Monetary Policy Uncertainty in Mexico: An Unsupervised Approach

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Introduction

- We study and measure **uncertainty** in the minutes of the meetings of the board of governors of the Central Bank of Mexico from 2011 to 2018 and relate it to monetary policy variables.

- We construct two uncertainty indices for the **Spanish version of the minutes** using unsupervised machine learning techniques.

- The first uncertainty index is constructed exploiting **Latent Dirichlet Allocation** (**LDA**), whereas the second uses the **Skip-Gram** model and **K-Means**.

- Finally, via a **Structural VAR** model, we investigate how shocks in uncertainty during the meetings of the Central Bank of Mexico board of governors lead to changes in key monetary and financial variables.

Literature review

1. **Communication of Latin American central banks** (Arango et al., 2017; Garcia-Herrero et al., 2019)
2. **Sentiment measures for Spanish language** (Ghirelli et al., 2019; Bernal et al., 2020)
3. **LDA in economic studies** (Hansen and McMahon, 2016; Bybee et al., 2020)
4. **LDA and Skip-Gram in economic studies** (Azqueta-Gavaldon, 2020; Soto, 2020)

Minutes of the Central Bank of Mexico

- Since 2011, the Central Bank of Mexico (Bank of Mexico or Banxico) has usually published the **Spanish version of the minutes** two weeks after the meeting and eight times a year.
- This paper studies the Spanish version of the minutes of the board governors published in the **period 2011-2018**.
- The minutes provide **in-depth information** on the meetings of the board of governors that is not provided by the initial statements regarding the monetary policy decision.

Minutes of the Central Bank of Mexico

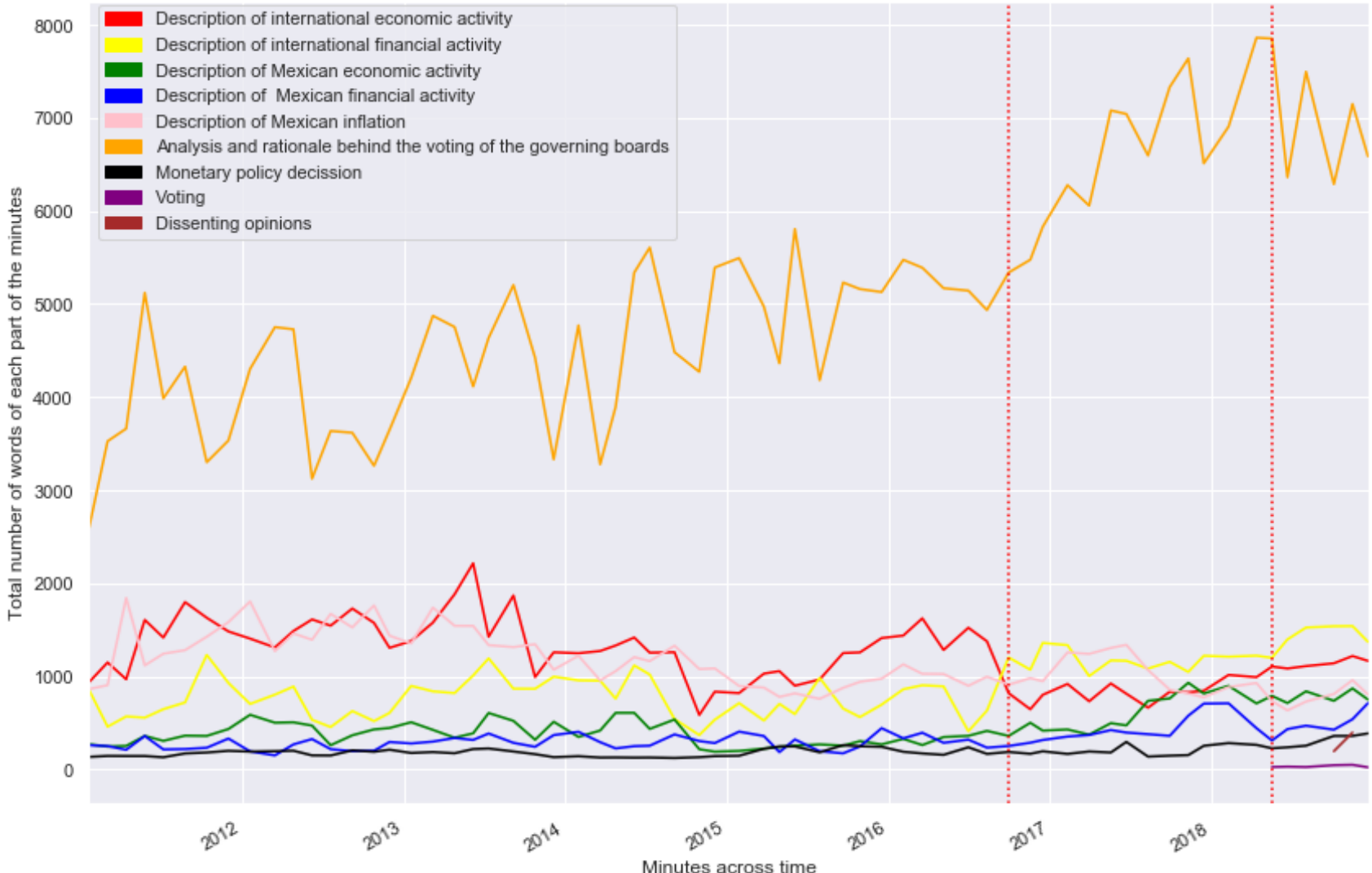
- We **delete unnecessary parts** for the analysis such as the cover, the graphs, the footnotes and the paragraphs in the minutes that do not provide any relevant information.

- The sections of the minutes are divided into several parts:

  1. Description of the **international** economic and financial situation;
  2. Description of the **Mexican** economic, financial and inflation situation;
  3. **Analysis** and **rationale** behind the governing board's vote;
  4. The monetary policy **decision**.

Minutes of the Central Bank of Mexico

Total number of words in the different sections of the Bank of Mexico minutes. The dotted red lines represent a change in the format of the minutes.



Latent Dirichlet Allocation

- First, we use **Latent Dirichlet Allocation** or **LDA** (Blei, Ng and Jordan, 2003) to construct the first uncertainty index.
- LDA assumes that each **document** in the corpus is a mixture of different **topics**.
- Each **topic** is a probability distribution over the **words** in the corpus.
- We apply Latent Dirichlet Allocation (LDA) to identify the probability of **twenty topics** occurring in the paragraphs of the corpus.

Latent Dirichlet Allocation

This table shows the first seven **words** with the highest probability for each of the first eight **topics**.

