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Narrative Fragmentation and the Business Cycle

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Narrative Fragmentation and the Business Cycle*

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Abstract

According to Shiller (2017), economic and financial narratives often emerge as a consequence of their virality, rather than their veracity, and constitute an important, but understudied driver of aggregate fluctuations. Using a unique dataset of newspaper articles over the 1950-2019 period and state-of-the-art methods from natural language processing, we characterize the properties of business cycle narratives. Our main finding is that narratives tend to consolidate around a dominant explanation during expansions and fragment into competing explanations during contractions. We also show that the existence of past reference events is strongly associated with increased narrative consolidation.

Keywords: Natural Language Processing, Machine Learning, Narrative Economics

***JEL* Classification:** C63, D84, E32, E7

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1 Introduction

An economic narrative is a simplified story that attempts to summarize the state of the economy or to interpret economic data. Shiller (2017) argues that economists have failed to adequately consider the role such narratives play in the generation of aggregate fluctuations. If narratives influence beliefs, then a widespread and compelling narrative could coordinate economic decision-making across households, firms, and financial market participants. Furthermore, narratives might have the capacity to generate the belief-driven waves of optimism and pessimism that Keynes (1936) suggested were an underlying driver of business cycles.

This paper contributes to the establishment of Shiller's proposed "narrative economics" literature by applying state-of-the-art methods from natural language processing (NLP) to a novel dataset of business cycle narratives. In this respect, we join recent work, such as Chahrour et al. (2019) and Larsen et al. (2019), which studies the role of narrative development in macroeconomic and financial contexts. We also contribute to the closely-related behavioral economics literature, which emphasizes the interaction between psychological biases and narratives (Tversky and Kahneman, 1973; Bondt and Thaler, 1985; Summers, 1986; Bondt and Thaler, 1987; Boudoukh et al., 2013; Goetzmann et al., 2016; Rabin, 2013).

Our objective is to establish stylized facts related to the consolidation of business cycle narratives that could serve as inputs to models and empirical research. In particular, we attempt to measure the extent to which narratives consolidate around a dominant explanation and how the degree of consolidation varies over the business cycle. We view this exercise as a necessary precursor to empirical work focused on causal inference and to the development of theoretical models.

To measure business cycle narratives, we introduce a unique dataset of Swedish newspaper articles over the 1950-2019 period. The length of the dataset allows us to capture general features of business cycle narratives, rather than the idiosyncrasies of a specific cycle. To identify the narratives, we use the latest variant of the Latent

Dirichlet allocation (LDA) topic model[1] – the dynamic embedded topic model (D-ETM) – which allows for dynamics and represents both vocabulary terms and topics using vectors of continuous features called embeddings (Blei et al., 2019).

Our first finding is that the consolidation of narratives is strongly, positively associated with GDP growth over the business cycle. As the economy expands, the media tends to converge on a dominant narrative for topics related to the business cycle; however, during contractions, narratives tend to fragment into competing explanations. While we do not make claims about causality, we do propose an explanation that is consistent with the theoretical framework in Eliaz and Spiegler (2020).

Our next finding exploits unique features of the Blei et al. (2019) model to demonstrate that the existence of a historical reference event is associated with increased narrative consolidation. For example, if the media had previously covered an oil supply shock, it will be more likely to consolidate around a dominant explanation for contemporaneous events in the oil market. We refer to the availability of historical reference events related to a particular narrative as "memory" and argue that the association we measure is consistent with the existence of an "availability bias" in media coverage (Tversky and Kahneman, 1973).

Finally, note that the objects of interest we measure in economic narratives – narrative consolidation and memory – are closely associated with the concepts of "narrative coherence" and "narrative fidelity" in communication theory, which are considered to be the primary determinants of whether a narrative is compelling (Fisher, 1987).

2 Data

All exercises make use of a novel text-based dataset collected from a high circulation Swedish newspaper (Svenska Dagbladet) over the 1950-2019 period. To prepare the data for use in a topic model, we first identify 62,506 passages in which the economy was referenced. We then clean each passage using standard natural language processing

[1]The LDA model was introduced in Blei et al. (2003) and extended in Blei and Lafferty (2006) and Blei and McAuliffe (2007).

(NLP) routines. This involves the removal of special characters and symbols, and the elimination of words that do not contain meaningful information about the content of the text.

