar to the preceding one). When the subcategory reappears, the current press release's similarity is equal to 0 (since it is perfectly dissimilar to the preceding press release).

[10] See http://www.bankofcanada.ca/rates/exchange/ceri/.

and Fratzscher 2007b) and construct the surprise component as the difference between the announced decision and market expectations, where the latter are measured by the mean expectation recorded in a Bloomberg survey.

Sample period

Our sample starts on 1 November 2001 and ends on 16 July 2015, comprising a total of 110 press releases and 3,431 trading days. The starting date of the sample is determined by the availability of a measure of the surprise component contained in monetary policy decisions. The Bank of Canada moved to a system of eight pre-announced policy decision dates in 2000. Subsequently, in the autumn of 2001, Bloomberg implemented its survey about the upcoming Bank of Canada monetary policy decisions. We begin the sample in November 2001, using the October 2001 press release as a starting point for constructing the similarity index in order to exclude the extraordinary press release following the terrorist attacks of 11 September 2001.

3.2 Estimation methodology

As mentioned above, we are interested in the response of 1-year government bond yields to the Bank of Canada's press releases. A natural econometric framework for this purpose is to use an ARCH-type model, which enables us to measure simultaneously the effects for the conditional means and the conditional variances. We estimate an EGARCH model, following Nelson (1991). An EGARCH (1,3) model is sufficient to address the non-normality of the data, in particular the serial correlation and heteroscedasticity of the daily returns.

The conditional mean equation is formulated as

$$r_t = \beta_0 + \beta_s \, s_t + \beta_{tone} \, tone_t + \mu_t \,. \qquad (3)$$

In line with much of the related literature, we estimate the model over all business days in the sample, i.e., including days when the Bank of Canada does not announce its interest rate decisions. Accordingly, t denotes trading days. r_t is the change in 1-year government bond yields.[11] The variable s_t denotes the surprise component contained in the announced interest rate decision, which we enter in order to separate the effect of the interest rate decision from the effect of the surrounding communication. The main variable of interest is the variable $tone_t$, which contains the tone of the press release (entered in different variants, as explained above). The variables s_t and $tone_t$ are equal to zero on days when the Bank of Canada does not announce its interest rate decisions, given that there is no news. Our hypotheses are that a positive surprise component contained in the announced interest rate decision as well as a relatively more positive press release will raise interest rates, i.e., that $\beta_s > 0$ and $\beta_{tone} > 0$.

The specification of the mean equation is interesting in itself, but it is also important to ensure that we identify the coefficients in the variance equation appropriately. A failure to control for all relevant factors in the mean equation will lead to larger residuals and a higher conditional variance of the disturbance, where $\mu_t \sim (0, h_t)$. We express the conditional variance h_t as

[11] Adding lags of the dependent variable (which are statistically insignificant) and further controls, such as day of the week effects, does not affect our results qualitatively, but often raises convergence problems.

$$\log(h_t) = \gamma_0 + \gamma_1\left(\frac{\mu_{t-1}}{\sqrt{h_{t-1}}}\right) + \gamma_2\left(\left|\frac{\mu_{t-1}}{\sqrt{h_{t-1}}}\right| - \sqrt{2/\pi}\right) + \sum_{k=1}^{3}\gamma_{2+k}\log(h_{t-k}) + \delta_s|s_t| + \delta_{sim}\, similarity_t \quad (4)$$

Here, the surprise component contained in the announced interest rate decision enters with its absolute value and helps separating the effect of the interest rate decision from the effect of the surrounding communication. $similarity_t$ denotes the semantic similarity. We set $similarity_t$ to 1 on days without press releases—since there is no news on such days, the content of the earlier press release is still "in place," implying perfect similarity. Our hypotheses are that larger absolute surprises and more similar press releases lower volatility, i.e., $\delta_s>0$ and $\delta_{sim}<0$. The latter hypothesis is based on the idea that relatively similar statements make it easy to grasp their content. If that is the case, there should be less disagreement among central bank watchers about their interpretation and market prices should adjust quickly to their new fundamental value. In contrast, if statements are harder to interpret, prices should take longer to adjust. In line with this reasoning, we would expect to see that more-similar press releases lower volatility.

The model is estimated via maximum likelihood, using the Berndt-Hall-Hall-Hausman and Broyden-Fletcher-Goldfarb-Shanno algorithms.

Beyond the 1-year government bond yields, we also test the effect on interest rates of different maturities, the stock market return and the exchange rate return. We include additional control variables $x_{k,t}$ for stock market returns (the contemporaneous return on the U.S. MSCI index) and for exchange rate returns (the contemporaneous rate of growth in energy commodity prices, the contemporaneous rate of growth in non-energy commodity prices and the change in the interest rate differential relative to the United States, as measured by 3-month rates).[12]

4. The Content of the Bank of Canada Press Releases and its Evolution over Time

Quantifying the Bank of Canada's communications allows us to better understand its content and how this has evolved over time.

Figures 1 and 2 here

Figure 1 plots the number of words in each press release, along with a moving average that facilitates the visualization of medium-term trends. Overall, press releases have become considerably longer—doubling from around 200 words at the beginning of our sample to around 400 words at the end of the sample, with a peak of around 600 words in 2011 (i.e., when the Bank of Canada provided additional guidance to market participants to correct their views about the pace of future tightening, see Carney 2012). The increasingly forward-looking nature of the Bank of Canada's communications during that period is also mirrored in the upper part of Figure 2, which plots the share of forward- and backward-looking text in the press releases.

[12] The energy and non-energy commodity indices are from the Bank of Canada; all other series are from Bloomberg. The specification of the exchange rate model follows Amano and van Norden (1998) and Issa, Lafrance and Murray (2008).

The lower part of Figure 2 breaks the content into different topics and highlights that, by far, the largest share of words deals with the domestic economy, with inflation coming second. Discussions of the global economy gained more prominence after the financial crisis, becoming the second most important category for some time, but falling back to third position more recently. Finally, the exchange rate constitutes a relatively small share throughout the entire sample period.

Tables 1 and 2 here

Table 1 provides summary statistics for the variables that measure the tone and semantic similarity of the press releases. Looking first at the tone of the press releases (Panel B), we find that, because of the long sample period under study, the tone of the press releases is close to zero on average. This is the case not only when looking at the press releases in their entirety but also for most subcategories. There is a wide variation over time, with the tone ranging from -0.91 (very negative) to +0.95 (very positive) over all the press releases and spanning the entire possible range from -1 to +1 for the various subcategories that we identify.

Looking at the correlation over time in Panel A of Table 2, it is apparent that the overall tone is reflected both in the backward- and the forward-looking parts of the press releases and in the discussion of domestic economic developments (all of which have a correlation coefficient of around 0.8 with the tone in the entire press release). The correlation is smallest for the discussion of foreign exchange developments. Interestingly, while there is a similar correlation between the entire press release and both the backward- and forward-looking components, the correlation between the backward- and forward-looking components themselves is much smaller, at 0.32, suggesting that these two dimensions are clearly separate.