Topic	Word 1	Word 2	Word 3	Word 4	Word 5	Word 6	Word 7
0. Growth Demand	trimestr	crecimient	consum	inversion	ritm	recuper	priv
	0.069	0.062	0.038	0.036	0.036	0.035	0.034
1. Expectations	expect	cient	plaz	median	larg	cierr	alrededor
	0.116	0.072	0.054	0.037	0.036	0.025	0.022
2. Federal Reserve	federal	reserv	referent	reunion	activ	dich	increment
	0.066	0.047	0.036	0.027	0.027	0.027	0.026
3. Monetary policy	monetari	polit	banc	central	unid	pais	postur
	0.133	0.111	0.092	0.054	0.032	0.023	0.023
4. Interest	plaz	interes	increment	larg	grafic	bas	punt
	0.075	0.07	0.037	0.034	0.033	0.032	0.03
5. Risk / uncertainty	riesg	podr	incertidumbr	balanc	factor	posibil	deterior
	0.157	0.04	0.039	0.035	0.027	0.024	0.023
6. Financial situation	financier	pes	volatil	pais	ultim	dol	grafic
	0.051	0.048	0.036	0.034	0.029	0.028	0.027
7. Monetary policy Mexico	monetari	objet	mexic	polit	postur	ajust	convergent
	0.063	0.037	0.037	0.037	0.024	0.023	0.023

LDA uncertainty index

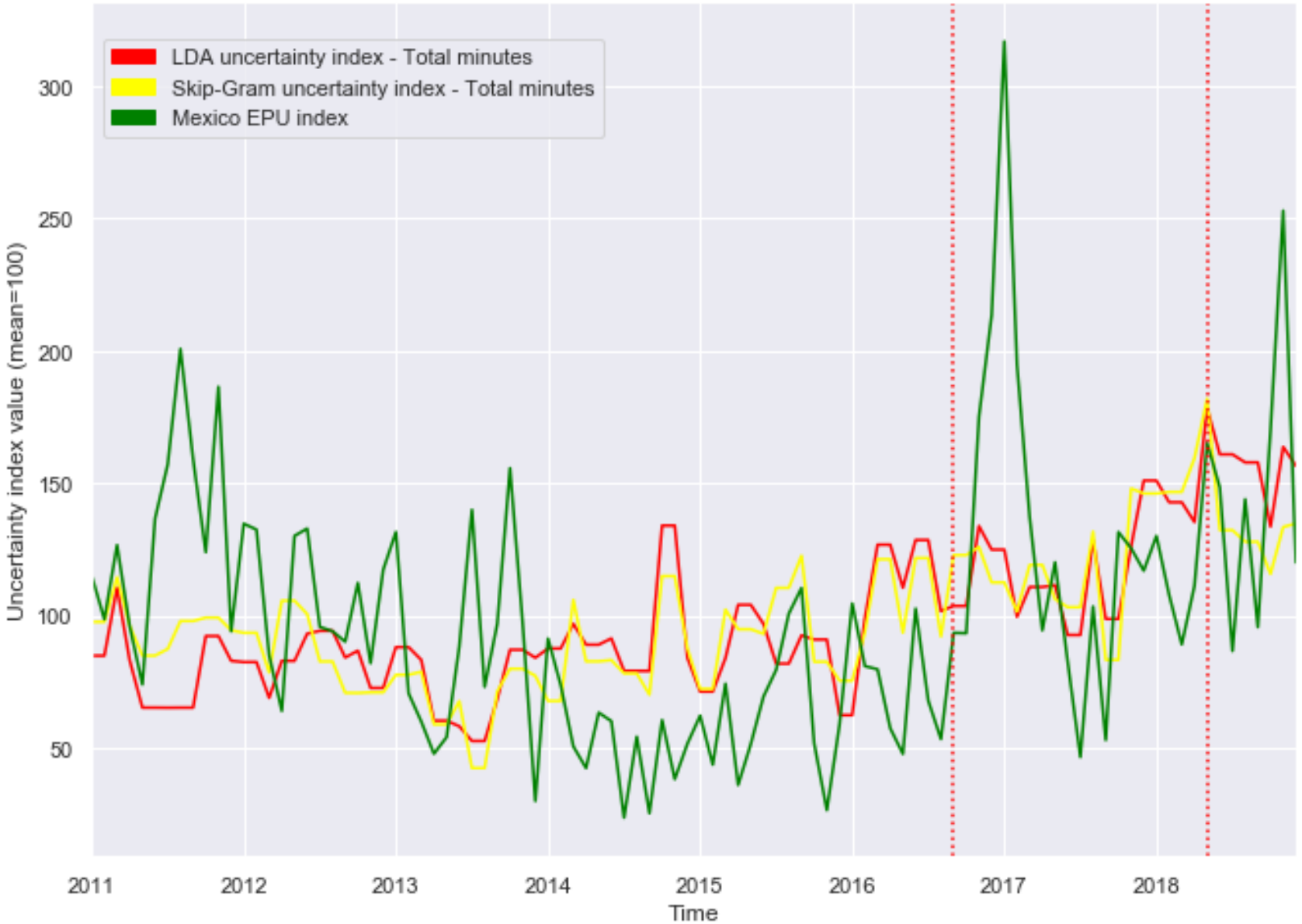
- In particular, we are interested in **topic 5** since it comprises words related to 'risk' and 'uncertainty'.

- Following Bybee et al. (2020), we use the weighting of topic 5 to construct an uncertainty index for the minutes, called **LDA uncertainty index**

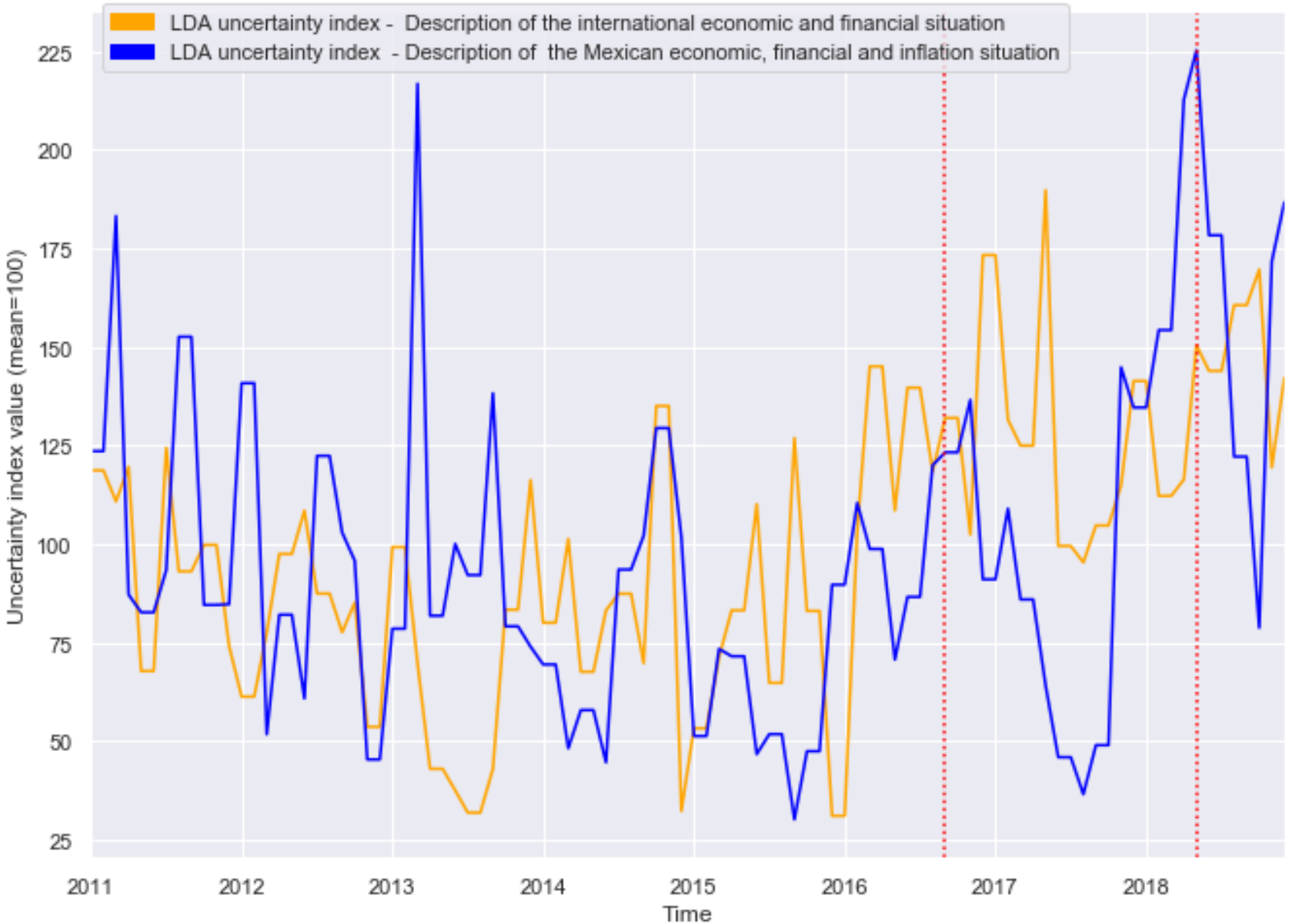
$$R_s = 100 \frac{U_s}{\frac{1}{M}\sum_{m=1}^{M} U_m}, \tag{1}$$

