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Spread the Word: International Spillovers from Central Bank Communication*

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Abstract

We use text analysis and a novel dataset to measure the sentiment component of central bank communications in 23 countries over the 2002-2017 period. Our analysis yields three key results. First, using directed networks, we show that comovement in sentiment across central banks is not reducible to trade or financial flow exposure. Second, we find that geographic distance is a robust and economically significant determinant of comovement in central bank sentiment, while shared language and colonial ties are economically significant, but less robust. Third, we use structural VARs to show that sentiment shocks generate cross-country spillovers in sentiment, policy rates, and macroeconomic variables. We also find that the Fed plays a uniquely influential role in generating such sentiment spillovers, while the ECB is primarily influenced by other central banks. Overall, our results suggest that central bank communication contains systematic biases that could lead to suboptimal policy outcomes. (*JEL* E52, E58, F42)

Keywords: communication, monetary policy, international policy transmission.

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1 Introduction

This paper offers the first study of international spillovers from central bank communication sentiment using a novel dataset. We ask four research questions. First, is there evidence for international spillovers from central bank communication sentiment? Second, do sentiment spillovers exhibit a different pattern than trade and financial flows? Third, which other factors contribute to the observed comovement in central bank sentiment? And fourth, do central bank sentiment spillovers matter for critical macroeconomic and policy variables?

A broad and growing literature has documented the domestic impact of central bank communication (Bernanke et al., 2004; Gürkaynak et al., 2005; Schmeling and Wagner, 2016), which has grown in degree and scope since the 1990s (Woodford, 2005; Bernanke, 2013). As Hansen and McMahon (2015) demonstrated, communication appears to be particularly salient during periods of unconventional policy, such as during the use of forward guidance. The claim that conventional monetary policy generates international spillovers is well-established[1], and has recently been extended by a large body of work on the spillover effects from unconventional policy.[2] Cross-country spillover effects from monetary policy, and the communication thereof, also gained attention in the recent policy debate (Rajan, 2014; Fischer, 2014; Bernanke, 2015).[3] Prior to this paper, however, there was no assessment of the qualitative and quantitative aspects of international spillovers from central bank communication. Our work offers a first step in this direction by studying the international spillovers from central bank communication sentiment, which is the latent, low-frequency

[1]This line of research dates back to Mundell (1963) and Fleming (1962), who studied the impact of exchange rate regimes on capital mobility. Canova (2005) and Maćkowiak (2007) identify the effects of U.S. monetary shocks on Latin American and East Asian countries, while di Giovanni and Shambaugh (2008) look at the effect of foreign interest rates on output growth in other countries. Dedola et al. (2017) offer a study extended to high income countries with a focus on the financial dimension. Rey (2015) relates spillovers in emerging markets to the global financial cycle governed by monetary conditions in the center.

[2]See, e.g., Eichengreen and Gupta (2015), who analyze the impact of the Federal Reserve's tapering talk on emerging markets; Neely (2014), who demonstrates the impact of unconventional monetary policy in the U.S on international bond yields and exchange rate; and Berge and Cao (2014), who show how it affects asset price responses. Morais et al. (2017) document how the corporate loan supply and risk-taking in Mexico is affected by foreign monetary policy shocks. For a study on the spillovers from unconventional policy measures in the Eurozone, see Fratzscher et al. (2016).

[3]Policymakers in emerging markets aired concerns that their economies were being negatively affected by loose U.S. monetary conditions, which initially generated a surge of capital inflows and exchange rate appreciations (Chen et al., 2014). These were later reversed in the so-called "taper tantrum" (Neely, 2014).

component in central bank communication, best captured central bank speeches (Andersson et al., 2006).

We approach our research questions by constructing a novel dataset that contains central bank speech data from 23 countries over the 2002-2017 period.[4] We measure the net positivity of central bank speech sentiment for each country using dictionary-based methods outlined in Loughran and McDonald (2011). To establish evidence for international spillovers in central bank communication, we start by describing the new dataset, focusing initially on how communication is transmitted across central banks. We do this by generating sentiment networks with the technique introduced in Billio et al. (2012), which allows us to uncover Granger-causal relations across central banks. Relative to trade or financial networks, edges in the sentiment network are more numerous and the relationships across countries are more complex. This suggests that comovement in communication across countries is unlikely to be driven entirely by exposure to trade and financial flows. Thus, it is possible that one central bank can generate policy spillovers through its influence over another central bank's communication, even if it does not directly affect bilateral trade or financial flows.

Next, we find that outgoing Granger casual communication sentiment links are not necessarily a function of the prominence of the bank. As expected, the Federal Reserve (Fed) has a strong impact on sentiment at other central banks; however, the Bank of Japan (BoJ) and the European Central Bank (ECB), are primarily influenced by other central banks, even though Japan and the Eurozone generate trade and financial flow exposures for many countries in the network. This, again, suggests that foreign central bank sentiment could influence domestic central bank sentiment, which could ultimately affect policy decisions and domestic movements in macroeconomic variables.

Having established the dissonance between trade and financial flows, and central bank sentiment, we next address the third research question: namely, which factors beyond real and financial linkages explain comovement in central bank sentiment? We do this by regressing the bilateral correlation in quarterly central bank communication sentiment on a dummy for shared language, a dummy for colonial ties, a measure of geographic distance between central banks, and a broad set of controls, including comovement in real GDP growth,

[4]The speeches are obtained from the Bank for International Settlements (BIS): `https://www.bis.org/cbspeeches/`.

bilateral trade flows, bilateral financial flows, country fixed effects, and a shared continent dummy. Our results suggest that shared language and colonial ties generate economically significant, but not robust, increases in central bank sentiment comovement. Furthermore, geographic distance between central banks emerges as a uniquely robust and economically significant predictor of central bank sentiment comovement. In the specification with the most extensive set of controls and fixed effects, distance remains significant at the 1% level. Furthermore, its economic significance is substantial, and implies that an 8,000km increase in distance (i.e. Beijing to London) is associated with a 45% reduction in sentiment correlation for the median pair of central banks.

We next consider the fourth research question, which asks whether spillovers from central bank communication sentiment matter for the real economy. To answer this question, we measure the impact of a shock to sentiment at one country's central bank on domestic and foreign sentiment, policy variables, and macroeconomic variables. We do this by running sign-restricted vector autoregressions (VARs). We first perform VARs on a set of domestic variables for a subset of countries in our network with a high number of speeches, independent monetary policy, and complete data on policy and macroeconomic variables for the 2002-2017 period. We show that a shock to central bank sentiment is associated with immediate increases in the most likely channels for international transmission: equity price growth, the exchange rate, and imports. The maximum impact on the policy rate and unemployment arrive with delay of up to 4 quarters.

We also consider the impact of spillovers more directly in a set of two-country sign-restricted VARs. Here, we place sign restrictions on the domestic variables only and make no assumptions about the impact of foreign central bank sentiment shocks on foreign sentiment, policy, or macroeconomic variables. In an analysis of large, influential central banks, we find that a positive, structural shock to Fed sentiment has a positive impact on ECB sentiment, a positive impact on the ECB's policy rate with a 4-quarter lag, and a negative impact on unemployment in eurozone countries with a 5-quarter lag. In all cases, the domestic impacts of sentiment (i.e. Fed sentiment on U.S. macro variables) are larger than the impact on ECB and eurozone variables. We find similar effects for a positive Fed sentiment shock on Bank of England (BoE) communication and policy, and U.K. macroeconomic variables.

In line with the network analysis, we find that structural shocks to BoE sentiment gen-

erate spillovers for ECB sentiment and policy rates, and eurozone unemployment; however, structural shocks to ECB sentiment affect neither the BoE nor the Fed. Finally, we show that BoJ sentiment shocks do not appear to influence foreign sentiment or macroeconomic variables. Similarly, Japan and the BoJ are relatively unaffected by foreign sentiment.

Overall, the VAR exercise provides evidence that central bank communication generates international spillovers for sentiment, policy, and macroeconomic variables. It also appears to act faster on the most salient channels for transmission: sentiment, equity price growth, exchange rates, and imports. The largest and most durable spillovers appear to be generated by the Fed, while the ECB primarily internalizes sentiment generated elsewhere. Together with our earlier findings, this suggests that domestic central bank sentiment can be influenced by foreign central bank sentiment and that comovement in sentiment across central banks is not reducible to trade and financial flow exposure. As a result, foreign central bank sentiment can have direct implications for domestic policy and macroeconomic variables, as well as indirect implications via domestic central bank sentiment. Moreover, if central bank communication is not primarily influenced by the countries to which that central bank is most exposed, but systematically affected by other factors, then communication may be misaligned, yielding suboptimal policy.

With respect to methods, we use the rejection approach introduced in Rubio-Ramirez et al. (2010) for the structural VAR exercise. This allows us to recover impulse responses to structural sentiment shocks with relatively few assumptions. Guided by theory, we apply the weakest possible set of sign restrictions, assuming that central banks conduct monetary policy following a Taylor-type interest rate. Most importantly, we exclusively use sign-restrictions for the effects on domestic variables on impact.

We use a dictionary-based method to extract the sentiment content from central bank speeches (Loughran and McDonald, 2011). This allows for interpretability and applicability across different central banks' speeches. Even though speeches address various topics, our measure will reflect the overall sentiment of central bank officials. This differs from the approach in Hansen and McMahon (2015), which shows how advanced computational linguistics can be used to gain insight into different dimensions of communication. While tools such as dynamic topic modeling may provide stronger predictions, we regard a dictionary-based approach suitable for our context, since it offers a general solution that captures overall

sentiment in a speech database with a diversity of topics and central banks. One caveat is that a dictionary-based method is unable to isolate different components of central bank communication. That is, it does not distinguish explicitly between a central bank's assessment of the state of the economy and its use of forward guidance. We will, however, show that a simple dictionary based index can reveal a central bank's latent position and predict its future policy rate decisions. Based on our findings, it is reasonable to infer that this measure does not entirely overlap with forward guidance information, or with the quantitative forecast of the central bank. We should treat sentiment as a mixture of the central bank's private information on the economy and "implicit" forward guidance with the former tending to dominate in our sample period.

Our paper extends the literature on monetary policy spillovers (Canova, 2005; Maćkowiak, 2007; di Giovanni and Shambaugh, 2008; Dedola et al., 2017) by analyzing spillovers of central bank communication sentiment. We, thereby, complement Hansen and McMahon (2015), who use textual analysis to study the domestic effects of central bank communication. Related work documents that central bank communication appears to predict policy decisions (Apel and Grimaldi, 2014), and movements in interest rates and equity prices (Schmeling and Wagner, 2016). Central bank communication is often used to prepare markets and typically has the strongest effect in advance of decisions (Ehrmann and Fratzscher, 2007b). Moreover, the effects from communication appear to have persisted during the zero lower bound (ZLB) period, but were primarily concentrated in long term yields (Carvalho et al., 2016).

Existing work on central bank communication spillovers has demonstrated a significant impact on exchange rates (e.g., Fratzscher (2006), Fratzscher (2008), and Burkhard et al. (2010)), but little is known about how communication affects foreign macroeconomic variables and foreign central bank communication. Our paper attempts to fill this gap in the literature. Beyond the gap on spillovers, the existing literature also focuses on central bank press conferences, where the impact of communication is measured in a short window around such the monetary policy announcement (e.g., Schmeling and Wagner (2016) and Ehrmann and Talmi (2017)). In contrast, we focus on the low-frequency component of central bank communication and its relationship with foreign macroeconomic variables, such as unemployment, output, inflation, and interest rates. Speech data is best suited to this task because it captures the low frequency component of communication (Andersson et al., 2006). Further-

more, focusing on speeches allows us to measure central bank sentiment beyond the carefully planned and highly anticipated announcements, and to characterize how communication at one central bank affects communication at others.

Finally, on a conceptual level, our paper is also related to the literature on sentiment and business cycle fluctuations (e.g., Angeletos and La'O (2013)). Central banks are key players in the economy, which gives them a naturally important role in the coordination of market participant beliefs (Morris and Shin 2002). In our paper, we identify the component of sentiment that is affected by foreign central banks. Moreover, we document its cross-country transmission, as well as its effect on domestic macroeconomic variables.

The paper is organized as follows: Section 2 describes the data and the process by which sentiment scores are computed. Section 3 describes the network analysis, the cross-sectional sentiment regressions, and the sign-restricted VAR exercise. And finally, Section 4 concludes.

2 Data

We first compiled a database of English-translated central bank speeches. We did this by scraping the Bank for International Settlements' (BIS) speech archive for the 2002-2017 period, collecting both speech text and metadata for all documents. This yielded 12,024 speeches, which were associated with 474 unique institution identifiers.

We also collected data on real GDP growth, trade flows, and financial flows for all 23 countries in the networks we construct. Additionally, for the United States, the United Kingdom, the Eurozone, Sweden, and Japan–the countries we examine in greater detail in the VAR exercise–we also collected data on unemployment, the policy rate, equity price growth, the exchange rate, and imports. All real GDP growth data came from the OECD, Eurostat, or the Atlanta Fed.[5] Unemployment, policy rate, equity price growth, exchange rate, and import data was also collected from the OECD or ECB. Bilateral trade flows were collected from the World Integrated Trade Solution (WITS) database. And finally, bilateral private financial flows were reconstructed from the BIS's Locational Banking Database. We used the X-13 approach to deseasonalize when seasonally-adjusted series were not available.

[5]We used the Atlanta Fed's series for quarterly Chinese GDP because it covers our entire sample period.

Finally, for the cross-sectional regression exercise, we collected additional data on geographic distance, language, and colonial ties. We used great circle distances in thousands of kilometers to measure the distance between country capitals. For the shared language variable, we required central banks in a pair to have at least one matching official language. Finally, for colonial ties, we required at least one country to have been a colony of another or to have gained independence from the other. We used the ICOW Colonial History Database (Hensel, 2014) to construct this variable.

