The Evolving Scope and Content of Central Bank Speeches

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Abstract:

Empirical research on central bank communication largely focusses on how the release of specialized reports or press releases following a monetary policy decision transmit information to financial markets. As central bank communications strategists shift their attention to engaging with a wider public audience, more research is needed to understand the role and influence of public speeches as a versatile communication tool. This paper empirically evaluates how the use of central bankers' speeches and content of these speeches has changed over time. We compare the use of speeches by the US Federal Reserve and the Bank of Canada, including the number of speeches by speaker, venue and topic over the last two decades. To extract topics from speeches, we use latent Dirichlet allocation—an unsupervised machine learning algorithm that estimates probability distributions over words to topics and topics to documents. Significant differences in the communications strategies of these two central banks are found, which are likely owing to differences in their governance and policy strategies. We show that the content of speeches became more concentrated at the Fed during the height of the international financial crisis from 2007 to 2009. Similarly, speeches appear to be used to address a wider range of issues after the introduction of new communications tools like regular press releases after FOMC meetings starting in 2000 and more elaborate press conferences by the Governor and Senior Deputy Governor of the Bank of Canada starting in 2014. Finally, financial markets tend to see less movement on the dates of central bankers' speeches, with a clear exception of speeches on the liquidity facility and financial market liquidity by Fed officials – likely related to the information content of these speeches during the crisis.

Keywords: central bank communication, speech content analysis, US Federal Reserve, Bank of Canada

JEL classification codes: E58, E52, E65

1. Introduction

Central bank communication strategies have changed dramatically over the past few decades. Gone are the days of "never explain, never excuse".[1] Central bankers now favour clear communication of policy decisions, embracing transparency in monetary policy as best practice.[2] While there are several compelling reasons for policymakers to improve transparency, the main argument by early proponents of the transition (scholars and central bankers alike) hinged on improving the transmission of monetary policy. Early research on central bank communication demonstrated its utility for managing financial market expectations and reducing financial market volatility (see Blinder et al. 2008 for an overview).

The 2008 global financial crisis (GFC) further fuelled the revolution in central bank communication (Yellen 2012). After interest rates in advanced economies reached record lows, communication of the expected future path of interest rates—i.e. forward guidance—became a monetary policy tool in and of itself. Economic research on central bank communication in the post-crisis period largely focused on the design and effectiveness of forward guidance policies (e.g. Campbell et al. 2012; Charbonneau and Rennison 2015; Filardo and Hofmann 2014).

Notably, both of these advances in central bank communication emphasize influencing financial market expectations. But financial markets are only one of many stakeholders of central banks, which also include governments, academics and central bank watchers, the media and the general public. Communications strategists are now placing more emphasis on public accountability and building trust with the general public.[3] The loss of trust from the GFC, changes in the way media is consumed and increasing political fragmentation could pose a threat to central bank independence. There is also a concern about inattention to the central bank's actions by the general public, which can result in more volatile inflation expectations (Coibion et al. 2018). These trends are driving the need to improve dialogue with the public (Donnery 2017).

The delivery of public speeches is a versatile communication tool that that can be used to connect with all of central banks' stakeholders. Speeches are used to engage various stakeholders on central bank activities, clarify the views of the monetary policy committee before or after policy deliberation, elaborate on policy shifts or revisions (such as the renewal of the inflation-control target at the Bank of Canada or the use of forward guidance at the Bank of England), and express the diversity of perspectives of individual central bankers (e.g. Bernanke 2004; Kozicki and Vardy 2017; Vallès and Schonhardt-Bailey 2015).

Despite the wide-range of applications, the use and impact of speeches by central bankers remains an under-studied aspect of communication strategies. The aim of this paper is two-fold. First, it assesses

[1] This motto is popularly attributed to Montagu Norman, Governor of the Bank of England from 1920 to 1944.
[2] There are of course different interpretations of what transparency should consist of and degrees of transparency among banks. Generally, there has been a shift toward improving transparency of central banks in the past few decades.
[3] This was one of the main themes that emerged out of the European Central Bank's communications conference in November 2017.

the use of speeches by the Bank of Canada (BoC) and the US Federal Reserve (Fed) over the past two decades and uses topic modelling to assess how the content of these speeches has evolved. These two central banks have very different communication strategies and institutional frameworks. As elaborated in Section 3, a comparative analysis of the BoC and the Fed can therefore help illuminate the role of speeches under different contexts. Second, it identifies which speech topics are more likely to affect financial markets.

In general, building public trust and maintaining stable financial markets go hand-in-hand: frequent financial market disruptions can harm the central bank's reputation and create a perception of failure (Vardy 2015). But dialogue with financial markets and the general public may require different approaches with regard to the channels of communication, style and even topic of discussion. Indeed, it implies engaging with stakeholders through new platforms, including social media and public speeches in more inclusive venues (e.g. Haldane 2016; Araujo 2016). It may also require changing the content of communication, and emphasizing simplicity and relevance to ensure the message being delivered is more accessible and appealing to a wider audience (Haldane and McMahon 2018).

While incorporating the principles of simplicity and relevance into communication appears evident, central bank policies are not simple and not always immediately relevant to the general public. As the revolution in central bank communication continues full speed, their challenge will be to balance: simplicity and nuance; and making policy discussions relevant to the general public versus communicating more in-depth policy analysis. This is the first paper, to our knowledge, that aims to empirically evaluate how the scope—measured as the number and types of topics being discussed—of central bankers' speeches is changing over time, and whether topics of discussion have a differential impact on financial markets.

We first compare trends in the use of speeches by officials at the BoC and Fed, including the number of speeches, speaker, venue, and topic of speeches over the last two decades. To extract topics from speeches, we use latent Dirichlet allocation (LDA)—an unsupervised machine learning algorithm that estimates probability distributions over words to topics and topics to documents (Blei et al. 2003). We then examine how the topics discussed by central bankers have evolved over time and consider what factors are driving the choice of topic; for example, preferences of individual central bankers, changes to the central bank's mandate, changes in the context of policymaking, or deliberate changes in communication strategy. Finally, a time series model is used to model the impact of speeches on asset price fluctuations.

The topics of speeches by BoC and Fed officials' have clear links to their respective communications strategies, institutional structures and important events of the time. For example, speeches by BoC officials are more likely to discuss international issues, reflecting Canada's position as a small-open economy that is vulnerable to international pressures. Fed officials, however, more frequently discuss the financial system, banking, and financial supervision and regulation; reflecting the Fed's additional responsibilities as a key financial regulatory agency (responsibilities not held by the BoC). Similarly, the topics of speeches by BoC officials tend to cluster around time periods. This reflect the BoC's centralized communications strategy that ensures that Governing Council members stay on message (including

discussing issues focused on their respective areas of responsibility at the Bank). In contrast, speeches by Fed officials tend to cluster around individual speakers, reflecting the individualistic dissemination of information.

The empirical evidence suggests that when central banks introduce additional communication tools, like the regular post-meeting announcements by the FOMC and providing additional information through press conferences after the MPR release at the BoC, they may begin to use speeches to discuss a wider range of topics. However, during period of crisis, speeches may be used to specifically address issues related to the crisis. We find that during the 2007-09 international financial crisis (IFC), speeches by Fed officials became more concentrated, focussing on issues relevant to the crisis. Finally, while central bankers attempt to improve their dialogue with the public, the paper shows that the linguistic complexity of central bankers' speeches has not decreased over time. More effort may therefore be needed to increase the accessibility of this form of communication.

In considering the impact of the content of speeches on financial markets, we observe that, in general, dates of central bankers' speeches are actually associated with lower market activity. There is one notable exceptions: Speeches by Fed officials on its lender of last resort (LOLR) function—speeches on liquidity facilities and financial market liquidity—tend to increase market fluctuations for both US and Canadian equities and sovereign bond yields. This may be related to the important information being delivered in these speeches during the height of the IFC. These results suggest that during critical periods, speeches should be an important component of the strategy to communicate timely information to financial markets. More generally, however, financial markets are not easily moved by other topics discussed in central bankers speeches; this communication tool may therefore be readily used for other matters of public outreach.

The rest of the paper is structured as follows. The next section discusses the relevant literature on central bank communication and the use of text mining in this scholarship. Section 3 details the data set, explains the communication strategies of the BoC and the Fed and provides descriptive statistics of the use of speeches by these central banks over the past two decades. Section 4 lays out the methodology for text mining and analyzes trends in the content central bankers' speeches over the past two decades. Section 5 assess the impact of speech content on financial market activity. Section 6 concludes.

2. Literature: Central Bankers Speeches and Text Mining Technique

Alongside the revolution in central bank communication is a burgeoning literature that attempts to identify best practice and analyzes the impact of talk on financial market behaviour. A comprehensive review of this literature is infeasible for a single paper. We therefore focus on the literature that is most relevant for this analysis, namely studies that assess the role and impact of speeches within central bank communication strategies and the use of text mining techniques in central banking.

The literature to date only scratches the surface of understanding the role and influence of speeches within central bank communications strategies. Thin analysis of this tool may be related to earlier studies' findings that speeches have little-to-no impact on financial market volatility (e.g. Connolly and Kohler 2004; Kohn and Sack 2004; Reeves and Sawicki 2007). But two features of these studies call these

results into questions. First, there was no differentiation in the topic of these speeches; speech variables were coded as dummies equal to one on the date of a speech and zero otherwise. Subsequent studies have focused on speeches that discussed interest rates, inflation or monetary policy, extracted based on newswire coverage (e.g. Ehrmann and Fratzscher 2007a, 2007b) or coded the speeches depending on the hawkishness or dovishness of the message being delivered (e.g. Andersson et al. 2006). Studies that differentiate the content of communications are more likely to conclude that speeches have a significant impact on asset prices or financial market volatility.

Second, the period of analysis in these earlier studies spanned the 1990s to the early 2000s, but communications strategies and market reactions to central bank talk have changed significantly since this time. Some studies find that speeches delivered by US Fed Chair Alan Greenspan had a larger impact on asset prices between 2000 and 2003 then before or after this period (Biefang-Frisancho Mariscal and Howells 2010), potentially owing to the explicit use of communication as a policy tool during that period. Similarly, the impact of US Fed officials' speeches on market volatility increased at the turn of the millennium, which coincides with intensified communication at the Fed (Ehrmann and Fratzscher 2007b). In the aftermath of the GFC, markets began to pay even close attention to central bankers' speeches as they looked for clues about the direction of unconventional monetary policies. Mario Draghi's famous 'whatever takes' speech in 2012 (Fratzscher et al. 2016) and Ben Bernanke's speech in late 2008 suggesting the potential purchase of Treasuries (Krishnamurthy and Vissing-Jorgensen 2011) are just two examples of influential speeches.

The literature also suggests that the speaker, content and timing of speeches matter. Most studies only analyze the speeches of the heads of central banks; and there is evidence that only the speeches of key speakers move asset prices (e.g. Gertler and Horvath 2017; Rosa 2016). However, the relevance of individual communications likely depends on the central bank's communications strategy and institutional framework (e.g. Connolly and Kohler 2004; Ronaldo and Rossi 2010). For example, the speeches of the Chair may be more relevant for a central bank with a collegial approach to decision making and individualist communications like the Fed, but the speeches of all members of the monetary policy committee may be relevant for a central bank that has both collegial approach to communication and decisions making like the European Central Bank (ECB) or BoC (Ehrmann and Fratzscher 2007a).