- We compute the LDA uncertainty index for each one of the following **sections** of the minutes:
  1. Description of the **international** economic and financial situation;
  2. Description of the **Mexican** economic, financial and inflation situation;
  3. **Analysis** and **rationale** behind the governing board vote;
  4. Monetary policy **decision**.

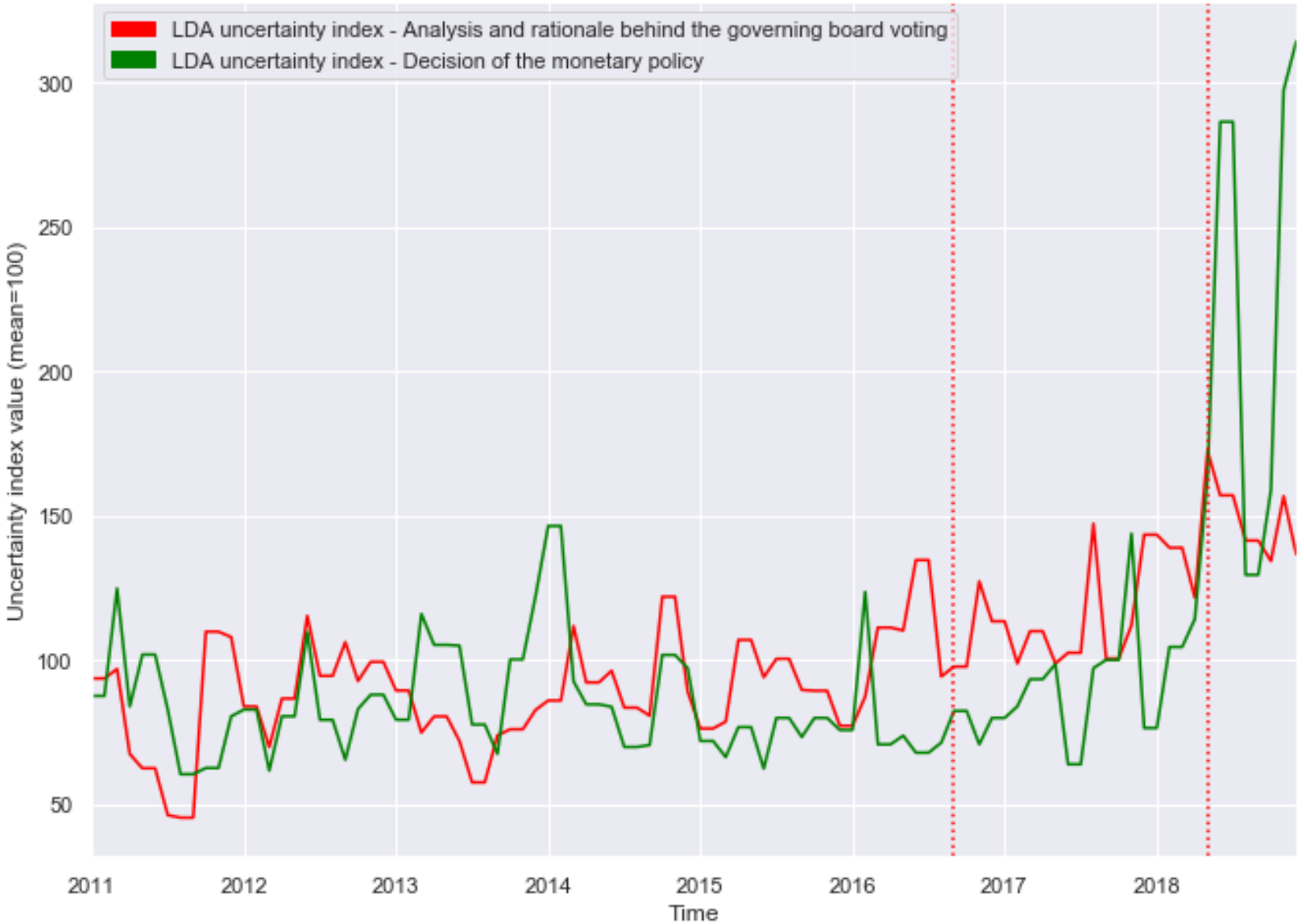
LDA uncertainty index



LDA section uncertainty indices



LDA section uncertainty indices



Skip-Gram

- **Word Embeddings** were introduced by Mikolov et al. (2013).

- Word Embeddings are continuous **vector representations of words** that preserve syntactical and semantic similarities between words in a Euclidean Space, having a limited number of dimensions.

1. the economy experienced growing **uncertainty** about the growth capacity,
2. the economy experienced growing **concerns** about the growth capacity,

- In this case, the **Skip-Gram** model (Mikolov et al., 2013) puts the vectors of words with similar meanings, such as **uncertainty** and **concerns**, into the same part of the vector space since they appear in the same context.

Skip-Gram

- The Skip-Gram model is a neural network method that tries to predict context words given a center word.
- For instance, in the first sentence above, **uncertainty** is the input or center word. The rest of the words are output or context words:

$$\underbrace{\text{economy experienced growing}}_{\text{Output}} \quad \underbrace{\textbf{uncertainty}}_{\text{Input}} \quad \underbrace{\text{about the growth capacity}}_{\text{Output}}$$

- The Skip-Gram model gives the probability distribution of each of the context words depending on the center word, uncertainty in this example. For instance, $P(\textit{growing} \mid \textit{uncertainty})$ or $P(\textit{about} \mid \textit{uncertainty})$.
- For each word ($t = 1, ..., T$), the number of the words in the context is given by the size of the **window**, m, that determines the number of context words before and after each center word.

K-Means

- **K-Means Clustering** is an unsupervised machine learning technique that tries to cluster observations close to each other in the input space.

- In this paper, we use **K-Means** to cluster the vectors from the Word Embeddings into C disjoint groups (clusters). We then identify the cluster that encompasses the words related to 'uncertainty' as in Soto (2019).

- Words in the **same clusters** have **similar meanings**. We put all the words in the clusters containing 'incertidumbre' (**uncertainty**), 'incierto' (**uncertain**), 'inquietud' (**unease** or **concern**) and 'riesgo' (**risk**) in the same list of words.

- We use this list as our **dictionary** related to the sentiments **'uncertain'** and **'risk'**.

