Four Facts about International Central Bank Communication[*]

Christoph Bertsch[a]   Isaiah Hull[b]

Robin L. Lumsdaine[c]   Xin Zhang[a]

[a]Sveriges Riksbank
[b]BI Norwegian Business School; CogniFrame
[c]Kogod School of Business, American University; Erasmus University Rotterdam;
National Bureau of Economic Research (NBER); Tinbergen Institute; Center for
Financial Stability

Conference on AI and Systemic Risk Analytics
June 7, 2024

Introduction

- CB communication plays a crucial role in monetary policy effectiveness and financial market stability.

- Advancements in NLP enable a deeper analysis of the content and sentiment of CB disclosures.

- This study introduces a novel database comprising text features extracted from over 20 years of CB speeches in the BIS archive across 53 institutions worldwide.

This talk

- **Methodology:** Use of cutting-edge NLP techniques to extract meaningful text features, uncovering patterns and insights into CB communication strategies.

- **Application:** Establish four facts about international central bank communication (INT CB COM).

Research Question

Q: What drives similarities and differences in international central bank communication?

- International factors?
  - ▶ Coordination with the base currency central banks.
- Institutional factors?
  - ▶ Exchange rate regimes.
- Domestic factors?
  - ▶ Political pressure; central bank transparency.

Contribution

Against the backdrop of limited existing research on INT CB COM, we make four contributions:

1. We employ state-of-the-art natural language processing (NLP) methods to accurately identify and analyze the textual content of a large panel of CB speeches.

2. We offer new insights into how exchange rate considerations shape CB COM.

3. We show that CB COM is used to provide guidance on future foreign exchange intervention.

4. We document that domestic factors, such as political pressure, can be important drivers of CB COM focus.

Data and Methodology

Description of the Data

- BIS archive: Speeches from 53 central banks (1996-2023).

Quarterly Sample	Albania, Australia, Canada, European Central Bank, France, Germany, India, Ireland, Italy, Japan, Malaysia, Norway, the Philippines, Singapore, South Africa, Spain, Sweden, Switzerland, Thailand, United Kingdom, United States
Annual Sample	Bahrain, Barbados, Chile, China, Czech Republic, Denmark, Fiji, Finland, Ghana, Greece, Hong Kong, Iceland, Indonesia, Israel, Kenya, Macedonia, Malta, Mauritius, Mexico, Netherlands, New Zealand, Pakistan, Papua New Guinea, Portugal, Romania, Serbia, South Korea, Sri Lanka, Trinidad and Tobago, Turkey, Uganda, Zambia

- NLP techniques used for text feature extraction.
  - ▶ Text features are constructed using a collection of LLMs fine-tuned on central bank communication (Bertsch, Hull, Lumsdaine and Zhang, 2022).

  - ▶ We perform two downstream tasks:
    - Measurement of semantic textual similarity (STS).
    - Zero shot classification (ZSC).

- Macro and financial market data from various papers.

Additional Datasets

- Macro variables from the FRED database and the IMF's IFS database.
- The FX intervention dataset from Adler, Chang, Mano and Shao (2021,2023): 122 central banks (2000Q1–2022Q4).
- The Ilzetzki, Reinhart and Rogoff (2019, 2021) dataset with classified exchange rate regimes for 194 central banks (1946–2019).
- The central bank transparency database from Dincer, Eichengreen and Geraats (2022) for 112 central banks (1998–2019).
- The central bank political pressure database from Binder (2021): 118 central central banks (2010Q1–2019Q1).

Text Feature Extraction: LLMs and Methods

1 **Transformer model.**
- ▶ Maps sequence of embeddings to sequence of contextualized embeddings.

2 **Large Language models (LLMs)**.
- ▶ Foundation models and transfer learning.
- ▶ Pretrained on large corpus using general language task.
- ▶ Fine-tuned on S2ORC corpus (Lo et al. 2020).

3 **Feature extraction methods.**
- ▶ STS and ZSC.