Table 3 here

To gauge whether our measure of tone captures the content of the Bank of Canada press releases in a meaningful way, we ran a few simple tests along the lines suggested by Sturm and de Haan (2011), Hayo and Neuenkirch (2011), and Rosa (2009), who all studied whether the tone of central bank communications can help predict future policy rate changes. This is done using ordered probit models to account for the fact that policy rates were changed in multiples of 25 basis points during our sample. We calculate robust standard errors. Table 3 reports the results, for the entire press release and for the backward- and forward-looking components. For each of these, we test whether the tone of a given press release explains policy rate changes at the next meeting, two meetings out or three meetings out.

We find that the tone has explanatory power for decisions not only at the subsequent meeting but also two meetings ahead. Despite the simplicity of our models, we explain a non-trivial amount of the variation in the data with a pseudo R^2 of up to 0.12. Somewhat surprisingly, however, the tone of forward-looking statements is less relevant than the tone of backward-looking statements. Overall, however, we take these results to indicate that our measure of tone is a meaningful proxy for the content of the press releases.

Figure 3 here

Turning to the semantic similarity, the press releases in their entirety show an average similarity of 0.44 (see Panel C of Table 1), lower than the corresponding estimate of 0.65 obtained for the United States in Acosta and Meade (2015). There is considerable variation over time, with the index ranging from 0.21 to 0.77. Looking at the time trend depicted in Figure 3, similarity had been trending up over the period from 2007 to 2013 and declined substantially afterward. Similar time trends are observed for the last

paragraph (even though the changes in magnitude are much larger than those of the similarity of the entire press releases), the parts dealing with the domestic economy, and backward- and forward-looking statements, although the variations are more pronounced in the forward-looking parts. As was the case for the tone of the press release, we find that the similarities of the various components are generally highly correlated (Panel B of Table 2).

5. Semantic Similarity and Market Volatility

5.1 Effects on 1-year government bond yields

We next report the empirical results. Our first model contains the variables that have been traditionally part of the announcement effect literature—the surprise component contained in the monetary policy decision in the mean equation and its absolute value in the variance equation. As expected, we find that this matters (see the first column in Table 4). A surprise tightening tends to raise interest rates one to one, and larger absolute surprises tend to raise volatility in interest rates.

Table 4 here

In the next step, we expand our model to include the tone variable in the mean equation and the semantic similarity in the variance equation. Results are reported in column 2 of Table 4. The first noticeable result is that by controlling for the tone of the press release, the estimated coefficients for the surprise component contained in the monetary policy decision remain statistically significant, but become smaller—somewhat for the surprise in the mean equation and markedly so for the absolute surprise in the variance equation. This suggests that the traditional models, which do not control for the content of the accompanying communication, overstate the effect of the surprise component in a given decision.

Financial markets are responsive to the tone of the press releases. Press releases that are, on balance, optimistic (pessimistic), i.e., have a positive (negative) value for the tone variable tend to raise (lower) bond yields. A one-standard-deviation change in this variable changes bond yields by around one basis point, a change along the interdecile range by 2.5 basis points. While statistically significant, the effect is economically small. Also the semantic similarity matters in the expected direction: relatively more-similar press releases are associated with lower market volatility, suggesting that they are more straightforward to interpret. To assess the economic magnitude of this effect, we find that after controlling for the absolute surprise contained in monetary policy decisions, semantic similarity explains an additional 9% of the variation in the log conditional variance on press release dates – a non-trivial effect.

Columns 3 to 8 of Table 4 report results when we control for different components of the entire press release. As mentioned above, we run separate regressions for each component because the various parts are highly correlated. When differentiating between backward- and forward-looking statements, it is apparent that the tone of both matters for interest rates. Forward-looking statements have a larger coefficient, but the difference is small. In contrast, the tense matters more when it comes to similarity. The coefficient for backward-looking statements is around 20% smaller than the one estimated for forward-looking statements. This is in line with Conrad and Lamla (2010) and Hansen and McMahon (2016), who show that markets react more to the forward-looking component of the ECB's and the Federal Reserve's communications than to the backward-looking component.

Regarding the different types of content, we find statistically significant coefficients for tone and similarity for all of them. Statements about the domestic economy appear to be the most important part of the press releases, as shown by both a relatively larger effect of similarity in the variance equation. This is not surprising, given that they constitute the largest share of the content of the press releases.

5.2 Effects on other financial markets

The focus of our analysis so far has been on 1-year government bond yields. Table 5 shows results for our benchmark specification (which captures the effects of the press releases in their entirety) across different maturities and for money markets, exchange rates and the stock market. Tightening surprises in monetary policy decisions raise bond yields along most of the maturity spectrum (and easing surprises lower them). We reproduce the well-known hump-shaped pattern that had been identified for the United States by Fleming and Remolona (1999), whereby the effect increases with longer maturities and subsequently decreases, to finally fade out at the 10-year maturity. Tightening surprises also appreciate the exchange rate, whereas we (surprisingly) cannot identify an effect on stock market returns.

Table 5 here

Turning to the tone of the press release, our findings for 1-year yields are confirmed—a positive tone raises interest rates. Interestingly, the peak effects are found for the shortest maturities, both for government bond yields and for money market rates. Tone appears to also affect exchange rates, but we do not identify an effect on stock markets. Based on these results, Canadian stock markets are generally not responsive to Bank of Canada actions and communications. While this is surprising, similar findings have been reported in the earlier literature (Hayo and Neuenkirch 2012b).

5.3 Interaction effects

To summarize the findings discussed so far, it seems that more similar statements are beneficial in the sense that they lead to less market volatility, presumably because they make it simpler for markets to understand how the Bank's view evolves. But is this a general finding that is true under all circumstances?

To look into this question, we focus on the last paragraph of the press releases. For some time, these have been used as key paragraphs to provide an outlook for the monetary policy stance, with very similar language.[13] This is immediately apparent in the relevant plot in Figure 3, which reveals that there have been several instances where the wording in the last paragraph was identical to its predecessor (i.e., our semantic similarity measure is 1). Interestingly, when such identical paragraphs were eventually changed (which could happen after one or repeated occurrences), the update tended to be quite substantial, leading to a rather low semantic similarity. Accordingly, this measure shows rather large swings. To see whether our earlier findings also apply to the last paragraph, we report results for our benchmark specification in the first column of Table 6. Results are robust; we even get a slightly larger log likelihood than we do for the similarity of the entire press release.

[13] http://blogs.wsj.com/canadarealtime/2014/03/05/poloz-brings-change-to-the-bank-and-its-statements/

Table 6 here

The large swings in this variable raise the question of whether volatility is low when statements are extremely similar and increases relatively more once such statements get updated. We test this hypothesis in the following manner. First, we construct a dummy variable for the 33% most-similar last paragraphs in our sample. Any last paragraph with a semantic similarity above 0.59 falls into this category. Second, we run regressions using a slightly altered variant of the conditional variance equation as follows:

$$\log(h_t) = \gamma_0 + \gamma_1\left(\frac{\mu_{t-1}}{\sqrt{h_{t-1}}}\right) + \gamma_2\left(\left|\frac{\mu_{t-1}}{\sqrt{h_{t-1}}}\right| - \sqrt{2/\pi}\right) + \sum_{k=1}^{3}\gamma_{2+k}\log(h_{t-k}) + \delta_s\,|s_t| + \delta_{sim}\,similarity_t + \delta_D\,D_{t_{-1}} + \delta_{interact}\,similarity_t\,D_{t_{-1}}, \quad (5)$$

where $D_{t_{-1}}$ denotes the newly created dummy variable lagged by one press release (meaning that it is equal to one when the previous last paragraph was extremely similar to the one before). Our hypothesis is that the market is more sensitive to similarity if the previous statements were extremely similar, because it is apparent that the central bank has updated its assessment in a more substantive manner, but it is relatively more difficult to identify and interpret the parts of the text that are relevant. Accordingly, we would expect $\delta_{interact}<0$.