‘Uncertainty’ dictionary

List of words of the cluster containing the word ‘uncertainty’.
américa, electoral, entorno_externo, eventos, evolución_desfavorable, factores_externos, incertidumbre, incertidumbre_asociada, incertidumbre_relacionada, interés_externas, libre_comercio, moneda_nacional, negociación, negociaciones, norte_tlcan, nuevo_episodio, nuevos_episodios, presionada, proceso_electoral, puede_descartarse, reacción_adversa, recrudecimiento, renegociación, tlcan, tratado, turbulencia, volatilidad_financiera.

Skip-Gram uncertainty index

- We construct an uncertainty index for the minutes of the Central Bank of Mexico using the **'uncertainty'** dictionary.

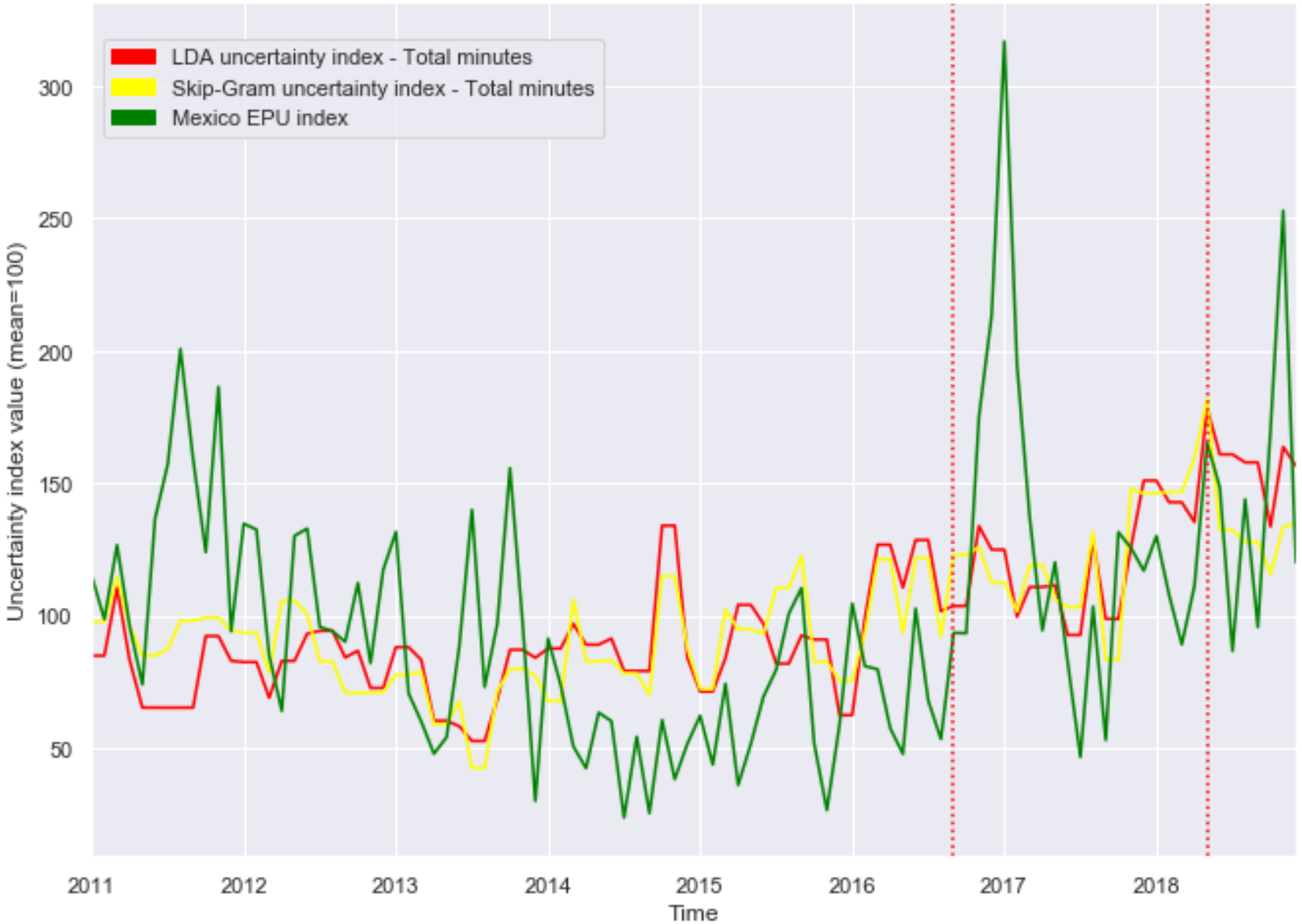
- To construct this uncertainty index, called **Skip-Gram uncertainty index**, we proceed as follows

$$S_s = T_s / N_s, \tag{2}$$

$$D_s = 100 \ \frac{S_s}{\frac{1}{M}\sum_{m=1}^{M} S_m}. \tag{3}$$

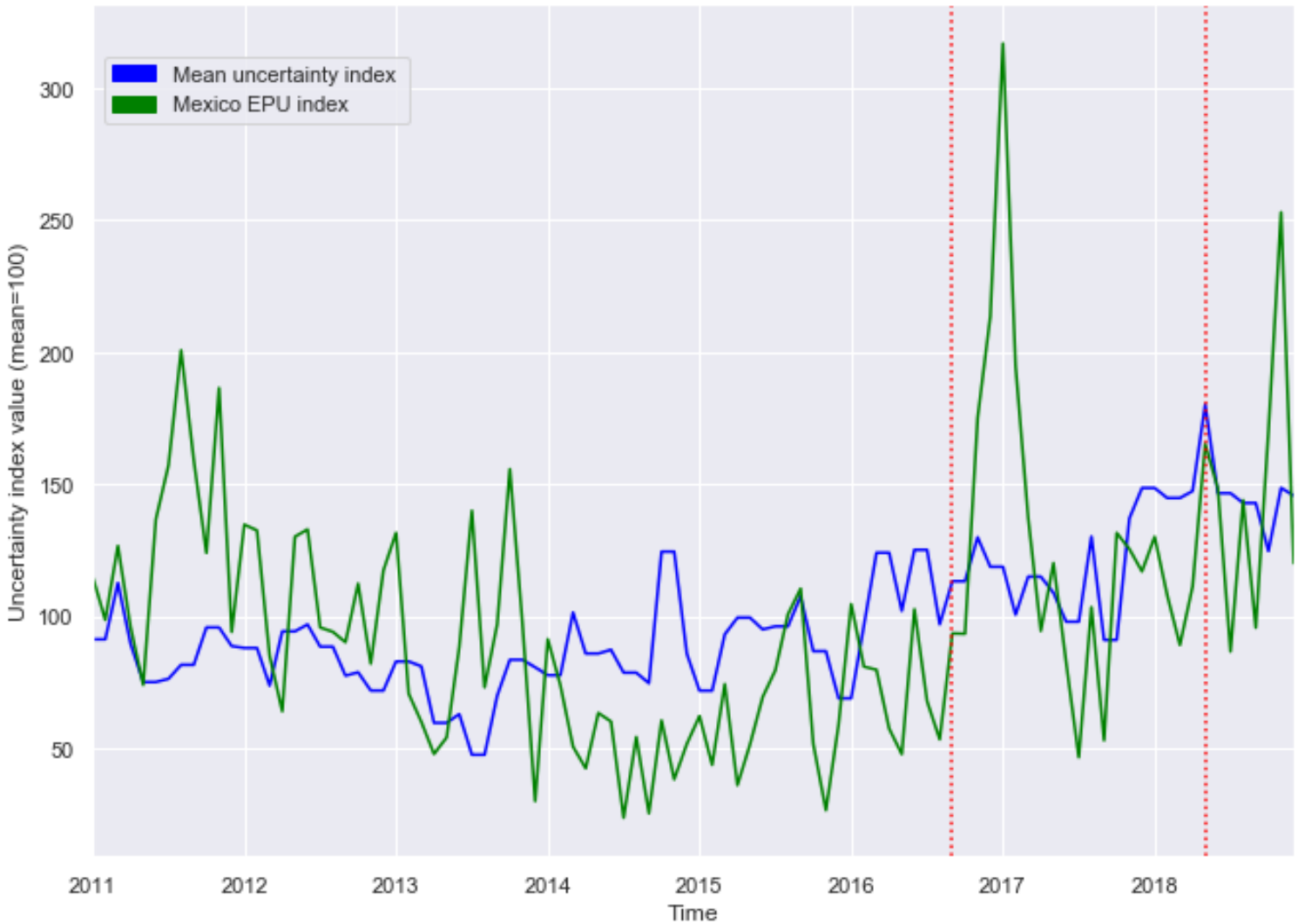
- We follow the same procedure to create the Skip-Gram uncertainty indices for the main **sections** of the minutes as we did for LDA.