Methodology - Details

Zero shot classification

- ZSC allows us to classify a passage of text without specifically training the model on the labels used.
- Outputs a probability score for a speech passage belonging to a pre-defined candidate topic.
- E.g., we can classify whether a passage discusses inflation.

Semantic textual similarity

- STS allows us to measure the closeness of two statements with respect to their semantic content.
- Outputs a cosine similarity score between speech embeddings and concept descriptions.
- E.g., we can check the extent to which paragraphs from two different speeches are related.

Zero Shot Classification

Sequence: "Banks continue to play this role but it has become more challenging today to do so because some lenders find themselves capital constrained as a result of recent losses and or sizable unanticipated additions to their balance sheets of formerly off balance sheet instruments."

Candidate Classes: ['financial stability', 'output', 'inflation', 'labor market']

Scores: [0.718, 0.203, 0.048, 0.031]

Semantic Textual Similarity

- **Use contextualized sentence embeddings and semantic textual similarity.**
  - ▶ Kiros et al. (2015), Conneau et al. (2017), Cer et al. (2018), Reimers and Gurevych (2019).
  - ▶ Train using Siamese and triplet networks (Schroff et al., 2015).

- **Compare sequences from speeches with descriptions of policy objectives or preferences.**
  - ▶ *"Monetary policy should be used to achieve financial stability."*
  - ▶ *"Banking regulation should be used to achieve financial stability."*

Text Features Dataset

Table: Text Features and Methods

Text feature	Method
`financial_crisis`	STS
`united_states_dollar`	STS
`bank_concern`	STS
`international_trade`	STS
`hawkish_sentiment`	STS
`output_employment`	ZSC
`financial_stability`	ZSC
`inflation`	ZSC
`exchange_rate`	ZSC

*** Example: Central Bank Speech Text Features ***

*** Validation ***

Application

Four Facts: A Summary

Fact 1. The characteristics of INT CB COM are strongly influenced by exchange rate regimes.
  - ▶ Systematic difference COM focus of CBs with pegged exchange rates in response to changes in the REER.

Fact 2. Spillovers from the Fed's COM sentiment to other CBs; the Fed's exchange rate COM plays an important coordinating role for CBs with dollar pegs.

Fact 3. CB COM provides guidance on future FX interventions,
  - ▶ Confirms relevance of the textual information we extract.

Fact 4. Domestic factors, such as political pressures, can be important drivers of CB COM focus. Transparency mitigates the effect of political pressure.

In previous work Armelius et al. (2020) document:

- Co-movement in sentiment across jurisdictions is not reducible to trade or financial flow exposures.
- International spillovers in COM sentiment, as well as from sentiment to policy rates and to unemployment
- Spillover effects from the Fed are particularly large and persistent.

→ Sentiment network and more.

In previous work Armelius et al. (2020) document:

- Co-movement in sentiment across jurisdictions is not reducible to trade or financial flow exposures.
- International spillovers in COM sentiment, as well as from sentiment to policy rates and to unemployment
- Spillover effects from the Fed are particularly large and persistent.

→ Sentiment network and more.

In Fact 1, we take a first step **beyond sentiment** and analyze the **commonalities in the discussion** of policy issues.

In previous work Armelius et al. (2020) document:

- Co-movement in sentiment across jurisdictions is not reducible to trade or financial flow exposures.
- International spillovers in COM sentiment, as well as from sentiment to policy rates and to unemployment
- Spillover effects from the Fed are particularly large and persistent.

→ Sentiment network and more.

In Fact 1, we take a first step **beyond sentiment** and analyze the **commonalities in the discussion** of policy issues.

