Analysis of the Macroeconomic Uncertainty Based on the News-based Textual Data with Financial Market

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***Abstract*—The uncertainty in the financial market, whether US—China trade war will slow down global economy or not, Federal Reserve Board (FRB) policy to increase the interest rates, or other similar macroeconomic events can have a crucial impact on the purchase or sale of financial assets.**

In this study, we aim to build a model for measuring the macroeconomic uncertainty based on the news text. Further, we proposed an extended topic model which uses not only news text data but also numeric data as a supervised signal for each news article.

Subsequently, we used our proposed model to construct four macroeconomic uncertainty indices. All these indices were similar to those observed in the historical macroeconomic events, and the correlation was higher with the volatility of the market index with respect to the uncertainty index. We also applied the impulse response function to analyze the impact of the uncertainty indices on financial markets.

***Index Terms*—Uncertainty, Economic policy, Topic model, Text mining**

I. INTRODUCTION

Macroeconomic uncertainty is a factor that influences the purchase and sale of financial assets. For investors, the macroeconomic uncertainty is the degree of unpredictability for the future direction of the economy, ranging from several topics, the monetary and fiscal policies in each country and the trade friction between any two countries.

Furthermore, investors find it difficult to decide whether to purchase or sell certain assets in case of an increase in the macroeconomic uncertainty. Under such circumstances, investors may act differently because they have different views of the macroeconomic future. Some investors may alternately purchase and sell assets, resulting in a high volatility with respect to the asset price.

For example, when the monetary policy of the Federal Reserve Board (FRB) monetary policy is uncertain, investors may be uncertain about the rate of increase in the interest rate. Under these circumstances, the investors maybe alternately purchase and sell treasury bills, thereby increasing their volatility. However, the monetary policy of the Bank of Japan monetary policy is very clear to investors because the Bank of Japan will not change the current policy of a low interest rate; therefore, the price of the Japanese government bond remains zero.

A. Measurement of the macroeconomic uncertainty

In a modern economic environment, several macroeconomic uncertainties are observed to co-exist; further, the investors can improve their investment strategies if they can quantitatively classify the uncertainty based on its source and measure the uncertainty. They can hedge the risk associated with a high macroeconomic uncertainty. Additionally, the investors may also utilize the uncertainty associated with stress testing.

The easiest way to quantitatively evaluate the uncertainty is to measure the volatility of certain assets with the respect to that macroeconomic uncertainty. However, if the assets are influenced by several macroeconomic uncertainties or if volatilities are influenced by demand and supply, measuring only volatility is insufficient to evaluate the financial risks.

Recently, an alternative method has been proposed to measure the macroeconomic uncertainty using a text mining method. Baker, Bloom, and Davis (2016) developed an approach to measure the policy of economic uncertainty index [1]. Manela & Alan (2017) developed the news-implied volatility [2]. Further, we will introduce the related studies in subsequent section.

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B. Our contributions

The objective of this study is to construct the macroeconomic uncertainty indices based on the news text. We proposed an extended topic model using both news text data and numeric data as a supervised signal for each news articles.

For our research, we used the supervised Latent Dirichlet Allocation(sLDA) and the uncertainties generated without the usage of pre-defined words for each uncertainty (sLDA is one of the topic models discussed in section V). Further, we classify the uncertainty using sLDAs word-topic distributions and the supervised signal response, revealing that the news exhibiting less responses to the supervised signal is excluded.

We also detail the macroeconomic uncertainty index analysis. The four constructed macroeconomic uncertainty indices, include the uncertainty index associated with the Japanese economic policy, the uncertainty index associated with the US economic policy, and the uncertainty index associated with the Chinese economy, the uncertainty index associated with the European economy. Additionally, we conducted qualitative as well as quantitative analyses of the selected uncertainty indices.

II. RELATED WORKS

Many previos studies have explored the uncertainty index or have preformed market volatility prediction using numeric data. For instance, Helena, Montserrat & Jorge (2017) use the stock price to construct the uncertainty index of the market [3]. Some researchers used numeric data, such as those obtained from Google Trends to predict the market volatility (Efrem & Trung (2017) [4], Alain (2015) [5]). Furthermore, Asaf & Alan (2017) used the news text to predict the market volatility [2].