Skip-Gram and LDA uncertainty indices



Mean uncertainty index

Finally, we create the **mean uncertainty index** as the mean of the Skip-Gram and the LDA uncertainty indices.



Structural VAR: relating uncertainty to monetary and financial variables

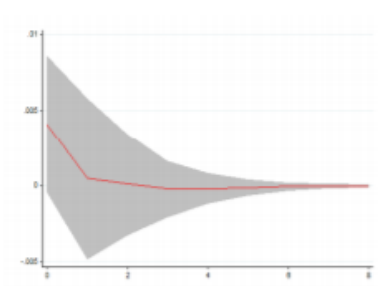
- We investigate how uncertainty in the minutes of the meetings of the Bank of Mexico board of governors affects the key financial variables for monetary policy such as the inter-bank rate. For this purpose, we estimate a **Structural VAR** model as follows:

$$B_0 Y_t = \sum_{i=1}^{p} B_i Y_{t-i} + \omega_t. \tag{4}$$

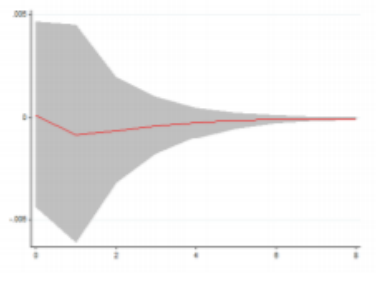
- In this model, the vector $Y_t = [\Delta f_t, \Delta i_t, \Delta m_t, \Delta e_t, \Delta \pi_t]$.

Structural VAR

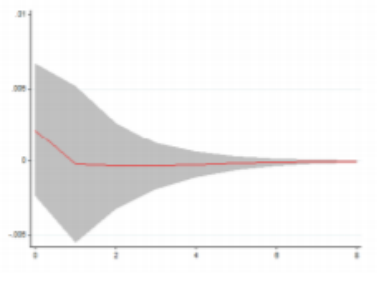
Inter-bank rate responses to an uncertainty shock.



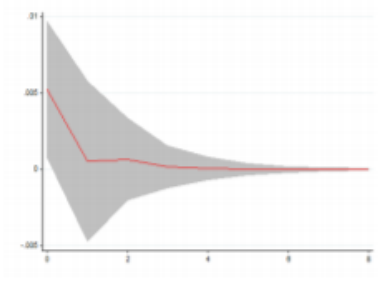
(a) LDA uncertainty index



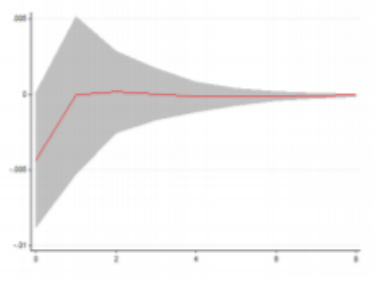
(b) Skip-Gram uncertainty index



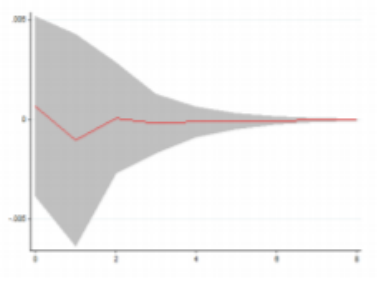
(c) Mean uncertainty index



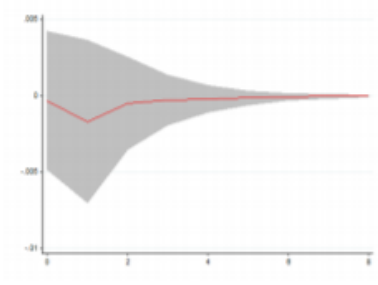
(d) LDA 'international' section UI



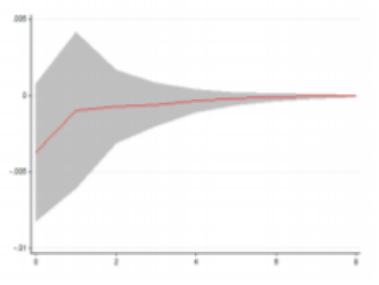
(e) LDA 'Mexican' section UI



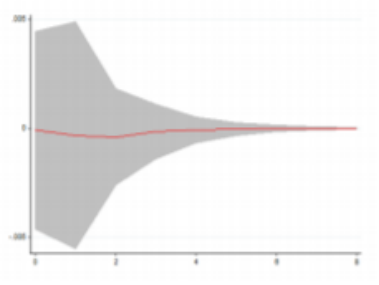
(f) LDA 'analysis' section UI



(g) Skip-Gram 'international' section UI



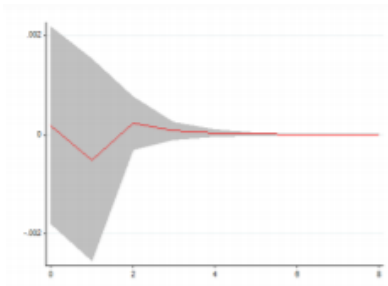
(h) Skip-Gram 'Mexican' section UI



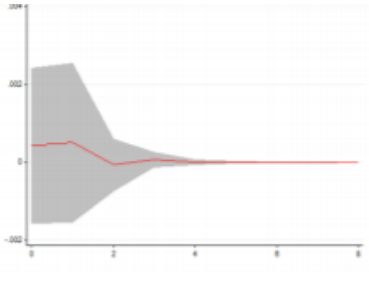
(i) Skip-Gram 'analysis' section UI

Structural VAR

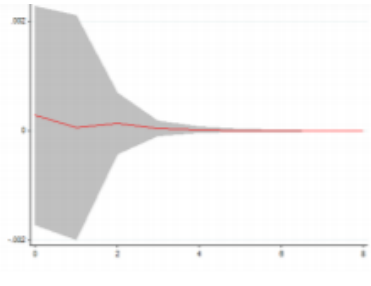
M3 responses to an uncertainty shock.