Column 2 of Table 6 reports the corresponding results. We do indeed find $\delta_{interact}<0$, with a large effect – the coefficient is three times as large as δ_{sim}. This suggests that the effects of similarity on volatility are substantially larger when the previous statements were very similar. To illustrate what this implies numerically, let us look at the following table, which reports the estimated parameter values under different cases—on the one hand, when the previous last paragraphs had been extremely similar or not; on the other hand, for different values of the semantic similarity, namely minimum, mean and maximum (see also Table 1):

	$similarity_t = 0$	$similarity_t = 0.443$	$similarity_t = 1$
$D_{t_{-1}} = 0$	0.000	-0.241	-0.545
$D_{t_{-1}} = 1$	1.237	0.332	-0.806

There are several things to note in the table above. First, the benchmark case is the one where $D_{t_{-1}} = 0$ and $similarity_t = 0$. For that constellation, the overall effect on volatility is zero. Second, moving to the right in the table shows that with increasing similarity, volatility decreases, regardless of the content of the previous statements (i.e., in both rows of the table). This simply repeats the earlier findings. Third, if we take the extreme case where a highly similar statement is followed by an entirely orthogonal statement (which is represented by the lower left entry in the table), volatility increases substantially. In contrast, repeating the same text for the third time or more often (the case of the lower right entry in the table when $D_{t_{-1}} = 1$ and $similarity_t = 1$), volatility decreases by even more than when the statement is repeated for the first time.

What these findings suggest is that markets find it increasingly easier to interpret statements if they keep getting repeated. In contrast, when statements are eventually updated, market volatility is substantially larger.

Columns (3) and (4) of Table 6 report results for another extension of the regression. We added the change in the length of the press releases (as measured by the change in the overall word count) and find that increases in length lower volatility (column (3)). In addition, there is an interesting interaction term when we estimate

$$\log(h_t) = \gamma_0 + \gamma_1\left(\frac{\mu_{t-1}}{\sqrt{h_{t-1}}}\right) + \gamma_2\left(\left|\frac{\mu_{t-1}}{\sqrt{h_{t-1}}}\right| - \sqrt{2/\pi}\right) + \sum_{k=1}^{3}\gamma_{2+k}\log(h_{t-k}) + \delta_s\,|s_t| + \delta_{sim}\,similarity_t + \delta_{\Delta wc}\,\Delta wc_t + \delta_{interact}\,similarity_t\,\Delta wc_t \quad (6)$$

To facilitate the interpretation of these results, let us tabulate the coefficients for different scenarios:

	$similarity_t = 0$	$similarity_t = 0.443$	$similarity_t = 1$
$\Delta wc_t = -150$	1.200	-0.382	-2.370
$\Delta wc_t = 0$	0.000	-0.518	-1.170
$\Delta wc_t = +150$	-1.200	-0.655	0.030

For high levels of similarity, lengthening the press release raises volatility, suggesting that longer statements provide less clarity. Interestingly, however, the relationship reverses at lower levels of similarity. To take the extreme case of $similarity_t = 0$, i.e., two orthogonal press releases, we find that lengthening the press releases lowers volatility, whereas shortening them lowers volatility. This suggests that a completely different statement is easier to understand if it is long than if it is short.

5.4 Robustness tests

We conduct a large number of robustness tests of our benchmark estimation, the effect of similarity in the entire press release on 1-year government bond yields. Column 1 in Table 7 repeats that benchmark for easier comparison with the various robustness results. As mentioned earlier, the way we code the tone of statements related to foreign exchange might be controversial. Given the small share of these statements in the press releases, we would not expect this to matter and indeed find that the overall results are robust when we reverse the coding (see column 2).

Table 7 here

The next test looks into the way we enter the tone of the press release. As mentioned earlier, we were somewhat surprised by the relatively small effect of tone on yield changes. An alternative specification is to explain yield changes by the changes in the tone variable between consecutive statements, rather than by the tone variable itself. Such a test is reported in column 3. It shows that both specifications are viable. The coefficients are broadly unchanged, and the log likelihood is very close.

When constructing the similarity index, we had applied a weighting scheme following Acosta and Meade (2015) that assigns higher weights to infrequent words, in order to emphasize subtle differences in language. Using an unweighted scheme leads to larger estimated effects of similarity, as shown in column 4. The next column of Table 7 checks

for the sensitivity of our results to the estimation methodology. When estimating a GARCH model (which assumes that both positive and negative news have a symmetric effect on volatility), our results hold.[14]

We also tested whether results are sensitive to measuring similarity pairwise for the current and the subsequent press release, or alternatively by comparing the current with more (in this case three) preceding press releases. As can be seen in column 6, either way our results are stable. We also tested whether our results are sensitive to including all non-announcement days. We did this as follows: we first estimated a simple EGARCH model over all business days, without including any additional regressors. We used the residuals from that estimation and ran a simple OLS regression with robust standard errors over all 110 announcement days to mimic our mean equation. In that regression, we do not identify an effect of tone. We also used the estimated conditional variance and analogously ran a simple OLS regression with robust standard errors over all 110 announcement days to mimic our variance equation, to find that the similarity effect also shows up as expected (column 7).

The remaining robustness tests add different control variables. First, we added a measure of uncertainty about the economy and monetary policy, namely the interquartile range across forecasters of the three-month interest rates three months out in Consensus Economics (following Dovern et al. 2012). This variable in itself is positively related to conditional volatility, but its addition does not alter our results qualitatively (column 8).

For parsimony of our econometric models and to facilitate convergence of our estimators, we abstracted from macroeconomic news, despite the fact that there is a large literature that documents their relevance for financial markets. Fortunately, since no indicators are systematically released on the same days as the Bank of Canada press releases, we do not expect our results to change materially when adding macroeconomic news. This is indeed the case, as seen in column 9. We added several Canadian and U.S. releases, following the earlier announcement literature for Canada (Gravelle and Moessner 2002). The variables account for the surprise component in the releases by subtracting the median expectation among forecasters in the corresponding Bloomberg survey from the actual announcement, normalized by the standard deviation of the surprise. The amount of macro news does indeed affect yields—higher than expected Canadian CPI inflation and retail sales as well as U.S. non-farm payrolls increase government bond yields, whereas higher than expected Canadian unemployment lowers them. In addition, the absolute surprise component in all our macro releases except for Canadian CPI inflation increase volatility. The sign of these coefficient estimates are all in line with theory. Most importantly for our purposes, all results regarding the communication variables are robust – if anything, the effect of similarity becomes somewhat larger.