2.1 Identifying the Institution

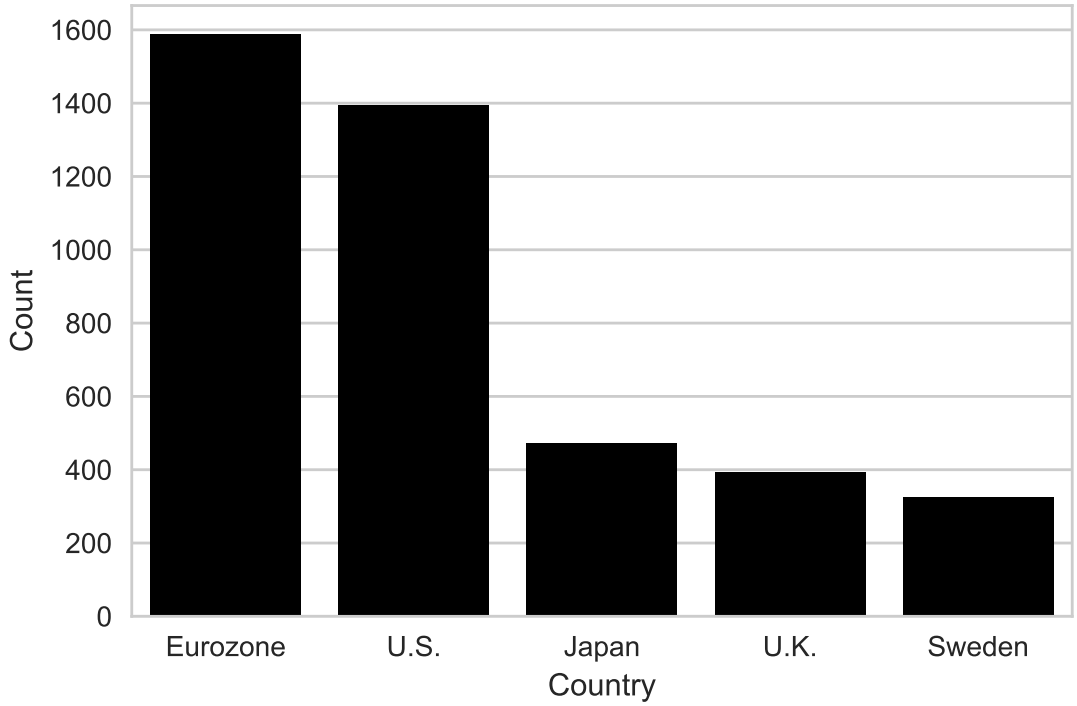
Since each central bank typically has multiple institutional identifiers, we next attempted to associate a unique institution with each speech. We did this by identifying the longest substring that is contained in all references to the central bank, and then checked each institution name for a match.

For some central banks, identifying the institution was straightforward, since the country was always contained in the central bank's name. Thus, searching for the country name is sufficient. In other cases, the name of the country was not always contained in references to the central bank. Figure I provides a list of speech counts for the five central banks that we examined in greater detail in the VAR exercise. Specifically, we selected the five most frequent communicators, subject to two constraints: 1) they must have control over their own monetary policy; and 2) they must have complete data for all macroeconomic and policy variables needed for the VARs.

Among the 474 institutions identified, we found 53 unique central banks.[6] Furthermore, within those 53 central banks, 23 gave at least 100 speeches over the 2002-2017 period. We restricted our sample to these institutions.

[6]Here, we treat the ECB and ESCB member central banks separately, even through ESCB banks coordinate and have strong ties. There could be a strategic component of the national banks' communication; however, we leave this question to future research.

Figure I: Speech Counts by Institution



This table provides speech counts for the central banks associated with the following monetary unions and countries: the ECB (Eurozone), the Fed (U.S.), the Bank of Japan (Japan), the Bank of England (U.K.), and the Riksbank (Sweden). All speeches were collected from the BIS's English language archive over the 2002-2017 period.

2.2 Cleaning the Data

Since our dataset consists of unstructured text contained in central bank speeches, we had to first clean the data and convert it to a useable format before we could use it to construct networks and perform regressions. We used the following procedure to format each text:

1. Convert the document from pdf to txt format.

2. Clean the document to remove all punctuation and special characters.

3. Remove stopwords, such as articles and prepositions.

The resulting documents are suitable for use in text analysis, which we perform next.

2.3 Measuring Sentiment

The final step in the data production process entails converting the text into a numeric format that is suitable for use in the construction of networks and the estimation of regressions. In this paper, we focus exclusively on the sentiment component of the texts, which tells us the extent to which a central bank official was positive or negative in his or her assessment of the economy. It also captures indications of potential paths for forward guidance. If, for instance, a monetary policy committee remains divided, speeches may give hints about about individual committee member positions.

We adopt the most commonly-used, dictionary-based method of measuring sentiment in economic and financial documents, which was constructed by Loughran and McDonald (2011).[7] This method was originally developed to assess the sentiment content of 10-K financial sentiments; and consists of a dictionary of words, which are classified as either positive or negative. The positivity, P, and negativity, N, of a document are then measured as follows, where net positivity is defined $P_N = P - N$:

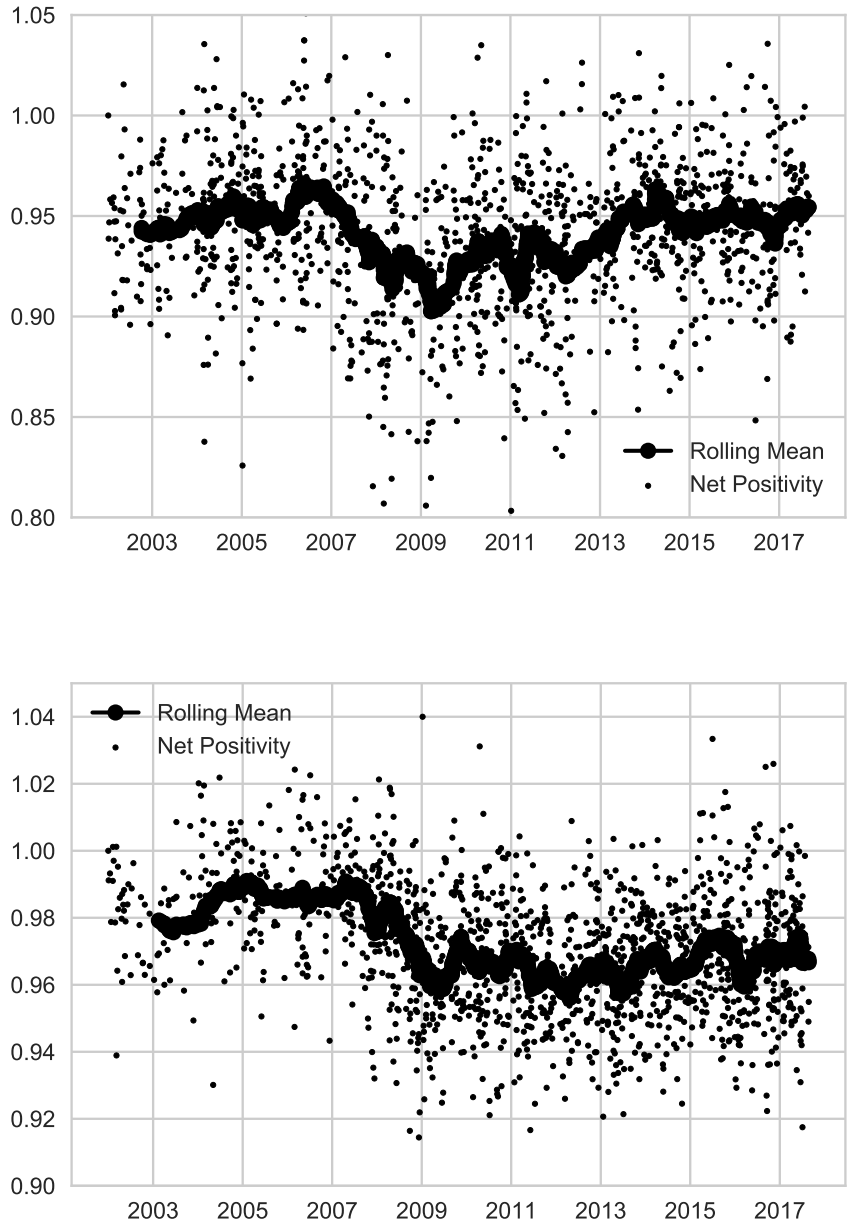
$$P = \frac{\#\text{ of Positive Words}}{\#\text{ of Total Words}} \qquad\qquad N = \frac{\#\text{ of Negative Words}}{\#\text{ of Total Words}}. \tag{1}$$

Figure II shows plots of normalized speech sentiment for the Fed and ECB over the 2002-2017 period. The line in each plot is the rolling net sentiment mean of the 40 most recent speeches. Note that Fed sentiment deteriorated earlier than ECB sentiment and prior to the financial crisis in 2007. Later, there is a noticeable uptick in Fed sentiment in 2012, a few years before the Federal Open Market Committee (FOMC) published its "Policy Normalization Principles and Plans" (FOMC, 2014), which proceeded the eventual increase in the Fed funds rate in December of 2015. The upward trend in Fed sentiment lasted till 2014 and experienced only a temporary dip during the taper tantrum in 2013. While Fed sentiment stabilized at a pre-crisis level after 2013, the ECB sentiment remained muted throughout, as additional crises afflicted the Eurozone.

Table I shows cross-country correlations for real GDP growth and central bank speech sentiment for the U.S., U.K., Eurozone, Japan, and Sweden. We select these four countries

[7] Apel and Grimaldi (2014) and Carvalho et al. (2016) have found that similar indices contain predictive content about future policy decisions and interest rates.

Figure II: Rolling Speech Sentiment for the Fed (top) and ECB (bottom).



The plots above show the normalized net sentiment scores associated with Fed (top) and ECB (bottom) speeches. The line shows the rolling net sentiment mean of the 40 most recent speeches. Sentiment scores are computed using a dictionary-based approach documented in Loughran and McDonald (2011).

and one monetary union because they communicate most frequently among the subset of central banks that 1) have complete data on macroeconomic variables; and 2) have control over their own monetary policy. One clear pattern that emerges is that real linkages, captured by real GDP growth, are not sufficient to explain comovement in cross-country central bank sentiment. Thus, it is unlikely that comovement in sentiment across countries is simply a reflection of comovement in business cycles across countries.

Table I: Cross-Country Correlations: Sentiment and Output

	Eurozone	U.S.	Japan	U.K.	Sweden
Real GDP Growth					
Eurozone	1.00	0.61	0.63	0.79	0.72
U.S.	-	1.00	0.43	0.62	0.61
Japan	-	-	1.00	0.53	0.51
U.K	-	-	-	1.00	0.58
Sweden	-	-	-	-	1.00
Central Bank Speech Sentiment					
Eurozone	1.00	0.38	0.37	0.38	0.34
U.S.	-	1.00	0.49	0.47	0.54
Japan	-	-	1.00	0.21	0.45
U.K	-	-	-	1.00	0.37
Sweden	-	-	-	-	1.00

Notes: This table provides cross-country correlations from our selection of five central banks. Cross-correlations are computed on quarterly sentiment data.

If, for instance, we look at the relationship between the U.S., the U.K., and the Eurozone, we can see that U.K. real GDP growth comoves most strongly with real GDP growth in the Eurozone; however, comovement in U.K. speech sentiment is strongest with U.S. speech sentiment. Similarly, real GDP growth in Japan comoves most strongly with the Eurozone, but sentiment comoves more strongly with the U.S. than with the Eurozone.

This basic, descriptive finding is non-trivial. It suggests that certain central banks may be attuned to the communication of certain other central banks in a way that is not justified by business cycle comovement. Since the literature has demonstrated that central bank communication affects policy-making and macroeconomic variables, this could be sufficient to generate international spillovers, even if there were no direct transmission of shocks from

foreign sentiment to domestic variables. If historical relationships, geographic distance, or linguistic ties cause central banks to overweight responses to the wrong country's shocks,[8] this could lead to suboptimal policy-making and hamper monetary policy transmission. A similar situation may arise if financial linkages cause central banks to overweight responses by more than is warranted.[9] We explore these hypotheses in greater detail in a cross-sectional regression.

The quarterly plots of net sentiment in Figure III further reinforce this relationship across central banks. Both Sweden and the United Kingdom appear to be more closely aligned with Fed sentiment than with the ECB, despite having stronger real linkages with the Eurozone. This feature could be related to historic or linguistic ties, as well as the the role the U.S. Dollar plays in global financial markets.

Our analysis proceeds in three steps. First, we characterize the macroeconomic and sentiment linkages between countries and central banks using Granger-causality networks in the style of Billio et al. (2012) for sentiment and directed networks for trade and financial flows. Next, we perform a set of cross-sectional regressions to determine whether a shared language, colonial ties, or geographic distance explains comovement in sentiment across central banks. Finally, we use sign-restricted vector autoregressions (VARs) to explore the impact of sentiment shocks on domestic policy and macroeconomic variables, as well as spillovers to foreign countries and central banks.

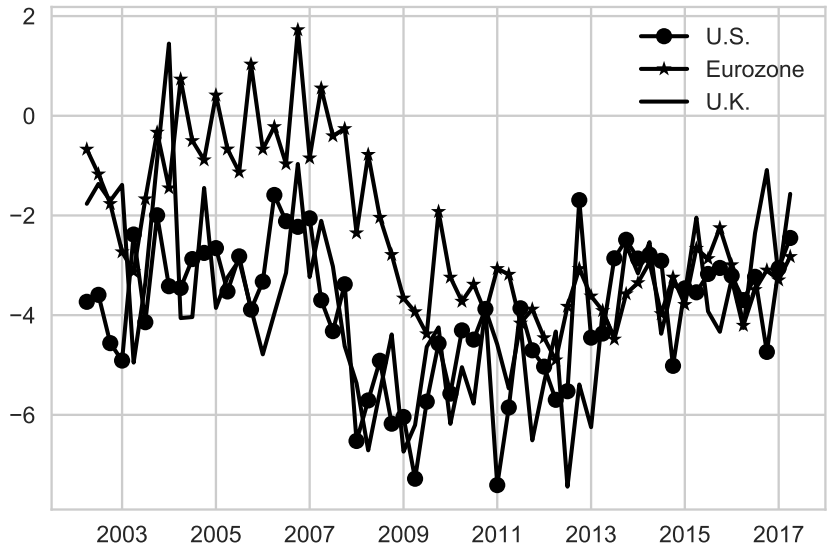
2.4 Interpreting Sentiment

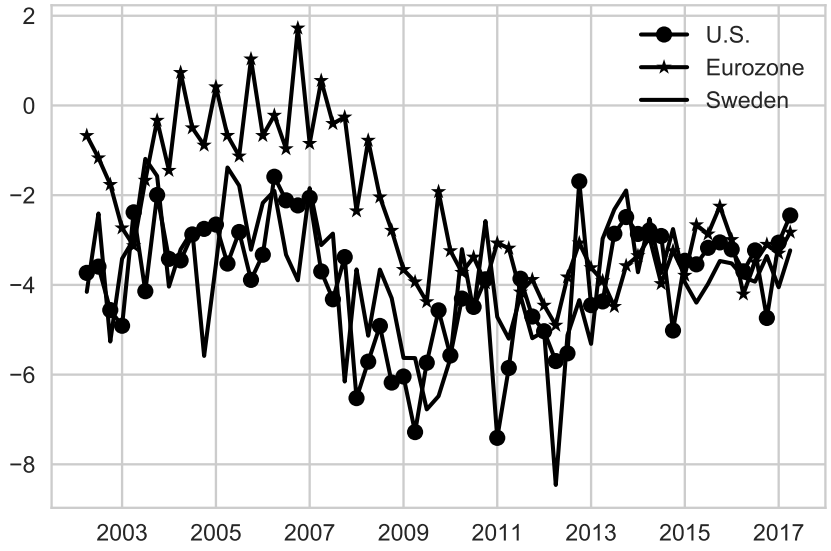
For simplicity, we will follow the literature (see, e.g., Blinder et al. (2008) for an overview) and assume that central banks conduct monetary policy using a Taylor-type interest rate rule, as shown in equation (2), where i_t is the nominal interest rate, x_t is a vector of economic variables, F_t is the rule's (possibly) time-varying functional form, and ϵ_t is a deviation:

[8] See David (1994) and Eichengreen (1985) for a historical exploration.