We encode the remaining words in 300-dimensional dense vectors called "embeddings." This enables us to treat each term in the vocabulary as a set of continuous features, allowing for the preservation of relationships between words. We make use of the pre-trained embeddings for the Swedish language introduced in Fallgren et al. (2016),[2] but "fine-tune" them when we train the Blei et al. (2019) model. This process localizes the embeddings by incorporating information about business cycle narratives.

Figure A.1 in the Appendix visualizes two features in the embedding space for the word "inflation" and the words most closely associated with it in the vocabulary. Notice that the fine-tuning process yields embeddings that locate "inflation" next to terms commonly associated with it in business cycle narratives, such as "central bank" and "interest rate increase."

3 Methods

To identify narratives in the data, we make use of the dynamic embedded topic model (Blei et al., 2019),[3] which encodes both vocabulary terms and topics as embedding vectors in $\mathbb{R}^L$. Each of the L elements can be interpreted as a continuous feature of the text. The probability that the n^{th} word in document d is term ν, given that the topic is k, is proportional to the exponentiated inner product of the vocabulary term and topic embeddings, as stated in Equation (1).

$$p(w_{dn} = \nu | z_{dn} = k, \alpha_{kt}) \propto \exp\{\rho'_\nu \alpha_{kt}\} \tag{1}$$

Note that the probability will be higher if the topic and vocabulary term have similar

[2]This allows us to use word representations that were constructed using a much larger corpus (collection of documents) and that encode more granular text features.

[3]The original dynamic topic model (Blei and Lafferty, 2006) exclusively uses a probability distribution over vocabulary terms to model topics.

features and, thus, are closer together in the embedding space. Figure A.2 in the Appendix visualizes this for all topics and the example vocabulary term "housing construction." An increase in the value of a series indicates that the embedding has become more closely related to "housing construction."

The Blei et al. (2019) model ensures smoothness in topic transitions by imposing a random walk in the topic embedding, α_{kt}, as shown in Equation (2), where $\mathcal{N}(\cdot)$ is a multivariate normal distribution. The prior over the topic proportion vector, θ, depends on a latent variable, η, where the evolution of η is assumed to follow a random walk.

$$p(\alpha_{kt}|\alpha_{kt-1}) = \mathcal{N}(\alpha_{kt-1}, \sigma^2 I) \tag{2}$$

The generative component of the model consists of a three-step sequence. First, α_{k0} and η_0 are initialized using draws from a standard normal distribution. Second, α_{kt} and η_t are simulated over the time path $t = 1, ..., T$. And third, topic proportions, θ, are drawn for each document, and both categorical topic assignments and word assignments are drawn for each document and word therein. In our case, note that $T = 69$ and $L = 300$.

Since estimating the posterior distribution over the model's latent variables is intractable, Blei et al. (2019) instead use amortized variational inference and select parameter values to minimize the Kullback-Leibler divergence of the approximating distribution and the posterior.[4] We adopt this approach to train a version of the model with 10 topics. After 200 iterations, the document completion perplexity for the validation sample ceases to decline, which is where we terminate the training process.[5]

[4]We refer readers to the original paper for additional detail on the inference routine, as well as Gershman and Goodman (2014) and Kingma and Welling (2014) for additional detail on variational inference.

[5]In NLP, document completion perplexity measures the model's ability to predict the final word in a sequence from the sequence itself.

4 Empirical findings

For the empirical exercises, we make use of three model outputs: the topic embeddings, the vocabulary term embeddings, and the vocabulary. Our analysis centers around the concept of entropy, which originated in the information theory literature, but has recently been used in economics to measure disorder, including in NLP applications (Nimark and Pitschner, 2019; Calomiris and Mamaysky, 2019). For each topic k and time period t, entropy is defined in Equation (3), where p_{kt} is the probability distribution over the vocabulary.

$$H(p_{kt}) = -\sum_{\nu} p_{kt\nu} log_2(p_{kt\nu}) \tag{3}$$

In each empirical exercise, we use detrended, standardized, within-topic entropy as our dependent variable. High values of entropy indicate increased fragmentation (reduced consolidation) within a narrative. Note that entropy is maximized when the distribution over the vocabulary is uniform and minimized when it is degenerate.