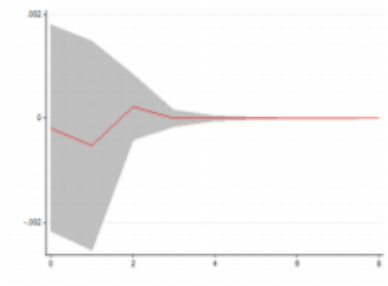
(a) LDA uncertainty index



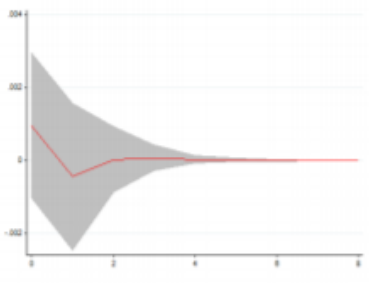
(b) Skip-Gram uncertainty index



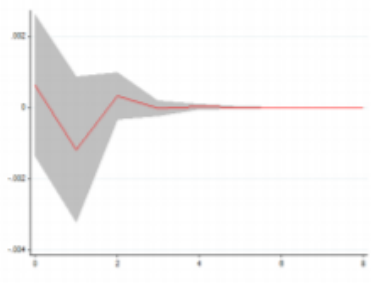
(c) Mean uncertainty index



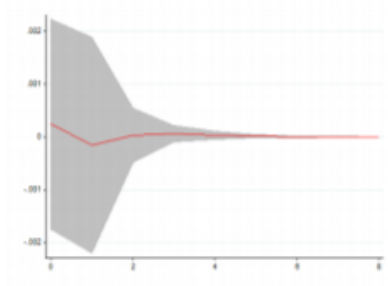
(d) LDA 'international' section UI



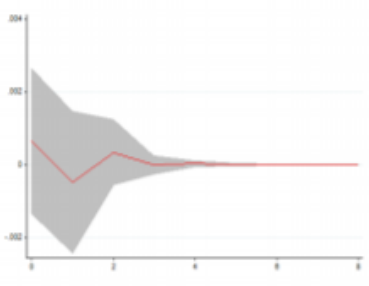
(e) LDA 'Mexican' section UI



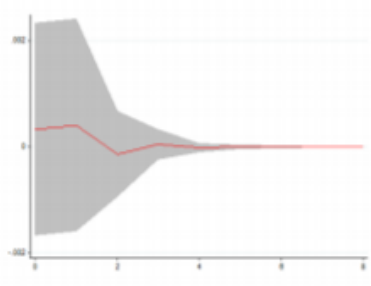
(f) LDA 'analysis' section UI



(g) Skip-Gram 'international' section UI



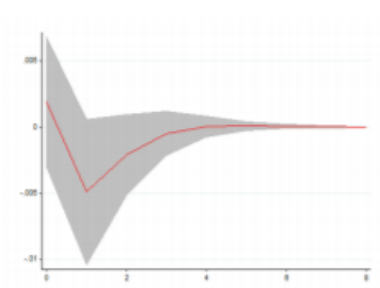
(h) Skip-Gram 'Mexican' section UI



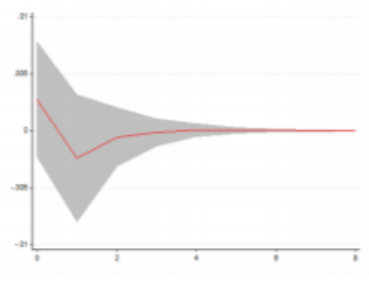
(i) Skip-Gram 'analysis' section UI

Structural VAR

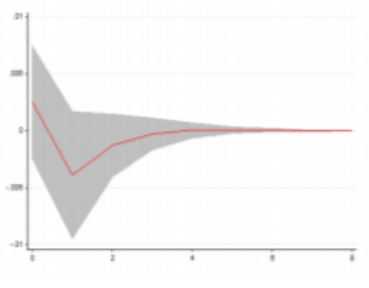
Exchange rate responses to an uncertainty shock.



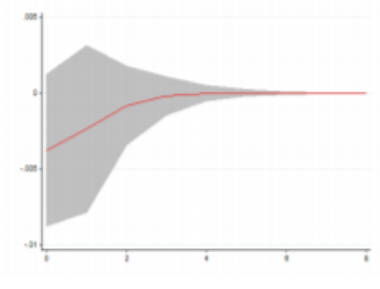
(a) LDA uncertainty index



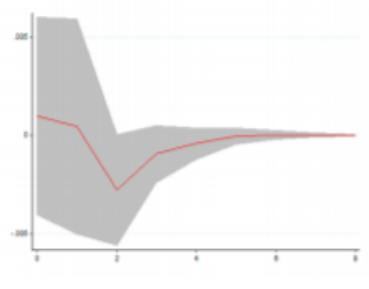
(b) Skip-Gram uncertainty index



(c) Mean uncertainty index



(d) LDA 'international' section UI



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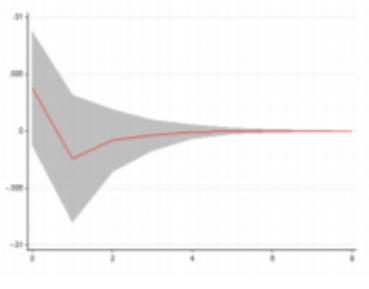
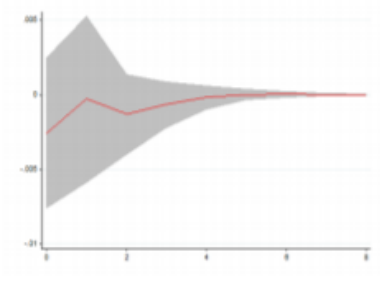
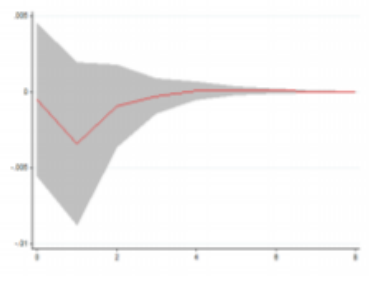


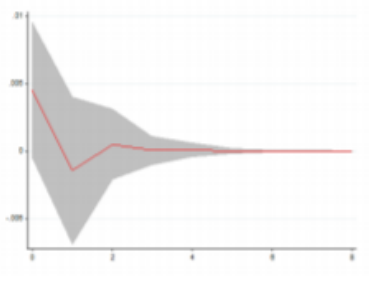
(f) LDA 'analysis' section UI



(g) Skip-Gram 'international' section UI



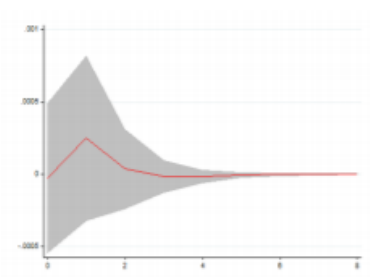
(h) Skip-Gram 'Mexican' section UI



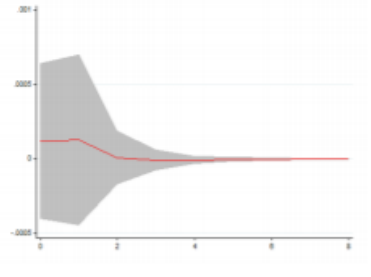
(i) Skip-Gram 'analysis' section UI

Structural VAR

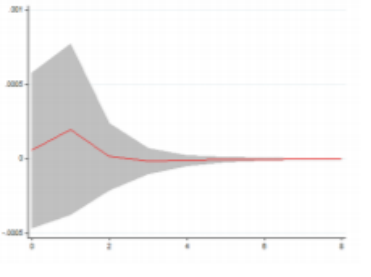
Consumer price index responses to an uncertainty shock.