[9] International capital flows are considerably more volatile than output, especially for emerging markets (see, e.g. Federico et al. (2013), for descriptive statistics on total gross capital inflow volatility and domestic output volatility). Broner and Rigobon (2006) document that only a small share of capital flow dynamics is explained by domestic and foreign macroeconomic variables.

Figure III: Quarterly Speech Sentiment for the U.S., U.K., Eurozone, and Sweden





The plots above show quarterly speech sentiment for the U.S., U.K., Eurozone, and Sweden. Quarterly sentiment is computed as the mean speech sentiment of all speeches given by a central bank official within the quarter.

$$i_t = F_t(x_t) + \epsilon_t. \tag{2}$$

Such a central bank may wish to communicate its views on the state of the economy, x_t, or its intent to deviate from the rule, ϵ_t, including through the use of forward guidance. Alternatively, it might wish to communicate that it is changing how it responds to economic inputs–that is, how it modifies the functional form of F_t. New board members, for instance, might place different weights on the components of x_t. This could also happen if a central bank decided to adopt an explicit inflation target.

One general problem we encounter when analyzing the effects of central bank communication is identification. Financial markets are volatile and could be reacting to information other than the central bank communication over long measurement windows. The most common approach for dealing with this issue is to focus on a narrow window around each monetary policy statement. While this approach is sensible for measuring forward guidance shocks, it may be less reliable for subtler forms of communication. If, for instance, a central bank wanted to communicate that it had changed the way it interprets some underlying economic trend, a speech might be a better channel to disseminate this information. This is particularly true in the case where no policy decision has yet been reached. For instance, a member of the central bank's board might use a speech to argue that high inflation is temporary and, thus, does not warrant an interest rate response. The financial market's reaction to such a speech might not be measurable until the next inflation data release. Furthermore, a speech might reveal a board member's optimism, which could ultimately have an impact on policy in the future, but would not be detectible in policy statements initially. Indeed, other work has shown that speeches appear to capture the low frequency component of communication better than statements and announcements (Andersson et al., 2006).

Beyond the frequency of the signal contained in central bank communication, it is also important to discern the likely economic content. A large body of existing work measures market responses to central bank communication. Hansen and McMahon (2015) use a factor-augmented vector autoregression (FAVAR) and computational linguistics to separately measure the impact of forward guidance and the state of the economy in FOMC statements. They find that information about forward guidance has more explanatory power. Gürkaynak et

al. (2005) show that FOMC announcements account for most of the movement in longer-term treasury yields. While there is ample evidence that communication in connection with interest rate decisions does influence financial markets, the evidence on the impact of central bank speeches is more mixed. Kohn and Sack (2004) and Reeves and Sawicki (2007) find no significant effects of speeches on financial markets, while Ehrmann and Fratzscher (2007a) and Andersson et al. (2006) find the opposite. As we demonstrate later in the paper, the low frequency component of sentiment appears to primarily capture the central bank's optimism about the underlying state of the economy; however, it also contains predictive content about future policy decisions that can be treated as "implicit" forward guidance.

We make a first attempt at describing the economic content of speech sentiment by computing its principal components. We do this using 23 countries that each gave over 100 speeches during the 2002-2017 period. Figure IX in the Appendix plots the variance share explained by the principal components. Note that the first principal component explains 28% of the variance; however, this declines rapidly, with the second principal component explaining only 12%. The first five principal components explain just over 50% of the variance and the first ten are needed to account for 75%. This suggests that the sentiment content of central bank speeches are not simply reducible to Fed, ECB, or BoE sentiment.

Figure X in the Appendix plots the first, second, and third principal components, along with their correlations with central bank sentiment for each of the 23 countries. Note that the first principal component appears to capture the underlying sentiment that drives central bank policy. This component declines prior to the Great Recession, remains flat until the 2013, begins to rise in response to the unwinding of asset purchase programs, and then rises again as central banks consider increasing rates for the first time. The first principal component also appears to be positively correlated with all countries considered, except China, whose monetary policy was less constrained by the Great Recession. In contrast to the first principal component, the second appears to be more closely associated with financial and macroeconomic variables, and begins to recover rapidly after the Great Recession.

Importantly, speech sentiment appears to contain central bank interpretations of macroeconomic and financial data; and, as we will show later, is predictive of central bank policy. One possible explanation for this is that central bankers have access to private information that could potentially influence the way they interpret incoming news about macroeconomic

variables. Their access to information relating to undisclosed financial stress-testing data is one clear example; however, they also have privileged conversations with political and private market representatives that might yield non-public information that is unavailable to other forecasters. Central bankers also attend international meetings and communicate with each other both formally and informally. It is possible that central banks that are larger or more transparent, or for other reasons have more listeners, could influence other central banks to interpret incoming data in the same way.

Another potential factor is that central bank communication can play a role in coordinating market participants' beliefs about macroeconomic fundamentals, as well as their interpretations of relevant macroeconomic information (Amato and Shin, 2002; Morris and Shin, 2002; Svensson, 2006). In other words, the reach of central bank communication and the role of central banks as key players in the economy gives them the ability to establish reference points for the beliefs of market participants and for other central banks. A stark example of this is when central banks strive to underpin market confidence, as was the case, for instance, with ECB president Mario Draghi's "whatever it takes" speech. More generally, central banks may attempt to influence the overall sentiment in the economy and thereby business cycle fluctuations (Angeletos and La'O 2013).

3 Empirical Section

In this section, we provide an empirical analysis of central bank communication spillovers, focusing specifically on network structure and impulse response functions. Additionally, we examine what role a shared language, colonial ties, and geographic distance plays in generating sentiment comovement.

3.1 Directed Networks: Trade and Financial Flows

We construct two types of directed networks in this paper. The first type, which we cover in this subsection, captures the direction of the trade and financial flows. The second type, which is based on the concept of Granger causality, is covered in the following subsection. Since bilateral trade and financial flows involve both countries and are, thus, directionally

ambiguous, we instead use a measure that captures the importance of such flows for the first type of networks: whether a country is a top five partner for trade or finance with another country. If, for instance, Japan is one of Indonesia's largest importers, but Indonesia is not one of Japan's largest importers or exporters, then the relationship is important for Indonesia, but not necessarily for Japan.

The trade network is constructed using data on bilateral import and export flows from the World Integrated Trade Solution (WITS) database and depicted in Figure XI in the Appendix. Edges in the network connect pairs of nodes where at least one country (node) is a top five import or export partner of the other. For the direction of the relationship, we use the concept described in the previous paragraph. If, for instance, China is one of the five countries from which Australia receives the most imports or one of the five countries to which Australia sends the most exports, then an edge will connect Australia to China in the network. Furthermore, an arrow will point from China to Australia, since this relationship is important for Australia, but not necessarily China. If Australia is also one of the top five destinations for China's exports or is one of top five sources of imports in China, then an additional edge will connect the two, but with an arrow pointing at China.

The financial flows network is constructed using information on bilateral financial claims from the BIS's Locational Banking Statistics (LBS) database and depicted in Figure XII in the Appendix. Similar to the trade network, the financial flows network has an edge between each pair of countries for which at least one country is a top five provider or receiver of cross-border funding flows. We also use a concept of direction that is similar to what we used in the trade networks: if Canada is a top five source or destination of funds for Mexico, then the arrow will point from Canada to Mexico. Furthermore, if Mexico is a top five source or destination of funds for Canada, then a separate edge will connect the two with an arrow that points from Mexico to Canada.

The purpose of constructing directed trade and financial flow networks is to provide a comparison for sentiment networks. In the following section, we will introduce sentiment networks, which will use a different concept of directionality, since sentiment is defined separately for each central bank. We will also compare the trade and financial flows networks with the sentiment networks. This will allow us to demonstrate that the sentiment network is not be explained by trade and financial flow exposure.

3.2 Granger Causality Networks: Sentiment

In the previous section, we constructed quarterly measures of net sentiment for 23 central banks. We will now use these time series to construct Granger causality networks. Specifically, we follow Billio et al. (2012), who construct linear Granger causality networks with inter-relationships that take the following form:

$$R^i_{t+1} = a^i R^i_t + b^{ij} R^j_t + e^i_{t+1} \tag{3}$$

$$R^j_{t+1} = a^j R^j_t + b^{ji} R^i_t + e^j_{t+1}. \tag{4}$$

Here, entities are indexed by i and j. Furthermore, it is assumed that entity j Granger-causes entity i when b^{ij} is significantly different from zero; and entity i Granger-causes entity j when b^{ji} is significantly different from zero. We then modify the process to deal with potential non-stationarity in the series using the following approach, which is outlined in Toda and Yamamoto (1995) and consists of four steps:

1. Compute m=max$\{m_i, m_j\}$, where m_j is the order of integration of R^j_t.
2. Recover the maximum lag length, p, for model variables using the Akaike Information Criterion (AIC).
3. Take the specification determined in step 2 and add m lags to each variable.
4. Apply a Wald test for Granger non-causality on the first p coefficients for the foreign entity in each equation.

The adjusted model equations are as follows:

$$R^i_{t+1} = a^i_0 + \sum_{s=0}^{p+m} a^i_s R^i_{t-1-s} + \sum_{s=0}^{p+m} b^{ij} R^j_{t-1-s} + e^i_{t+1} \tag{5}$$

$$R^j_{t+1} = a^j_0 + \sum_{s=0}^{p+m} a^j_s R^j_{t-1-s} + \sum_{s=0}^{p+m} b^{ji} R^i_{t-1-s} + e^j_{t+1}. \tag{6}$$

If the test rejects the null of Granger non-causality in step 4, we claim that there is evidence for Granger causality. We perform the same test for each country pair. In each case, we run separate VARs and perform separate Granger causality tests for real GDP growth and for net central bank speech sentiment.

We then construct a network diagram for net central bank sentiment using the following procedure:

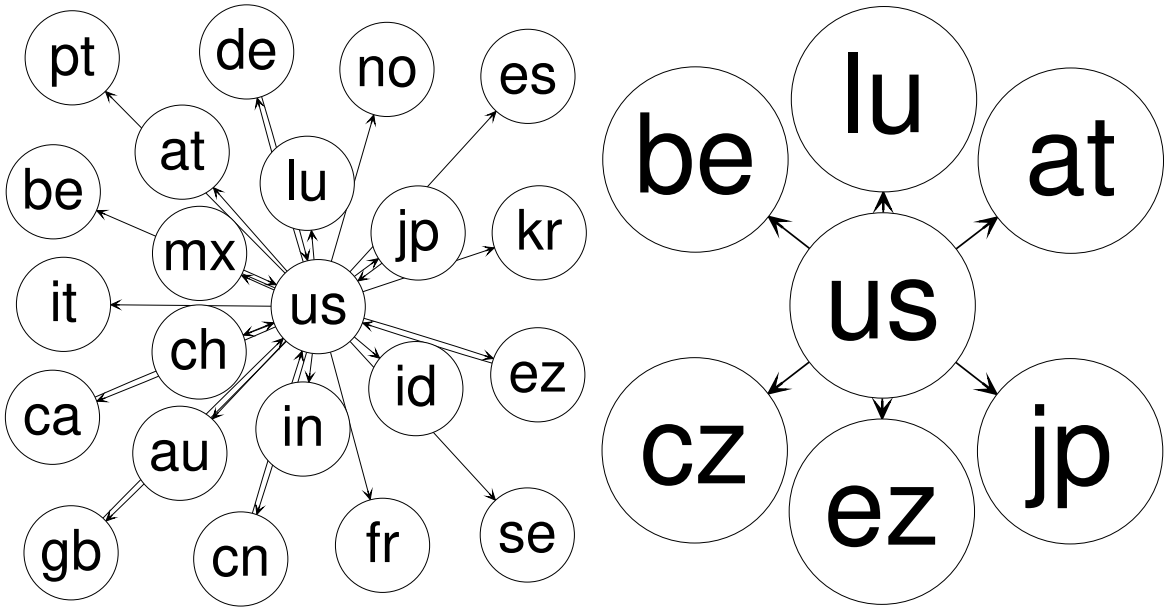
1. Each country pair with at least one Granger causal link in either direction is connected by an edge.

2. If the Granger causal connection runs from country j to country i, then the arrow on the edge connecting j and i will point to i.

Figure XIII in the Appendix shows the Granger causal net sentiment network across central banks. Importantly, there are stark differences between the network structure for trade and financial flows, and central bank speech sentiment. The network for central bank net sentiment contains many more edges and features substantially more complex relationships; however, the most obvious difference is the directionality of relationships. We can also see that some of the largest network nodes have many incoming and outgoing Granger causal connections. In the rest of this section, we will examine the trade and sentiment subnetworks for the largest nodes, including their incoming and outgoing connections. We will skip a detailed analysis of the financial flows network due to its similarity to the trade network.

We will start with the subnetworks for the United States, which are depicted in Figure IV. The network on the left shows the linkages in trade between all countries and the United States. As we might expect, the U.S. is a top source of imports and destination of exports for many countries. It also has inbound links from large economies, such as the Eurozone, China, the United Kingdom, Japan, Germany, and Canada. With respect to sentiment transmission, the U.S. has a tighter network, but affects large central banks, such as the ECB and BoJ. Furthermore, it does not have inbound links, which suggests it is a generator, rather than receiver, of central bank sentiment. Overall, this largely conforms to what we might expect for a large economy. As we will show later in a VAR exercise, the Fed appears to have unique statistical and economic significance as a generator of central bank sentiment.