Q: How similar is CB COM across jurisdictions? Are there identifiable COM clusters along important dimensions?
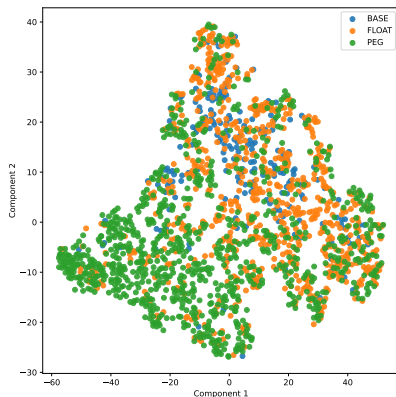
Notes: The figure visualizes the output of the t-stochastic nearest neighbors (t-SNE) algorithm applied to the exchange rate, U.S. dollar and international trade text features for all 21 central banks between 1996 and 2023. We construct three categories for the visualization: "base" currencies in blue (U.S. dollar/Federal Reserve System, Euro/European Central Bank), floating currencies in orange, and pegged currencies in green, which includes the national central banks of the euro area.

Q: Where do the systematic differences in the CB COM lie?

We run the following regression using quarterly data:

$$
\begin{aligned}
\tau_{i,t} \quad = \quad & \alpha + \beta_0 PEG_{i,t-1} + \beta_1 \Delta REER_{i,t-1} \qquad (1) \\
& + \beta_2 PEG_{i,t-1} \times \Delta REER_{i,t-1} + \beta_3 REER_{i,t-1} \\
& + \beta_4 X_{i,t-1} + \gamma_i + \delta_t + \epsilon_{i,t},
\end{aligned}
$$

where $\tau_{i,t}$ is the text feature of interest for central bank i at time t, i.e. discussion about the *exchange rate*, *inflation*, *trade*, the *U.S. dollar*, *financial crises*, and *financial stability*.

Table: **CB COM Heterogeneity: Peggers vs. Floaters**

	(1) exchange rate	(2) inflation	(3) int. trade	(4) USD	(5) financial crisis	(6) financial stability
$PEG_{i,t-1}$	0.145	0.084	-0.017	0.015	0.155	-0.328
	(0.177)	(0.202)	(0.187)	(0.193)	(0.196)	(0.246)
$\Delta REER_{i,t-1}$	-0.009	0.021*	-0.001	0.005	-0.003	-0.015*
	(0.008)	(0.012)	(0.008)	(0.012)	(0.009)	(0.008)
$PEG_{i,t-1} \times \Delta REER_{i,t-1}$	-0.007	-0.000	-0.010	-0.023*	-0.013	0.024**
	(0.013)	(0.016)	(0.014)	(0.012)	(0.019)	(0.010)
$REER_{i,t-1}$	0.006	-0.009*	0.000	-0.007	-0.001	0.007
	(0.007)	(0.004)	(0.004)	(0.006)	(0.008)	(0.005)
Controls	YES	YES	YES	YES	YES	YES
CB FE	YES	YES	YES	YES	YES	YES
Year-quarter FE	YES	YES	YES	YES	YES	YES
Std. Err.	CB	CB	CB	CB	CB	CB
No of obs	1511	1511	1511	1511	1511	1511
Adj. R^2	0.180	0.204	0.124	0.198	0.249	0.162

Notes: The table reports the coefficient estimates of the regression (1). The control variables include the economic controls (interest rates, inflation rates, and real GDP growth rates), as well as central bank and year-quarter fixed effects. * $p < .1$, ** $p < .05$, *** $p < .01$.

Fact 2: Spillovers from the Federal Reserve

Q: Does the Fed have a coordinating role when it comes to discussing exchange rate issues?

We run a similar regression to before, but include the Federal Reserve text features as explanatory variables:

$$\tau_{i,t} = \alpha + \beta_0 \tau_{us,t} + \beta_1 \Delta REER_{i,t-1} + \beta_2 REER_{i,t-1} \quad (2)$$
$$+ \beta_3 X_{i,t-1} + \gamma_i + \delta_t + \epsilon_{i,t},$$

where β_0 captures the coordination (or correlation) of communication text features between the central bank in country i (which excludes the U.S.) and the Fed.

Table: CB COM Spillovers from the Federal Reserve.