4.1 GDP growth and within-topic entropy

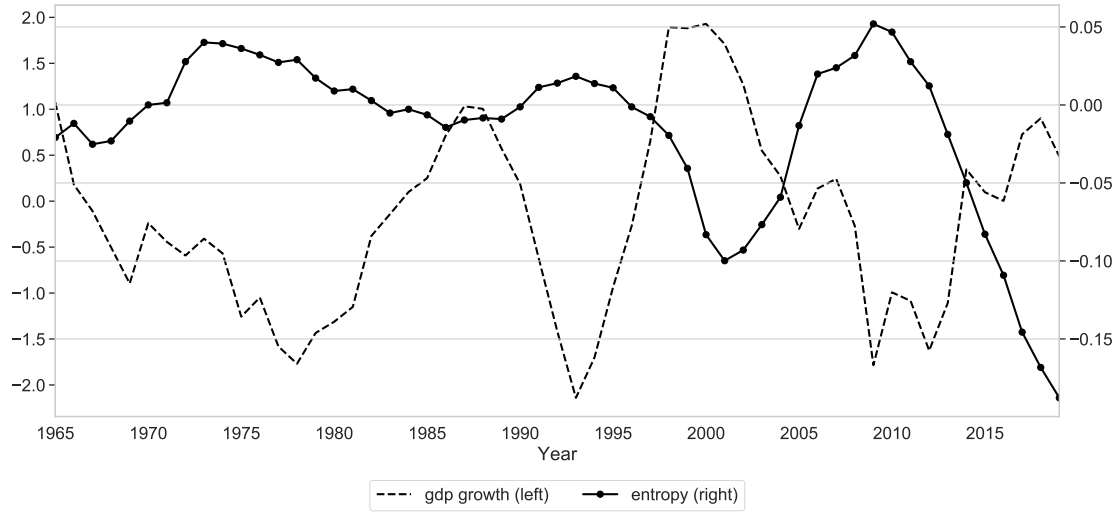
Since our empirical analysis centers on the relationship between within-topic entropy and GDP growth over the business cycle, we detrend both variables by removing their respective 10-year rolling means.[6] Figure 1 provides a comparison of the rolling means of the detrended GDP growth series and the average of the detrended entropy series over the 1965-2019 period.[7] The two series have a strong and negative correlation of -0.69.

We also evaluate the significance and magnitude of this relationship in column (1) of Table 1, which shows the regression results from estimating Equation (4). Note that

[6]Note that our results are robust to different methods of detrending.

[7]To evaluate the importance of heterogeneity in entropy, we performed principal component analysis (PCA) on the 10 within-topic entropy series. We found that 80% of variation in the data is explained by the first two principal components. Furthermore, examining individual series, we identified heterogeneity in the intensity of the associations with GDP growth. Forward-looking topics that were centered around projections and developments had the strongest associations.

Figure 1: GDP Growth and Within-Topic Entropy



The figure above shows the rolling mean of detrended GDP growth plotted against detrended, within-topic entropy, averaged over all topics for the sample period 1965-2019.

$H(p_{kt})$ is the detrended, standardized entropy of topic k at time t, y_t is detrended GDP growth at time t, and γ_k is the fixed effect for topic k.

$$H(p_{kt}) = \beta y_t + \gamma_k + \epsilon_{kt} \tag{4}$$

We find that a 1% increase in GDP growth above its trend value is associated with a 0.05 standard deviation decrease in within-topic entropy.[8] Stated differently, this implies that the worst single year of growth during the Great Recession would be associated with a one-third of a standard deviation decrease in entropy. Note that this result is statistically significant at the 5% level using Newey-West standard errors.

We expand on this in columns (2)-(4) of Table 1, where we examine how consecutive periods of growth acceleration or deceleration affect the fragmentation of the narrative. In column (2), we swap y_t with an indicator for whether GDP growth did not accelerate

[8]We do not argue for a causal interpretation of our results; however, it is probably less controversial to claim that GDP growth drives narrative entropy, as our regression specification implies. Furthermore, we find that lagging GDP growth intensifies the estimated impact on entropy, which hints at a direction for the relationship.

Table 1: Entropy Regression Results

	(1)	(2)	(3)	(4)	(5)
gdp_growth_t	-0.0546**				-0.0522**
	(0.0224)				(0.0234)
$accelerations_t$			-0.0688**		
			(0.0282)		
$decelerations_t$				0.0931***	
				(0.0344)	
$no_accelerations_t$		0.3055***			
		(0.0828)			
$memory_share_{kt}$					-34.4629***
					(7.5676)
Topic FEs	✓	✓	✓	✓	✓
Newey-West SEs	✓	✓	✓	✓	✓
R^2	0.0087	0.0230	0.0165	0.0140	0.0782
N	640	640	640	640	500