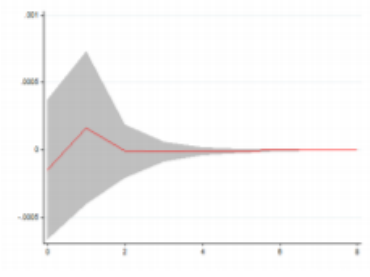
(a) LDA uncertainty index



(b) Skip-Gram uncertainty index



(c) Mean uncertainty index



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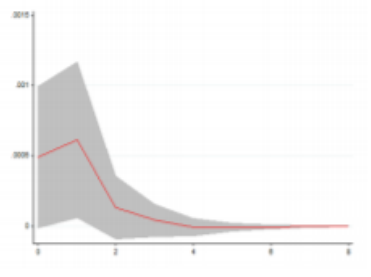

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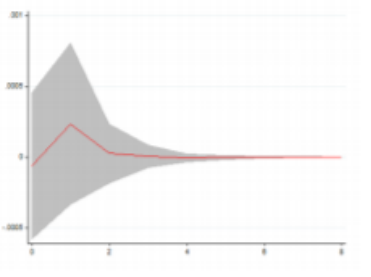
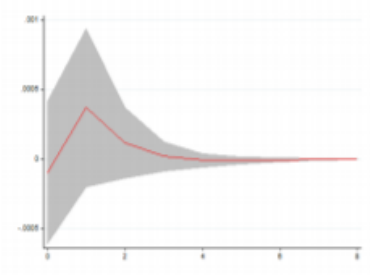
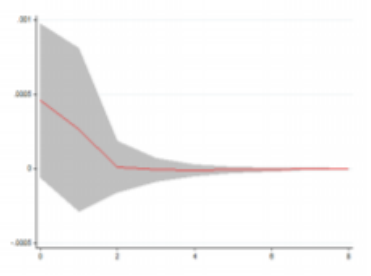


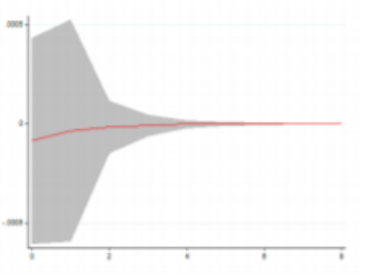
(f) LDA 'analysis' section UI



(g) Skip-Gram 'international' section UI



(h) Skip-Gram 'Mexican' section UI



(i) Skip-Gram 'analysis' section UI

Conclusion

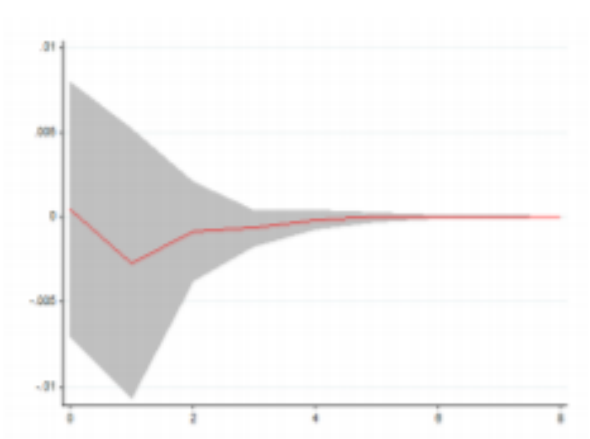
- We construct uncertainty measures with unsupervised machine learning techniques using the **Spanish version of the minutes of Banxico**.
- **Future research** could use other machine learning techniques to create sentiment indices for the Banxico minutes or use more complex models to analyze the impact on the markets.

Thank you for your attention!

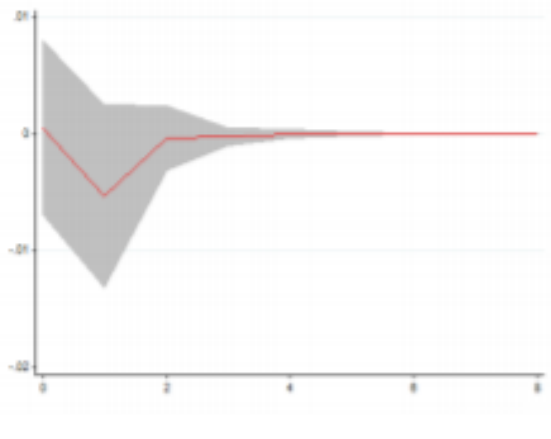
Questions and suggestions?

Structural VAR

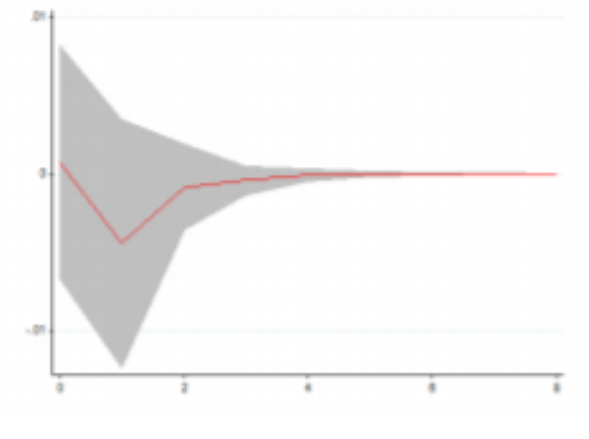
Target interest rate responses to an uncertainty shock.



(a) LDA uncertainty index



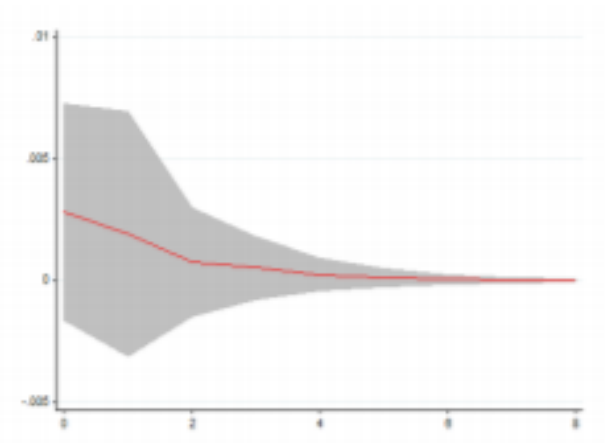
(b) Skip-Gram uncertainty index



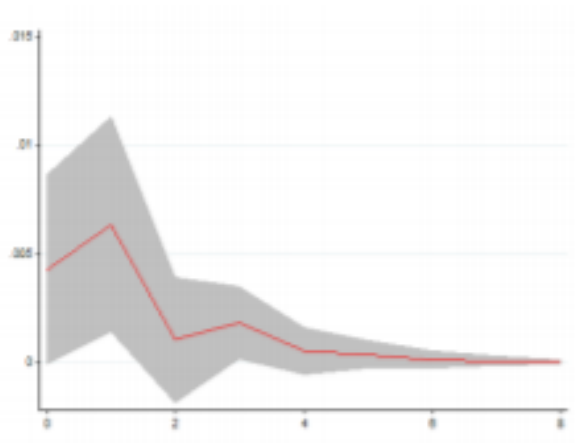
(c) Mean uncertainty index

Structural VAR

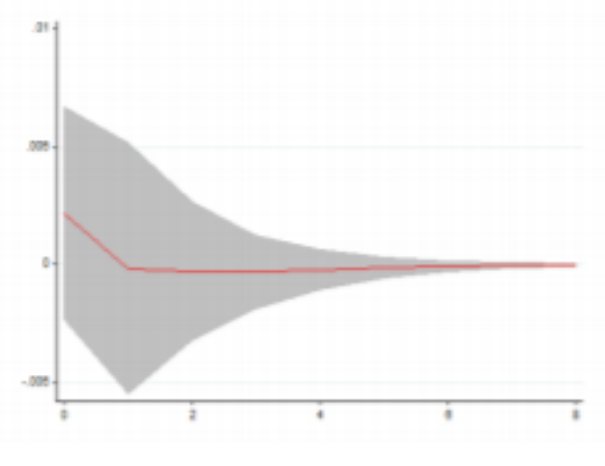
Inter-bank rate responses to an uncertainty shock.