Baker et al.(2016) [1] introduced the policy uncertainty index using the text data and pre-defined words for policy and uncertainty to count a number of news articles that contains there words. Moreover, the conducted monthly aggregate seasonal adjustments using these methods. With respect to the policies associated with the uncertainty indices of countries, Elif, Steven, Arata, Naoko & Ikuo (2017) created the Japan Policy Uncertainty Index [6], whereas Ellen, Hans, Walter, Enric & David (2018) developed the Belgium Policy Uncertainty Index [2].

Other studies analyzed the economic activities using the uncertainty index (Jonathan & Andrew (2015) [7]; Rdiger, Steffen & Eric (2013) [8]). Further, an extension of uncertainty index using different types text data is also discussed. Bennett & Julieta (2018) extracted certain texts from Federal Reserve Beige Books [9]. Andrs (2017) used topic models to build an uncertainty index similar to that presented in our model [10].

III. DATASETS

In this study, we extract the uncertainty index based on the news text and apply the renowned topic model with respect to the news text for classifying the topic of uncertainty. News text is considered to be the dataset for the model. In addition, numeric data is also considered to be the dataset as the supervised signal to each article.

TABLE I
TERM SETS FOR UNCERTAINTY.

Uncertainty Terms
"Uncertainty" or "Uncertain"
"Indetermination or "Indeterminate"

A. Text data

The text data were obtained from the Japanese Reuters news articles, and we extracted the global economy news article from Reuters website. In total collected 32000 articles from August 2009 to January 2019. More than ten global economy news articles are published on the Reuters'website per day, and each article contains an average of 1200 words. The news articles on global economy category are observed to focus on the economic events and monetary policy on each major countries. Furthermore, comments and columns of economists columns are available at the website. We used the news articles from the global economy category because the text corpus should contain articles related to global economic uncertainty and not individual firm issues or market price movement.

B. Numeric data

We selected the volatility index (VIX) as the supervised signal for the sLDA model. The VIX concept is used to formulate theoretical expectations of the volatility implied by the S&P 500 index, which is disseminated and calculated on a real-time basis by the Chicago Board Options Exchange. VIX is an index that allows investors to measure the uncertainty with respect to the future market trends. Thus, we collect the VIX dataset daily similar to the interval during which we collect the text data.

IV. PROCESS

Figure 1 divides the entire process into three parts. The first part is the prepossessing of the input data, and the second part is the topic classification that is performed using sLDA. The final part is to measure uncertainty index. We use topic distribution for each document and normalize in each month.

A. Text data preprocessing

After obtaining Reuters news articles from the global economy category of the Reuters'website, we extracted articles that explained the uncertainty. First we define uncertainty terms.(Table I) For all articles, we extracted articles which contains any of the uncertainty terms. Because some Reuters articles contain articles that are not related to uncertainty but views about economic forecast, we should eliminate these articles from the corpus. Subsequently, we conduct Japanese language morphological analysis and extract nouns using Mecab (Japanese Part-of-Speech and Morphological Analyzer). As a result of text data preprocessing, the corpus contains 3115 documents and approximately 2.95 million words with 1786 distinct terms.

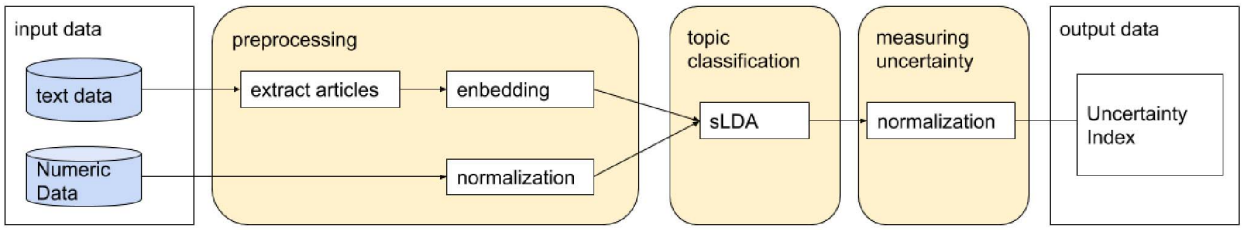

Fig. 1. Overall process

B. Numeric data prepossessing

For numeric data, we use the VIX index as the supervised signal for sLDA. We conducted normalization to convert VIX index to exhibit a zero average and a standard deviation of one. Further, we use the converted VIX index as the supervised signal for each article.