Notes: The table above provides regression results for all empirical exercises. In each case, the dependent variable is the detrended, standardized within-topic entropy. The regressors of interest are as follows: 1) detrended annual GDP growth for Sweden, *gdp_growth*; 2) an indicator for whether detrended growth did not accelerate, *no_accelerations*; 3) the number of consecutive periods of GDP growth acceleration, *accelerations*; 4) the number of consecutive periods of GDP growth deceleration, *decelerations*; 5) and the share of past periods that were similar to the current period, *memory_share*. All specifications include topic fixed effects and use Newey-West standard errors. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

in the same period. Consistent with our results in column (1), we find that a lack of acceleration in GDP growth leads to fragmentation in the narrative. In particular, it is associated with a 0.31 standard deviation increase in entropy.

In columns (3) and (4), we again replace y_t, but this time with the number of periods of consecutive acceleration and deceleration in GDP growth, respectively. Here, we find evidence that entropy decreases in the number of consecutive growth accelerations and increases in the number of decelerations. The impact is larger in magnitude for decelerations than it is for accelerations.

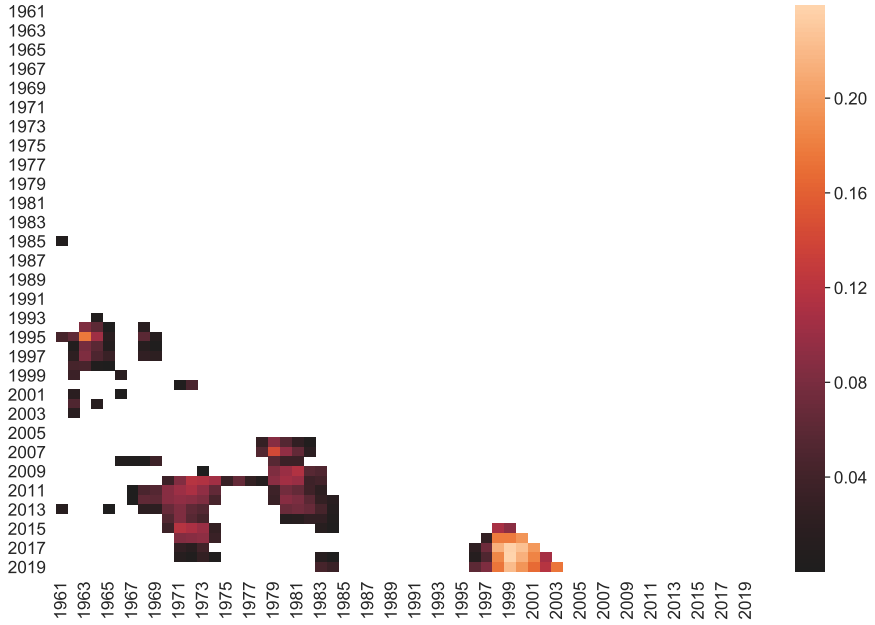
4.2 Reference events and within-topic entropy

Shiller (2017) argues that narratives may become dominant as a consequence of their virality, rather than their veracity. In this section, we evaluate one possible driver of

virality: the existence of reference events, such as a past oil supply shock or stock market crash, which can provide structure for emerging narratives. We refer to the availability of such events as "memory."

The topic embeddings, α, allow us to measure memory by computing the inner product between topic k's embedding at two points in time (e.g. $\alpha_{kt}{}' \alpha_{kt-s}$). This is only possible using D-ETM, since it incorporates both dynamics and topic embeddings.[9] Given that we want to capture changes in embedding features, rather than comparing the embeddings themselves, we will use detrended versions of the embeddings.

Figure 2: Heatmap of Memory for "Policy" Topic



The figure above shows the inner product of the detrended topic embeddings at different points in time for the "policy" topic. Lighter values indicate a higher value of the inner product. Negative inner products are excluded, along with high values that are located near the diagonal, which primarily arise from the persistence of the model and are too close to contemporaneous events to be considered "memory."

Figure 2 provides a heatmap of the non-negative inner products for the "policy"

[9]Earlier embedded topic models did not explicitly model dynamics and dynamic topic models lacked embeddings.

topic.[10] The heatmap suggests that narratives about policy during the 2014-2019 and 1997-2003 periods were highly similar. Furthermore, the inner products of the topic and vocabulary embeddings (not shown) suggest that monetary policy and interest rate terms featured prominently in both periods, which were both characterized by below-target inflation.