	(1) exchange rate	(2) USD	(3) hawkish sentiment	(4) exchange rate	(5) USD	(6) hawkish sentiment
exchange rate$_{us,t}$	0.009 (0.043)			0.067* (0.026)		
USD$_{us,t}$		-0.007 (0.027)			0.144 (0.070)	
hawkish sentiment$_{us,t}$			0.087*** (0.023)			0.142 (0.094)
$\Delta REER_{i,t-1}$	-0.008 (0.007)	-0.003 (0.008)	0.006 (0.013)	-0.030 (0.013)	-0.008 (0.022)	0.035* (0.012)
$REER_{i,t-1}$	0.011 (0.010)	-0.011 (0.008)	-0.011* (0.006)	-0.000 (0.009)	-0.027* (0.010)	-0.037** (0.011)
Controls	YES	YES	YES	YES	YES	YES
USD Pegging	NO	NO	NO	YES	YES	YES
CB FE	YES	YES	YES	YES	YES	YES
Year-quarter FE	YES	YES	YES	YES	YES	YES
Std. Err.	CB	CB	CB	CB	CB	CB
No of obs	1128	1128	1128	184	184	184
Adj. R^2	0.150	0.233	0.117	0.229	0.324	0.230

Notes: The table reports the coefficient estimates from regression (2). The control variables, comprising the lagged text features and the economic controls (interest rates, inflation rates, and real GDP growth rates), are always included.

- Columns (1)-(3): subsample of non-USD pegged CBs.
- Columns (4)-(6): subsample of USD pegged CBs.

Q: Can CB COM predict subsequent FX interventions? Are differences between CBs operating under pegged and floating exchange rate regimes in their use of FX (forward) guidance?

Fact 3: FX (Forward) Guidance

Q: Can CB COM predict subsequent FX interventions? Are differences between CBs operating under pegged and floating exchange rate regimes in their use of FX (forward) guidance?

Literature shows that CB COM is an effective tool to:

- Signal future MP changes (Hansen and MacMahon, 2016)
- Provide information about economic conditions (Cieslak and Schrimpf, 2019; Hansen, McMahon and Tong, 2019)
- Stabilize (Jansen and De Haan, 2005; Fratzscher, 2006) or influence (Fratzscher, 2008; Mirkov et al., 2019; Fratzscher et al., 2019) exchange rates.

Fact 3: FX (Forward) Guidance

Q: Can CB COM predict subsequent FX interventions? Are differences between CBs operating under pegged and floating exchange rate regimes in their use of FX (forward) guidance?

Literature shows that CB COM is an effective tool to:

- Signal future MP changes (Hansen and MacMahon, 2016)
- Provide information about economic conditions (Cieslak and Schrimpf, 2019; Hansen, McMahon and Tong, 2019)
- Stabilize (Jansen and De Haan, 2005; Fratzscher, 2006) or influence (Fratzscher, 2008; Mirkov et al., 2019; Fratzscher et al., 2019) exchange rates.

Literature on FX interventions (FXI):

- BIS survey: frequent use; common goals: maintain price stability and curb speculation (Patel and Cavallino, 2019).
- FX forward guidance is optimal (Fanelli and Straub, 2021).

To measure whether CB speeches contain information about future FXI and thus provide guidance to market participants, we run a predictive regression of the form:

$$
\begin{aligned}
FXI_{i,t} &= \alpha + \beta_0 \tau_{i,t-1} + \beta_1 \Delta REER_{i,t-1} + \beta_2 REER_{i,t-1} \\
&\quad + \beta_3 X_{i,t-1} + \gamma_i + \delta_t + \epsilon_{i,t},
\end{aligned} \tag{3}
$$

using quarterly data. The dependent variable $FXI_{i,t}$ is the FXI measure for CB i at time t from Adler et al. (2021,2023).