The impact of speeches on financial markets may also depend on the timing and sequencing of communications. There is some evidence that there is interdependence among news events. Markets have been found to react more strongly to communication, including speeches, ahead of Federal Open Market Committee (FOMC) meetings, providing a rational for the blackout period—also known as Purdah—practiced by many central banks (Ehrmann and Fratzscher 2009). Ehrmann and Sondermann (2012) find that the release of the Bank of England's Inflation Reports reduces conditional volatility, and that volatility increases based on time elapsed since the report's release. There is also the potential for news to be crowded out, as the impact of communications has been found to decrease with its "stock" over short periods of time (Ehrmann and Fratzscher 2007a). Of course, media plays a role in translating information released by central banks, and there is evidence that media coverage of Fed Chair speeches is more likely to occur if central bank communication has been stale (Neuenkirch 2014).

A few studies have attempted to assess the relative importance of the content of speeches. Ehrmann and Fratzscher (2007b) find that speeches on monetary policy had more of an impact on asset prices before the FOMC introduced regular statements after policy meetings. Speeches on the economic outlook, however, had a stronger impact on financial market volatility once FOMC statements became more regular. Siklos and Bohl (2007) were the first to demonstrate that speeches can complement actions taken by a central bank via a change in the policy rate instrument. They classify speeches by Bundesbank officials according to their content and find that speeches dealing with economic policy, prices and exchange rates are useful instruments that bring actual policy making closer to the theoretical expectations of a conventional Taylor rule. Speeches conveying different monetary policy inclinations than current expectations are more likely to get newswire coverage (Neuenkirch 2014) and are therefore more likely to translate to financial markets (Hayo and Neuenkirch 2015).

There is also a risk that sending mixed signals can increase financial market volatility or misalign market expectations. Di Giorgio and Rossi (2012) find that ambiguity in the message of speeches by members of the ECB's Governing Council increases volatility of interbank rates and dispersion of expectations about future interest rates. Similarly, a high degree of dispersion of the policy inclinations among individual committee members has been found to be detrimental to the ability of financial markets to understand the future path of monetary policy (Ehrmann and Fratzscher 2007c). It is possible that sending mixed signals about what economic developments are relevant for monetary policy, for example international trade, labour markets or inequality, could increase market volatility.

Analysis of central bankers' speeches is often only one small component of research on the impact of communication on financial markets. We try to fill this gap by assessing the role of speeches in central bank communications strategies, how the use of speeches to communicate the role and policies of the central bank has evolved over time, and whether these changes have any material impact on how financial markets digest information. Research that uses text mining to assess central bank communication is therefore of relevance for this study.[4]

Early research manually coded central bank statements as dovish (negative), neural (zero) or hawkish (positive) (e.g. Jansen and De Haan 2005; Rosa and Verga 2007; Berger, De Haan and Sturm 2011; Musard-Gies 2006; Gerlach 2007). This is a simple methodology useful for identifying whether communication had the intended impact on financial markets. Among the drawbacks of this approach are that the choice of coding is subjective and, since the classifications are not made in real time, the context in which markets digested the news cannot be fully understood (Blinder et al. 2008).

Another popular approach is to quantify the topic or sentiment of communications using a 'bag of words' measurement. These studies measure the occurrences of a dictionary of key words or word associations in a text. This methodology has been used to gauge relative dovish/hawkishness of communications (e.g. Apel and Blix Grimaldi 2012), assess dispersion of views in deliberations (e.g. Meade et al. 2015) and identify how communication changed after the global financial crisis (Siklos

[4] This paper only provides a brief overview of this literature; readers are directed to Bholat et al. (2015) for a more comprehensive review of text mining for central banking.

2013). Using a larger list of words generated from a training set of documents, the bag of words methodology has also been used to extract the tone or sentiment of central bank communications (e.g. Lombardi et al. 2017; Schmeling and Wagner 2017).

The 'bag of words' methodology is useful for creating a time series measuring the content of texts. One limitation of this technique, however, is that the words in the dictionary are selected by the researcher; topics are therefore imposed on the data rather than being derived from the natural language of the corpus. Others criticize the information content extracted using this approach and suggest identifying word-association (called n-grams) is a superior methodology (e.g. Amaya and Filbien 2015; Picault and Renault 2017). However, Tang (2017) uses this methodology as well as an supervised machine learning technique—multinomial Naïve Bayes classification model—to identify the extent of discussion of labour market in Fed statements and finds that the two estimates are highly correlated. These results suggest that, at least for some purposes, using a simple method may be just as good as a complex algorithm.

When trying to organize central bank communications along several dimensions, for example topic identification, machine learning techniques may be more suitable. Central bank research has used principal component analysis (PCA) to infer policy leanings from financial market reactions, which reduces asset prices and price volatility to a few dimensions (e.g. Gürkaynak, Sack and Swanson 2005; Gürkaynak 2005). A similar approach has been used to explain variation in the text of central bank communications. Latent semantic analysis (LSA) applies singular value decomposition to a term-document matrix—a matrix consisting of all the words in a corpus as rows and documents as columns, with each element representing a count of word i in document j. Similar to PCA, the singular value decomposition estimates the linear combination of words and documents that explain the most variation within the corpus by extracting the eigenvalues of the corpus and eigenvectors associated with the documents and words.

LSA is a powerful tool for measuring document similarity. The methodology was used by Acosta (2015) to assess the impact of changes in transparency at the Fed on policy deliberations. The author finds that the Humphrey-Hawkins Act of 1978 increased Fed transparency by improving the relation of FOMC meeting transcripts, which were not being released the time, to meeting minutes (or records of policy actions). By comparing similarities among statements by FOMC members during policy deliberations before and after it was known that transcripts were stored and would be publicly released in 1993, they also found that transparency increases conformity in deliberation.

This methodology has also been used for topic modelling (e.g. Boukus and Rosenberg 2006; Hendry and Madeley 2010; Hendry 2012). Analyzing BoC interest rate statements, Hendry (2012) finds discussion of some topics increase market volatility, such as oil prices, while other reduce volatility, such as discussion of the balance of risk to economic projections. Similarly, Boukus and Rosenberg (2006) find that market reaction to FOMC meeting minutes depends on the topics being communicated and economic circumstances. A critical drawback in using LSA for topic modelling is that the identification of topics is not straightforward as terms and documents can contribute both positively and negatively to topics.

Another technique that provides a richer and more intuitive classification of topics within a corpus is latent Dirichlet allocation (LDA).[5] LDA is an unsupervised machine learning algorithm that uses Dirichlet distribution to assign words to topics and topics to documents. Like Acosta (2015), Hansen et al. (2018) use LDA to assess how transparency affects monetary policy deliberations by analyzing changes in discussion, focusing on topics that are more informative about policy preferences. This methodology has also been used to model topics in monetary policy committee meeting minutes (Jegadeesh and Wu 2017; Oshima and Matsubayashi 2018). This research finds that financial markets react differently to topics being discussed in communications, and this impact varies depending on the economic circumstances. Our analysis will also use LDA to analyze trends in public speeches of central bankers over time and assess the variational impact of topics in speeches on financial market behaviour. Details regarding the text mining methodology are provided in Section 4.

3. Communications Strategies of the Bank of Canada and the US Federal Reserve

We have established that central bank communications have changed over time and are continuing to evolve. While a consensus has emerged on the importance of transparency, the communications strategies among jurisdictions still vary significantly depending on several factors, such as the organizational structure, institutional mandate and preferences of individual central bankers. In this section we discuss the differences in the communications strategies of the BoC and US Fed and explain why a comparative analysis of the use of speeches by these two central banks is useful. The data set of speeches is then detailed, along with descriptive statistics of the use of speeches by these central banks over the last two decades.

BoC and Fed Communications Strategies

Monetary policy decisions at the BoC are made by consensus of the Governing Council – a six-member committee that includes the Governor, Senior Deputy Governor and four Deputy Governors. The Governing Council is a creation of former Governor Gordon Thiessen who, in the early 1990s, made substantial changes to the transparency of the BoC (see Thiessen 2001). Although the Governor alone remains statutorily responsible for policy decisions, the effective role in public outreach of the other five Council members have been increasing over the last few decades. The Governor and Senior Deputy Governor are appointed by the independent members of the BoC Board, with approval of the Governor in Council (Cabinet), and the other Deputy Governors are appointed by the Board, creating a layer of separation between the government and the appointment of central bankers.

At the Fed, policy decisions are made by majority vote of the 11 voting members of the Federal Open Market Committee (FOMC). Voting members include the seven-member Board of Governors of the Federal Reserve System, the President of the New York Fed and four of the remaining 12 regional reserve bank presidents who serve one-year rotating terms. The Fed Board of Governors are nominated

[5] Other approaches, such as active learning or supervised machine learning, may have similar benefits. By accepting user input during the estimation process, it also allows the user to add expertise in the areas that the algorithm can't handle.

by the US President and approved by the Senate. The direct relationship to the political process is one reason why the Fed Chair's Congressional testimonies attract more attention and are more consequential than the BoC Governor's appearances before the parliamentary committees. However, the regional bank Presidents are accountable to a different set of stakeholders, including the regional bank's board of directors, private sector shareholders and regional constituency.

There are key differences in how the BoC and Fed organize and disseminate information (Table 1). The BoC has a centralized communications strategy to align with its consensus-oriented policy approach. According to the BoC's *Principles for External Communication by Members of the Governing Council*, individual members cannot publicly share personal views, instead, any external communications on monetary policy or the economic outlook must reflect the consensus view of the Governing Council (also see Kozicki and Vardy 2017).[6]

The US Fed's communication strategy, on the other hand, can be categorized as decentralized with individualistic dissemination of information (Ehrmann and Fratzscher 2007). Members of the FOMC are free to express their personal views on the economic outlook as well as their judgments about the policy path. As Ben Bernanke (2004) put it, "the willingness of FOMC members to present their individual perspectives in speeches and other public forums provides the public with useful information about the diversity of views and the balance of opinion on the Committee". Guidelines adopted by the Fed in 2011 suggest that in expressing their individual views, they should also be clear about the Committee's rationale for policy decisions (US Federal Reserve Board of Governors 2017a).

Table 1: Factors that Influence the Communication Strategies of the BoC and Fed

	Bank of Canada	**US Federal Reserve**
Organization	Centralized	Decentralized
Dissemination	Consensus-oriented	Individualistic
Monetary Policy Decision Making	Consensus	Majority vote (Collegial)
Monetary Policy Operational Guide	Inflation Targeting	Dual Objective
Other Responsibilities	➢ Financial market infrastructures oversight ➢ Lender of last resort (LOLR) ➢ Assessing financial stability ➢ Participates in national and international bodies on matters related to financial system stability ➢ Currency design, issuance and distribution ➢ Funds Management	➢ Financial market infrastructures oversight ➢ Lender of last resort (LOLR) ➢ Assessing financial stability ➢ Participates in national and international bodies on matters related to financial system stability ➢ Currency design, issuance and distribution ➢ Funds Management ➢ Macroprudential supervision and regulation

[6] The policy does not specifically indicate that external communication on financial risks must also reflect the consensus viewpoint, however it does not that in the communication of 'the evolution of risks' can only be communicated though venues that are widely accessible to the public.