Figure IV: Trade and Sentiment Networks: United States

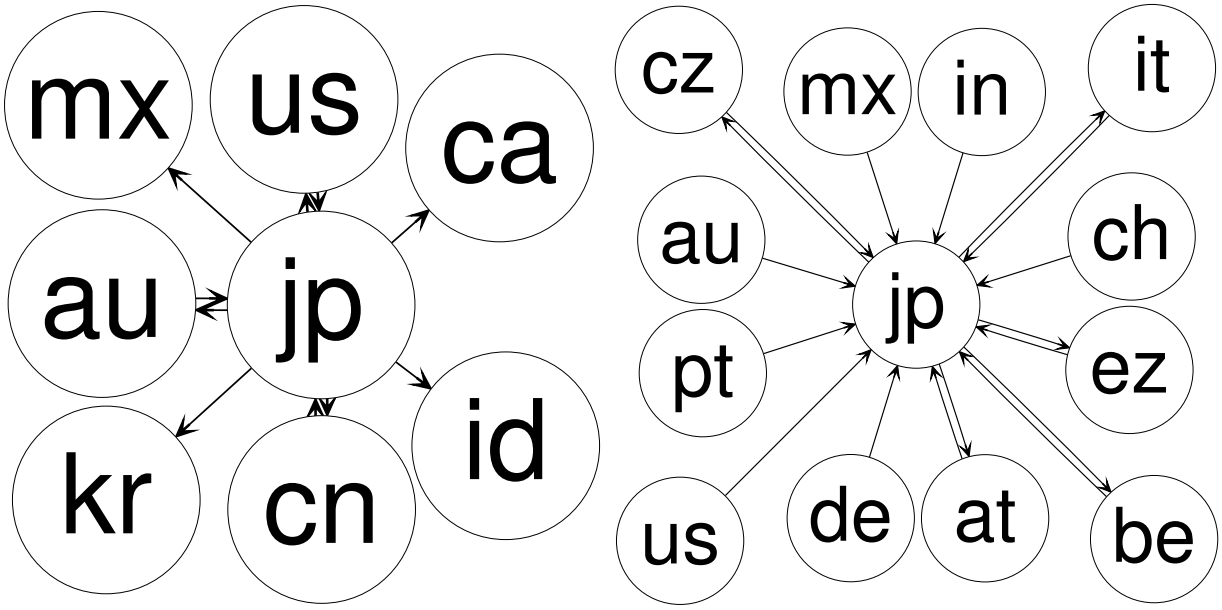


The subnetwork on the left depicts trade flows for the United States. The subnetwork on the right shows central bank sentiment for the United States.

Figure V shows the equivalent subnetworks for Japan. The trade network aligns well with our expectations for a large economy. Japan has strong trade connections with neighboring countries, such as South Korea, China, Indonesia, and Australia. It also has ties to North American countries: the United States, Mexico, and Canada. Most of these connections are outgoing, which suggests that Japan tends to create trade exposures, rather than accepting them. The sentiment network, however, is distinctly different from the U.S.'s and also distinctly different from Japan's trade network. Rather than having many outgoing causal connections, incoming connections dominate for the BoJ. They primarily emanate from large economies and financial centers, such as the U.S., Switzerland, and Germany, and geographically close countries, such as Australia and India. Countries with both incoming and outgoing causal connections in sentiment are primarily large trading partners located within Europe.

We next consider the Eurozone subnetwork, which is shown in Figure VI. Note that we treat speeches given by national banks in the Eurozone separately from the ECB. Here, we

Figure V: Trade and Sentiment Networks: Japan



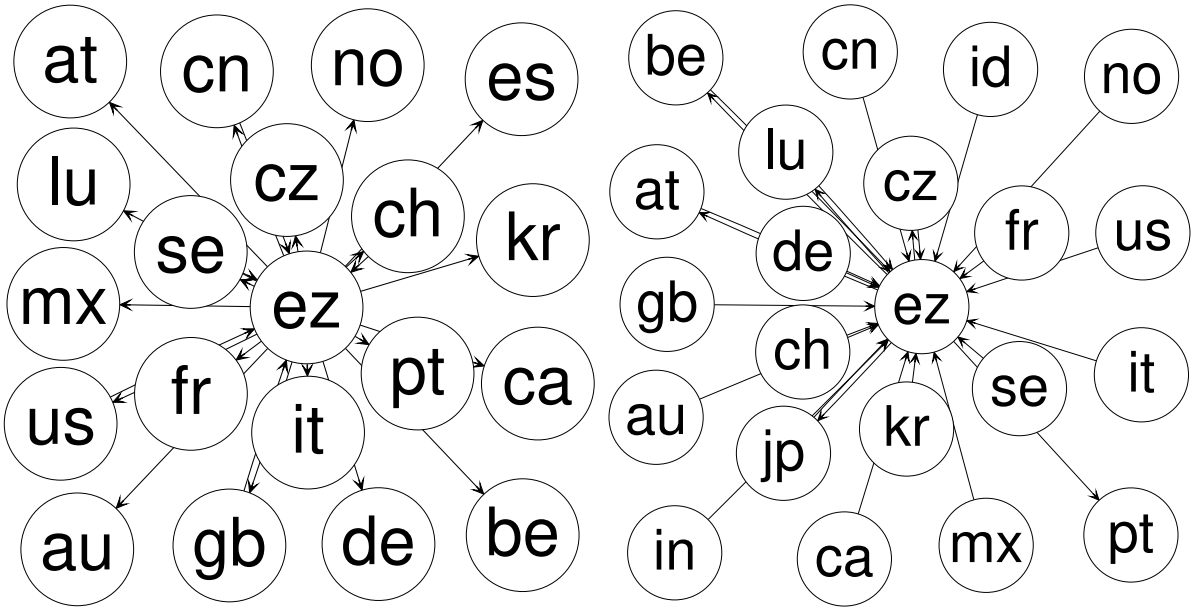
The subnetwork on the left depicts trade flows for Japan The subnetwork on the right shows central bank sentiment for Japan.

find a stark difference between the trade and sentiment networks. While most Eurozone trade links are outbound, virtually all sentiment links are inbound. This could be related to the ECB's institutional mandate as the representative of all Eurozone countries.

Next, we examine the trade and sentiment networks for the United Kingdom, shown in Figure VII. We can see that the United Kingdom is an important trade partner for many countries. It has outgoing links to many small and large economies, as well as inbound links from large economies, such as China, the United States, France, and Germany. With respect to sentiment, however, the Bank of England exclusively has outgoing links, but to relatively fewer banks. Most notably, it affects sentiment at the ECB, but is not affected by the ECB in a Granger causal sense.

Finally, we consider the networks for Sweden. With respect to trade, Sweden is the smallest economy we consider and, thus, has only two outgoing links to Norway and to the Eurozone. The remaining incoming links come from the United States, Germany, the United Kingdom, Norway, and the Eurozone. Importantly, however, Sweden appears to have

Figure VI: Trade and Sentiment Networks: Eurozone



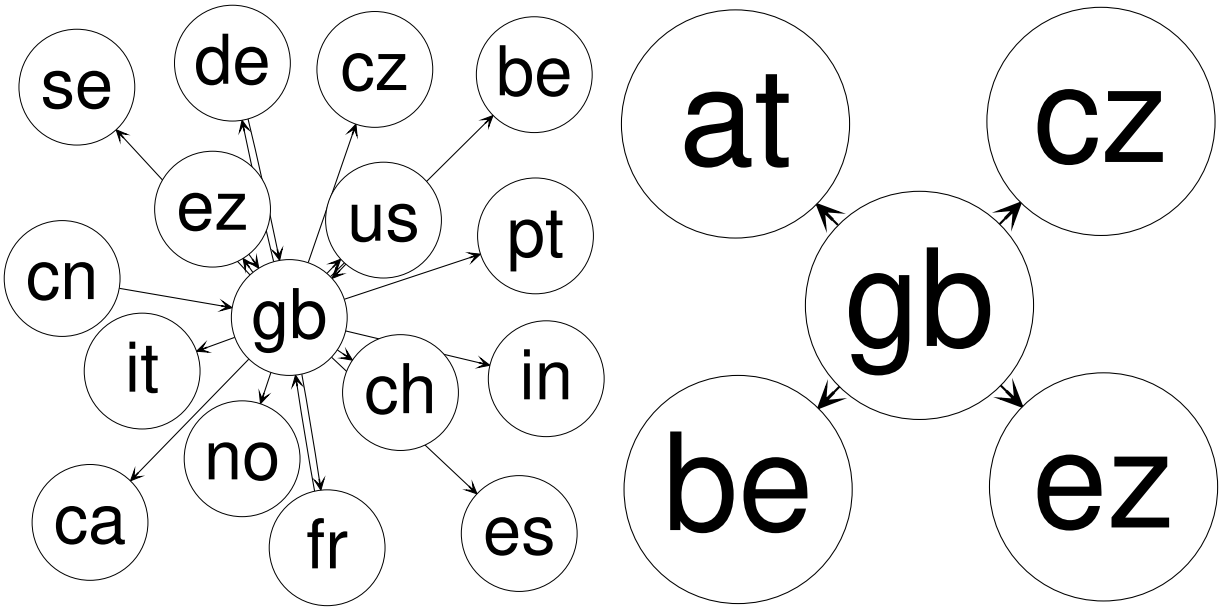
The subnetwork on the left depicts trade flows for the Eurozone. The subnetwork on the right shows central bank sentiment for the Eurozone.

a stronger impact on the sentiment of other central banks with outbound links pointing at the Czech Republic, Belgium, Austria, Italy, and the Eurozone.

Overall, we find substantial differences across large nodes in the network. Some primarily take in sentiment from other central banks. Others primarily or exclusively influence other central banks' sentiment. We also find substantial differences between exposure to trade and financial flows, and comovement in sentiment across countries.

As stated earlier, the network construction exercise should be interpreted primarily as descriptive. The purpose of using Granger causality is to generate directed networks. For this reason, we will revisit the idea of spillovers later in a sign-restricted VAR exercise with an extended vector of variables to tease out international spillover effects. However, we will first take a more detailed look at the drivers of sentiment comovement in the following section.

Figure VII: Trade and Sentiment: United Kingdom



The subnetwork on the left depicts trade flows for the United Kingdom. The subnetwork on the right shows central bank sentiment for the United Kingdom.

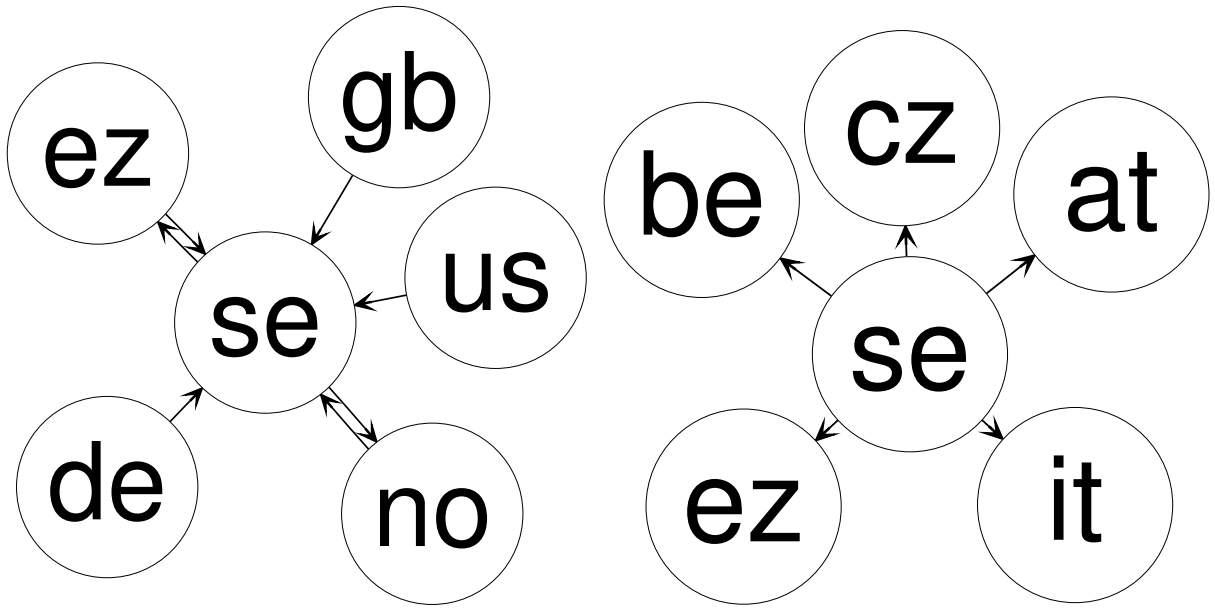
3.3 Cross-Sectional Regressions

We have now demonstrated that a shock to central bank sentiment affects domestic macroeconomic variables, and may spillover to foreign central bank sentiment, policy rates, and macroeconomic variables. We also showed that sentiment cannot be reduced to exposure to trade and financial flows. In fact, in some extreme cases, countries that have a broad reach with respect to trade and financial flows are receivers, rather than generators, of central bank sentiment. In the empirical exercise in this subsection, we consider what explains strong comovement in sentiment between pairs of central banks. In particular, we estimate equation (7):

$$\rho_{i,j} = \beta_0 + \beta_1 D_{i,j} + \beta_2 L_{i,j} + \beta_3 C_{i,j} + \beta_4 X_{i,j} + \gamma_{i,j} + \zeta_{i,j} + e_{i,j}. \tag{7}$$

Note that i and j in the equation above index countries i and j. The dependent variable, $\rho_{i,j}$, is the cross-country correlation in central bank sentiment. Our variables of interest

Figure VIII: Trade and Sentiment Networks: Sweden



The subnetwork on the left depicts trade flows for Sweden. The subnetwork on the right shows central bank sentiment for Sweden.

are $D_{i,j}$, $L_{i,j}$, and $C_{i,j}$, where $D_{i,j}$ is the distance in thousands of kilometers between a pair of central banks;[10] $L_{i,j}$ is an binary variable that is equal to 1 if the pair of countries share a common language; and $C_{i,j}$ indicates whether one country was a colony of or gained independence from the other. The vector, $X_{i,j}$, is a set of control variables. And finally, $\gamma_{i,j}$ are country fixed effects and $\zeta_{i,j}$ is a binary variable that indicates whether a pair of central banks is located on the same continent.

Our results are given in Table IV in the Appendix. Column 1 shows the results for distance, $D_{i,j}$, with no controls included. Column 2 adds shared language, $L_{i,j}$, and colonial ties, $C_{i,j}$. Column 3 adds three controls, $X_{i,j}$: 1) the pairwise correlation in real GDP growth; 2) a dummy variable that is equal to 1 if at least one of the two countries is a top five import or export partner of the other; and 3) a dummy variable that is equal to 1 if at least one of the two countries is a top five provider or receiver of private financial flows to the other.[11]

[10] We compute this as the great circle distance between a pair of countries' capital cities.

[11] Private financial flows are constructed using the Bank for International Settlements' Locational Banking Statistics database.

Column 4 includes a control for the natural logarithm of the number of speeches given by the pair. Column 5 adds country fixed effects, $\gamma_{i,j}$, which indicate whether either country i or j is country k. Column 6 includes a dummy, $\zeta_{i,j}$, for whether the two central banks are located on the same continent. Column 7 clusters standard errors at the continent level, rather than using heteroskedasticity-robust standard errors, as is done in all other specifications. Columns 8 and 9 drop China and the U.S., respectively.

Columns 1-4 indicate that all three variables of interest–distance, shared language, and colonial ties–have at least a weak impact on the correlation in sentiment across central banks. The coefficient on shared language implies that two central banks with a common language have, on average, a 0.0645 higher correlation in sentiment. This is a 21% increase for the median pair of central banks. Similarly, if one central bank in a pair is located in a country that was a colony of the other or gained independence from the other, this is associated with a 0.1149 increase in sentiment correlation. This amounts to a 37% increase in correlation for the median pair of central banks. Importantly, however, shared language and colonial ties are robust to the inclusion of economic control variables, but not country fixed effects. This suggests that the channel might be somewhat subtler. Namely, being a colony or a colonizer or sharing a language with many other countries may explain a substantial share of the comovement in sentiment with other central banks.