Our subsequent test controls for another aspect of the Bank of Canada communications in the conditional variance equation, namely a dummy variable for press releases that coincide with the release of the Bank's *Monetary Policy Report* (MPR). The MPR contains the Bank's projections and a narrative around the Bank's assessment of the economic situation and the stance of monetary policy. It can therefore provide additional information to markets; press releases on MPR dates are actually around 100 words longer, on average (even though similarity is not statistically significantly lower). Market

[14] The coefficients in the variance equation are of a different order of magnitude because the GARCH model explains the conditional variance itself, whereas the EGARCH model explains its logarithm.

volatility is not different in MPR months and the effect of semantic similarity remains significant.[15]

Adding the Flesch-Kincaid measure of readability of the press releases, we replicate the finding by Jansen (2011) that more complex statements raise volatility in financial markets, while our result for similarity remains unaffected (column 11). Finally, results are also robust to the addition of dummy variables for the tenure of the different Bank of Canada Governors (column 12), for the time period of the Bank of Canada's forward guidance (column 13) or for the post-Lehman Brother failure (column 14).

Additional tests that, for brevity, we do not report show that lags of the absolute surprise variable and of the semantic similarity to the conditional variance equation are insignificant.

6. Conclusions

Over the past few years, several central banks have released press statements that show an increasing semantic similarity. Often, the previous release is used as a starting point for drafting the subsequent version. An advantage to this practice is that it is easy to identify where the central bank has updated the text. According to our results, another advantage is that the evolution of the central bank's views is more easily understood—relatively similar statements are absorbed by financial markets with lower volatility, an effect which is identified after controlling for the content of the press release.

However, at some point, any statement must be updated more materially, and we find that, in these instances, market volatility is four times as sensitive to similarity as otherwise. We therefore conclude that both starting from the previous press releases and starting from a blank page are viable communication strategies. While similar press releases appear to be easier to interpret in the short run, this is not necessarily the case over a longer horizon.

It is important to stress that other factors need to be considered when choosing a communication strategy. For instance, central banks need to take into account whether similar press releases impose a constraint on what the central bank can communicate. Furthermore, it is not always the case that more market volatility is undesirable from the point of view of the central bank. We leave these issues for future research.

[15] The effect of similarity in MPR months is not different from its effect in other months, as shown by an insignificant interaction term (not shown for brevity).

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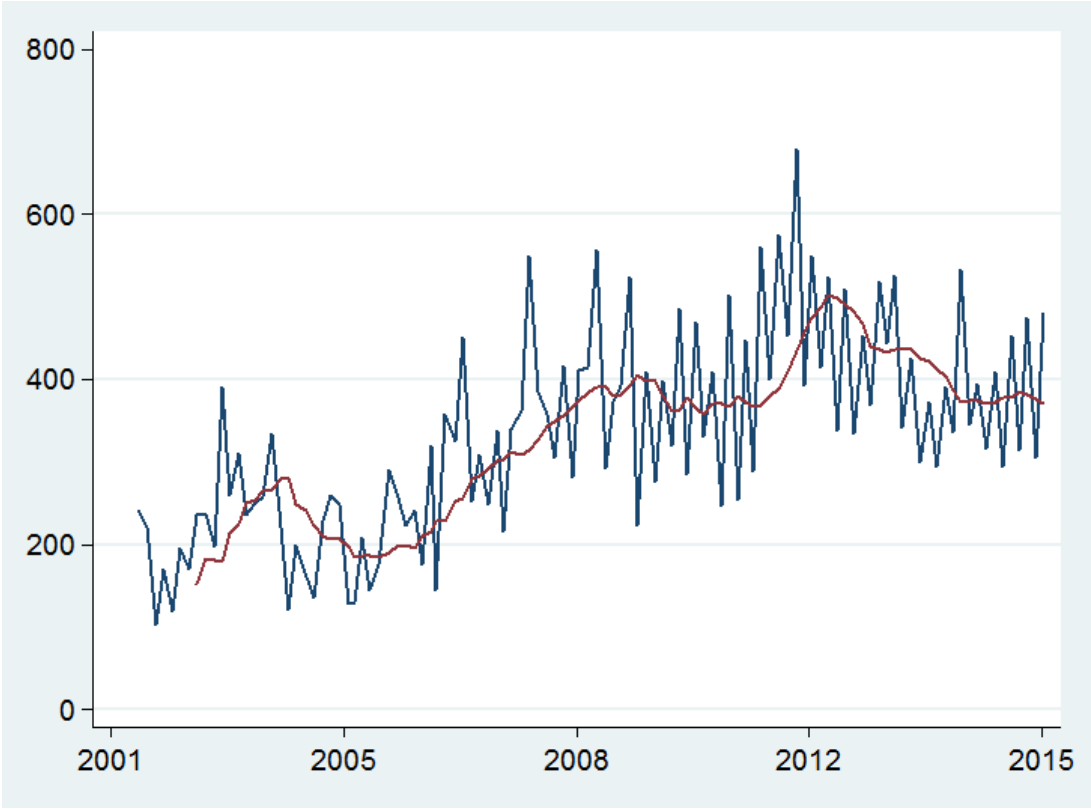
Figure 1: Length of Bank of Canada press releases