Table: CB COM about Exchange Rates and FX Interventions

	(1)	(2)	(3)	(4)	(5)
	$FXI_{i,t}$	$FXI_{i,t}$	$FXI_{i,t}$	$FXI_{i,t}$	$FXI_{i,t}$
exchange rate$_{i,t-1}$	0.152*	0.120*	0.129	0.073	-0.033
	(0.077)	(0.065)	(0.079)	(0.056)	(0.056)
inflation$_{i,t-1}$	-0.035	0.008	0.025	-0.019	-0.177
	(0.033)	(0.019)	(0.027)	(0.040)	(0.141)
int. trade$_{i,t-1}$	-0.143	-0.120	-0.114	-0.133*	-0.269
	(0.106)	(0.094)	(0.091)	(0.064)	(0.238)
USD$_{i,t-1}$	-0.055	-0.101	-0.095	0.065*	-0.359*
	(0.045)	(0.077)	(0.073)	(0.035)	(0.140)
$\Delta REER_{i,t-1}$	0.007	0.001	-0.005	-0.007	0.169*
	(0.009)	(0.009)	(0.012)	(0.014)	(0.068)
$REER_{i,t-1}$	0.012*	0.003	0.003	0.015*	-0.043*
	(0.007)	(0.006)	(0.006)	(0.008)	(0.016)
Currency peg	ALL	ALL	ALL	NON-USD	USD
Controls	YES	YES	YES	YES	YES
CB FE	NO	YES	YES	YES	YES
Year FE	NO	YES	NO	NO	NO
Quarter FE	NO	YES	NO	NO	NO
Year-quarter FE	NO	NO	YES	YES	YES
Std. Err.	CB	CB	CB	CB	CB
No of obs	1295	1295	1295	964	231
Adj. R^2	0.024	0.056	0.047	0.068	0.106

Notes: The table reports the coefficient estimates from regression (3). The control variables, comprising the lagged text features and the economic controls (interest rates, inflation rates, and real GDP growth rates), are always included. We run the regression on the full sample in the first three columns and then on two subsamples, the non-USD peggers and the USD peggers. * $p < .1$, ** $p < .05$, *** $p < .01$.

Fact 4: Transparency and Political Pressure

Q: How do transparency and political pressure affect CB discussions about the exchange rate and the U.S. dollar, as well as their policy stance?

There is an extensive literature on central bank independence, transparency and credibility. We use:

- The transparency measure by Dincer et al. (2022), which captures five broad aspects of CB transparency: political, economic, procedural, policy and operational.
- The political pressure index by Binder (2021), who constructs a novel measure based on narrative information in country reports from the Economist Intelligence Unit (EIU) and Business Monitor International (BMI).

We run the following regression using quarterly data:

$$
\begin{aligned}
\tau_{i,t} = {} & \alpha + \beta_0 Transparency_{i,t} + \beta_1 Pressure_{i,t} \quad\quad (4)\\
& + \beta_3 Transparency_{i,t} \times Pressure_{i,t} + \beta_4 \Delta REER_{i,t-1}\\
& + \beta_5 REER_{i,t-1} + \beta_6 X_{i,t-1} + \gamma_i + \delta_t + \epsilon_{i,t},
\end{aligned}
$$

where the political pressure index has three possible values: no-pressure, resist-pressure, and succumb-pressure.

Table: **CB COM: Transparency and Political Pressure**

	(1) exchange rate	(2) exchange rate	(3) exchange rate	(4) USD	(5) USD	(6) hawkish sentiment	(7) hawkish sentiment
$Transparency_{i,t}$	-0.158** (0.064)		-0.023 (0.064)		-0.199** (0.077)		0.081 (0.080)
$Resist_{i,t}$		-0.359** (0.148)	-0.543 (1.076)	-0.081 (0.159)	1.591 (1.081)	0.346* (0.193)	2.377** (1.171)
$Succumb_{i,t}$		-0.080 (0.183)	-3.127 (2.851)	-0.171 (0.146)	-1.706 (1.846)	0.017 (0.193)	0.159 (1.994)
$Resist_{i,t} \times Transparency_{i,t}$			0.017 (0.096)		-0.162 (0.103)		-0.187* (0.107)
$Succumb_{i,t} \times Transparency_{i,t}$			0.274 (0.256)		0.138 (0.162)		-0.013 (0.168)
$\Delta REER_{i,t-1}$	-0.014 (0.008)	-0.016 (0.018)	-0.017 (0.018)	-0.015 (0.011)	-0.011 (0.011)	0.013 (0.014)	0.012 (0.014)
$REER_{i,t-1}$	0.007 (0.007)	0.015*** (0.005)	0.016*** (0.005)	0.005 (0.004)	0.006 (0.004)	-0.010** (0.005)	-0.009* (0.005)
Controls	YES	YES	YES	YES	YES	YES	YES
CB FE	YES	YES	YES	YES	YES	YES	YES
Year-quarter FE	YES	YES	YES	YES	YES	YES	YES
Std. Err.	CB	Robust	Robust	Robust	Robust	Robust	Robust
No of obs	1278	555	555	555	555	555	555
Adj. R^2	0.134	0.348	0.344	0.377	0.385	0.309	0.308