Finally, we consider the impact of distance, which is our most robust finding. It remains significant at the 1% level in all specifications, even when economic control variables, country fixed effects, and shared continent dummies are included. It also remains significant if the U.S. or China is dropped, and does not appear to be sensitive to method used to construct standard errors. Moreover, it remains significant even in specifications where the correlation in real GDP growth does not. Our preferred specification in column 6 suggests that a 1,000 kilometer (km) increase in distance between a pair of central banks is associated with a 0.0175 reduction in central bank sentiment correlation. Thus, an 8,000km increase in distance (e.g. from London to Beijing) is associated with a 0.14 decrease in central bank sentiment correlation. This is a 45% reduction for the median central bank pair.

Our findings have important implications for policy. Namely, they suggest that distance remains an important factor in the alignment of central bank communication. Even when country, language, colonial ties, continent, and business cycle comovement are controlled

for, distance stands alone as a uniquely statistically and economically significant predictor of comovement in central bank sentiment. If central bank communication is influenced more by distance than by exposure to common shocks, then it might be possible to reap substantial policy gains by adjusting communication to correct for this bias.

3.4 Sign-Restricted VARs

With the basic network structure of sentiment transmission across central banks in place, we next quantify the impact shocks to central bank communication have on domestic and foreign macro and policy variables. We do this by performing sign-restricted VARs with the rejection method described in Rubio-Ramirez et al. (2010). This approach allows for partial identification of impulse responses functions (IRFs) to a single structural shock. In each case, we examine the impact of a shock to net domestic speech sentiment on domestic or foreign variables. We focus specifically on the five central banks with the highest number of speeches, among those with complete data and independent monetary policy. Furthermore, we do not differentiate between sentiment that contains news about the underlying state of the economy and news that signals future policy. More precisely, a shock to net speech sentiment is the combined effect of central bank reactions to perceived changes in the underlying state of the economy and central bank signaling about future policy.

We perform two sets of VARs. The first captures the domestic impact of sentiment shocks with an expanded set of macroeconomic variables. For each central bank, we perform a sign-restricted VAR with quarterly measures of central bank speech sentiment, the policy rate, unemployment, equity price growth, the real exchange rate, and imports.[12] The second set of VARs are quarterly and also have six variables: domestic and foreign central bank sentiment, domestic and foreign central bank policy rates, and domestic and foreign unemployment. Note that for the second set of VARs, we drop equity price growth, the real exchange rate, and imports. We make the following sign restrictions on all VARs in this subsection:

1. A positive structural shock to domestic central bank sentiment has a weakly positive

[12]We have also tried alternative specifications that included real GDP growth and inflation. We generally find that the impact of a sentiment shock on real GDP growth is weaker than the impact on unemployment. Additionally, the impact on inflation is minimal for the period we consider, other than for developing countries with high and volatile inflation rates.

effect on domestic central bank sentiment on impact.

2. A positive structural shock to domestic central bank sentiment has a weakly positive effect on the domestic policy rate on impact.

3. A positive structural shock to domestic central bank sentiment has a weakly negative effect on domestic unemployment on impact.

4. A positive structural shock to domestic central bank sentiment has a weakly positive effect on domestic equity price growth on impact.

5. A positive structural shock to domestic central bank sentiment has a weakly positive effect on the real broad effective exchange rate on impact.

6. A positive structural shock to domestic central bank sentiment has a weakly positive effect on imports on impact.

While the first sign restriction is self-explanatory, the remaining sign restrictions are based on the theory discussed in section 2.4. A positive structural shock to domestic central bank sentiment has a direct and positive effect on the domestic policy rate if the change in sentiment signals future policy. Instead, if the shock to domestic central bank sentiment stems from the positive assessment of the underlying state of the economy, then a weakly positive effect on the domestic policy rate follows from the Taylor rule in equation (2). In both cases, we arrive at the postulated sign restriction.

Next, a positive structural shock to domestic central bank sentiment, which stems from a positive assessment of the underlying economy, has a direct effect that is weakly negative on unemployment at impact. At the same time, a positive assessment of the economy is likely to be associated with subsequent contractionary policy under the Taylor rule. This indirect effect via an increase of the domestic policy rate may be associated with an increase in unemployment. However, such an indirect effect would come with a delay of several quarters.[13] Taken together, the direct effect associated with a weakly negative effect on

[13]C.J. et al. (1999) document in the Handbook of Macroeconomics that a U.S. monetary policy shock affects U.S. real GDP with about a year's lag, and the effect on unemployment would, if anything, come even later.

unemployment dominates the indirect effect–at least on impact–thereby justifying the third sign restriction.[14] Moreover, we expect the initial positive assessment to have similar effects on impact on equity price growth, the real exchange rate, and imports, justifying the imposed sign restrictions.

Importantly, we do not make any assumptions about the effect on foreign country or foreign central bank variables. Rather, we exclusively make assumptions about the effect on impact for domestic variables that are in line with the existing literature on central bank communication and are justified through theory. Additionally, our results are qualitatively robust to adjustments on the sign restriction for domestic unemployment. In particular, we find similar results if we instead assume that the impact comes with a single-quarter delay. Finally, consistent with the literature, all IRFs shown use 68% confidence intervals.

We will start by examining the results for the domestic VARs. Table II provides a summary of the impulse responses from five single-country VARs. All entries that contain an '–' correspond to IRFs with no statistically significant result. Other entries correspond to IRFs with significance in at least one period. For instance, +1 indicates that the maximum effect was positive and occurred on impact. Note that the impact of a positive sentiment shock on sentiment is largest and positive in the first period for all single-country VARs. Similarly, the maximum impacts on channels that are critical for international transmission–such as equity price growth, the real exchange rate, and imports–arrive within the first quarter. The impact on the policy rate arrives later, generating a positive and significant effect after 2-4 additional quarters. Similarly, the impact on unemployment is negative and appears 1-3 quarters after impact of a positive sentiment shock.

Next, we consider whether central bank communication generates international spillovers. The results of 20 VARs with both domestic and foreign variables are summarized in Table III. All results shown are for spillovers from the "domestic" to "foreign" country or monetary union. The first entity listed receives the shock to domestic central bank speech sentiment. Again, all results with a sign (+/-) and a period of maximum impact were statistically significant in at least that period.

Our results indicate that Fed communication has the most expansive impact of all central

[14] If we instead assume that the impact comes with a single-quarter delay, results are qualitatively similar.

Table II: VAR Summary: Domestic Impact

	Sentiment	Policy Rate	Unemployment	Equity Price Growth	Exchange Rate	Imports
Eurozone	+1	+5	-4	+1	+1	+1
U.S.	+1	+4	-4	+1	+1	+1
Japan	+1	+3	-2	+1	+1	+1
U.K.	+1	+4	-4	+1	+1	+1
Sweden	+1	+3	-4	+1	+1	+1

Notes: This table provides a summary of the single-country VAR IRFs for the Eurozone, U.S., Japan, U.K., and Sweden. Each VAR contains sentiment, the policy rate, unemployment, equity price growth, the real broad effective exchange rate, and imports of goods and services. In each case, we examine the response to a domestic sentiment shock. We indicate the sign of the maximum impact and the quarter in which it arrived. For example, +1 indicates that the maximum effect was positive and occurred on impact.

banks considered, generating spillovers to sentiment, the policy rate, and unemployment in the Eurozone and the U.K., and spillovers to sentiment and the policy rate in Sweden. Furthermore, consistent with the weaker network structure results, none of the central banks considered appear to affect U.S. sentiment, the policy rate, or unemployment.

The ECB, which communicates more frequently than any other central bank, affects sentiment, the policy rate, and unemployment in Sweden, but does not affect any of the other central banks. The BoJ does not appear to have an impact on communication directly, but does influence policy rates at other central banks. Finally, the BoE appears to have a substantial impact on the ECB and Eurozone and a weaker impact on Sweden. The Riksbank affects the ECB policy rate with a delay and sentiment at the BoE.

We next examine relationships between the most frequent communicators within a selected group of central banks: the Fed, the BoE, and the ECB. We will start with the ECB and BoE. Note that all IRFs are shown in the Appendix. Figure XIV shows the impact of a positive structural shock to BoE sentiment on domestic and foreign (ECB and Eurozone) policy and macroeconomic variables. Here, we find that the impact on domestic sentiment lasts 4 quarters, but has a longer impact on the BoE's policy rate and domestic unemployment. We also see symmetric effects on ECB sentiment, the ECB's policy rate, and Eurozone unemployment. These effects, however, arrive with a substantial delay for the ECB policy rate and Eurozone unemployment.

Table III: VAR Summary: Cross-Country Spillovers

	Sentiment	Policy Rate	Unemployment
Eurozone			
Eurozone → U.S.	–	–	–
Eurozone → U.K.	–	–	–
Eurozone → Japan	–	–	–
Eurozone → Sweden	+1	+5	-4
U.S.			
U.S.→ Eurozone	+1	+5	-5
U.S. → Japan	–	–	–
U.S. → U.K.	+2	+3	-6
U.S. → Sweden	+2	+5	–
Japan			
Japan → Eurozone	–	+5	–
Japan → U.S.	–	–	–
Japan → U.K.	–	+2	–
Japan → Sweden	–	+2	–
U.K.			
U.K. → Eurozone	+2	+7	-6
U.K. → U.S.	–	–	–
U.K. → Japan	–	–	–
U.K. → Sweden	–	+2	–
Sweden			
Sweden → Eurozone	–	+5	–
Sweden → U.S.	–	–	–
Sweden → Japan	–	–	–
Sweden → U.K.	+2	–	–

Notes: This table provides a summary of spillover effects from two-country VAR IRFs for the Eurozone, U.S., Japan, U.K., and Sweden. Each VAR contains foreign and domestic sentiment, policy rates, and unemployment. In each case, we examine the response to a domestic sentiment shock, where the "domestic" country is listed first. We indicate the sign of the maximum impact and the quarter in which it arrived. For example, +1 indicates that the maximum effect was positive and occurred on impact. Finally, note that '–' alone indicates that there were no significant results.

Importantly, as shown in Figure XV, the impact of a structural shock to ECB sentiment on ECB, Eurozone, BoE, and U.K. variables is not symmetric. The shock to ECB sentiment

has only a small, one-quarter impact on domestic macroeconomic variables and policy variables. Additionally, there are no spillovers from ECB sentiment shocks to the U.K. or to BoE sentiment or policy.

Next, we consider the impact of Fed sentiment on the U.S. and on the Eurozone in Figure XVI, and the impact of ECB sentiment on the Eurozone and the U.S. in Figure XVII. Here, we find that a positive shock to Fed sentiment has stronger and more persistent effects on future Fed sentiment, the target policy rate, and unemployment. We also find larger and more persistent effects on ECB sentiment and policy, as well as Eurozone unemployment.

Again, we do not find spillovers from a positive shock to ECB sentiment to the Fed or to U.S. unemployment. Along with the network analysis, this suggests that the ECB primarily takes in sentiment from large foreign central banks, rather than influencing it. While this may appear counterintuitive, it is likely consistent with its mandate as an institution that represents many countries within the Eurozone.

Finally, we examine spillovers between the Fed and the BoE in Figures XVIII and XIX. Figure XVIII suggests that there are weak spillovers from Fed sentiment to BoE policy rates and U.K. unemployment. And Figure XIX suggests that these spillovers do not flow in the opposite direction from the BoE to the Fed.

Overall, we find evidence for international spillovers from sentiment to sentiment, sentiment to policy rates, and sentiment to unemployment. These effects are typically only in one direction; and the Fed appears to generate particularly large and durable spillover effects. The prominence of the Fed in affecting central bank sentiment is rather intuitive, and there are a few channels that may explain this result. One possible explanation is that the U.S. economy has been a strong growth driver for the world economy. This could explain why other central banks are highly influenced by the Fed's speech sentiment. Alternatively, it could reflect the Fed's key role in setting the risk free interest rate in the integrated global financial market. Investors across the world pay close attention to Fed communication, and other central banks react accordingly. Another explanation is that this finding could be the result of the Fed being in a unique position to interpret global business cycle shocks or to affect global sentiment. In our sample, the Federal Reserve System delivers a large number of speeches, which could potentially update market participants on the Fed view of the economy. It is, however, challenging to test these channels separately.

4 Conclusion

We construct a novel dataset using English-translated central bank speeches from the BIS's archive. We extract the sentiment content from speeches given by 23 of the central banks over the 2002-2017 period by applying the Loughran and McDonald (2011) dictionary. Using the net positivity measure, we perform three exercises. First, we construct directed networks to capture trade and financial flow exposure, and Granger causality networks to capture sentiment linkages between central banks. Second, we examine the drivers of comovement in sentiment across central banks in a cross-sectional regression. And third, we revisit the network results, focusing specifically on important nodes in greater detail by performing sign-restricted VARs for selected country pairs.

We show that the central bank speech sentiment network is not reducible to exposure to trade, financial flows, or business cycle comovement. This is important because it suggests that cross-country comovement in sentiment is not simply driven by comovement in output over the business cycle. Rather, there is a component of cross-country sentiment comovement that is unrelated to real linkages. Since the existing literature has demonstrated that a central bank's own communication predicts policy and macroeconomic variables, this alone suggests that the sentiment-to-sentiment spillovers we observe in the network may imply that policy and macroeconomic outcomes could be affected by common communication strategies, relationships between central banks, or shared conceptual frameworks for understanding the macroeconomy. Furthermore, our network analysis also shows that the largest central banks are not necessarily the most influential. While the Fed and BoE tend to influence sentiment at other central banks, the BoJ and the ECB are primarily influenced by other central banks.

In a separate cross-sectional regression exercise, we delve deeper into the underlying drivers of central bank sentiment comovement. We show that having either a shared language or colonial ties tends to generates positive comovement in central bank speech sentiment. Furthermore, we find that geographic distance between central banks is a uniquely statistically and economically significant predictor of comovement in central bank sentiment. This relationship persists in the presence of country fixed effects, a shared continent dummy, and controls for business comovement, trade, and financial flows.

Finally, we use sign-restricted VARs to demonstrate that there are substantial interna-

tional spillovers in sentiment, policy rates, and macroeconomic variables between important nodes in the central bank communication network. In particular, we document that positive shocks to Fed and BoE sentiment predict increases in ECB sentiment, increases in the ECB's policy rate, and decreases in Eurozone unemployment. Furthermore, the relationship does not flow in the opposite direction: ECB sentiment shocks do not affect U.S. or U.K. macroeconomic or policy variables. Importantly, we establish these findings by making identification assumptions exclusively about the impact on domestic sentiment, policy variables, and macroeconomic variables.

We leave it to future research to consider the impact of sentiment on inflation in countries with high or volatile inflation rates. Furthermore, future research might make use of the data introduced in this paper to study international policy cooperation.