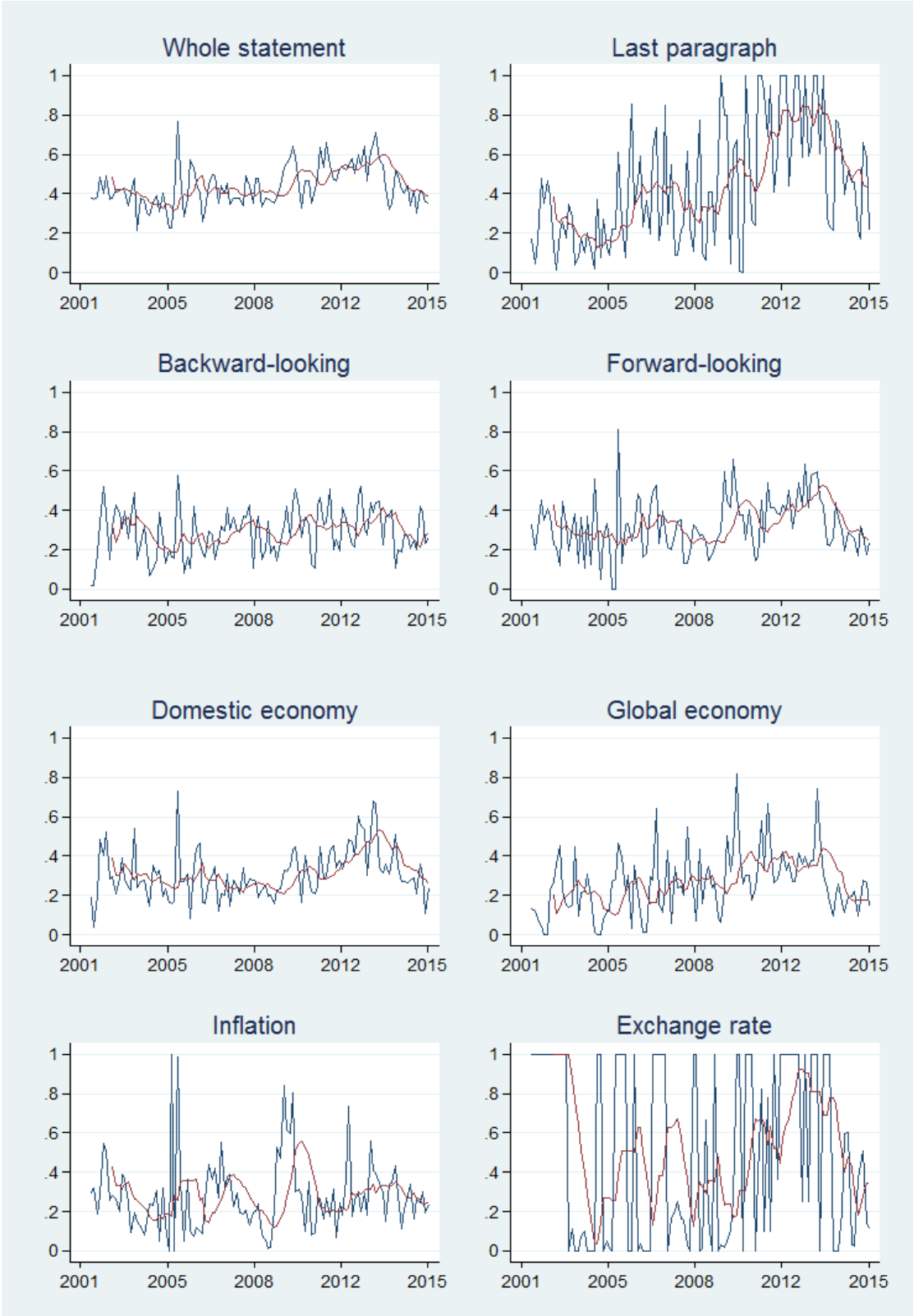


Notes: The figure shows the number of words of the Bank of Canada press releases (blue line) and a moving average covering the previous eight press releases (red line).

Figure 2: Content of Bank of Canada press releases

Notes: The figure shows the share of words that are allocated to backward- and forward-looking statements (Panel A) and to each topic (Panel B) in the Bank of Canada press releases.

Figure 3: Semantic similarity of Bank of Canada press releases



Notes: The figure shows the semantic similarity of the Bank of Canada press releases (blue line), measured as described in equation (2) and an eight-press-release moving average (red line).

Table 1: Summary statistics for central bank communications variables

Variable	Obs.	Mean	Std. Dev.	Min	Max
A: Surprises					
Mean	110	-0.008	0.066	-0.250	0.258
Absolute mean	110	0.030	0.059	0.000	0.258
B: Tone					
Total	110	0.022	0.346	-0.905	0.951
Backward-looking	110	0.051	0.505	-1.000	1.000
Forward-looking	110	-0.020	0.391	-1.000	1.000
Domestic	110	0.107	0.443	-1.000	1.000
Global	110	-0.123	0.547	-1.000	1.000
Inflation	110	-0.111	0.511	-1.000	1.000
Exchange rate	110	0.292	0.689	-1.000	1.000
C: Similarities					
Total	110	0.440	0.106	0.213	0.770
Last paragraph	110	0.443	0.310	0.000	1.000
Backward-looking	110	0.289	0.121	0.016	0.580
Forward-looking	110	0.325	0.144	0.000	0.811
Domestic	110	0.309	0.127	0.037	0.732
Global	110	0.262	0.160	0.000	0.818
Inflation	110	0.280	0.187	0.000	1.000
Exchange rate	110	0.507	0.455	0.000	1.000

Notes: The table shows summary statistics for the surprise component contained in monetary policy decisions in Panel A, the tone of the Bank of Canada press releases in Panel B and the semantic similarity of the Bank of Canada press releases in Panel C.

Table 2: Correlation of central bank communications variables

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A: Tone	Total	Backward	Forward	Domestic	Global	Inflation	Exchange rate
Whole statement	1.000						
Backward-looking	**0.795**	1.000					
Forward-looking	**0.787**	**0.321**	1.000				
Domestic	**0.838**	**0.655**	**0.690**	1.000			
Global	**0.390**	0.170	**0.419**	**0.228**	1.000		
Inflation	**0.681**	**0.626**	**0.473**	**0.407**	-0.031	1.000	
Exchange rate	0.048	0.176	-0.120	-0.023	-0.060	-0.040	1.000

B: Similarity	Total	Last para-graph	Backward	Forward	Domestic	Global	Inflation	Exchange rate
Whole statement	1.000							
Last paragraph	**0.679**	1.000						
Backward-looking	**0.530**	**0.262**	1.000					
Forward-looking	**0.702**	**0.426**	**0.289**	1.000				
Domestic	**0.693**	**0.434**	**0.537**	**0.696**	1.000			
Global	**0.629**	**0.391**	**0.489**	**0.371**	**0.395**	1.000		
Inflation	**0.368**	**0.192**	**0.244**	**0.448**	**0.313**	0.158	1.000	
Exchange rate	**0.302**	0.140	0.160	**0.229**	**0.293**	0.160	0.096	1.000

Notes: The table shows correlation coefficients of the variables measuring the tone of the Bank of Canada press releases in Panel A and the variables measuring the semantic similarity of the Bank of Canada press releases in Panel B. Numbers in bold are statistically significant at the 5% level.

Table 3: The predictive power of the tone of Bank of Canada press releases

	Whole statement			Backward-looking			Forward-looking		
	1st lag	2nd lag	3rd lag	1st lag	2nd lag	3rd lag	1st lag	2nd lag	3rd lag
Tone	1.560***	0.734**	0.162	1.266***	0.665***	0.224	0.581**	0.229	-0.012
	(0.371)	(0.292)	(0.273)	(0.227)	(0.191)	(0.199)	(0.293)	(0.279)	(0.252)
Observations	110	110	110	110	110	110	110	110	110
Pseudo R^2	0.096	0.024	0.001	0.125	0.040	0.005	0.020	0.003	0.000

Notes: The table shows results from simple ordered probit models that explain the change in policy rates (in basis points) using the tone variable at different horizons. Numbers in brackets are standard errors. ***/**/* denote statistical significance at the 1%/5%/10% level.

Table 4: The effect of Bank of Canada press releases on 1-year government bond yields