Notes: The table reports the coefficient estimates from regression (4) with clustered standard errors at the CB level in column (1) and with robust standard errors in (2)-(7), where the measures for political pressure reduce the sample size.

Conclusion

- What drives similarities and differences in international central bank communication?
  - ▶ International factors: coordination with the base currency country central banks (Fact 2).
  - ▶ Institutional factors: exchange rate regimes (Facts 1); FX intervention guidance (Fact 3).
  - ▶ Domestic factors: political pressures, central bank transparency (Fact 4).

- Future projects: LLM-generated credibility measure of central banks, to disentangle the political economy dimension of central bank communication, and to understand the LLM features with the sentiment (direction).

Contact us if you are interested in the dataset
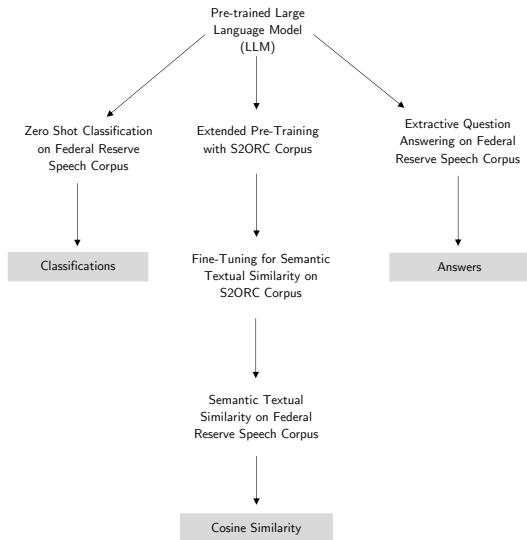
Zero Shot Classification: Attention Mechanism Example
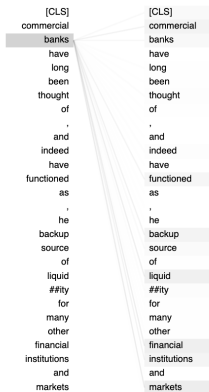
Extended Pretraining with TSDAE

text without noise

decoder

pooling

encoder

text with noise
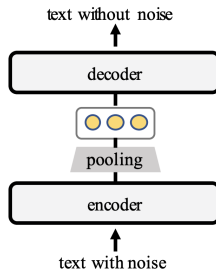
Figure 1: Architecture of TSDAE.

Figure taken from Wang et al. (2021).
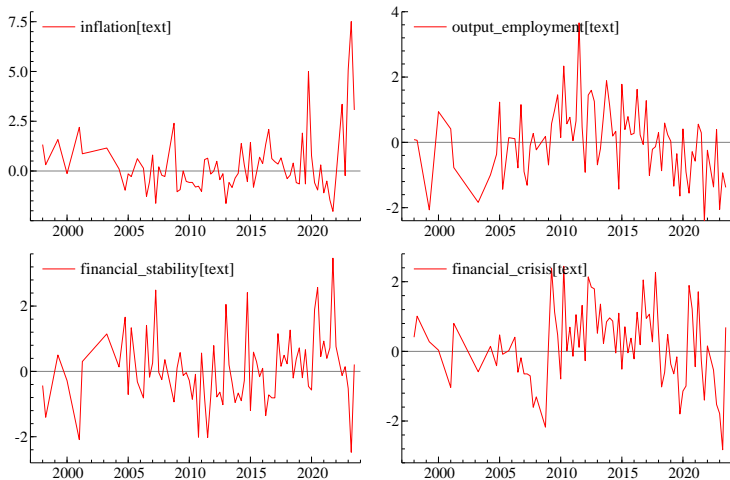
Notes: The figure visualizes the text features: inflation, output and employment, financial stability, and financial crisis text features.