We also use a regression exercise to measure the impact of memory. For all year-topic combinations, we count prior instances of reference events. We then divide by the number of years in the sample prior to that date. This yields the share of all periods in which there was a relevant reference event, m_{kt}. Equation (5) modifies our regression specification to include the memory share.

$$H(p_{kt}) = \beta y_t + \zeta m_{kt} + \gamma_k + \epsilon_{kt} \tag{5}$$

Column (5) of Table 1 contains the results for this exercise. We find that the association between the memory share and within-topic entropy is negative and significant at the 1% level. Our interpretation of this result is that an increase in the proportion of years that contained reference events is positively associated with narrative consolidation in the description of contemporaneous events. Furthermore, the effect is also large in magnitude: a 0.1 increase in the memory share is associated with a 3.4 standard deviation reduction in topic entropy.

5 Discussion

Eliaz and Spiegler (2020) formalize narratives by treating them as simplified stories that attempt to explain correlations in economic variables. Within this framework, economic expansions could provide false affirmations of optimistic beliefs, as they tend to generate a strong, positive correlation between asset price growth, the expansion of

[10] Note that we explicitly consider non-negative embeddings only for this exercise. We also remove elements on the diagonal and below it, since the model imposes smoothing in the embedding transitions, which naturally leads to persistence in nearby values.

credit, and economic activity (Kindleberger and Aliber, 2011).

While an optimistic narrative may appear to offer a plausible explanation during a steady economic expansion and may grow in dominance over time, this story could fray when the economy is exposed to larger shocks at the onset of a recession, giving rise to contradictions and a cacophony of competing explanations. This is consistent with our finding about GDP growth and entropy.

The existence of reference events plays an important role in providing structure for narratives. While we do not test for this explicitly, our finding about memory could arise as a consequence of the "availability bias" described in Tversky and Kahneman (1973). That is, the media may tend to use reference events as a means of constructing narratives about the business cycle. We leave an investigation of causality to future work.