C. Topic classification

The topic classification is conducted using sLDA. The supervised signal for each article is the converted VIX having the same date the article was published.

D. Uncertainty measurement

After the topic classification was completed using sLDA, the topic distribution was extracted for each document. We aggregated the mean of topic distribution each topics and each month. Subsequently, we normalized the average score of each topic to 100.

V. TOPIC MODEL

A. Supervised Latent Dirichlet Allocation

LDA is one of the most popular topic models proposed by Blei et al.(2003) on the basis that all the documents are a mixture of latent topics and that each topic is a probability distribution with respect to words [11].

sLDA is an expansion of LDA proposed by Mcauliffe & Blei (2008) [12]. sLDA is a model developed by adding a response variable associated with each document to LDA model, which jointly model the documents and responses, to find latent topics that will optimally predict the response variables in case of future unlabeled documents.

Figure 2 presents the graphical model representation of sLDA and Table II presents the sLDA notations. In our research, the converted VIX index is used as a signal for the article.

VI. RESULTS

A. Topic classification

We performed topic classification by sLDA using the following parameters: $\alpha = 0.035, \beta = 0.01, K = 6$. The topic classification results obtained using the sLDA model were presented in Table III in which four topic were selected from among six classified topics.

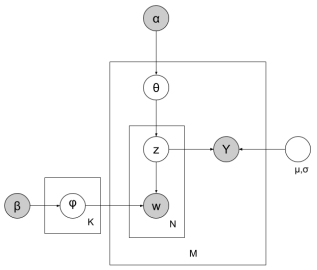

Fig. 2. The graphical model representation of sLDA

TABLE II
NOTATIONS IN SLDA

Notation	Definition
α, β	Hyperparameters
φ	The distribution over words
K	The number of topics
θ	The document specific topic distribution
Z	A topic
w	A word in the document
N	The number of words
M	The number of documents
Y	Response variable
μ, σ	Hyperparameters for the response variable

With respect to the top words of each topic word distribution, TOPIC 4 is related to the uncertainty in the US economic policy; TOPIC 0 is related to the uncertainty in the Japanese economic policy; TOPIC 2 is related to the uncertainty in the Chinese economy; and TOPIC 5 is related to the uncertainty in the European Economy.

B. Macroeconomic uncertainty index

In Figure 3, we plot the following four macroeconomic uncertainty indices using the topic classification: US economic policy; Japanese economic policy; Chinese economy; and and European economy.

The uncertainty index of the Japanese economic policy decreased when the Bank of Japan announced a target of 2% inflation target in January 2013 (Figure 3, A). This announcement was very comprehensible for investors and removed uncertainty of the the Bank of Japan's policy whether they are accommodative or not and caused the decrease of the index.

TABLE III
TOP 10 WORDS OF TOPIC WORD DISTRIBUTION OF THE SLDA MODEL

TOPIC 4	TOPIC 0	TOPIC 2	TOPIC 5
FRB	BOJ	China	Uncertainty
Uncertainty	Government	Uncertainty	problem
Financial Policy	Japanese Economy	Export	EU
Economy	Japan	Recovery	European Union
Inflation	Tokyo	Company	Agreement
FRB	Economy	GDP	Uncertainty
Rate Hike	Degree	Increase	Implementation
Content	Effect	Growth	Europe
President	Expectation	Decrease	Euro zone
Inflation Rate	Future	Quarter	Greece

However, the index peaked when it announced additional monetary easing by increasing the amount of asset purchase in October 2014 (Figure 3, B) and in January 2016 (Figure 3, C) when it announced a monetary easing policy using a negative interest rate. This two additional monetary policy increase the investors uncertainty for the Bank of Japan's policy because of investors are suspicious about the new policy's effects.

The uncertainty index of the Chinese economy peaked when the Chinese economic growth was expected to drastically decrease in the mid-2013 from an annual rate of 10% to 7% (Figure 3, D), and the US-China trade friction influenced the Chinese economy in the mid-2018 (Figure 3, E). When Chinese economy was stagnated, investors were anxious about influence of Chinese economy to the global financial market and caused the index to increase.