		➢ Microprudential supervision and regulation ➢ Consumer protection
Blackout Period (Purdah)	Yes	Yes
Accountability of Monetary Policy Committee Members	The Governor and Senior Deputy Governor are members of the Board of Directors; they are appointed by the independent Board members with approval of the Governor in Council (Cabinet). Board members are appointed by the Minister of Finance, with the approval of the Governor in Council. The other Deputy Governors are appointed by the Board.	Members of the Board of Governors are nominated by the US President and confirmed by the US Senate.

The central bank's policy responsibilities and its monetary policy operational guide will affect the content of speeches by defining the set of topics that can be discussed. The BoC's inflation control target will likely imply that Governing Council members devote less attention to the employment situation than Fed officials would under their dual objective—which includes stable prices and full employment—will give the FOMC. Similarly, the Fed has a wider scope of responsibilities than the BoC, including microprudential supervision and regulation, some macroprudential authority, and consumer protection and economic development, creating additional topics of discussion that fit within the boundaries of its mandate.

These central banks also have different guidelines for discussing topics that are matters of 'public interest'. The BoC's guidelines state that when discussing matters of public interest, "Governing Council members consider any potential risk to integrity and impartiality of the Bank". The Fed's guidelines appear more flexible, the *Voluntary Guide to Conduct for Senior Officials* states that members "should feel free to express their personal views concerning questions of System or public interest, but they should carefully consider whether their remarks may create public misunderstanding of the System's actions, or impair the effectiveness formulation and implementation of System policies or lessen the prestige of the System" (US Federal Reserve Board of Governors 2017b).

Some central banks also adopt a blackout period to limit communication about monetary policy ahead of interest rate decisions. The Governing Council is restricted from delivering speeches or speaking to media about the economic outlook, direction of monetary policy or anything else relevant to the interest rate decision seven-days prior and on the date of an interest rate decision (Bank of Canada 2018).[7] The FOMC is restricted from discussing matters related to monetary policy approximately 10 days before a meeting and the day after a meeting (US Federal Reserve Board of Governors 2017a).

Despite significant differences in communication strategies, one approach is not necessarily more effective than the other. The institutional and economic context within which the central bank operates

[7] When the decision is accompanied by a Monetary Policy Report, the blackout period spans eight day prior to a rate decision and ends when the press conference associated with the report begins.

affects the role and influence of communications. Ehrmann and Fratzscher (2007) show that communication by the Fed and the European Central Bank, which has consensus-oriented decision making and communications, are both effective at aligning financial market expectations. In addition, as Blinder et al. (2008, 934) put it, "Markets, of course, adapt to a central bank's communication style." As central bank communications continue to evolve, with emphasis being placed on improving accountability and creating a dialogue with the general public, best practices will certainly change but will likely still vary depending on the institution's relationship with the public.

Sample and Descriptive Statistics

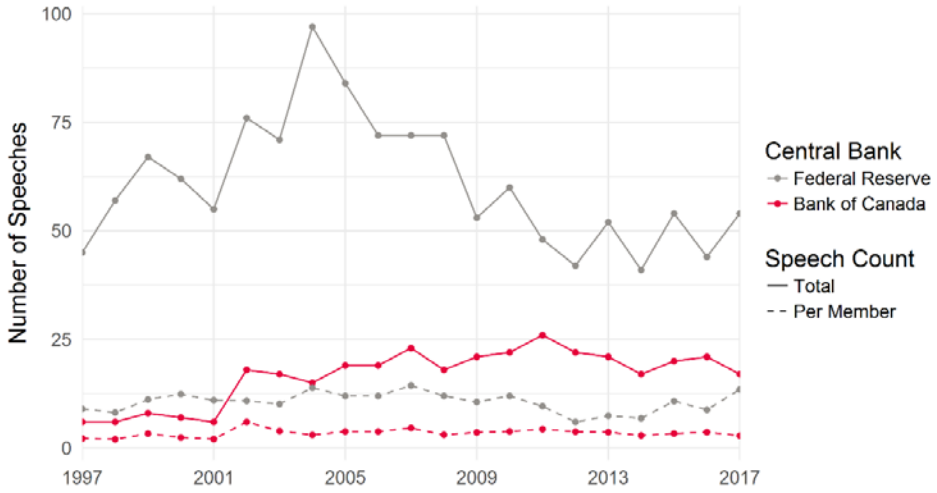
The sample consists of all speeches by members of the BoC's Governing Council and the Fed's Board of Governors from 1997 to 2017. We select only the members of the Fed Board of Governors because these are permanent voting members of the FOMC and they are directly accountable to the US Congress and responsible for overseeing the Federal Reserve System as a whole. Their speeches would therefore provide a stronger indication of how the Fed uses speeches in its communication strategy.[8]

Figure 1 shows the number of speeches delivered by BoC and Fed officials per year. This figure already reveals a significant difference in the use of speeches by these two central banks; namely, that Fed officials deliver far more speeches than BoC officials. Governing Council members delivered a total of 349 speeches in the last 21 years, while the US Fed Board of Governors delivered 1,278. There are a few trends worth highlighting. The number of speeches delivered by Fed officials increased from 47 in 1997 to a peak of 97 in 2004 under Greenspan's tenure. Some of this can likely be explained by efforts to increase transparency at the Fed around this period; but the results also show that having a full seven-member Board of Governors between 2002 and 2005 also played a role. After the 2007-09 IFC, the number of speeches delivered per year fluctuated around 50. The decline from the pre-crisis period is partially related to having fewer members on the Board of Governors, it may also relate to there being a less pressing need to deliver timely information to financial markets.[9]

Officials at the BoC have delivered fewer than 30 speeches per year. Part of the gap in the volume of public addresses by these two central banks can be explained by differences in the role of the head versus the other committee members; specifically, the Governor of the BoC delivers a larger share of the total speeches than does the Fed Chair (see Table 2a). This is because the Governor was the only Council member to deliver public addresses until 2006 and has continued to be the key figure in public engagements after this time.[10] There is a sharp increase in the number of speeches by BoC officials in 2002 when David Dodge assumed leadership, and a slight increase in 2007 when other members began giving speeches.

[8] The Fed's regional bank Presidents are accountable to a different set of stakeholders (see discussion in previous section); their speeches are therefore likely to be more targeted to these communities.
[9] The Fed only had a full seven-member board for six years of the sample: 1998, 2002-2005, 2012-2013.
[10] There are two exceptions: Senior Deputy Governor Bernard Bonin delivered one speech in 1998 and Senior Deputy Governor Paul Jenkins delivered one speech in 2004.

Figure 1: Total Speeches per Year (1997-2017)



Data Source: Central banks' online speech archives.

Table 2: Speeches by Central Bank Leader

a. Bank of Canada

Governor	Gordon Thiessen	David Dodge	Mark Carney	Stephen Poloz	Full Sample
Applicable Tenure	1 JAN 1997 – 31 JAN 2001	1 FEB 2001 – 31 JAN 2008	1 FEB 2008 – 1 JUN 2013	3 JUN 2013 – 31 DEC 2017	1 JAN 1997 – 31 DEC 2017
Average number of speeches by the Governor per year	6.6	13.4	9.8	6.8	9.8
Share of speeches in total speeches by members of the Governing Council	96%	80%	47%	34%	59%

b. US Federal Reserve

Chair	Alan Greenspan	Ben Bernanke	Janet Yellen	Full Sample
Applicable Tenure	1 JAN 1997 – 31 JAN 2006	1 FEB 2006 – 31 JAN 2014	3 FEB 2014 – 31 DEC 2017	1 JAN 1997 – 31 DEC 2017
Average number of speeches by the Chair per year	19.4	21.1	11.2	18.5
Share of speeches in total speeches by members of the Board of Governors	29%	36%	23%	30%

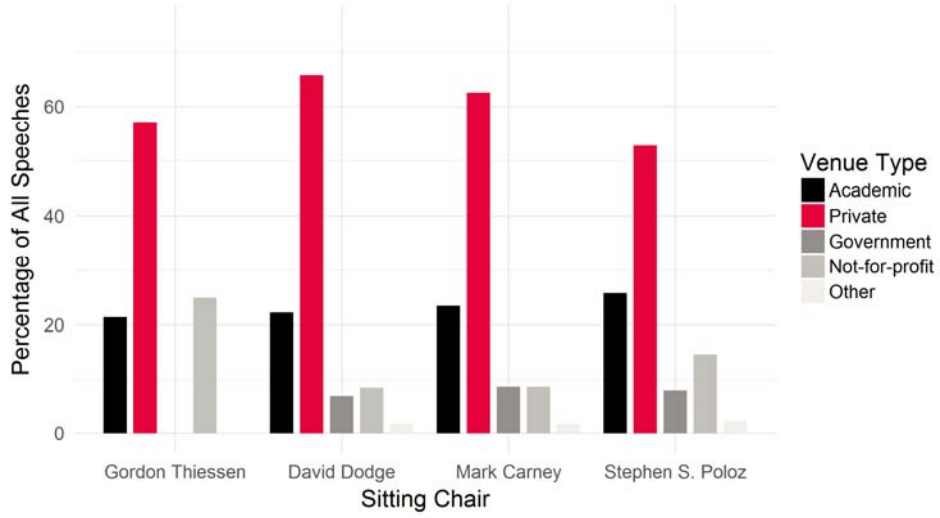
Data Source: Central banks' online speech archives.

In contrast, Fed Chairs have delivered around one-third of all speeches, showing the prominent role of other members of the Fed Board of Governors in public engagements (Table 2b). In particular, Janet Yellen delivered under one-quarter of speeches during her tenure (despite having a smaller-sized board) as she championed having a more democratic representation of FOMC officials (see Yellen 2017). This difference relative to the BoC can be linked to the structure of monetary policy decision-making. Decisions by the FOMC are taken by majority vote, so, in theory, each member's opinion has equal

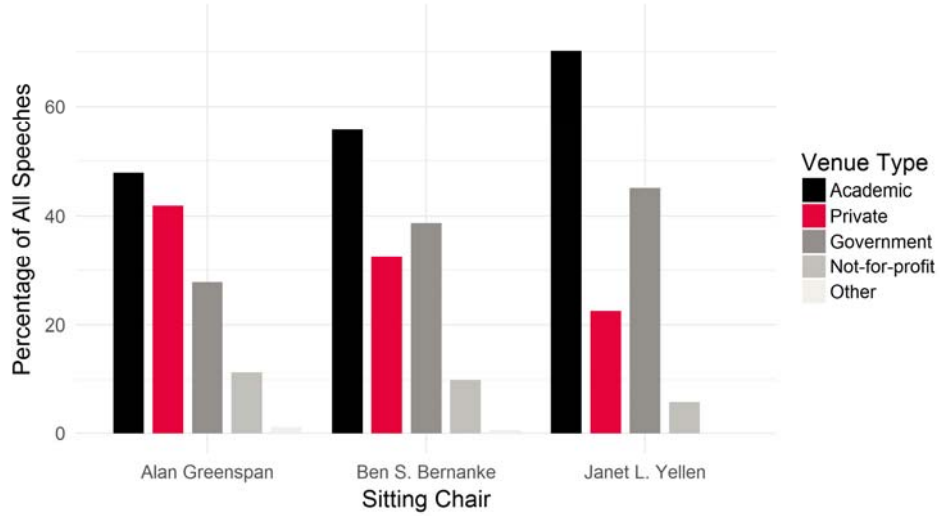
weight. As noted above, the BoC Governor alone is statutorily responsible for making monetary policy decisions, but over time the other Council members have been given more a role in public outreach; this is reflected in their increased share of speeches over time.