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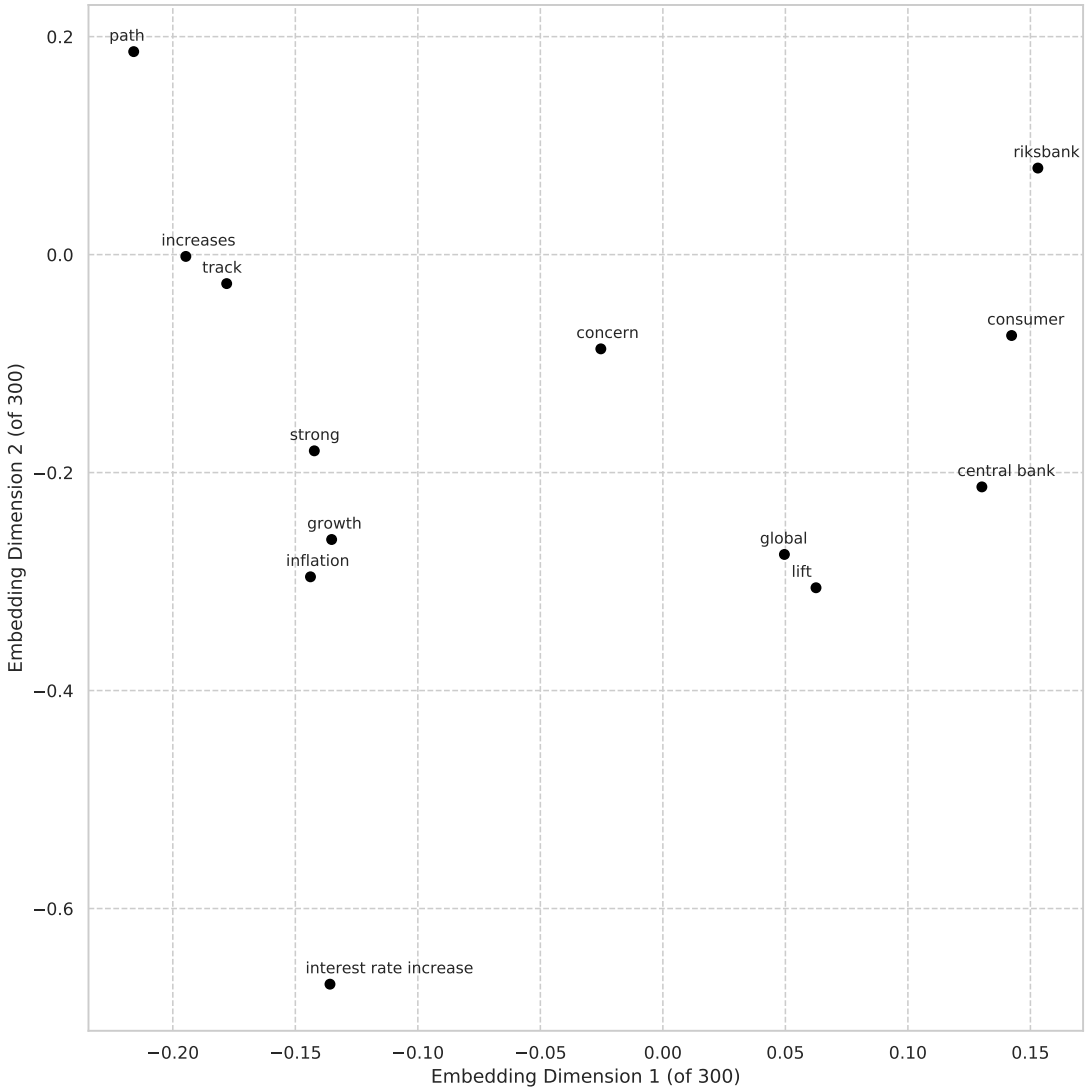
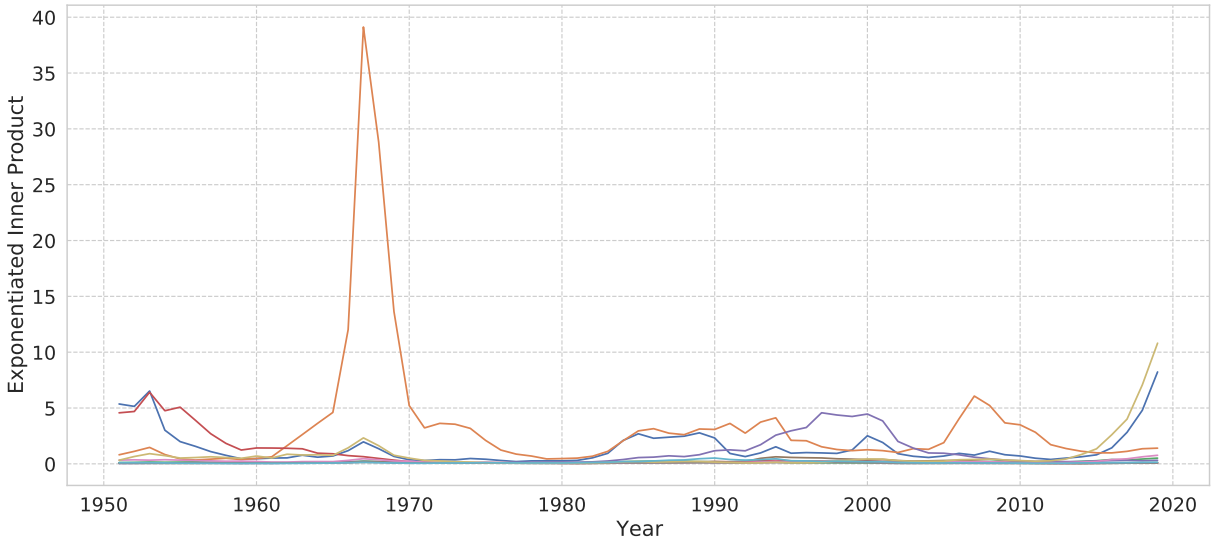
A Appendix

Figure A.1: Nearest Neighbors for Term "Inflation" in Embedding Space



The figure above shows a scatterplot of two dimensions of the embedding vectors for vocabulary terms closely related to inflation. We identify the terms by using the nearest neighbors algorithm. Points that are close together in the scatterplot are more closely related with respect to the two features shown. Notice that the terms shown are all related to the term inflation in business cycle narratives, suggesting that the fine-tuning process produced embeddings that are appropriately localized to the context of economic narratives.

Figure A.2: Evolution of Topic Embeddings Relative to Term "Housing Construction"



The figure above shows the time series of exponentiated inner products between the topic embeddings and the vocabulary term "housing construction." A higher value indicates that a given topic is more closely associated with the term "housing construction." The policy topic, shown by the orange line, spikes in the 1960s and 1970s, coinciding with a historically ambitious government program that aimed to produce one million new homes.

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