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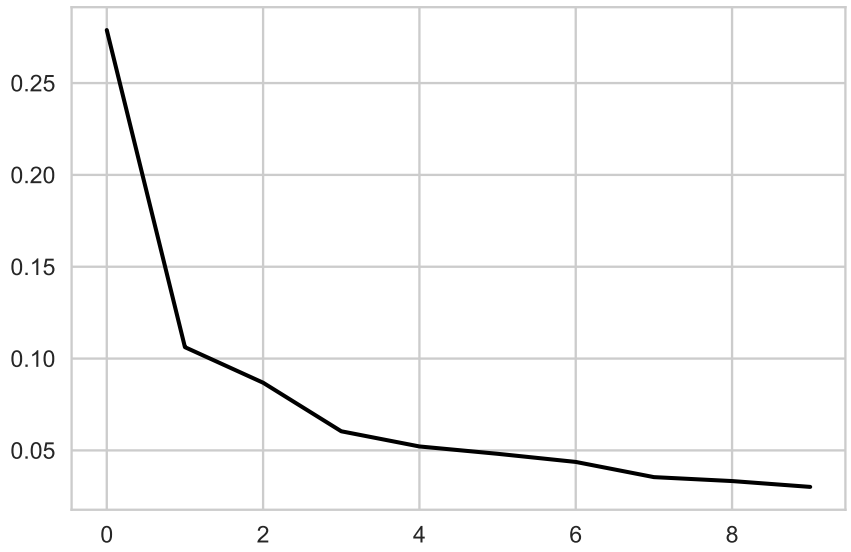
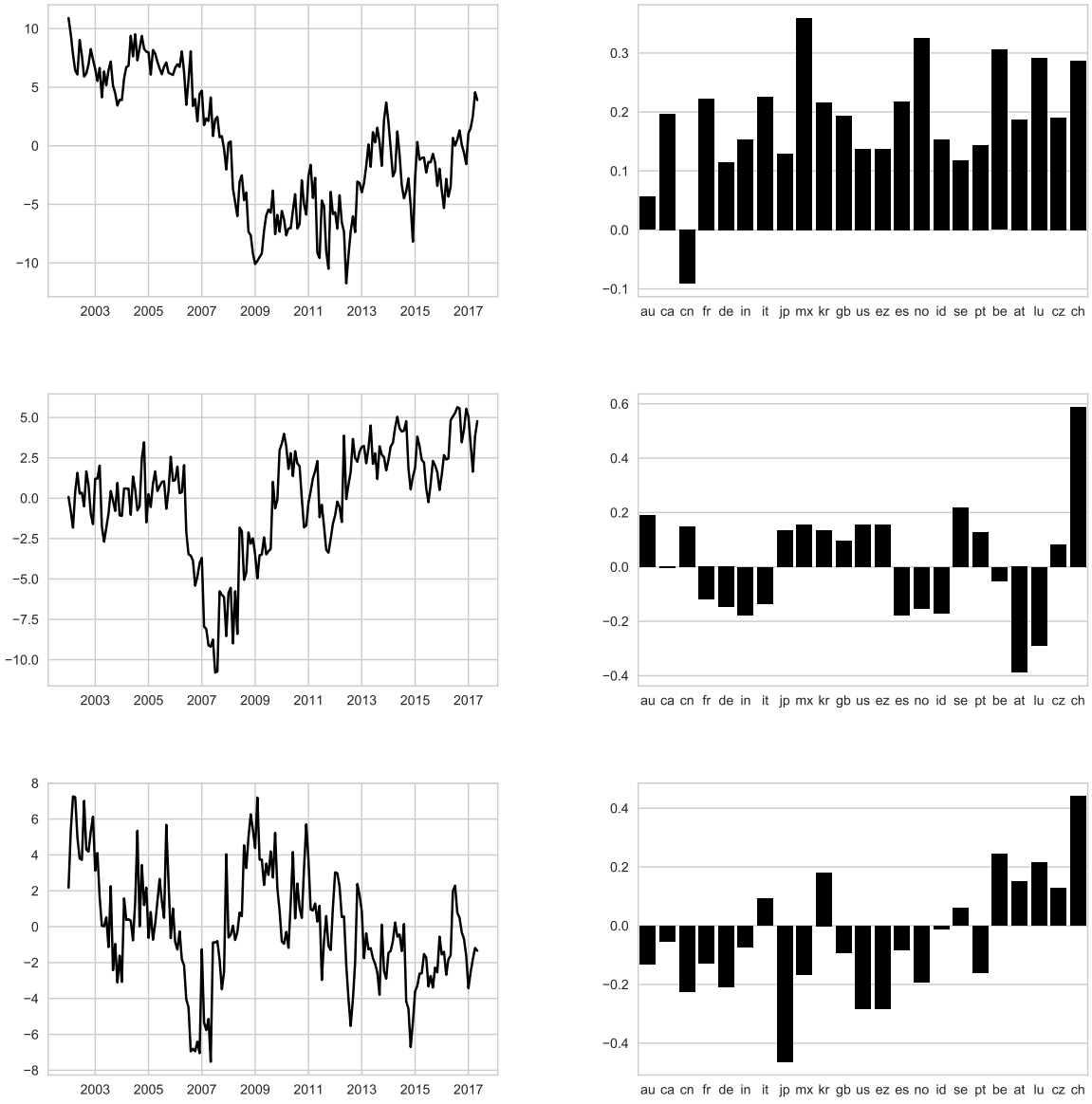
5 Appendix

Figure IX: Explained Variance Ratio for Principal Components



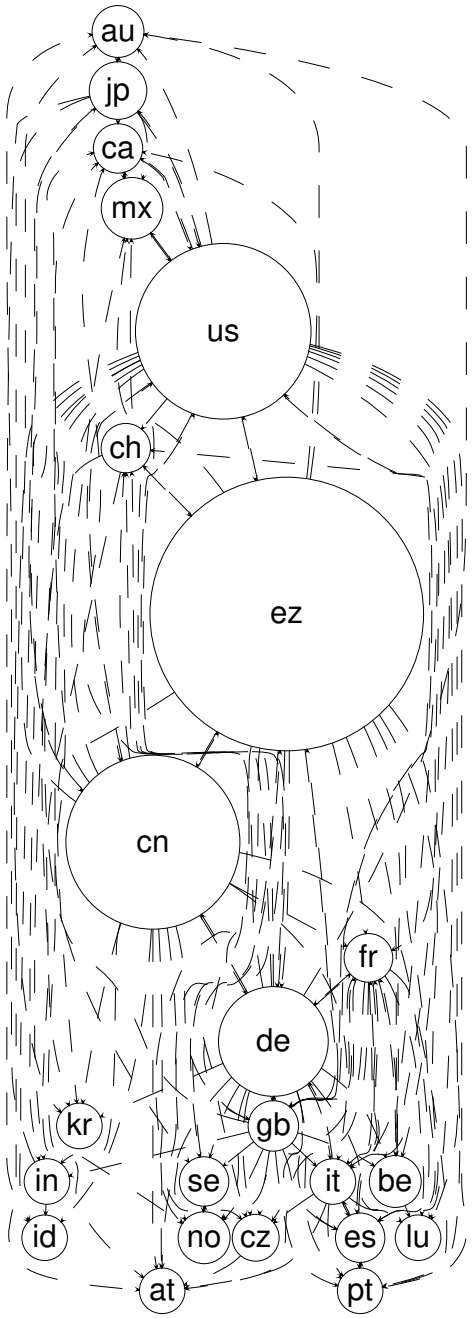
The plot above shows the share of variance explained for each principal component. Note that the first principal component explains over 25% of the variation in the data. We performed principal components on the net sentiment series for 23 countries over the 2002-2017 period.

Figure X: First, Second, and Third Principal Component and Correlations



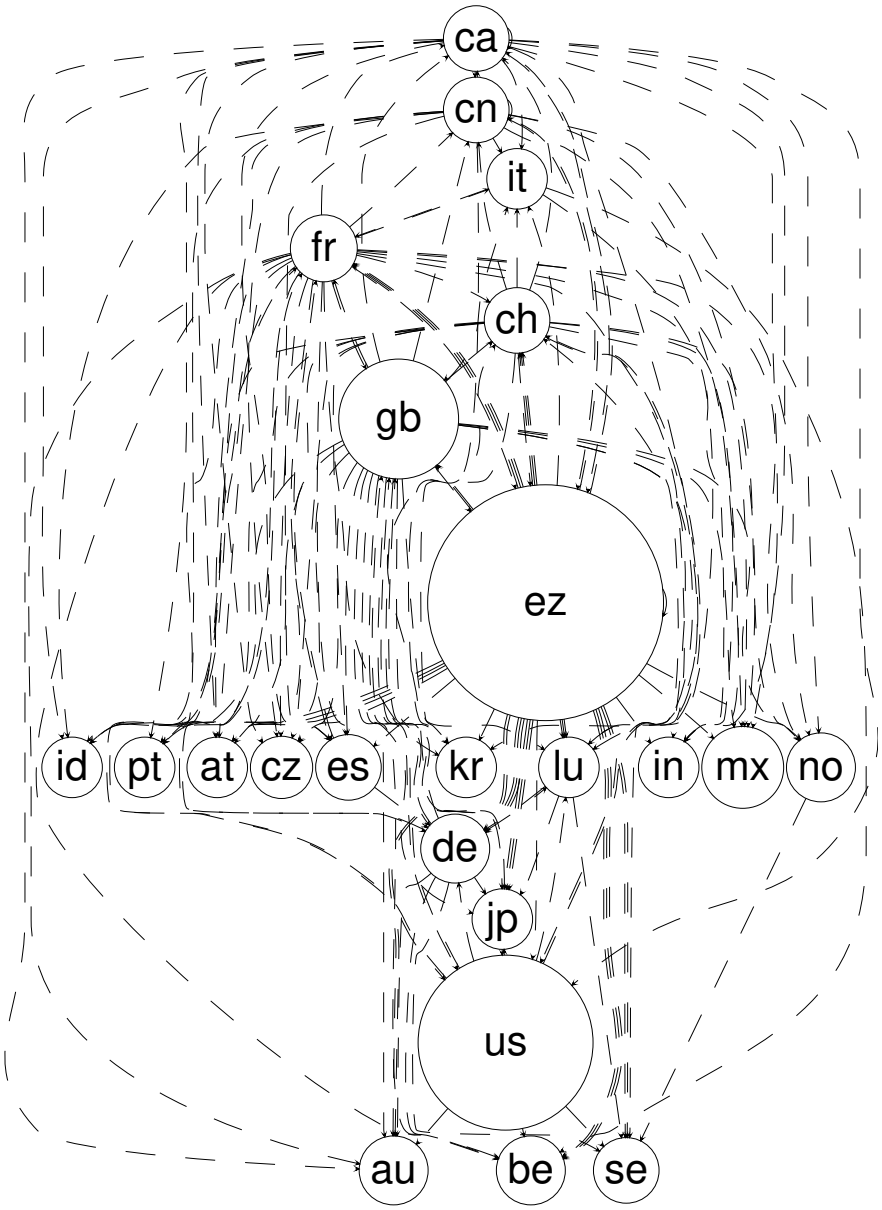
The top panel shows the time series of the first principal component (left) and correlations between the first principal component and country series (right). In the mid and bottom panels we do the same for the second and third principle component, respectively. All analysis is done for 23 countries over the 2002-2017 sample period.

Figure XI: Directed Network: Trade



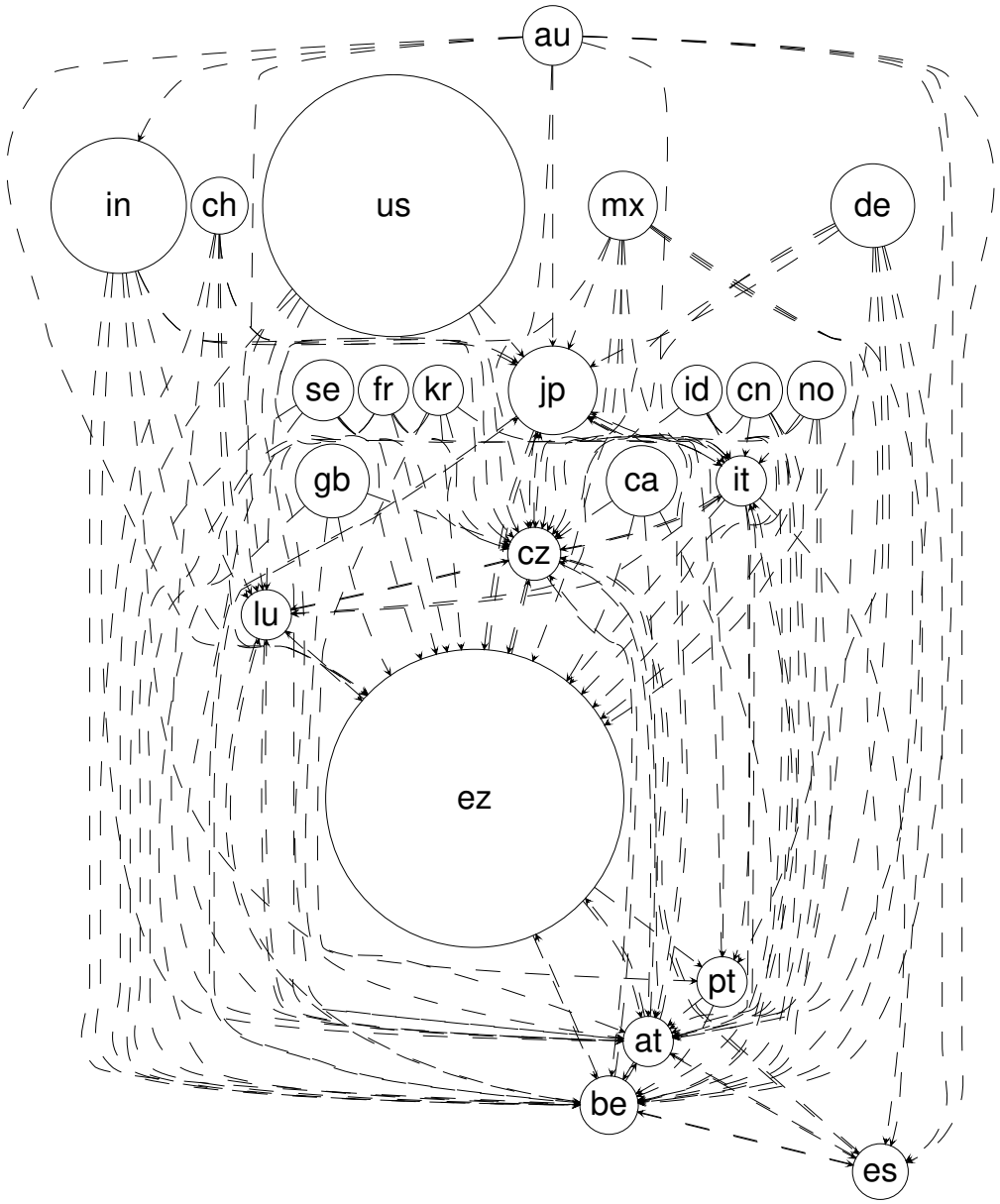
The network diagram above shows a directed network of trade flows. Edges indicate that at least one country is a top five import or export partner of the other. Arrows point to the country for which the trade relationship is important. An arrow pointing from Germany to Luxembourg indicates that Germany is a top five import or export partner of Luxembourg. Note that the size of each node is proportional to total trade.