Figure 2: Portion of Speeches by Venue Type, across Central Bank Leader Tenures

a. Bank of Canada



b. US Federal Reserve



Data Source: Authors' elaboration on speeches from central banks' online archives.
Note: Academic includes universities, think tanks, academic conferences and central bank conferences. Private includes professional associations (including markets, builders, and workers), chambers of commerce and boards of trade. Government includes government forums and government-sponsored events (including international organizations and central banks). Not-for-profit includes non-profit organizations with a public good mission. Other includes media, museums and public forums. The sum of the proportions of speeches by venue need not add up to 100 percent, see footnote 8.

The choice of venue reveals additional differences in communication strategy (Figure 2). Over 50 percent of all speeches by BoC Governing Council members are delivered at private sector venues, such

as professional associations, chambers of commerce, and boards of trade.[11] Fed officials have historically had a more balanced set of venues, however, the share of speeches delivered at academic venues (including universities and think tanks) increased to 70 percent under Chair Yellen's tenure, with many of these being central bank conferences. Several factors could explain a larger share of speeches delivered at government venues versus private sector venues by the Fed. One explanation is that the Federal Reserve System hosts many events featuring FOMC members as speakers. Congressional scrutiny may also play a role, as the Fed officials do not want to appear to have a cozy relationship with the private sector. The perception of the Fed's relationship with the private sector is particularly important given the Fed's additional responsibilities as a financial regulator. The fraction of speeches delivered to a foreign audience is also larger for the BoC (average of 21 percent) than for Fed officials (10 percent). The fact that Canada is a small open economy is no doubt one factor.

The trends highlighted above already show how the use of speeches as a communication tool differs at central banks with dissimilar communications strategies and institutional frameworks. Of key interest to this paper, however, is how the *content* of central bankers' speeches has changed over time. In the next section, we discuss the LDA methodology for topic modelling and describe differences in the content of these central banks' speeches over time.

4. Topic Modelling and the Evolving Scope of Central Bankers' Speeches

Like other recent efforts to model the topic of central bank communication, as discussed in Section 2, we use LDA to assess the content central bankers' speeches.

Latent Dirichlet Allocation

LDA is an unsupervised machine learning algorithm that estimates a probabilistic distribution of words over topics and topics over documents developed by Blei et al. (2003). Distribution of topics over documents (θ) and words over topics (z) are the latent variables in the model.

$$\theta \sim Dirichlet(\alpha)$$

A Dirichlet distribution is a distribution over distributions; specifically, it is a conjugate prior for the multinomial distribution. For each of the N words in a document w_N, the distribution of words over topics is chosen from the prior Dirichlet distribution θ:

$$z_n \sim Discrete(\theta)$$

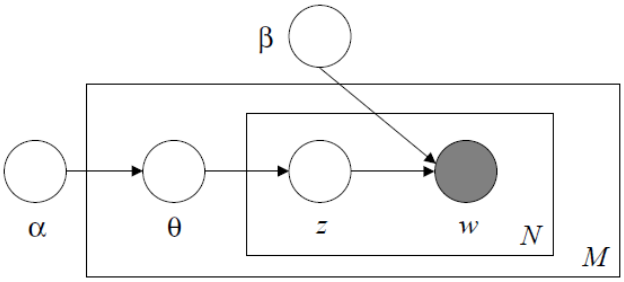
LDA follows a three-layer process (Figure 3). The first layer are parameters that are fixed at the corpus level, meaning they are assumed to be sampled once in the process of generating a corpus. The first is of these hyperparameters is α which defines the Dirichlet distribution from which the distribution of topics over documents (θ) are sampled from. The second hyperparameter is δ which defines another Dirichlet

[11] The sum of the proportions of speeches by venue need not add up to 100 percent. Many speeches are delivered at venues that span multiple categories, for example central bank conferences are categorized as both academic and government venues, and speeches to industry associations may include government representation or participation. See note to Figure 2 for a definition of each venue category.

distribution from which the distribution of words over topics are sampled from (β). More specifically, β is the distribution of words over topics, a k x V matrix where the elements represent the probability of a word ($w_i \in \{1, \dots, V\}$) belonging to a given topic z_n.

The second layer are parameters that are unique to each document: θ_d is the distribution of topics over documents, sampled once per document d_i ($d_i \in \{1, \dots, M\}$). The third layer are parameters unique to each word: z_{dn} and w_{dn} are sampled once for each word in each document w_d ($w_d \in \{1, \dots, N_d\}$).

Figure 3: Model Representation of Latent Dirichlet Allocation Estimation



Source: Blei et al. (2003).

The posterior distribution of the latent variable $p(\theta, z|w, \alpha, \beta)$ cannot be tractably computed.[12] There are a few methods to derive this distribution from the observed data, w_N (Blei et al. 2003; Griffiths and Steyvers 2004; Hoffman et al. 2013; Grün and Hornik 2011). We follow the method used by Hansen et al. (2018) and developed by Griffiths and Steyvers (2004) that uses a Markov Chain Monte Carlo and a Gibbs sampling algorithm to estimate the posterior distribution.

Using this approach, the hyperparameters α and δ are fixed *a priori*. We set α equal to 10/k, where k is the number of topics, and δ equal to 0.1 following the examples of Griffiths and Steyvers (2004).[13] The Dirichlet distributions are integrated out of the joint distribution $p(w, z)$ and the following conditional distributions are estimated:

$$P(z_i = j|z_i, w) \propto \frac{n_{-i,j}^{(w_i)} + \delta}{n_{-i,j}^{(\cdot)} + W\delta} \frac{n_{-i,j}^{(d_i)} + \alpha}{n_{-i}^{(d_i)} + T\alpha} \quad (4.1)$$

where $n_{-i,}^{(\cdot)}$ is a count that does not include the current assignment of i. The first ratio expresses the probability of w_i under topic j, and the second ratio expresses the probability of topic j in document d_i. The z_i is assigned an initial value, determining the initial state of the Markov chain. The chain is iterated several times, finding a new state by re-sampling from the distribution. After an initial number of iterations for the chain to approach the target distribution, also called the 'burn-in', we store every 200th

[12] It is intractable because it would take an exponential amount of time to estimate.

[13] Griffiths and Steyvers (2004) set α equal to 50/k. Given that their range of estimates for k go from 50 to 1000, the value of α ranges between 1 and 0.05. The log-likelihood function is maximized at k at 300, and therefore α equal to 0.17. Given that we are examining a smaller range of topics, with k set around 50, α equal to 10/k creates a similar value as that used by Griffiths and Steyvers (2004).

iteration up to 4,000, and select the iteration that maximizes log likelihood function.[14] Refer to Griffiths and Steyvers (2004) and the appendix in Hansen et al. (2018) for more details about this methodology.

Topic Modelling: Bank of Canada and US Federal Reserve Speeches

The texts require pre-processing before being fed through the LDA algorithm. The corpus of speeches was cleaned by removing stop-words (e.g. it, the, a, and), stemming words (i.e. removing affixes such as -ing, -y, and -ies) using Porter's (1980) algorithm, removing punctuation and numbers, and converting text to lower case. Words that are used infrequently or very frequently many not provide useful information content. Terms that occur in less than 2.5 percent of speeches or more than 90 percent of speeches are therefore removed.[15]

After cleaning the speeches, the corpus is transformed into a document-term matrix of dimensions $M \text{ x } V$; that is, each row of the matrix represents a document ($d \in M$), and each column represents a word in the corpus ($w_i \in \{1, \dots, V\}$). Table 3 details the properties of the BoC and Fed corpuses.

Table 3: Corpus Properties

	Bank of Canada	**US Federal Reserve**
Sample Size	349	1,278
Raw Text Unique Words	33,370	77,962
Processed Text Unique Words	2,480	2,748

The number of topics, k, must also be specified *a priori*. Since we are interested in comparing the topics discussed by officials at the BoC versus the Fed, topics are estimated separately for these central banks. We choose the optimal number of topics by implementing the algorithm over a range of values (between 5 and 100 at intervals of five) and selecting the one that maximizes the loglikelihood function. For the BoC, 45 topics are selected, which roughly corresponds to the number of topics listed on the BoC website, and 65 topics are selected for the Fed. One would indeed expect that a larger number of topics is needed to explain the Fed data given its additional responsibilities and a more decentralized communication strategy, as discussed above.

The set of topics estimated from the speech corpuses of the two central banks and some properties of each topic are presented in Table 4. The topic labels were manually identified based on the words and documents with the highest probabilities in the topic (see Appendix A).[16] The second column shows the probability of the corpus within each topic: each document is assigned a probability over the k set of

[14] Following Hansen et al. (2018), we initially set the burn-in number of iterations to 4,000 and ran an additional 4,000 iteration. However, we found that a burn-in of 2,000 and total iterations of 4,000 was sufficient to stabilize the estimated loglikelihood and is less computationally expensive.

[15] Whether or not to remove infrequently used words remains an unresolved issue. We chose to remove these terms because words that were used in less than 2.5% of speeches may not be meaningful in capturing longer-term trends in topic selection, and because of the computational cost of using a larger set of words.

[16] This approach requires significant judgment on the part of the researcher. However, providing topic labels improves the researchers and readers ability to interpret the estimation results. It is unclear whether there is a preferable method for labelling the topics.

topics, the probability of topic j over the corpus is equal to the sum of the probabilities of topic j over all documents D divided by D ($p(z_j|w,D) = \sum_{d=1}^{D} \theta_{d,j}/D$).

Overview of the topics of central bankers' speeches

Despite emphasizing some of the differences in the two central banks being analyzed, specifically with regard to the institutional structure and communications strategies, there are generally more similarities than differences among these institutions, and this is clearly observed in the topics generated. Some topics are sufficiently similar that they are labeled identically; including speeches on the economic outlook, liquidity facilities, global imbalances, the housing market, the labour market, corporate accounting and disclosure, and the payments system. Others have strong similarities but differ in the specifics of their focus. This is partly owing to the larger number of topics specified for the Fed; for example, the Fed topics labelled housing market and household debt are both similar to the BoC housing market topic. Slight differences in the focus on topics can also be attributed to the different policy objectives of these central banks; for example, discussion of monetary policy objectives at the Fed is similar to discussion of the inflation targeting regime at the BoC.