Back
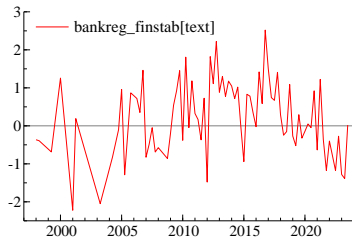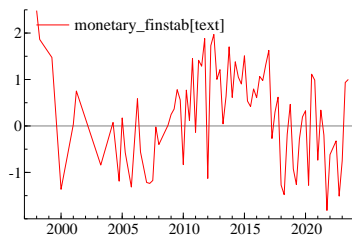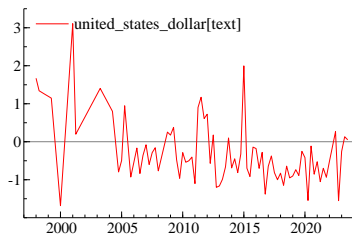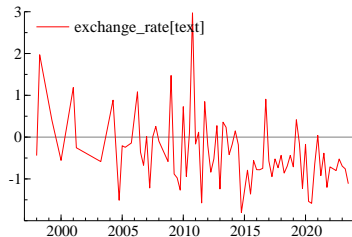
Notes: The figure visualizes the text features: the exchange rate, U.S. dollar, "use monetary policy to achieve financial stability goals", and "use bank regulation to achieve financial stability goals" text features.

Table: Text Feature Examples: U.S Dollar

Date	Institution	Passage
2004-03-02	US Federal Reserve System	Other East Asian monetary authorities, in an endeavor to hold their currencies at a par with the yen and the renminbi, accumulated about $120 billion in reserves in 2003 and appear to have continued that rate of intervention since.
2001-11-30	US Federal Reserve System	This point brings us to the question: How does a currency become an international currency? The question is particularly intriguing because, in the reign of fiat currencies, its answer is unlike the explanation of how a currency becomes dominant within a country.
2011-06-07	US Federal Reserve System	In fact, we recognize that the United States, as the issuer of the global reserve currency, has singular responsibilities within the global system. The central role of the dollar and dollar assets rests on several pillars: ...
2005-03-02	US Federal Reserve System	... to keep their own currencies strong, they would run out of the foreign assets to sell to support their own currency. But in keeping the dollar strong, all central banks have to do is to create reserves, and central banks can create reserves.
2017-12-20	US Federal Reserve System	In doing so, we also recognize the individuals past and present who have played a role, often behind the scenes, in managing the Federal Reserveâs dollar account operations for the global official sector.

Notes: The table provides examples of statements with a high classification score for the `united_states_dollar` feature.

Back

Table: Text Feature Examples: U.S Dollar

Date	Institution	Passage
2010-01-19	European Central Bank	I am convinced that the US authorities â both the central bank and the Treasury â consider that a strong dollar vis-a-vis the other major floating currencies is in the interests of the United States. Ben Bernanke and Tim Geithner have made this very clear.
2019-09-17	European Central Bank	The general consensus, however, is that other currencies continue to face considerable obstacles to displacing the US dollar in the international monetary and financial system, and that the broad contours of the system can be expected to remain unchanged in the near term.
2008-07-11	European Central Bank	I have said publicly that it is very important in my eyes that the President of the United States, the Secretary of the Treasury and the Chairman of the Federal Reserve have said that a strong dollar is in the interest of the United States of America.
2010-01-19	European Central Bank	When the financial crisis intensified in 2008, the ECB and the Federal Reserve cooperated closely, together with other central banks, including through swap agreements. We ourselves supplied US dollars on this side of the Atlantic as part of this very close cooperation.
2015-10-02	European Central Bank	Chitu, L., B. Eichengreen and A. Mehl (2014), âWhen did the dollar overtake sterling as the leading international currency? Evidence from the bond marketsâ, Journal of Development Economics 111, pp. 225-245.