Figure XII: Directed Network: Financial Flows



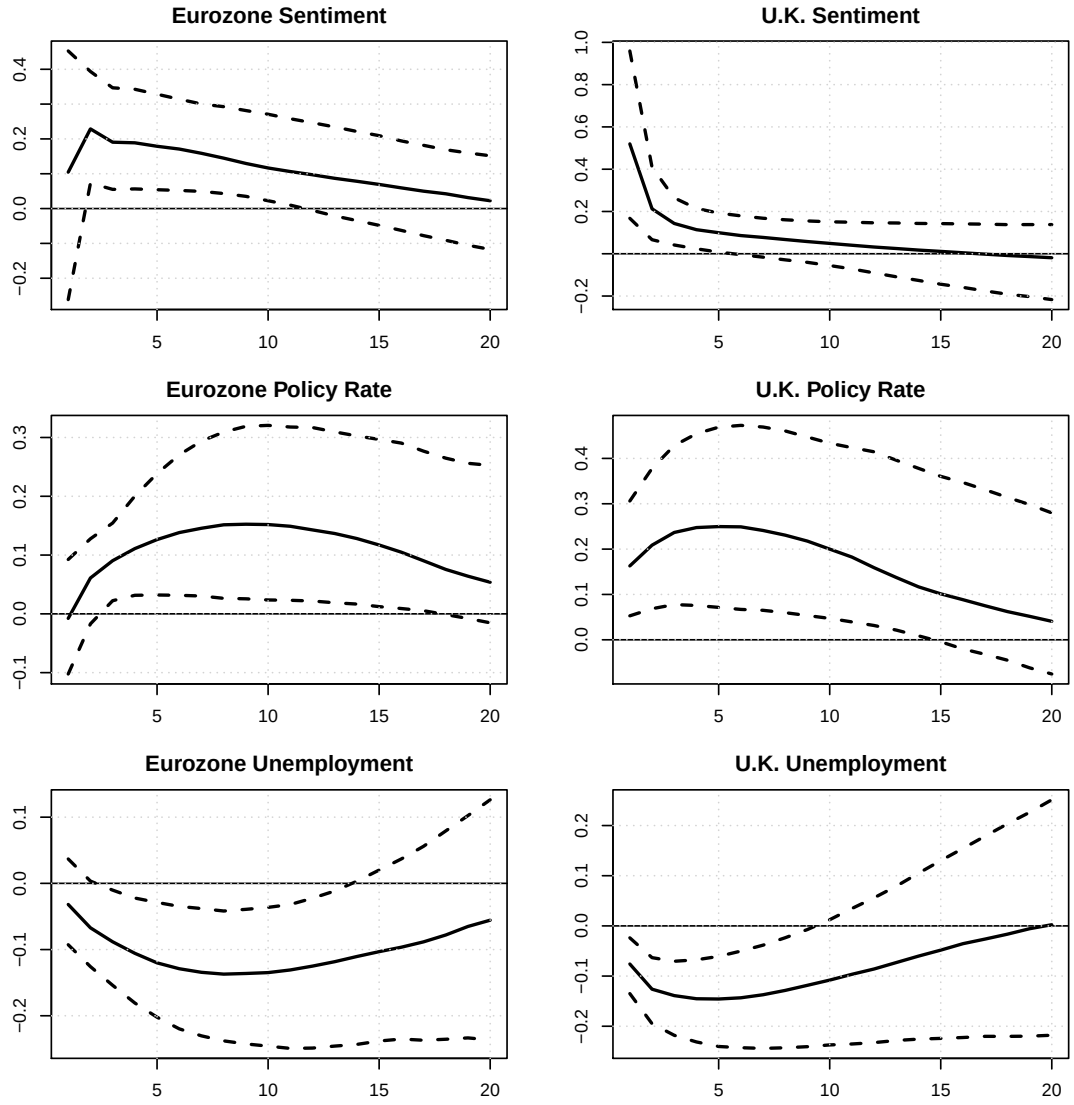
The network diagram above shows a directed network of private financial flows. Edges indicate that at least one country is a top source or destination of funds from the other. Arrows point to the country for which the flow is important. An arrow pointing from Switzerland to Italy indicates that Switzerland is either a top five provider of funds to Italy or a top five destination of funds for Italy. Note that size of each node is proportional to gross financial flows.

Figure XIII: Granger Causality Network: Central Bank Sentiment



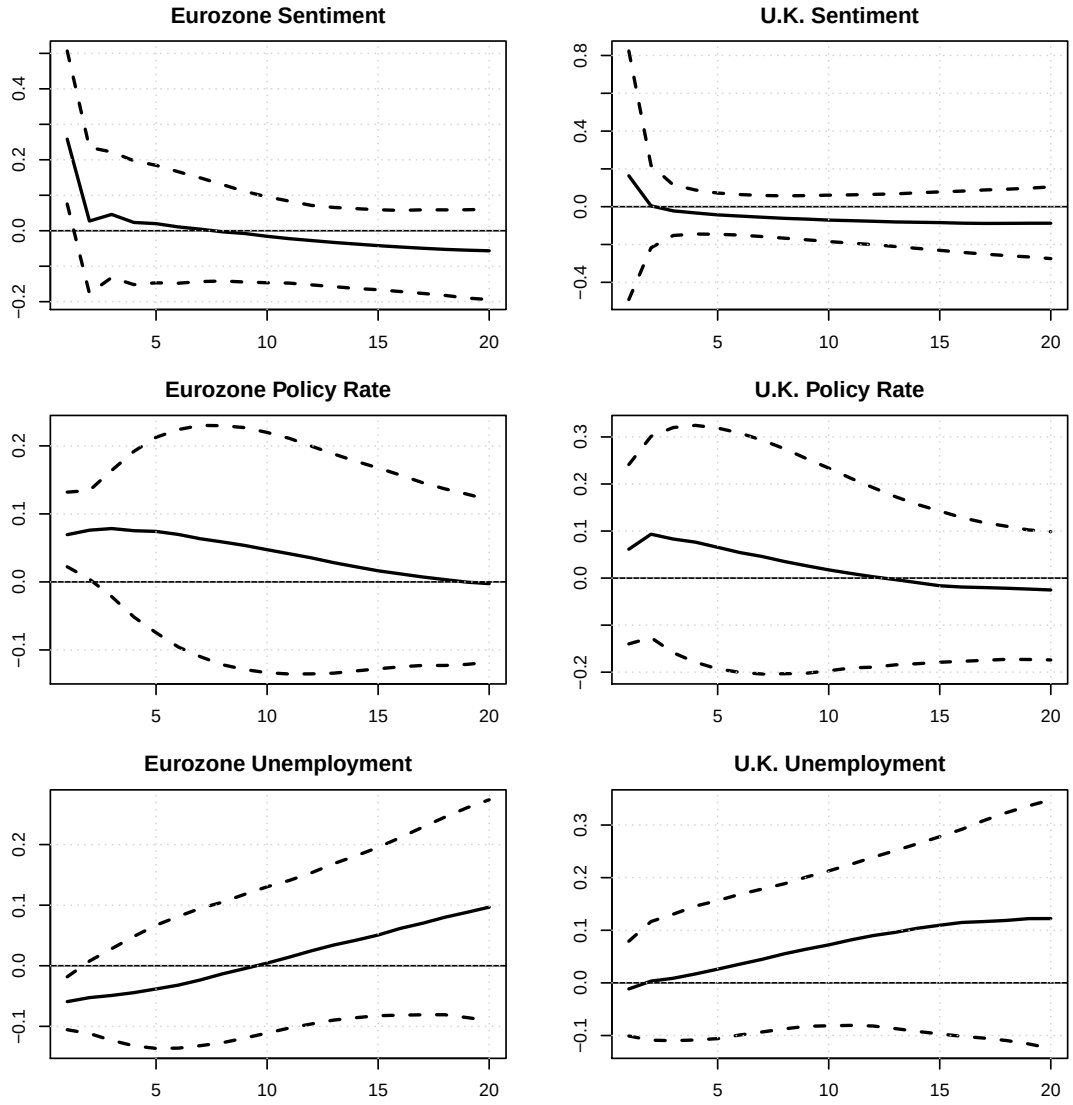
The network diagram above shows Granger causal connections in sentiment between each pair of countries in our dataset. Edges indicate the presence of at least one Granger causal connection between two nodes. Arrows indicate the direction of causality. Node size is proportional to the total number of speeches given by officials at the central bank over the 2002-2017 period.

Figure XIV: Impact of Positive Shock to BoE Speech Sentiment on U.K. and Eurozone



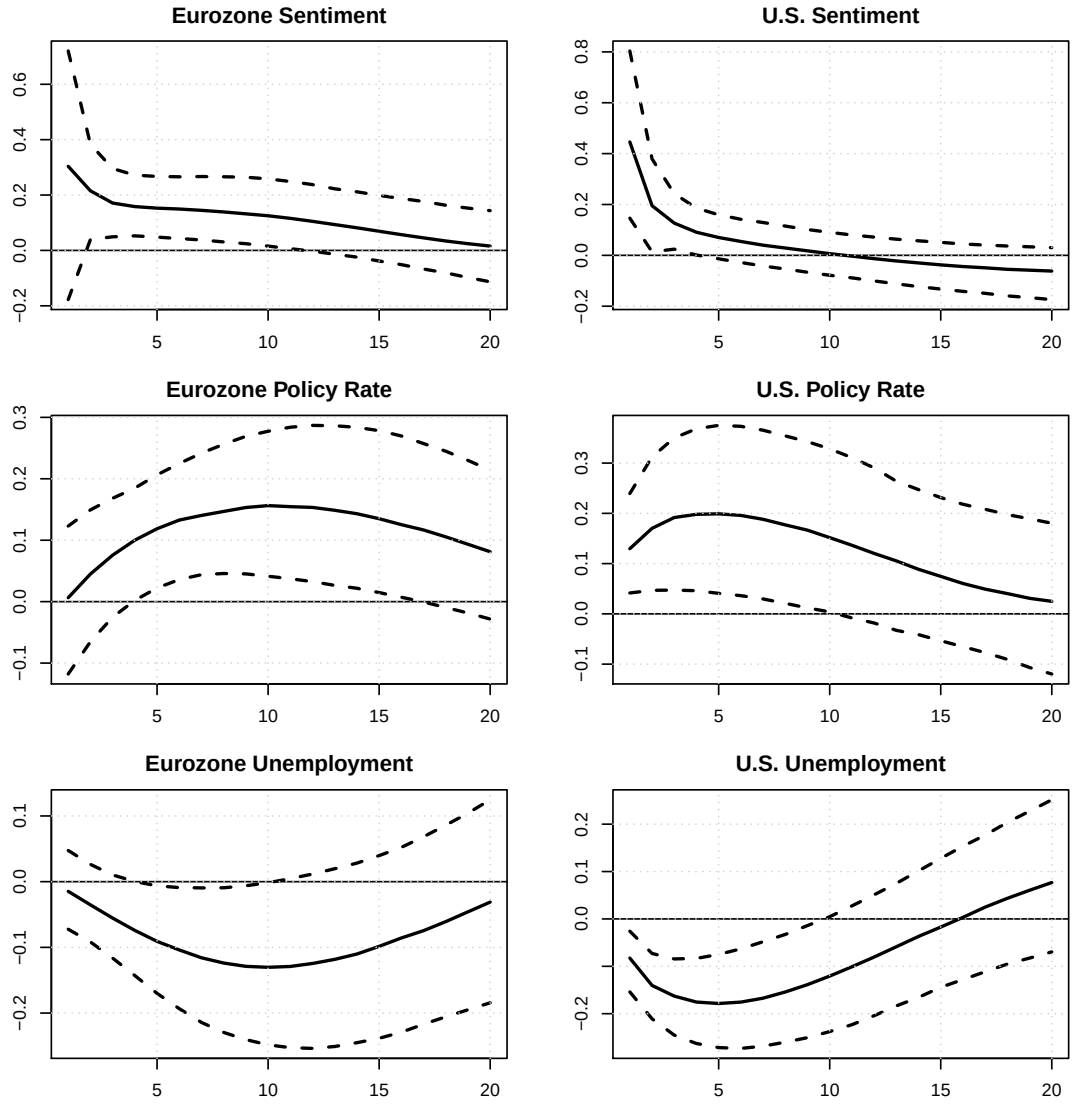
The plots above show IRFs from a positive structural shock to Bank of England speech sentiment. We computed the IRFs using the using the rejection method introduced by Rubio-Ramirez et al. (2010). For identification, we exclusively make assumptions about first period impacts on domestic variables.

Figure XV: Impact of Positive Shock to ECB Speech Sentiment on Eurozone and U.K.