The substantive differences in the corpuses can be attributed to the relative position of these countries globally and the different roles of the central bank. The BoC has more topics related to international activities, with issues directly related to global economy and finance comprising around 20 percent of topics (e.g. international financial architecture, global financial integration, and global trade integration). This reflects Canada's position as a small-open economy that may be influenced by international events. Over half of the Fed's topics, on the other hand, are related to the financial system, banking and financial supervision and regulation. This is owing to the Fed's additional responsibilities as a key US financial regulatory agency. Specifically, speeches concerning community banks, reinvestment and economic development, as well as speeches concerning asset bubbles and subprime mortgage lending, appear in the Fed corpus but not the BoC corpus.

Almost one-tenth of the content of speeches by BoC officials concern the role of the central bank and its inflation targeting framework. While the role of the Fed is certainly a topic in officials' speeches, it is not as prominent a component of the corpus. This illustrates a key difference in the communications strategies of these central banks. Using the centralized strategy at the BoC, the central bank made a deliberate effort starting in 2006 to use speeches by Deputy Governors to discuss the role of the BoC at various venues around Canada. Given a more individualistic approach to communication, similar concerted efforts to discuss the role of the Fed.

Interestingly, while the Fed has a dual monetary policy objective of price stability and full employment, the term 'employment' only shows up in the top 15 words of three topics—labour market, monetary policy outlook and recession and recovery—while inflation shows up in six topics. What is notable is that all three topics that feature employment as a key word increased sharply as a share of the corpus after the IFC. The share of speeches concerning inflation outlook, on the other hand, decreased significantly in 2009. This provides evidence that Fed officials were more focussed on the inflation objective prior to as well as at the height of the crisis and switched attention to full employment in the aftermath of the

crisis. A similar trend is not observed for the BoC where 'employment' only shows up in two topics—labour market and inflation outlook—which do not follow an upward trend after the IFC.

Table 4: Topic Distributions of BoC and Fed Officials Speeches (1997-2017)

Notes: See Appendix A for an explanation of how probability distributions over words for each topic and over topics for each speech are estimated.
Topic labels were manually identified based on the probability distribution over words and documents for each topic (see Appendix B for a list of the top ten words for each topic). The percent of the corpus in the topic is the sum over all speeches of the probability of the topic in each speech.
Data source: Authors' elaboration on speeches from central banks' online archives.

a. Bank of Canada

	Topic Labels	Percent of Corpus in Topic
1	Economic Outlook	6.4%
2	Inflation Targeting Framework	5.6%
3	Adjusting to Globalization	3.8%
4	Productivity & Innovation	3.6%
5	Global Economic Recovery	3.6%
6	Inflation Outlook	3.5%
7	Role of the Bank of Canada	3.5%
8	Financial System Regulation & Reform	2.9%
9	Principles for Good Economic Policy (Washington Consensus)	2.9%
10	Understanding Low Economic Growth	2.8%
11	Export Competitiveness	2.8%
12	Systemic Risk & Financial Stability Policy	2.8%
13	Liquidity Facilities	2.3%
14	Global Imbalances	2.3%
15	International Financial Regulatory Reform	2.2%
16	Financial System Regulation & Efficiency	2.2%
17	Exchange Rate Regime	2.2%
18	Oil Price Shock	2.1%
19	Credit Markets	2.1%
20	Measuring Inflation	2.0%
21	Monetary Policy Decision-Making	2.0%
22	International Financial Architecture	1.9%
23	Global Financial System Turbulence	1.9%
24	Financial Market Infrastructure	1.8%
25	Canada in the Global Economy	1.8%
26	Financial Market Developments	1.8%
27	Education & Public Engagement	1.8%
28	Lessons from the Past and from Other Countries	1.8%
29	Potential Output	1.7%
30	Commodity Markets	1.7%
31	Unconventional Monetary Policies	1.7%
32	Housing Market	1.6%
33	Currency Issuance	1.6%
34	Re-Evaluating the Monetary Policy Framework	1.6%
35	Global Economic Governance	1.6%
36	Labour Market	1.4%
37	Economic Modelling and Uncertainty	1.4%
38	Global Trade Integration	1.3%

39	Corporate Accounting & Disclosure	1.3%
40	Fiscal Policy	1.2%
41	Global Financial Integration	1.2%
42	Macroeconomic Stabilization Policy	1.1%
43	Wage Setting	1.1%
44	Payments System	1.0%
45	Pensions	0.8%

b. Federal Reserve

	Topic Labels	Percent of Corpus in Topic
1	GDP Growth	2.9%
2	Financial Regulatory & Supervisory Framework	2.9%
3	Challenges for Monetary Policy	2.8%
4	Challenges of Macroeconomic Policy	2.7%
5	Community Economic Development	2.5%
6	Economic Flexibility & Adaptation	2.5%
7	Technology & Innovation	2.4%
8	Liquidity Facilities	2.2%
9	Monetary Policy Outlook	2.1%
10	Balance Sheet Policies	2.1%
11	Basel II	2.1%
12	Bank Supervision	2.1%
13	Education	2.0%
14	Credit Risk	2.0%
15	Evaluating Circumstances	2.0%
16	Bank Lending	1.9%
17	Role & Governance of the Fed	1.9%
18	Modernizing Financial Services Regulation	1.9%
19	Corporate Risk Management	1.9%
20	Economic Recession & Recovery	1.8%
21	Inflation Dynamics & Outlook	1.8%
22	Potential Output & Productivity	1.8%
23	Housing Market	1.7%
24	Economic Research & Modelling	1.7%
25	Monetary Policy Objectives	1.7%
26	Monetary Policy Communication	1.7%
27	Prudential Regulation	1.6%
28	Global Capital Flows & Economic Integration	1.6%
29	Community Banks Regulation & Supervision	1.6%
30	Financial Literacy	1.5%
31	Managing International Financial Crises	1.5%
32	Too Big To Fail	1.5%
33	Financial Stability Policy	1.5%
34	Economic Outlook	1.4%
35	Rule of Law & Market Capitalism	1.4%
36	Payments System	1.3%
37	Data Collection & Measuring Economic Activity	1.3%
38	Small Business Financing	1.2%
39	Business Investment	1.2%
40	Consumer Protection	1.2%

41	Financial Market Liquidity	1.2%
42	Household Debt	1.2%
43	Financial Market Clearing & Settlements	1.2%
44	Global Imbalances	1.2%
45	Preparing for Financial Services Disruptions	1.2%
46	Fiscal Budgets	1.1%
47	Labour Market	1.1%
48	Subprime Mortgage Lending	1.1%
49	Corporate Governance	1.1%
50	Monetary Policy Rules	1.1%
51	Income & Wealth Inequality	1.0%
52	International Trade	1.0%
53	Asset Bubbles	1.0%
54	Bond Yields	1.0%
55	Consolidation of Banking Industry	1.0%
56	Corporate Accounting & Disclosure	1.0%
57	Bank Stress Tests	1.0%
58	Social Security	0.9%
59	Currency & Exchange Rates	0.9%
60	Energy Markets	0.9%
61	US Treasury & Government-Sponsored Enterprise Debt	0.8%
62	Consumer Credit	0.8%
63	Foreign Banks	0.7%
64	Monetary System	0.7%
65	Community Reinvestment Act	0.6%

What explains the choice of speech topic?

In analyzing what explains the choices of topics over time, there appears to be both supply and demand factors, whereby topics cluster around time periods and individual speakers, and to some degree around venue types. The economic and policymaking context naturally creates a demand for speeches by the central bank's stakeholders and speeches on such topics are important for improving the institution's accountability. From a supply side, individual speakers may have preferences for speaking on certain topics of expertise or interest, and the central bank's research output might also inspire a speech. As one would expect, there is often a natural fit between the central bank's research and the policymaking context, as well as with individual's expertise, blurring the divide between supply and demand drivers.

In some cases, clusters around time periods relate to economic events. For example, economic recovery was prominent in the aftermath of the 2008-09 global financial crisis; while discussion of corporate accountability and disclosure were significantly larger between 2002 and 2004, coinciding with the accounting scandals of Enron and World Comm. Topics also cluster around time periods because of policy context. For example, a higher share of speeches between 2007 and 2010 discussed liquidity facilities; while speech content related to unconventional monetary policies was most dominant between 2009 and 2013. Finally, topics cluster around time periods to reflect evolving institutional structure or policymaking by central banks. For example, most of the discussion surrounding financial regulatory reform occurred between 2011 and 2015. At the BoC, speeches about re-evaluating

monetary policy occurred between 2008 and 2012, coinciding with consideration of price-level targeting and incorporating financial stability in the 2011 inflation-control target renewal.

Topics at the BoC are generally more concentrated around time periods than they are at the Fed. This is likely owing to the more centralized and consensus-oriented communication strategy. Clustering of topics around individual speakers can be attributed to their role at the central bank or the individual's background and interests. This appears to be more prominent at the Fed than the BoC, likely owing to the decentralized communications strategy that allows individualistic dissemination of information. A few examples of this trend include: Susan Bies, who had come from a Risk Management and Auditing background, delivered the majority of Fed speeches on corporate accountability and corporate governance; Ben Bernanke, who is an academic monetary economist, delivered half of the speeches on the monetary system; and Daniel Tarullo, who oversaw supervision and regulation at the Fed, covered the majority of discussion on prudential regulation.

Proportional clustering of certain speech topic according to venue types also occurs for both central banks. Topics that are more likely to be presented in academic venues concern macroeconomic policy, the monetary system and modelling. For private venues, more speeches center around the economy and specific markets, as well as Basel II and corporate governance and risk management in the case of the Fed. The topics that are most likely to be presented in government venues are related to economic policy making and governance. Interestingly, only in the case of the Fed, topics presented in not-for-profit venues seem more relevant to the audience (e.g. financial literacy, community economic development, and consumer protection). The fact that a similar trend is not observed for the BoC is likely owing to differences in mandate as well as in outreach and accountability mechanisms to the public.

Changing Scope of Central Bankers' Speech Topics

As new forms of communication have been introduced, the role of speeches in the communication strategy is expected to change. For example, the Fed Chair began delivering quarterly press conferences after the conclusion of FOMC meetings in 2011 (see Yellen 2013). Similarly, starting around 2014, the Governor and Senior Deputy Governor of the BoC began using the quarterly press conferences after the release of the MPR to explain how information in the MPR is informing the deliberation on monetary policy (Poloz 2018). These new communication tools, along with many other introduced over the past few decades, may change the information the central bank conveys through speeches. Indeed, prior to the post-FOMC meeting press conferences, additional information about monetary policy decisions was often conveyed in speeches. Another example is the recent use of speeches to provide economic progress reports the day after interest rate decisions that are not accompanied by an MPR (Poloz 2018).

Figures 4 and 5 represent an attempt to illustrate how the scope of central bank speeches has evolved over time. By scope, we are referring to the number of topics being discussed in central bankers' speeches within a given period; in other words, it represents the concentration of topics in speeches. Figure 4 plots the number of topics required to explain 67 percent of the content of speeches within a one-year period, plotted over a one-month rolling window. The number of topics being discussed by

speeches of BoC officials has been increasing over time. Indeed, during Gordon Theisen's tenure, discussion of the inflation and economic outlook covered between 20 to 50 percent of the discussion in any given period, with other topics like the exchange rate regime, global financial system turbulence and inflation targeting framework given significant attention as well. More recently, as BoC official more clearly explain how economic circumstances are affecting interest rate decisions in the press conferences, speeches cover a wider range of topics which may be related to the BoC's research and other significant economic issues that are changing the methods the Bank uses to interpret information.