The uncertainty index of the US economic policy peaked when FRB was about to when about to announce the current monetary policy before Quantitative Easing 2 ended on June 2011 (Figure 3, F) and before Quantitative Easing 3 is ended on December 2013 (Figure 3, G). The policy made the investors suspicious of the next action and increase the uncertainty. Further, the index also peak when US—China trade friction influenced the US economy in mid-2018 (Figure.3, H). This make investors anxious about influence of US economy to the global financial market.

The uncertainty index of the European economy peaked during the European financial crisis(Figure 3, I), Greek crisis that occurred in late 2011 (Figure 3, J) and in the mid-2015 (Figure 3, K). At all these crisis point, investors were anxious about influence of crisis might slow down global economy and crash the financial market and caused the index to increase.

C. Correlation with the volatilities of other market indices

In Table IV, we present the macroeconomic uncertainty index correlations of volatility of market indices (10 years government bond of the US, Japan, China, German), volatility of major stock market (S&P500 , Nikkei 225, Shanghai Composite), and volatility of USD/JPY exchange market and VIX index that we used for supervised signal for sLDA.

The results denote that for each macroeconomic uncertainty index, the correlation coefficient with respect to the volatility of the government Bond and the volatility of the stock market index with respect to the macroeconomic uncertainty are higher than other indices. For example, the uncertainty index of Chinese economy exhibits a high correlation coefficient for a 10-year government bond of China and with volatility of Shanghai Composite. The uncertainty index of Japanese Economic policy also has a high correlation coefficient with a 10-year government bond of Japan and the volatility of Nikkei 225. In case of the uncertainty index of European economy, a high correlation coefficient is recorded for the 10-year German and Greece government bond. This denotes that each of macroeconomic uncertainty indices exhibit a significance effect.

D. Impulse Response Analysis

We conducted impulse response analysis by applying the Vector autoregression (VAR) model to each uncertainty index and the related market data. For each uncertainty index, we used the market data (stock index, government bond, and exchange rate) related to that uncertainty index and uncertainty index itself as the variables of the VAR model. The VAR model is applied because the model captures the dynamics between the variables and for performing time series analysis in finance.

The result of impulse response is depicted in Figure 4. 4.

With respect to uncertainty index of the Japanese economic policy, when the uncertainty increases, the stock price and the government bond interest rate fall. From Table I, the uncertainty index is observed to be strongly related to Bank of Japan's monetary easing policy. When the uncertainty index increases, the market participants expect an additional monetary easing policy although the Bank of Japan did not announce a new monetary policy. Under such circumstances, the market will consider the presence of an additional monetary easing policy(lowering of interest rate).

As for uncertainty index of the US economic policy, when the uncertainty increases, the stock price and the interest rates of the government bond increase. From Table I, the uncertainty index is observed to be strongly related to the FRB policy of increasing the interest rates. When the uncertainty index increases, the market participants expect FRB to formulate a policy to increase the interest rates. Although FRB did not yet make such an announcement, the market already considers an interest rate under such circumstances.

Fig. 3. The macroeconomic uncertainty index

TABLE IV
CORRELATION OF THE MACROECONOMIC UNCERTAINTY INDICES WITH THE VOLATILITY OF THE MARKET INDICES

	VIX	Government Bond					Stock Market Index			FX
		US	JP	CH	DE	GR	Nikkei	SH	S&P	
Japan	-0.087	-0.047	**0.259**	-0.158	0.059	0.136	**0.335**	0.194	0.073	0.152
China	0.003	0.099	0.053	**0.106**	0.088	0.177	-0.028	**0.108**	0.069	-0.054
US	-0.335	-0.343	-0.031	-0.326	-0.300	-0.203	-0.170	-0.175	-0.335	-0.141
EU	**0.318**	0.296	-0.158	0.317	**0.369**	**0.338**	-0.028	-0.115	0.249	0.011

VII. CONCLUSIONS &FUTURE WORKS

In this study, we apply the sLDA model to extract uncertainty indices from the news text and the VIX index as a supervised signal. We constructed four uncertainty indices (the uncertainty indices associated with the Japanese economic policy, the US economic policy, the Chinese economy,and the European Economy) based on the topics generated by sLDA. Further, We conducted correlation analysis based on the volatility of the market indices and impulse response analysis based on the related market indices. The results denote that the macroeconomic uncertainty indices exhibit a high correlation with the volatility of the market indices, making a certain market to react to the impulse of the the uncertainty index.