	(1) Baseline	(2) Whole statement	(3) Past	(4) Future	(5) Domestic	(6) Global	(7) Inflation	(8) Exchange rate
Mean equation								
Surprise	1.075***	0.988***	1.009***	1.014***	1.033***	1.017***	1.019***	1.066***
	(0.031)	(0.046)	(0.047)	(0.044)	(0.043)	(0.045)	(0.044)	(0.035)
Tone	--	0.027***	0.014***	0.018***	0.011***	0.011***	0.010***	0.006***
		(0.004)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.002)
Constant	-0.000	-0.000	-0.000	-0.000	-0.000	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Variance equation								
Absolute surprise	3.696***	2.290**	2.930***	1.819*	1.891*	2.507***	2.761***	3.086***
	(0.700)	(1.001)	(1.001)	(0.982)	(0.966)	(0.961)	(0.992)	(0.776)
Similarity	--	-1.165***	-0.826***	-1.063***	-1.062***	-0.810***	-0.763***	-0.668***
		(0.116)	(0.088)	(0.091)	(0.085)	(0.080)	(0.084)	(0.050)
Constant	-0.081***	1.053***	0.716***	0.951***	0.951***	0.691***	0.646***	0.570***
	(0.013)	(0.115)	(0.089)	(0.090)	(0.084)	(0.082)	(0.083)	(0.051)
EGARCH terms								
γ_1	-0.021***	-0.033***	-0.032***	-0.034***	-0.034***	-0.029***	-0.029***	-0.026***
	(0.006)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)
γ_2	0.254***	0.321***	0.321***	0.320***	0.317***	0.321***	0.325***	0.299***
	(0.019)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.018)	(0.017)
γ_3	0.845***	0.505***	0.525***	0.504***	0.507***	0.526***	0.535***	0.633***
	(0.085)	(0.052)	(0.053)	(0.051)	(0.052)	(0.053)	(0.056)	(0.065)
γ_4	-0.042	0.221***	0.197***	0.226***	0.217***	0.202***	0.211***	0.112
	(0.126)	(0.067)	(0.070)	(0.067)	(0.067)	(0.070)	(0.073)	(0.092)
γ_5	0.181**	0.257***	0.260***	0.253***	0.259***	0.252***	0.235***	0.237***
	(0.073)	(0.048)	(0.049)	(0.048)	(0.048)	(0.048)	(0.051)	(0.060)
Observations	3,431	3,431	3,431	3,431	3,431	3,431	3,431	3,431
Log likelihood	7136	7164	7155	7166	7162	7153	7152	7155

Notes: The table shows coefficient estimates for the effect of Bank of Canada press releases on 1-year government bond yields, following equations (3) and (4). The model underlying column (1) does not control for Bank of Canada press releases, the one underlying column (2) controls for the entire content, those underlying columns (3) and (4) control for backward-looking (past) and forward-looking (future) statements only, and those underlying columns (5) to (8) control for statements related to the specific topics indicated in the header of the column. Numbers in brackets are standard errors. ***/**/* denote statistical significance at the 1%/5%/10% level.

Table 5: The effect of Bank of Canada press releases on different financial markets

	Government of Canada bonds							Money market			Stock market		Exchange rates	
	3-month	6-month	12-month	2-year	5-year	10-year	30-year	3-month	6-month	12-month	TSX	MSCI	USD/CAD	CERI
Mean equation														
Surprise	0.968***	1.004***	0.988***	0.734***	0.364***	0.134	0.027	1.058***	1.028***	1.008***	-2.501**	-2.900***	3.548***	3.620***
	(0.021)	(0.029)	(0.046)	(0.046)	(0.056)	(0.088)	(0.076)	(0.006)	(0.009)	(0.012)	(1.027)	(1.086)	(0.659)	(0.654)
Tone	0.023***	0.024***	0.027***	0.038***	0.021***	-0.005	-0.010	0.001***	0.009***	0.020***	-0.026	-0.067	0.177	0.372***
	(0.002)	(0.004)	(0.004)	(0.007)	(0.008)	(0.009)	(0.009)	(0.000)	(0.001)	(0.002)	(0.164)	(0.169)	(0.113)	(0.105)
U.S. stock market	--	--	--	--	--	--	--	--	--	--	0.590***	0.621***	--	--
											(0.008)	(0.009)		
Energy index	--	--	--	--	--	--	--	--	--	--	--	--	0.045***	0.035***
													(0.003)	(0.003)
Non-energy index	--	--	--	--	--	--	--	--	--	--	--	--	0.173***	0.211***
													(0.014)	(0.014)
Rate differential	--	--	--	--	--	--	--	--	--	--	--	--	0.002	0.017*
													(0.014)	(0.010)
Constant	0.001***	-0.000	-0.000	0.000	-0.001	-0.001	-0.001	0.000***	0.000***	0.000	0.010	0.008	0.000	-0.002
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.009)	(0.010)	(0.008)	(0.007)
Variance equation														
Absolute surprise	-0.119	1.976**	2.290**	0.054	0.079	3.038**	2.407*	1.512***	3.894***	2.049***	0.305	-0.116	-0.927	-0.821
	(0.975)	(1.002)	(1.001)	(0.885)	(0.379)	(1.398)	(1.333)	(0.439)	(0.523)	(0.715)	(1.424)	(1.306)	(0.940)	(1.145)
Similarity	-1.348***	-0.974***	-1.165***	-0.281*	0.115*	0.295	0.253	-2.590***	-1.549***	-1.085***	0.036	-0.048	-0.250*	-0.364**
	(0.112)	(0.115)	(0.116)	(0.145)	(0.060)	(0.213)	(0.229)	(0.058)	(0.068)	(0.089)	(0.209)	(0.195)	(0.143)	(0.167)
Constant	1.133***	0.822***	1.053***	0.224	-0.138**	-0.441**	-0.532**	2.392***	1.392***	0.971***	-0.043	0.042	0.234*	0.343**
	(0.114)	(0.114)	(0.115)	(0.144)	(0.059)	(0.223)	(0.242)	(0.063)	(0.071)	(0.090)	(0.207)	(0.192)	(0.141)	(0.164)
EGARCH terms														
γ_1	-0.059***	-0.035***	-0.033***	-0.027***	-0.011***	0.007	0.017	0.045***	0.009	-0.006	-0.068***	-0.053***	-0.016*	-0.032***
	(0.006)	(0.007)	(0.008)	(0.009)	(0.003)	(0.013)	(0.013)	(0.006)	(0.006)	(0.007)	(0.013)	(0.012)	(0.009)	(0.011)
γ_2	0.351***	0.338***	0.321***	0.207***	0.052***	0.173***	0.169***	0.510***	0.374***	0.324***	0.214***	0.194***	0.133***	0.188***
	(0.017)	(0.015)	(0.017)	(0.016)	(0.006)	(0.018)	(0.020)	(0.012)	(0.015)	(0.015)	(0.024)	(0.023)	(0.024)	(0.019)
γ_3	0.651***	0.547***	0.505***	0.814***	2.159***	0.255***	0.571***	0.406***	0.464***	0.433***	0.428***	0.495***	1.391***	0.795***
	(0.031)	(0.030)	(0.052)	(0.081)	(0.076)	(0.088)	(0.200)	(0.017)	(0.036)	(0.042)	(0.119)	(0.127)	(0.221)	(0.050)
γ_4	0.085***	0.103***	0.221***	-0.246***	-1.909***	0.051	0.044	0.568***	0.515***	0.549***	0.408***	0.390**	-0.858**	-0.554***
	(0.032)	(0.038)	(0.067)	(0.089)	(0.133)	(0.090)	(0.270)	(0.017)	(0.036)	(0.043)	(0.137)	(0.153)	(0.342)	(0.071)
γ_5	0.234***	0.326***	0.257***	0.421***	0.746***	0.670***	0.342**	--	--	--	0.151	0.103	0.457***	0.746***
	(0.037)	(0.038)	(0.048)	(0.061)	(0.064)	(0.084)	(0.155)				(0.111)	(0.117)	(0.159)	(0.051)
Observations	3,431	3,431	3,431	3,431	3,431	3,431	3,431	3,431	3,431	3,431	3,431	3,431	3,431	3,431
Log likelihood	9051	8267	7164	5905	5474	5735	6531	12840	10110	8437	-3115	-3261	-2566	-2299

Notes: The table shows coefficient estimates for the effect of Bank of Canada press releases on different financial markets, following equations (3) and (4). Numbers in brackets are standard errors. ***/**/* denote statistical significance at the 1%/5%/10% level.