Notes: The table provides examples of statements with a high classification score for the `united_states_dollar` feature.

Back

Table: Text Feature Examples: U.S Dollar

Date	Institution	Passage
2003-11-03	Bank of Greece	Today, many historians blame the gold standard for helping precipitate the Great Depression that began in 1929. Regardless, the global stock market crash of 1929 and the ensuing global financial crisis of September 1931 saw many countries driven off the gold standard.
2008-07-01	Bank of Italy	On the foreign exchange front, the dollar, in spite of its present weakness, remains the currency of the worldâs largest economy, with deep, open and liquid financial markets and a central bank with a firmly established reputation for independence.
2017-06-16	The Bank of Spain	The system to which the Bretton Woods agreements gave birth replaced gold with the US dollar, insofar as exchange rates were fixed in relation to the dollar rather than to gold, although an indirect link to gold was maintained through the dollar/gold parity.
2019-09-10	Deutsche Bundesbank	Universally accepted currencies are not a new phenomenon: be it gold during the gold standard, the pound sterling during the Industrial Revolution or the US dollar to this day, all have served as major internationally accepted units of account.
2008-05-30	Sveriges Riksbank	Another factor that has certainly been significant is the depreciation of the dollar. Commodities are priced in dollars, and this may mean that commodities exporters will try to gain compensation through higher prices if the dollar falls.

Notes: The table provides examples of statements with a high classification score for the `united_states_dollar` feature.
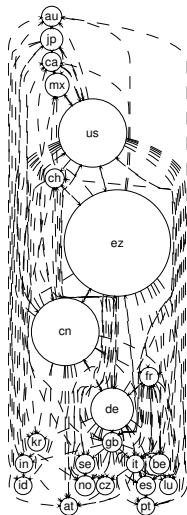
Back

Figure: Directed Network for Trade Exposures

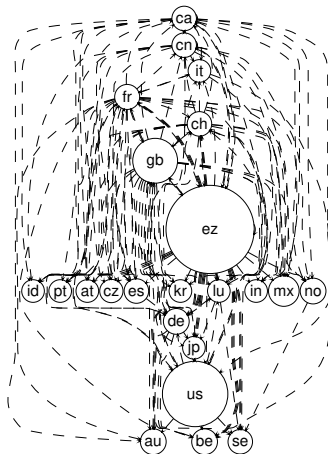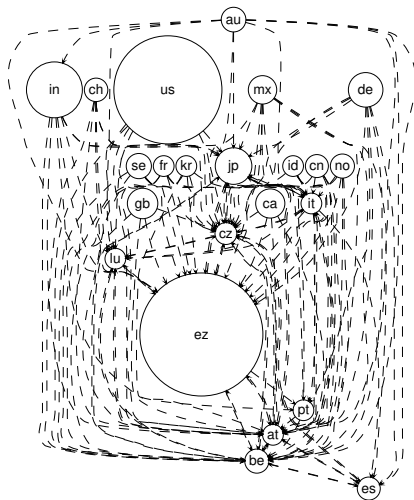Figure: Directed Network for Financial Flow Exposures

Figure: Granger Causality Network for Sentiment

Refine STS Performance with Fine-Tuning

1. Use S2ORC abstracts (Lo et al. 2020).

2. Randomly draw *similar* sequence pairs from the same paper abstract.

3. Randomly draw *dissimilar* sequence pairs from different abstracts.

4. Train on STS and compare using cosine similarity.

$$sim(S_i, S_j) = \frac{S_i \cdot S_j}{\|S_i\| \|S_j\|}$$