Figure 4: Number of Topics Needed to Explain Two-Thirds of Central Bankers' Speeches in a 1-year Rolling Window (1997-2017)

a. Bank of Canada

b. US Federal Reserve

Note: Plotted is the number of topics required to explain two-thirds (67 percent) of the content of speeches over a one-year horizon and a one-month rolling window.

At the Fed, the number of topics explaining the speech corpus was largest between 2001 and 2005. Given that the Fed introduced fixed announcement dates in 2000, this may have freed up some room to

discuss matters other than the economic outlook. The estimates indeed shows that speeches on the topic of the economic outlook represented an average of 4.6 percent of speeches before 2000, and only around 1.3 percent of speeches during the rest of Greenspan's tenure.

Importantly, there is a clear correlation between the number of topics that are required to explain two-thirds of the corpus and the number of speeches delivered. Figure 5 controls for this relationship by plotting the value in Figure 4 divided by the number of speeches delivered within the one-year rolling window. Given that so few speeches were delivered under Gordon Thiessen's tenure, the number of topics needed to explain the speeches is quite large relative to the rest of the sample. Beyond this period, we do observe a slight decrease in the concentration of topics from 2005 to 2017.

Figure 5: Number of Topics Needed to Explain Two-Thirds of Central Bankers' Speeches 1-year Rolling Window Divided by the Number of Speeches in the Reference Period (1997-2017)

a. Bank of Canada

b. US Federal Reserve

Note: Plotted is the number of topics required to explain two-thirds (67 percent) of the content of speeches over a one-year horizon and a one-month rolling window, divided by the number of speeches delivered during the one-year horizon.

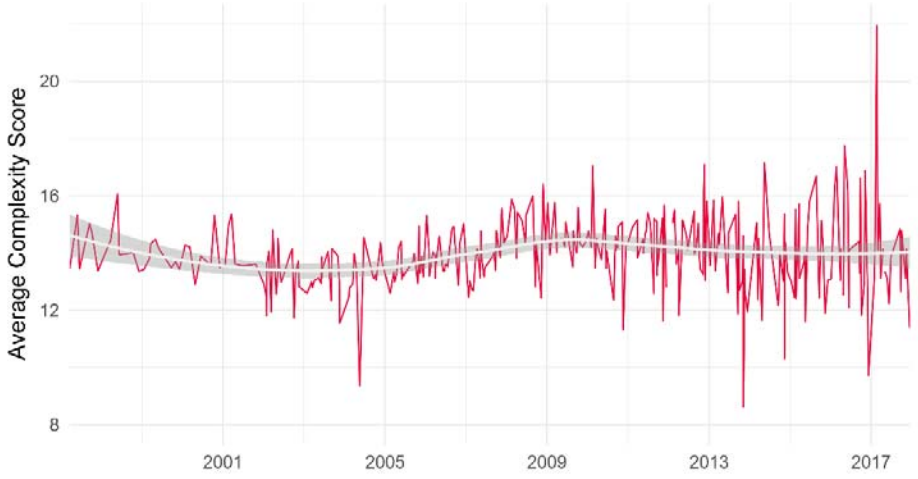
At the Fed, we still observe a decrease in the concentration of topics (i.e. an increase in the index value) around the introduction of fixed announcement dates. A similar trend is observed around 2011 when Bernanke introduced quarterly press conferences after FOMC meetings. Perhaps most striking, however, is the sharp increase in the concentration of topics (i.e. decrease in the index value) around the height of the IFC from 2007 to 2008. During this period, liquidity facilities, credit risk, challenges for monetary policy, inflation dynamics and outlook, the housing market and consumer protection became key issues. Representing over one-third of speeches during that period, versus 9 percent prior to the preceding 3 years and 11 percent in the subsequent years. A similar drop in the concentration of topics is observed during the 2002-03 recession in the US.

Linguistic Complexity of Central Banker's Speeches

As discussed above, the new phase of the revolution in communications is emphasizing making central bank talk digestible to a wider audience (e.g. Haldane 2016, 2017; Poloz 2018). To identify whether efforts are being taken to make speeches more accessible, Figure 6 plots the linguistic complexity score of each speech.[17] In general, the complexity score appears to have increased slightly over time, showing that, on average, central bankers' speeches have become less accessible to a general audience (see also Deslongchamps 2018). However, the variance of complexity scores for individual texts has been increasing, perhaps reflecting the complexity of the text becoming more tailored to the topic or audience.

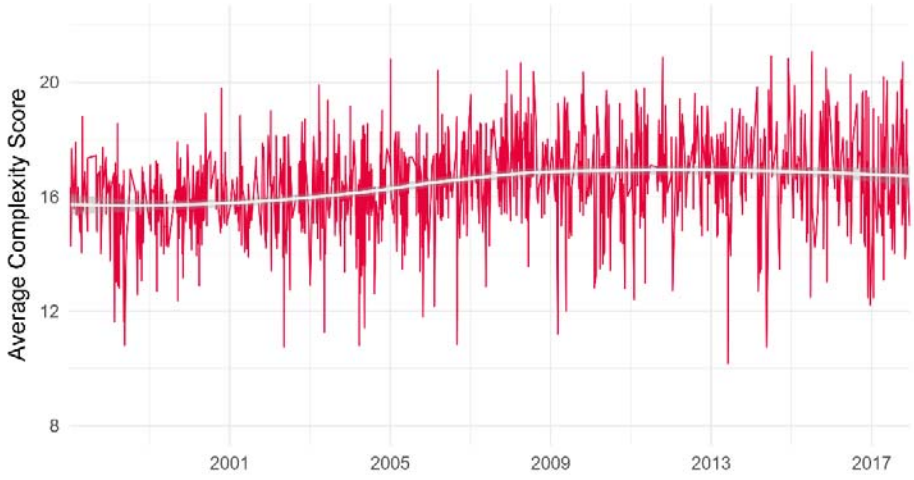
Figure 6: Average Text Complexity Score (1997-2017)

a. Bank of Canada



[17] The linguistic complexity score is an average of Flesch-Kincaid, Gunning Fog, Coleman-Liau, SMOG and Automated Readability indices.

b. US Federal Reserve



Note: The linguistic complexity score is an average of Flesch-Kincaid, Gunning Fog, Coleman-Liau, SMOG and Automated Readability indices. The smoothing function is local quadratic regression with the smoothing parameter equal to 0.75, with 95 percent confidence interval.

The lowest complexity scores for the Fed are, somewhat ironically, often commencement addresses to university graduates. The least complex speeches at the BoC are typically about currency issuance. The average complexity of Fed speeches (16.4) is higher than that of speeches by BoC officials (13.9), potentially reflecting the larger portion of Fed speeches delivered at events hosted by central banks and delivered in academic fora. Interestingly, one of the speakers with the lowest complexity score overall is Stephen Poloz at 12.9. Stephen Poloz is known for discussing economics in an accessible way, including through analogies; perhaps this style of speaking is captured by the lower complexity of the text. The BoC has indeed been making deliberate efforts to improve the accessibility of central bank communications under his leadership (Poloz 2018).

5. Changing Scope of Central Bank Speeches and Implications for Financial Markets

The aim of this section is to assess whether the topics of speeches have differential impact on financial markets, and in what contexts speeches are influential. As discussed in Section 2, it has been found that speeches that focus on the economic outlook, inflation or monetary policy tend to move markets. Speeches delivered by the heads of central banks, especially by the Chair of the US Fed, have been found to be generate news, while the timing and sequencing of central bankers' speeches may also be relevant.

Methodology and Data

Given the number of speeches and our interest in understanding how various topics affect financial markets, we employ a time-series methodology. An event study would be inappropriate because we are interested in identifying a general trend, rather than the impact of specific speeches. To control for the impact of major news events, we estimate the following AR(1) process with GARCH(1,1) errors:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \beta \boldsymbol{X}_t^j + \varepsilon_t \quad (5.1)$$

The subscript t represents the date and j identifies the country origin of an event. The dependent variable of equation 5.1 is the daily log-return of a financial asset, $\boldsymbol{X}$ is a vector of monetary policy surprises, macroeconomic surprises and a US policy uncertainty index. The asset prices we examine include 3-month interest rate futures (forward interest rate agreement for the US and bankers acceptances for Canada), sovereign bond yields on a range of maturities, equity indices (S&P500 for the US and TSX300 for Canada), and foreign exchange rates (USD-CAD exchange rate for Canada, and real effective exchange rate for the US). It is well known that US economic events can have a major impact on Canadian financial markets; therefore, we include independent variables for both Canada and the US in the regressions on Canadian financial assets. See Appendix B for a detailed list of the variables used in the analysis.

There is no clear methodology for quantifying the size or directional value of the content of speeches.[18] As we are not interested in whether speeches have an intended effect on financial markets, but rather whether they affect financial markets at all, we assess the impact of speech data on the logged squared residuals of model (5.1)[19]:

$$\ln(\varepsilon_t^2) = \delta_0 + \delta_1 \ln(\varepsilon_{t-1}^2) + \eta \boldsymbol{C}_t^j + \omega_t \tag{5.2}$$

where η measure the effects of speech data ($\boldsymbol{C}$) from country j on day t.

Disregarding content, we first examine the relationship between the dates of speeches and movement in financial markets (Table 5). Somewhat surprisingly financial markets tend to move less on the dates of central bankers' speeches. In Canada, there appears to be a stronger relationship between Fed speeches and financial markets, than with speeches by BoC officials. If we isolate the impact of speeches by the heads of the central bank, it appears that speeches by the Chair of the Fed create more movement in short term bond yields.

Table 5: Impact of Speeches on Financial Markets

a. US Fed

	3m Bond	3m Bond	1y Bond	1y Bond	10y Bond	10y Bond	Equities	Equities	REER	REER
Fed Speech	-0.37*** (0.13)	-0.50*** (0.14)	-0.16 (0.11)	-0.16 (0.13)	-0.14 (0.10)	-0.20* (0.10)	-0.08 (0.10)	-0.11 (0.11)	-0.18** (0.09)	-0.22** (0.10)
Speech by Chair		0.40*** (0.24)		-0.01 (0.21)		0.21 (0.17)		0.09 (0.19)		0.12 (0.17)
Adj-R^2	0.29	0.29	0.10	0.10	0.02	0.02	0.03	0.03	0.01	0.01
N	3,861	3,861	3,891	3,891	3,861	3,861	3,860	3,860	4,007	4,007

b. Bank of Canada

	3m Bond	3m Bond	1y Bond	1y Bond	10y Bond	10y Bond	Equities	Equities	USD forex	USD forex

[18] It is possible to quantify an intended effect of a speech aimed at delivering a message to financial markets, but as we are interested in the full sample of speeches, this is approach is inappropriate for this analysis.

[19] We also ran the regressions on the absolute value of the residuals and the key results were unchanged.