Table 6: The effect on 1-year government bond yields—interaction terms

	Last paragraph		Δ Word count	
	(1) Benchmark	(2) With interaction	(3) Benchmark	(4) With interaction
Mean equation				
Surprise	1.017***	1.015***	1.002***	1.053***
	(0.046)	(0.046)	(0.047)	(0.042)
Tone	0.023***	0.011**	0.027***	0.026***
	(0.004)	(0.005)	(0.004)	(0.004)
Constant	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Variance equation				
Absolute surprise	1.687	3.434***	2.230**	2.299**
	(1.057)	(1.159)	(1.027)	(1.064)
Similarity	-1.035***	-0.545***	-1.164***	-1.170***
	(0.094)	(0.146)	(0.119)	(0.119)
$D_{t_{-1}}$ / Δ word count	--	1.237***	-0.001*	-0.008***
		(0.198)	(0.000)	(0.003)
Interaction	--	-1.498***	--	0.016***
		(0.275)		(0.006)
Constant	0.909***	0.429***	1.054***	1.057***
	(0.094)	(0.143)	(0.118)	(0.118)
EGARCH terms				
γ_1	-0.036***	-0.041***	-0.034***	-0.035***
	(0.008)	(0.009)	(0.008)	(0.008)
γ_2	0.321***	0.321***	0.320***	0.319***
	(0.017)	(0.017)	(0.017)	(0.017)
γ_3	0.490***	0.501***	0.514***	0.527***
	(0.051)	(0.050)	(0.053)	(0.055)
γ_4	0.236***	0.199***	0.213***	0.214***
	(0.065)	(0.067)	(0.068)	(0.070)
γ_5	0.254***	0.281***	0.256***	0.241***
	(0.046)	(0.048)	(0.048)	(0.049)
Observations	3,431	3,431	3,431	3,431
Log likelihood	7166	7174	7164	7167

Notes: The table shows coefficient estimates for the effect of Bank of Canada press releases on 1-year government bond yields, following equations (3) and (4), (5) and (6). Columns (1) and (2) test for the effect of similarity of the last paragraph of Bank of Canada press releases. Column (2) also controls for a dummy variable that is equal to one if the preceding statement had been extremely similar ($D_{t_{-1}}$) and an interaction of this dummy variable with the semantic similarity. Columns (3) and (4) relate to the entire press release but also control for the change in length of the press release (Δ word count) and an interaction of this additional variable with the semantic similarity. Numbers in brackets are standard errors. ***/**/* denote statistical significance at the 1%/5%/10% level.

Table 7: The effect of Bank of Canada press releases on 1-year government bond yields—robustness tests

.

	(1) Bench-mark	(2) Reversed fx coding	(3) Δ Tone	(4) Un-weighted	(5) GARCH	(6) Three-statement similarity	(7) Only announce ment days	(8) Add forecast dispersion	(9) Add macro news	(10) Add MPR	(11) Add clarity	(12) Add Governor dummies	(13) Add forward guidance	(14) Add post-crisis dummy
Mean equation														
Surprise	0.988***	1.005***	0.997***	0.996***	0.848***	1.003***	0.830***	0.958***	0.954***	0.983***	0.990***	0.976***	0.988***	0.983***
	(0.046)	(0.046)	(0.041)	(0.044)	(0.045)	(0.045)	(0.182)	(0.056)	(0.061)	(0.047)	(0.046)	(0.050)	(0.046)	(0.045)
Tone	0.027***	0.018***	0.032***	0.029***	0.032***	0.025***	0.007	0.026***	0.025***	0.027***	0.026***	0.027***	0.027***	0.027***
	(0.004)	(0.004)	(0.005)	(0.004)	(0.002)	(0.004)	(0.021)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
CPI (CAN)	--	--	--	--	--	--	--	--	0.007***	--	--	--	--	--
									(0.001)					
Retail sales (CAN)	--	--	--	--	--	--	--	--	0.008***	--	--	--	--	--
									(0.002)					
Unemployment (CAN)	--	--	--	--	--	--	--	--	-0.006***	--	--	--	--	--
									(0.002)					
Non-farm pay-rolls (U.S.)	--	--	--	--	--	--	--	--	0.018***	--	--	--	--	--
									(0.002)					
NAPM (U.S.)	--	--	--	--	--	--	--	--	0.001	--	--	--	--	--
									(0.002)					
Constant	-0.000	-0.000	-0.000	-0.000	0.000	-0.000	0.011*	-0.000	-0.000	-0.000	-0.000	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.006)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)

Notes: The table shows coefficient estimates for the effect of Bank of Canada press releases, following equations (3) and (4). Column 1 repeats the benchmark estimates. Column 2 contains results when the coding of foreign exchange statements is reversed. Column 3 uses the change in tone as opposed to the level. Column 4 is based on an unweighted similarity index. Column 5 estimates a GARCH(1,1) model instead of an EGARCH model. Column 6 contains results with a similarity measure that compares a statement with the previous three statements. Column 7 only includes the 110 announcement days (using the residuals from a simple EGARCH model estimated over all days in the mean equation, and the estimated conditional variance in the variance equation. Columns 8 to 14 add, respectively, the interquartile range among Consensus Economics forecasts for 3-month interest rates three months ahead, macro news, a dummy for press releases that coincide with the release of the *Monetary Policy Report*, the Flesch-Kincaid measure of clarity, dummy variables for the tenure of Governors Carney and Poloz (with Governor Dodge as benchmark), a dummy variable for Bank of Canada forward guidance (April 2009 to April 2010), and a post-crisis dummy variable (one as of September 15, 2008). Numbers in brackets are standard errors. ***/**/* denote statistical significance at the 1%/5%/10% level

Table 7 (continued)