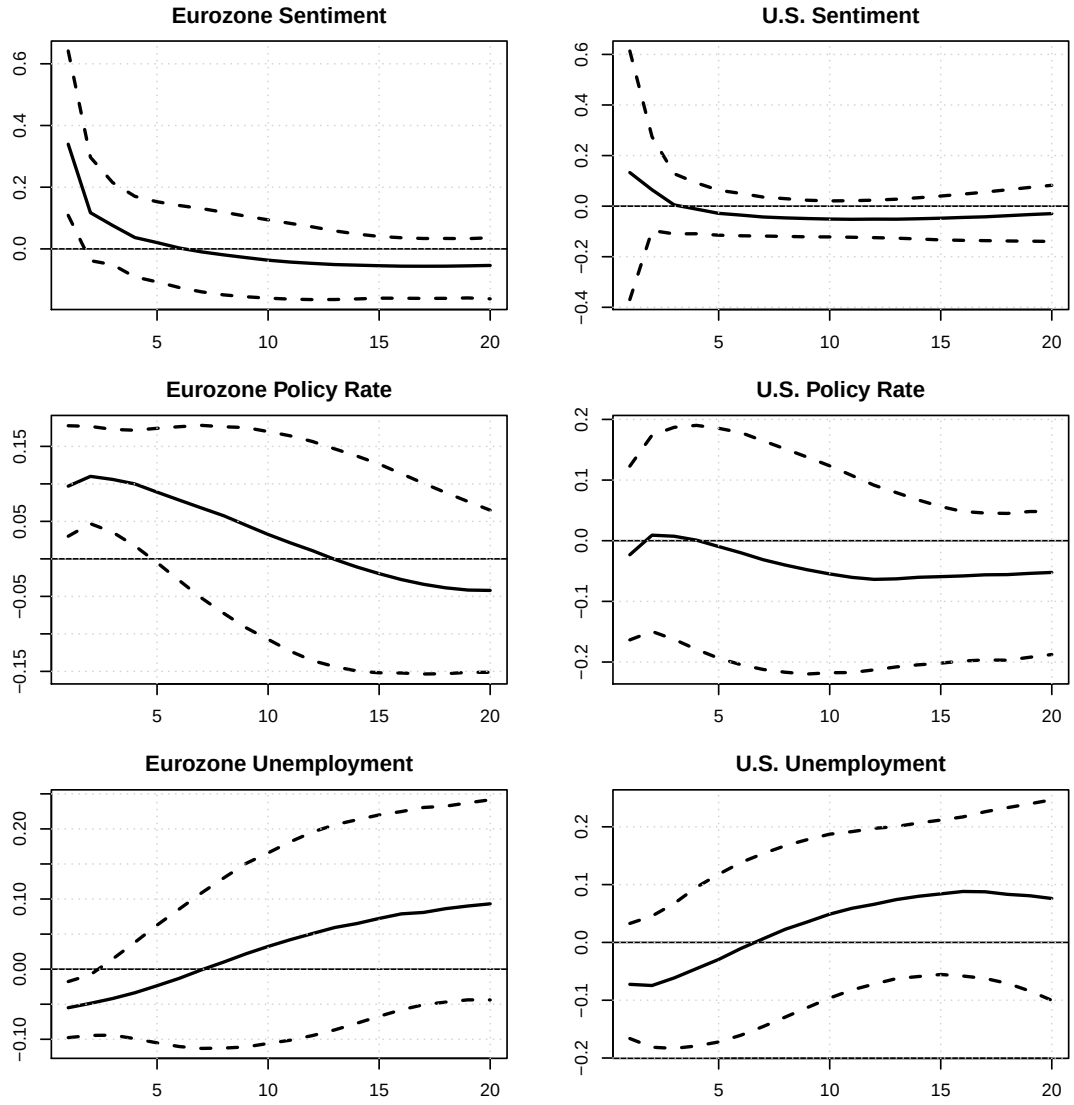
The plots above show IRFs from a positive structural shock to European Central Bank speech sentiment. We computed the IRFs using the using the rejection method introduced by Rubio-Ramirez et al. (2010). For identification, we exclusively make assumptions about first period impacts on domestic variables.

Figure XVI: Impact of Positive Shock to Fed Speech Sentiment on U.S. and Eurozone



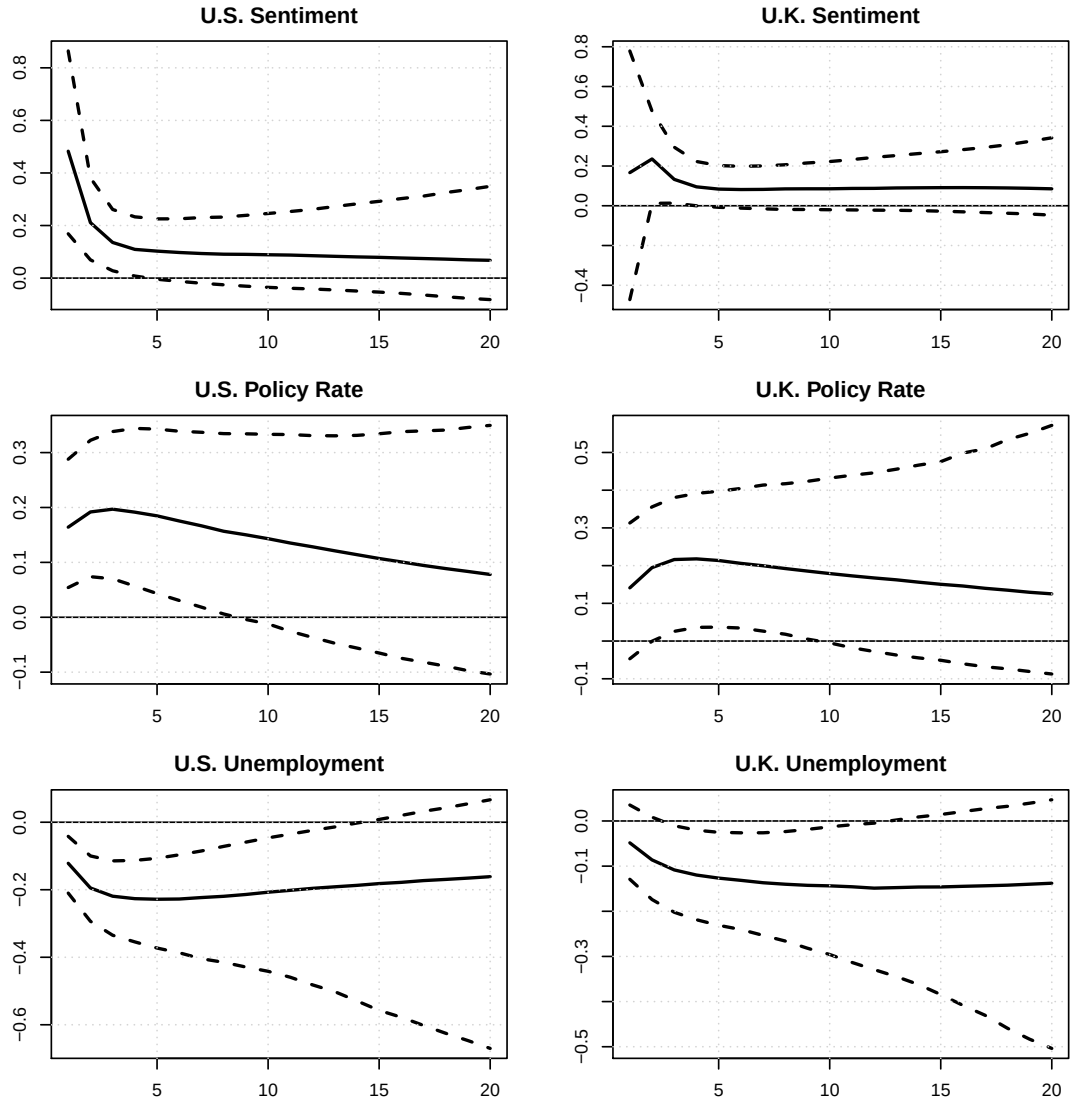
The plots above show IRFs from a positive structural shock to Federal Reserve speech sentiment. We computed the IRFs using the using the rejection method introduced by Rubio-Ramirez et al. (2010). For identification, we exclusively make assumptions about first period impacts on domestic variables.

Figure XVII: Impact of Positive Shock to ECB Speech Sentiment on Eurozone and U.S.



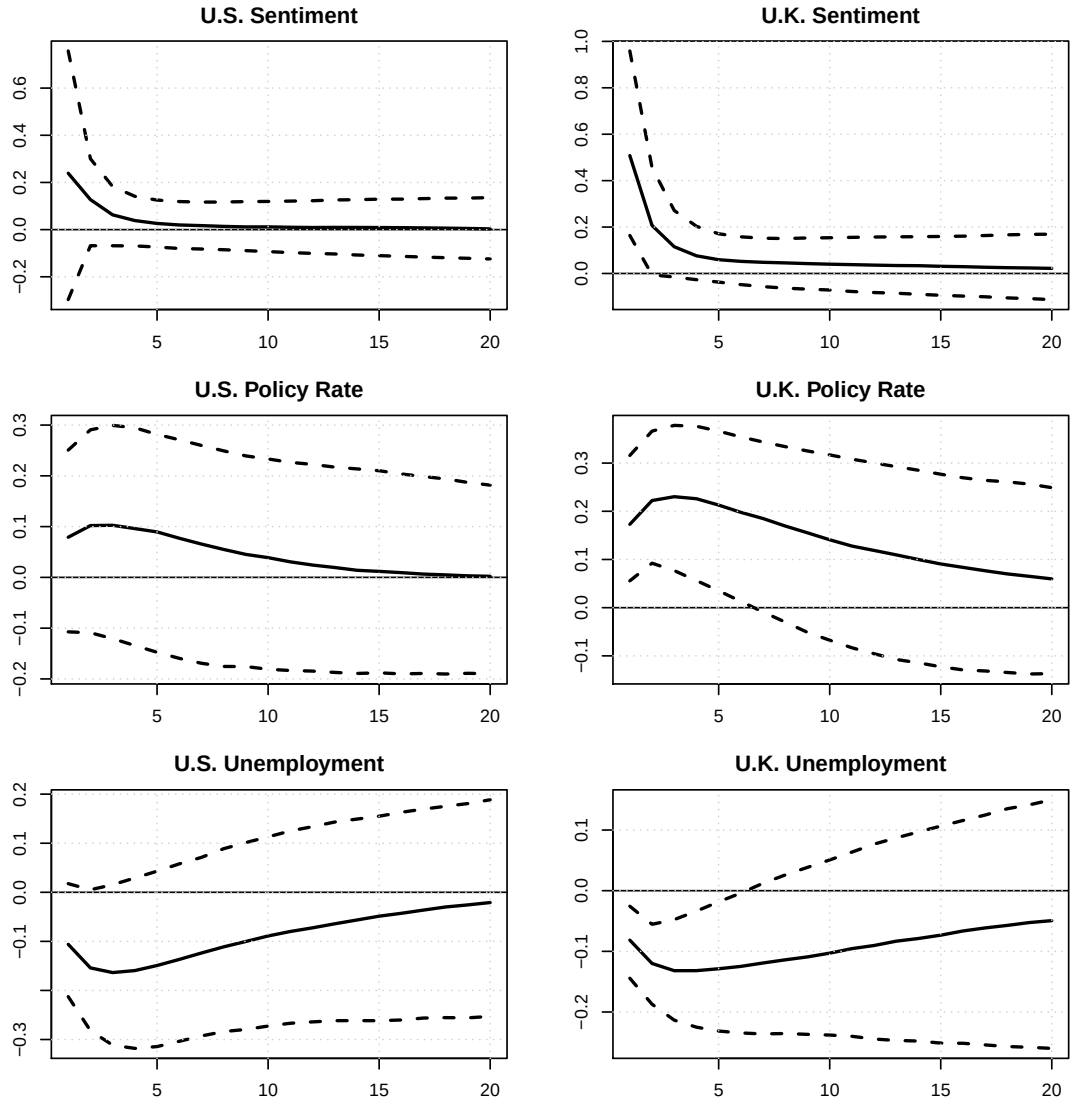
The plots above show IRFs from a positive structural shock to European Central Bank speech sentiment. We computed the IRFs using the using the rejection method introduced by Rubio-Ramirez et al. (2010). For identification, we exclusively make assumptions about first period impacts on domestic variables.

Figure XVIII: Impact of Positive Shock to Fed Speech Sentiment on U.S. and U.K.



The plots above show IRFs from a positive structural shock to Federal Reserve speech sentiment. We computed the IRFs using the using the rejection method introduced by Rubio-Ramirez et al. (2010). For identification, we exclusively make assumptions about first period impacts on domestic variables.

Figure XIX: Impact of Positive Shock to BoE Speech Sentiment on U.K. and U.S.



The plots above show IRFs from a positive structural shock to Bank of England speech sentiment. We computed the IRFs using the using the rejection method introduced by Rubio-Ramirez et al. (2010). For identification, we exclusively make assumptions about first period impacts on domestic variables.

Table IV: Impact of Distance, Shared Language, and Colonial-Ties on Central Bank Sentiment Correlation

	(1) (OLS)	(2) (OLS)	(3) (OLS)	(4) (OLS)	(5) (OLS)	(6) (OLS)	(7) (OLS)	(8) (OLS)	(9) (OLS)
Distance	-0.0115***	-0.0112***	-0.0104***	-0.0112***	-0.0157***	-0.0175***	-0.0175***	-0.0148***	-0.0183***
	(0.0026)	(0.0026)	(0.0029)	(0.0031)	(0.0030)	(0.0049)	(0.0002)	(0.0051)	(0.0052)
Shared Language		0.0730**	0.0639**	0.0645**	-0.0052	-0.0035	-0.0035	-0.0032	-0.0263
		(0.0332)	(0.0312)	(0.0301)	(0.0341)	(0.0352)	(0.0175)	(0.0345)	(0.0376)
Colonial Ties		0.0896*	0.1149***	0.1139***	0.0297	0.0258	0.0258	0.0119	0.0693
		(0.0537)	(0.0438)	(0.0436)	(0.0567)	(0.0607)	(0.0051)	(0.0614)	(0.0648)
Real GDP Correlation			0.1972***	0.1916***	-0.0930	-0.1057	-0.1057	-0.0091	-0.1460*
			(0.0625)	(0.0602)	(0.0848)	(0.0863)	(0.0273)	(0.0897)	(0.0875)
Trade Flows			-0.0818***	-0.0923***	-0.0066	-0.0043	-0.0043	-0.0015	-0.0184
			(0.0279)	(0.0300)	(0.0239)	(0.0249)	(0.0211)	(0.0248)	(0.0262)
Private Financial Flows			-0.0070	-0.0111	0.0009	0.0019	0.0019	0.0380	0.0015
			(0.0291)	(0.0295)	(0.0258)	(0.0259)	(0.0013)	(0.0239)	(0.0301)
Log(Speeches)				0.0200	-0.0011	-0.0040	-0.0040	-0.0252	-0.0462
				(0.0195)	(0.0205)	(0.0209)	(0.0354)	(0.0207)	(0.0366)
Country FE	NO	NO	NO	NO	YES	YES	YES	YES	YES
Shared Continent FE	NO	NO	NO	NO	NO	YES	YES	YES	YES
Standard Errors	RE	RE	RE	RE	RE	RE	CE	RE	RE
No China	NO	NO	NO	NO	NO	NO	NO	YES	NO
No U.S.	NO	NO	NO	NO	NO	NO	NO	NO	YES
Adj. R-squared	0.058	0.072	0.139	0.139	0.568	0.567	0.5667	0.373	0.600
N	231	231	231	231	231	231	231	210	210

Notes: The dependent variable is the bilateral correlation in quarterly central bank sentiment over the 2002-2017 period. "Distance" is the great circle distance in thousands of kilometers between the capital cities of each country pair. "Colonial Ties" is a dummy variable equal to 1 if either country in the pair was a colony of the other or gained independence from it. "Real GDP Correlation" is the correlation in real GDP growth per capita between the country pair. "Private Financial Flows" is an indicator for whether at least one country is a top 5 counterparty to the other country's private financial claims. We construct this variable using bilateral private financial flows from the BIS's Locational Banking Statistics. "Trade Flows" indicates whether at least one country is either a top 5 importer or export partner for the other. Finally, "Log(Speeches)" is the natural logarithm of the sum of the speech counts for the central banks in the pair. Standard errors are either heteroskedasticity robust (RE) or are clustered at the continent level (CE). *** indicates significance at 1%, ** indicates significance at 5%, and * indicates significance at 10%.

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