BoC Speech	0.37 (0.24)	0.33 (0.33)	-0.27 (0.18)	0.33 (0.33)	0.18 (0.16)	0.11 (0.22)	0.20 (0.16)	0.11 (0.23)	0.11 (0.19)	0.26 (0.26)
Speech by Gov		0.07 (0.46)		0.07 (0.46)		0.15 (0.32)		0.17 (0.31)		-0.31 (0.36)
Fed Speech	-0.02 (0.15)	-0.18 (0.17)	-0.22* (0.11)	-0.18 (0.17)	-0.20** (0.10)	-0.20* (0.12)	-0.03 (0.10)	-0.06 (0.12)	-1.17*** (0.12)	-1.11*** (0.14)
Speech by Chair		0.52* (0.28)		0.53* (0.28)		-0.02 (0.20)		0.10 (0.20)		-0.19 (0.22)
Adj-R^2	0.13	0.14	0.11	0.14	0.02	0.02	0.03	0.03	0.03	0.03
N	3,282	3,282	3,307	3,307	3,302	3,302	3,313	3,313	3,429	3,429

Note: Results of model (5.2) regression estimates with dummy variables equal to one on dates of speeches by Fed and BoC officials. m and y indicate months and year. FRA is forward rate agreement, BA is bankers' acceptance, Bond is sovereign bond yield, Equities is S&P500 for the US and S&P/TSX Composite for Canada, USD forex is the CAD-USD nominal exchange rate and REER is real effective exchange rates. See Appendix B for more details regarding data and data source.

Next, we are interested in understanding how different topics affect financial markets. As a first pass at categorizing the speech topics, we manually divide topics along the lines of each central bank's responsibilities (i.e. monetary policy making, financial market infrastructure, currency issuance, etc.), topics on the economic outlook, and other topics that did not appear to fit well into these categories (see Appendix C for a breakdown of the topics in each category).[20] We then calculate the probability a speech belongs to the topics in a given category ($p(z_j|w_d) = \sum_{j=1}^{N} \theta_{d,j}$, where j indicates the topics in each category).

Generally, we continue to observe a pattern whereby speeches by US Fed officials reduce daily financial market fluctuations. There is one exception: speeches on the Fed's LOLR function tend to increase market fluctuations in both the US and Canada. Speeches in this category concern the Fed's liquidity facilities and financial market liquidity conditions. It is likely that these statistically significant results reflect the information being delivered on these subjects during the IFC. Other speech topics that tend to increase market activity in of Canadian short-term bond yields are those on the topic of the economic outlook delivered by either BoC or Fed officials. Speeches on the economic outlook by Fed officials affect near term yields, that is 3-month sovereign bond yields, whereas speeches by BoC officials tend to cast a longer horizon, impacting the 1-year yield.

Table 6: Impact of Speeches on Financial Markets by Topic

a. US Fed

	3m Bond	1y Bond	10y Bond	Equities	REER
Financial Market Infrastructure	0.26 (1.28)	-1.22 (1.13)	-0.25 (0.91)	-1.91* (1.02)	0.30 (0.92)
LOLR	2.65** (1.11)	2.68*** (0.97)	2.63*** (0.78)	3.26*** (0.87)	2.59*** (0.79)
Financial System Stability &	0.92	0.37	0.62	-0.20	-1.80***

[20] Alternative approaches to categorizing topics may be preferable and are being considered by the authors. For example, topics could be clustered into categories based on the distribution of words over topics.

Macroprudential Policy	(0.96)	(0.83)	(0.66)	(0.74)	(0.67)
Microprudential Policy	-1.39***	-0.39	-1.00***	-0.29	-0.04
	(0.37)	(0.32)	(0.26)	(0.29)	(0.26)
Community Development &	-1.06*	-0.32	0.32	0.87*	-0.01
Consumer Protection	(0.56)	(0.49)	(0.40)	(0.44)	(0.40)
Other	-0.84*	-0.73*	-0.28	0.04	-0.44
	(0.44)	(0.40)	(0.31)	(0.35)	(0.32)
Adj. R^2	0.30	0.10	0.03	0.04	0.02
N	3,861	3,891	3,861	3,860	4,007

b. Bank of Canada

	3m Bond	1y Bond	10y Bond	Equities	USD forex
BoC Economic Outlook	2.04	1.82*	0.61	-0.05	1.77*
	(1.27)	(0.98)	(0.87)	(0.87)	(0.99)
BoC International Economics	-0.56	-0.92	0.36	-0.06	-1.44*
& Governance	(0.98)	(0.75)	(0.67)	(0.68)	(0.77)
BoC Other	0.44	-1.34*	0.05	0.09	-0.19
	(1.04)	(0.80)	(0.72)	(0.70)	(0.80)
US Economic Outlook	1.28*	0.37	0.81*	0.16	-1.11**
	(0.66)	(0.51)	(0.45)	(0.46)	(0.51)
US Monetary Policy Making	-0.72	-0.35	-0.58	-0.46	-1.54***
	(0.56)	(0.44)	(0.39)	(0.39)	(0.44)
US LOLR	4.53***	1.40	2.28***	2.02***	0.12
	(1.23)	(0.95)	(0.85)	(0.86)	(0.98)
US International Economics &	-1.16	-0.26	-1.82**	-0.51	-1.86**
Governance	(1.14)	(0.88)	(0.78)	(0.79)	(0.91)
US Microprudential Policy	-0.24	-0.91***	-0.57*	0.27	-1.65***
	(0.46)	(0.35)	(0.31)	(0.31)	(0.36)
US Community Development	0.41	-0.49	-0.57	-0.15	-1.83***
& Consumer Protection	(0.70)	(0.54)	(0.48)	(0.49)	(0.56)
US Other	-0.58	-0.57	-0.60	-0.16	-0.84*
	(0.54)	(0.42)	(0.38)	(0.38)	(0.43)
Adj. R^2	0.14	0.11	0.03	0.03	0.04
N	3,282	3,307	3,302	3,313	3,429

Note: Results of model (5.2) regression estimates with speech variables equal to the sum of the probability of topics in a speech that belong to each category (see Appendix C), and zero on the dates where no speeches were delivered. Bond is sovereign bond yield, Equities is S&P500 for the US and S&P/TSX Composite for Canada, USD forex is the CAD-USD exchange rate and REER is real effective exchange rates. See Appendix B for more details regarding data and data source. See Appendix C for a summary of the topics allocated to each category; all categories were included in the regressions, but only categories with statistically significant results are shown to reduce congestion in the table.

Extensions

Several extensions are being considered to capture the potential variation in the impact of speeches according to the speaker, timing, sequencing and context surrounding the event, as discussed in section 2. To understand whether the linguistic complexity of speeches affects the response of financial markets, the speech dummies can be interacted with their linguistic complexity scores (see section 4). Variables capturing the speaker include a dummy variable indicating whether the speaker is the head of the central bank (e.g. Rosa 2017) and a dummy variable indicating whether the central banker's tenure on the monetary policy committee is greater than 180 days (e.g. Gertler and Horvath 2017). Indicators

for the timing of speeches could include a dummy representing the blackout period for the central bank (see discussion surrounding Table 1; Ehrmann and Fratzscher 2009) and a variable identifying the duration since last Monetary Policy Report release (for Canada only). Finally, sequencing is captured by the time since the last communication and the stock of communication on the subject over the past 10 days (Ehrmann and Sondermann 2012).

[Results from additional extensions are forthcoming]

6. Conclusion

This paper provides empirical evidence of how the content of BoC and Fed officials speeches has changed over the past two decades, and how the topics in these communications affect movement in financial markets. The revolution in central bank communication is continuing full speed as strategists focus on improving dialogue with the general public in an effort to boost accountability and bolster central banks' reputations. As of 2017, however, this paper shows that the general accessibility of central bankers' speeches has not improved. A significant challenge in these efforts will be to make the central bank's message more relatable, while also clearly communicating its policy actions.

Despite these challenges, we do show that the use of speeches within the central banks' communications strategies have evolved over time. During periods of financial crisis, speeches become more concentrated on issues concerning the financial system and the policy response. In addition, as new forms of communication are introduced, like press announcements after FOMC meetings starting in 2000 and the communication of a richer set of information in BoC press conferences starting in 2014, speeches began to be used to discuss a wider range of topics. This is likely because new communications were serving the role that speeches once did (i.e. such as economic outlook updates).

There are several possible avenues for future work. One avenue that may be of interest is exploring how speeches can be used to engage with different stakeholders. For example, one could relate the topics of central bankers' speeches with those that are most likely to be picked up by the media or those that may be of more interest to the general public. Another avenue for research would be to assess the interrelation of speech topics across central banks to identify the strength of the transnational epistemic community of central bankers relative to the influence of domestic economic issues. This type of analysis could also be used to identify which central banks are thought leaders when it comes to identifying new topics of interest to the central banking community. Finally, an analysis of whether central banks are ahead of the curve in discussing economic and financial risk, or late to the game, would be useful for understanding their ability to identify coming crises. For example, the peak discussion of household debt by the US Fed occurred in 2004, and subprime lending was a hot topic starting in 2000, suggesting that Fed officials had some foresight into the risks stemming from this economic activity.