	(1) Bench-mark	(2) Reversed fx coding	(3) Δ Tone	(4) Un-weighted	(5) GARCH	(6) Three-statement similarity	(7) Only announce ment days	(8) Add forecast dispersion	(9) Add macro news	(10) Add MPR	(11) Add clarity	(12) Add Governor dummies	(13) Add forward guidance	(14) Add post-crisis dummy
Variance equation														
Absolute surprise	2.290**	2.087**	1.471	2.723***	14.979***	2.192**	6.294***	3.138***	2.343*	2.324**	2.261**	3.036***	2.277**	2.631***
	(1.001)	(0.998)	(0.959)	(0.947)	(2.891)	(0.997)	(1.929)	(1.137)	(1.254)	(1.006)	(0.991)	(1.068)	(1.000)	(0.958)
Similarity	-1.165***	-1.219***	-1.147***	-2.279***	-5.837***	-1.327***	-2.633***	-1.202***	-1.527***	-1.103***	-1.129***	-1.083***	-1.177***	-1.069***
	(0.116)	(0.108)	(0.123)	(0.240)	(1.419)	(0.122)	(1.003)	(0.126)	(0.124)	(0.123)	(0.123)	(0.123)	(0.117)	(0.121)
Additional var. (see column header)	--	--		--	--	--	--	0.140***	--	0.070	-0.008***	--	0.023***	-0.029***
								(0.018)		(0.098)	(0.001)		(0.007)	(0.005)
CPI (CAN)	--	--	--	--	--	--	--	--	0.067	--	--	--	--	--
									(0.071)					
Retail sales (CAN)	--	--	--	--	--	--	--	--	0.220***	--	--	--	--	--
									(0.065)					
Unemployment (CAN)	--	--	--	--	--	--	--	--	0.246***	--	--	--	--	--
									(0.075)					
Non-farm pay-rolls (U.S.)	--	--	--	--	--	--	--	--	0.490***	--	--	--	--	--
									(0.080)					
NAPM (U.S.)	--	--	--	--	--	--	--	--	0.149***	--	--	--	--	--
									(0.050)					
Constant	1.053***	1.106***	1.040***	2.171***	-8.339***	1.216***	-5.950***	0.901***	1.343***	0.992***	1.117***	0.906***	1.069***	0.925***
	(0.115)	(0.108)	(0.100)	(0.239)	(1.070)	(0.121)	(0.482)	(0.129)	(0.123)	(0.121)	(0.121)	(0.126)	(0.117)	(0.122)
EGARCH terms														
γ_1	-0.033***	-0.034***	-0.034***	-0.033***	0.085***	-0.033***	--	-0.030***	-0.027***	-0.033***				
	(0.008)	(0.008)	(0.008)	(0.008)	(0.004)	(0.008)		(0.009)	(0.009)	(0.008)	-0.028***	-0.047***	-0.038***	-0.040***
γ_2	0.321***	0.322***	0.315***	0.318***	--	0.316***	--	0.330***	0.390***	0.321***	(0.008)	(0.009)	(0.008)	(0.008)
	(0.017)	(0.017)	(0.017)	(0.017)		(0.017)		(0.018)	(0.019)	(0.017)	0.313***	0.321***	0.319***	0.309***
γ_3	0.505***	0.502***	0.539***	0.519***	0.924***	0.516***	--	0.418***	0.343***	0.503***	(0.017)	(0.017)	(0.017)	(0.016)
	(0.052)	(0.051)	(0.055)	(0.053)	(0.003)	(0.054)		(0.054)	(0.032)	(0.052)	0.512***	0.538***	0.503***	0.546***
γ_4	0.221***	0.222***	0.194***	0.205***	--	0.228***	--	0.282***	0.317***	0.221***	(0.052)	(0.051)	(0.051)	(0.054)
	(0.067)	(0.066)	(0.073)	(0.070)		(0.069)		(0.061)	(0.037)	(0.067)	0.205***	0.167**	0.221***	0.158**
γ_5	0.257***	0.257***	0.249***	0.259***	--	0.239***	--	0.265***	0.318***	0.259***	(0.069)	(0.072)	(0.066)	(0.074)
	(0.048)	(0.048)	(0.051)	(0.049)		(0.048)		(0.051)	(0.036)	(0.048)	0.266***	0.269***	0.259***	0.272***
Observations	3,431	3,431	3,431	3,431	3,431	3,381	110	3,431	3,431	3,431	3,431	3,431	3,431	3,431
Log likelihood	7164	7161	7166	7162	7143	7102		7181	7277	7164	7171	7173	7166	7171

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Appendix Table A1: Examples of statement coding

Topic	Tense	Tone	Examples
Domestic economy	Backward-looking	Positive	*"The Canadian economy continued to expand in the first quarter of 2003, reflecting firmness in domestic demand"*
		Negative	*"Economic growth in Canada moderated in the final three months of 2002"*
		Neutral	*"The Canadian economy has been growing broadly in line with the Bank's expectations"*
	Forward-looking	Positive	*"On the upside, there is a possibility that household demand in Canada could be stronger than anticipated."*
		Negative	*"Although temporary supply chain disruptions are expected to restrain growth sharply in the current quarter […]"*
		Neutral	*"The Bank anticipates that business investment and net exports will make a relatively larger contribution to growth."*
Global economy	Backward-looking	Positive	*"Since the July* Monetary Policy Report Update *(MPRU), the global economy has continued its solid expansion"*
		Negative	*"While there has been some moderation in U.S. economic growth […]"*
		Neutral	*"U.S. economic activity has come in largely as expected"*
	Forward-looking	Positive	*"Strong growth in the United States is expected to resume in the second quarter of 2015"*
		Negative	*"[…] but over the medium term, risks related to global imbalances are increasing"*
		Neutral	*"Fiscal drag in the United States over the next two years remains consistent with the Bank's January projection"*
Inflation	Backward-looking	Positive	*"Inflation has risen by more than expected. The increase in inflation over the past year is largely […]"*
		Negative	*"However, other developments since October suggest that the downside risks to the Bank's inflation projection have increased."*
		Neutral	*"Canadian consumer price data for January show core inflation at 1.8 per cent and total CPI inflation at 1.3 per cent."*
	Forward-looking	Positive	*"In these circumstances, the persistence of above-target rates of inflation has elevated the risk of an increase in inflation expectations"*
		Negative	*"[…] it now appears that both core and total CPI inflation will return to the 2 per cent target somewhat earlier than the Bank expected in April." (after period of above-target inflation)*
		Neutral	*"As the economy reaches and remains at full capacity around the end of 2016, both total and core inflation are projected to be close to 2 per cent on a sustained basis."*
Exchange rate	Backward-looking	Positive	*"[…] and the Canadian dollar has traded in a higher range against the U.S. dollar and other major currencies"*
		Negative	*"The reduction in commodity prices has been a significant factor in the decline of the Canadian dollar against the U.S. dollar"*
		Neutral	*"The Canadian dollar has also largely traded in the range assumed in the July MPRU"*
	Forward-looking	Positive	*"These challenges include the persistent strength of the Canadian dollar, which is being influenced by safe-haven flows and […]"*
		Negative	*"Consequently, the effects on core inflation of the lower dollar and the output gap will continue to offset each other."*
		Neutral	*"However, there is uncertainty about the extent to which the appreciation of the Canadian dollar will offset the effects of […]"*
None of the above			*"The interest rate cut announced today brings the cumulative easing in the target for the overnight rate over the past 12 months to 3 3/4 percentage points."*

Appendix Table A2: Summary statistics of financial market variables

Financial market variables (differences / growth rates)	Obs.	Mean	Std. Dev.	Min	Max
Government bonds					
3-month	3,431	-0.001	0.039	-0.560	1.030
6-month	3,431	-0.001	0.034	-0.320	0.450
12-month	3,431	-0.001	0.042	-0.680	0.420
2-year	3,431	-0.001	0.052	-0.340	0.320
5-year	3,431	-0.001	0.053	-0.280	0.330
10-year	3,431	-0.001	0.047	-0.230	0.240
30-year	3,431	-0.001	0.037	-0.150	0.210
Money markets					
3-month	3,431	-0.001	0.021	-0.367	0.251
6-month	3,431	0.000	0.025	-0.299	0.211
12-month	3,431	0.000	0.034	-0.257	0.351
Stock markets					
TSX	3,431	0.028	1.100	-9.324	9.823
MSCI index	3,431	0.029	1.149	-9.907	10.212
Exchange rates					
USD/CAD	3,431	0.006	0.604	-3.199	4.061
CERI	3,431	0.007	0.565	-3.664	4.739

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