Currently our research is conducted by Japanese news articles and it's limited to Reuters News only. In the future work, we will expand our news corpus to several sources and also we will conducted the same analysis in English version of news articles.

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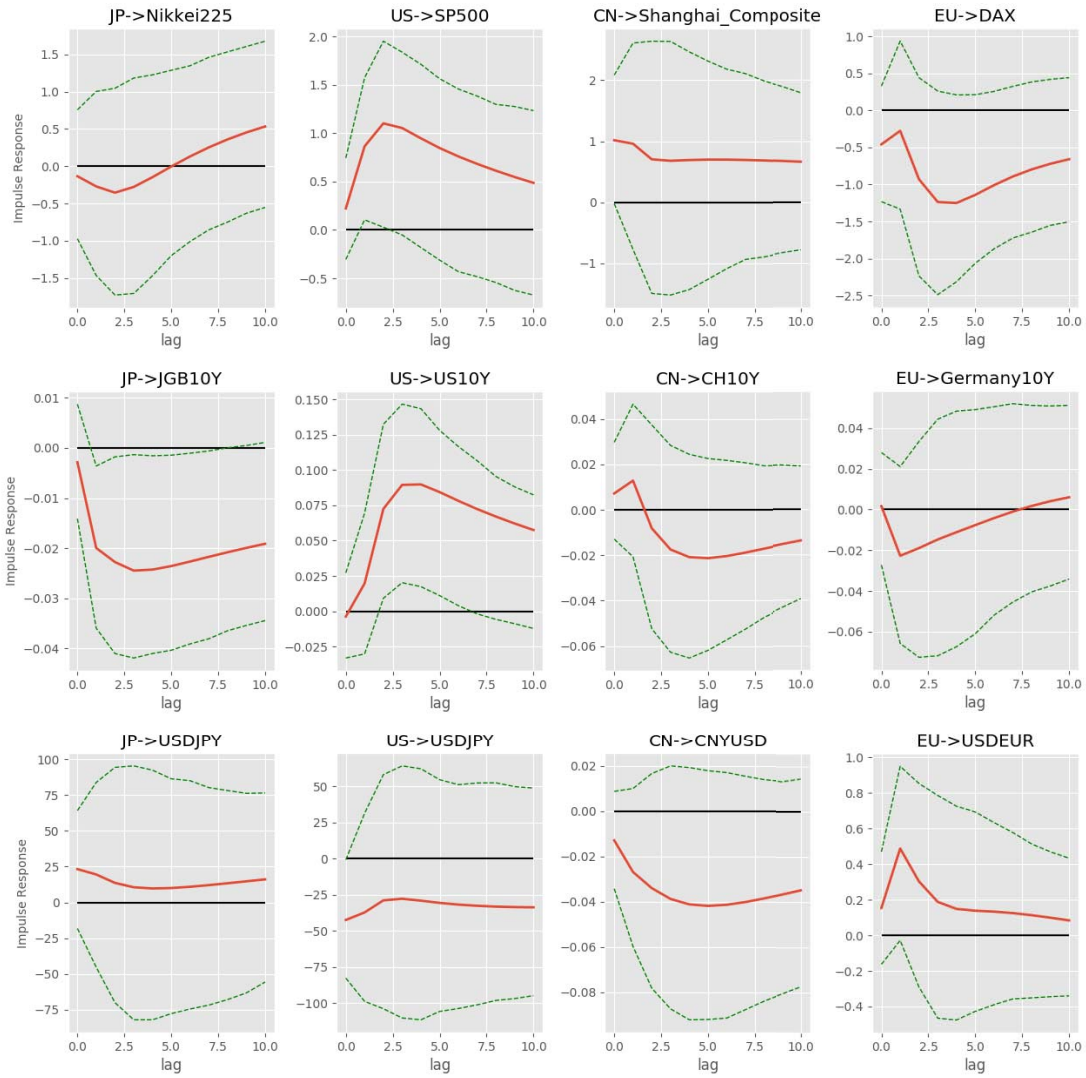

Fig. 4. Impulse Responses to Unit Standard Deviation Uncertainty Index Innovation

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