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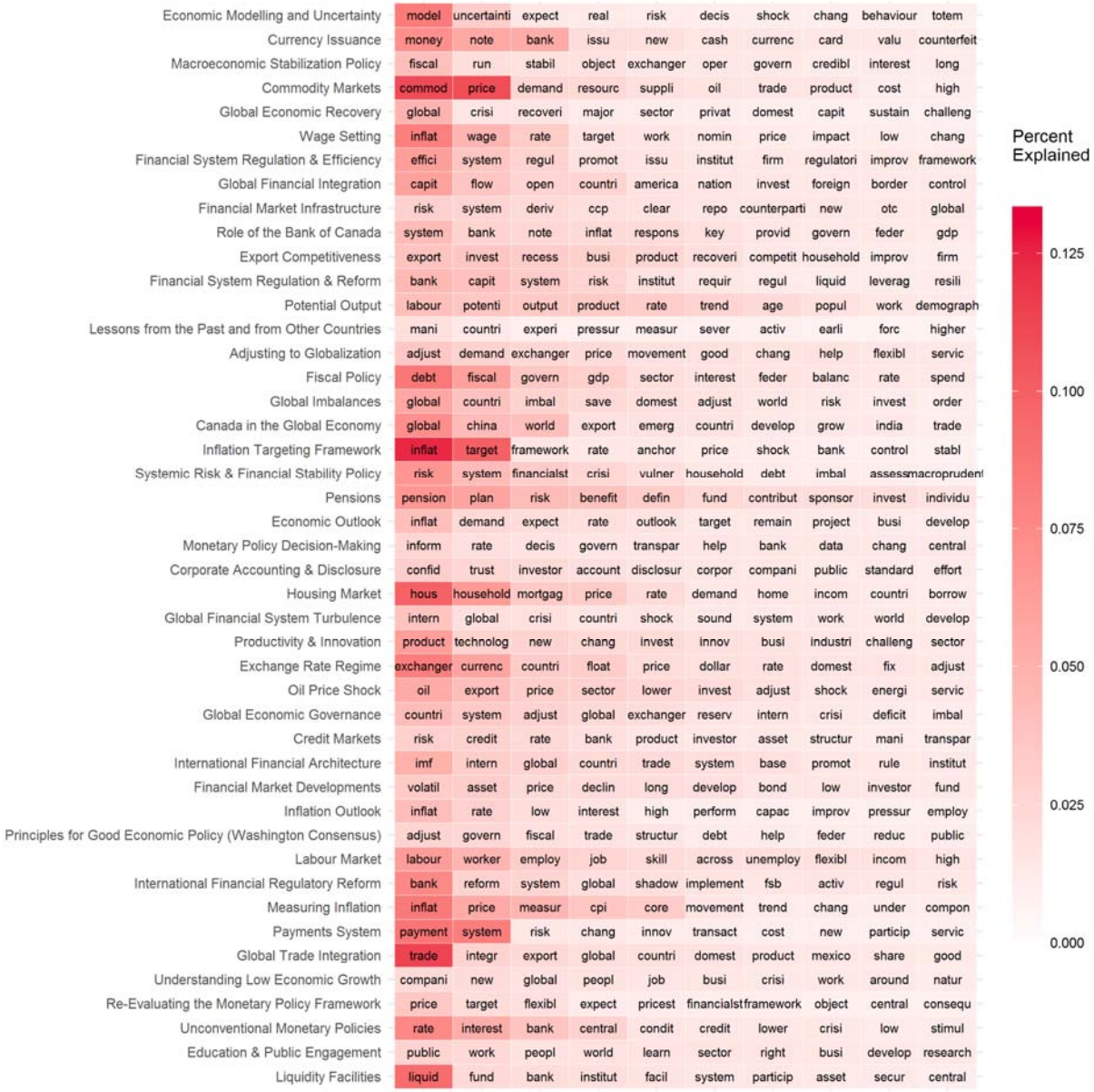
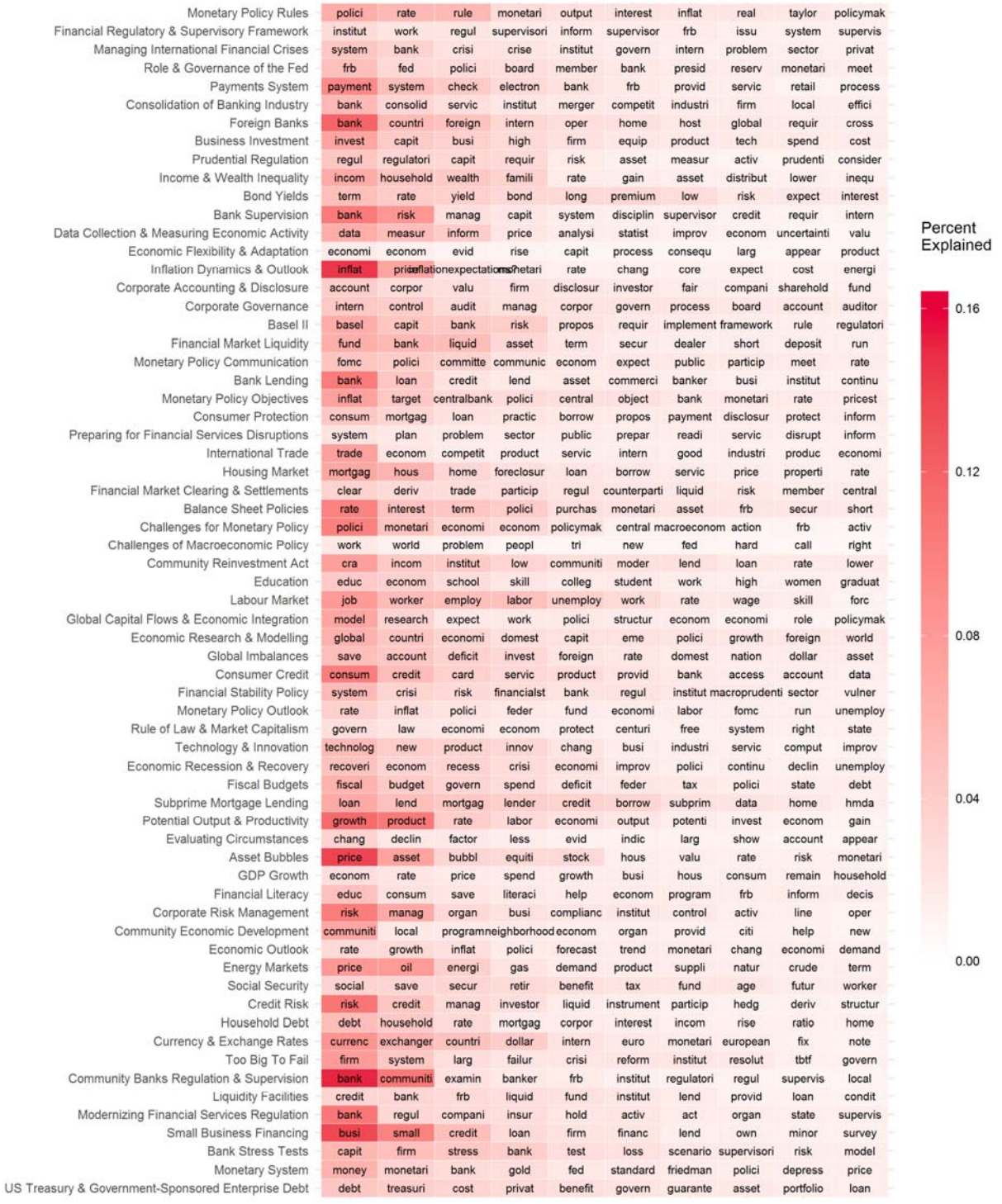
Appendix A: Topic Heat Map (Top 10 Words)

a. Bank of Canada



b. Federal Reserve



Appendix B: Data Description

Dependent Variables	**Description**	**Source**
Sovereign Bond Yields	3-month, 2-year and 10-year maturities	Thomson Reuters Eikon
Equity Index	S&P500 for the United States; TSX300 for Canada	Thomson Reuters Eikon
Exchange Rates	(1) Effective exchange rate index for the United States, trade weighted bilateral exchange rates covering 61 economies. (2) USD-CAD exchange rate for Canada.	(1) Bank for International Settlements (2) Thomson Reuters Eikon
Independent Variables Included in Equation 5.1	**Description**	**Source**
Monetary Policy Surprises	United States: Dummy variable on the day of (1) US FOMC monetary policy statements, (2) US Fed UMP announcements (QE and forward guidance); and first difference of 1st principal component of US Treasury futures (2-year to 30-year maturity) on the day of FOMC monetary policy statements. Canada: Dummy variable on the day of interest rate decisions; and first difference of 1st principal component of Canada bond futures (2-year and 10-year maturity) on the day of interest rate decisions.	Central bank website
Surprise Macroeconomic Announcements	Difference between the observed value and the most recent forecast, normalized over the sample period. Includes ten key US macroeconomic announcements: GDP growth, unemployment, non-farm payroll, sales, consumer credit, durable goods orders, manufacturing, housing starts, and existing home sales. Canadian indicators pending data collection.	Econoday
Policy Uncertainty	US policy uncertainty index.	Baker, Bloom and Davis (2016)
Independent Variables Included in Equation 5.2	**Description**	**Source**
Speech	Dummy variable equal to 1 if a speech is delivered by a member of the BoC Governing Council (Canada) and a member of the Fed Board of Governors (US) on that date, and zero otherwise.	Central bank website
Chair or Governor Speech	Dummy variable equal to 1 if a speech is delivered by the head of the central bank on that date, and zero otherwise.	Central bank website
Content	Equal to the sum over the probabilities of a speech in the topics that fall into the indicated category (see Appendix C), and zero on the dates when there is no speech.	Authors' elaboration on data from central bank website

Appendix C: Topic Categories

Note: The topics were manually distributed into topics based on their fit with the responsibilities of the central bank and whether the speeches with high probabilities in these topics are focused on discussing the economic outlook (see Table 1). Topics that did not fit neatly into a category were labelled 'other'.

Categories	Fed Topics	BoC Topics
Economic Outlook	Economic Outlook, GDP Growth, Economic Recession & Recovery, Monetary Policy Outlook, Labour Market, Inflation Dynamics & Outlook	Economic Outlook, Inflation Outlook, Oil Price Shock, Understanding Low Economic Growth, Global Economic Recovery
Monetary Policy Making	Monetary System, Economic Research & Modelling, Challenges of Macroeconomic Policy, Challenges for Monetary Policy, Balance Sheet Policies, Monetary Policy Objectives, Monetary Policy Communication, Data Collection & Measuring Economic Activity, Role & Governance of the Fed, Monetary Policy Rules	Unconventional Monetary Policies, Re-Evaluating the Monetary Policy Framework, Measuring Inflation, Principles for Good Economic Policy (Washington Consensus), Monetary Policy Decision-Making, Inflation Targeting Framework, Adjusting to Globalization, Economic Modelling and Uncertainty
Currency	Currency & Exchange Rates	Currency Issuance
Financial Market Infrastructure	Financial Market Clearing & Settlements, Payments System	Payments System, Financial Market Infrastructure
LOLR	Liquidity Facilities, Financial Market Liquidity	Liquidity Facilities
Financial System Stability & Macroprudential Policy	Credit Risk, Asset Bubbles, Bank Stress Tests, Financial Stability Policy	Financial Market Developments, Credit Markets, Global Financial System Turbulence, Pensions, Systemic Risk & Financial Stability Policy, Financial System Regulation & Efficiency
International Economics & Governance	Global Imbalances, Global Capital Flows & Economic Integration, Managing International Financial Crises, International Trade	International Financial Regulatory Reform, International Financial Architecture, Global Economic Governance, Global Imbalances, Financial System Regulation & Reform, Global Financial Integration, Global Trade Integration, Canada in the Global Economy, Export Competitiveness
Microprudential Policy	Modernizing Financial Services Regulation, Community Banks Regulation & Supervision, Too Big To Fail, Corporate Risk Management, Preparing for Financial Services Disruptions, Basel II, Corporate Governance, Corporate Accounting & Disclosure, Bank Supervision, Prudential Regulation, Foreign Banks, Consolidation of Banking Industry, Financial Regulatory & Supervisory Framework	N/A
Community Development & Consumer Protection	Small Business Financing, Household Debt, Community Economic Development, Subprime Mortgage Lending, Consumer Credit, Community Reinvestment Act, Consumer Protection, Bank Lending	N/A
Other	US Treasury & Government-Sponsored Enterprise Debt, Social Security, Energy Markets, Financial Literacy, Evaluating Circumstances, Potential Output & Productivity, Fiscal Budgets, Technology & Innovation, Rule of Law & Market Capitalism, Education, Housing Market, Economic Flexibility & Adaptation, Bond Yields, Income & Wealth Inequality, Business Investment	Education & Public Engagement, Labour Market, Exchange Rate Regime, Productivity & Innovation, Housing Market, Corporate Accounting & Disclosure, Fiscal Policy, Lessons from the Past and from Other Countries, Potential Output, Role of the Bank of Canada, Wage Setting, Commodity Markets, Macroeconomic Stabilization Policy