(a) Global EPU index



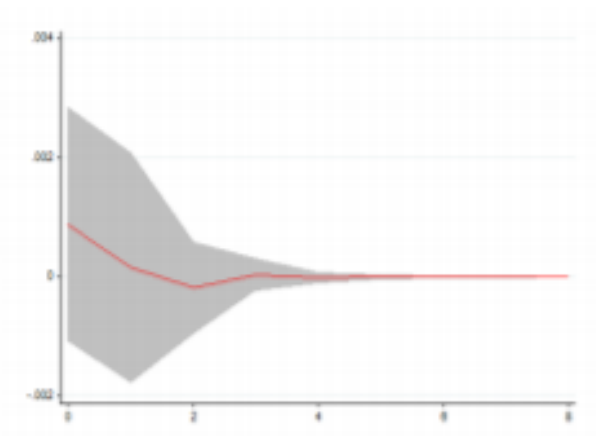
(b) Mexico EPU index



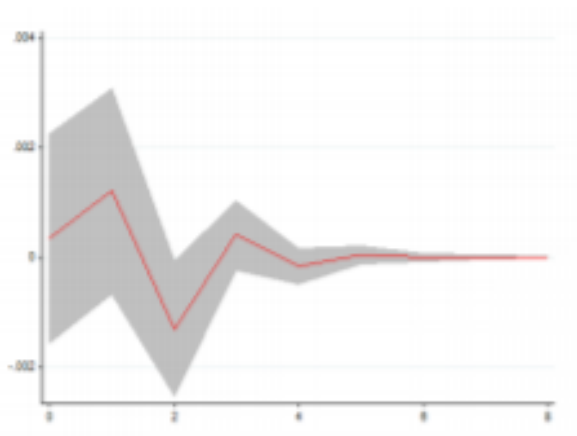
(c) Mean uncertainty index

Structural VAR

M3 responses to an uncertainty shock.



(a) Global EPU index



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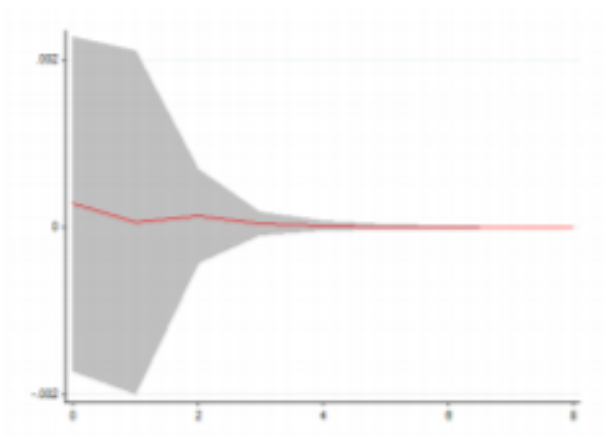
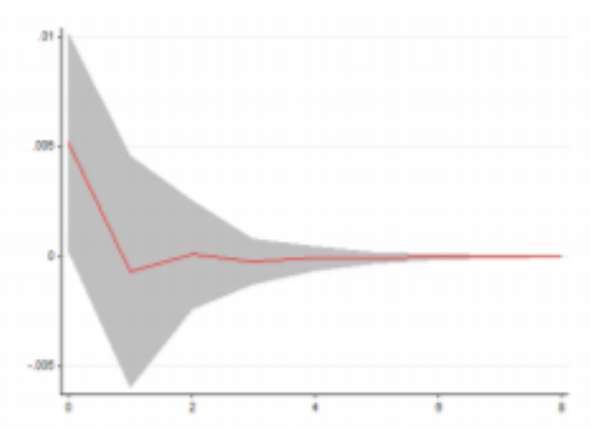


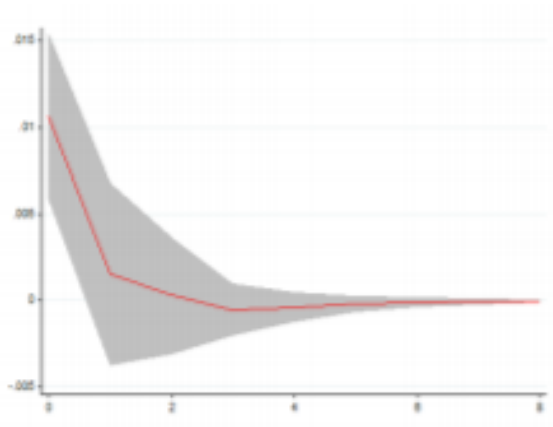
(c) Mean uncertainty index

Structural VAR

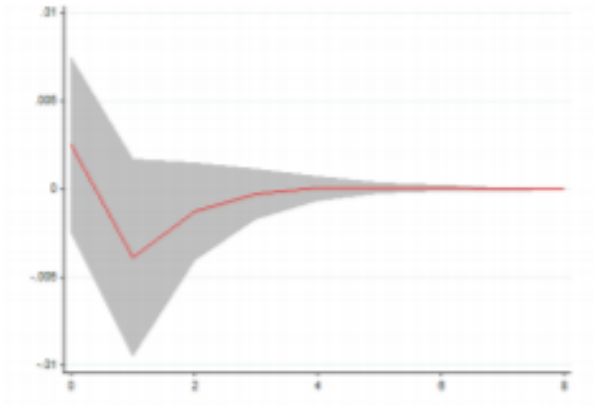
Exchange rate responses to an uncertainty shock.



(a) Global EPU index



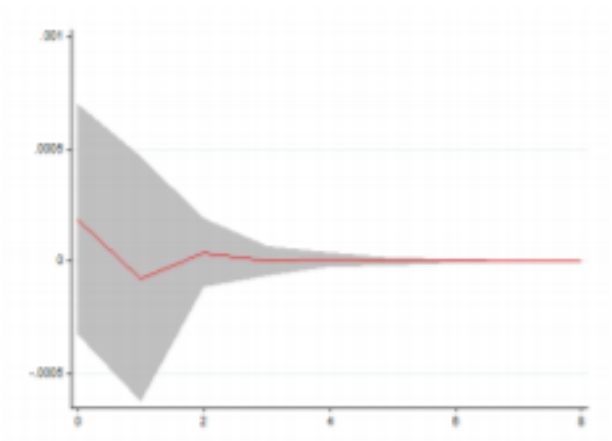
(b) Mexico EPU index



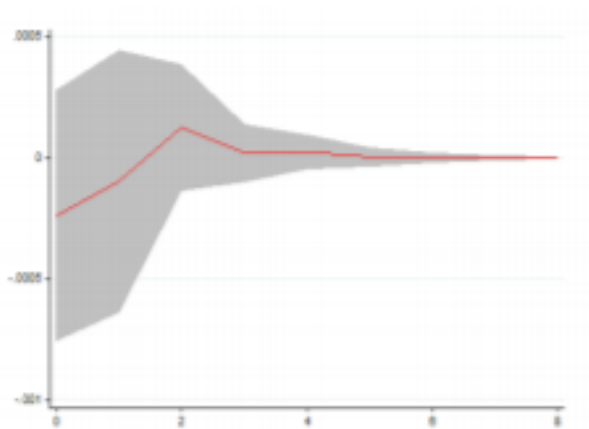
(c) Mean uncertainty index

Structural VAR

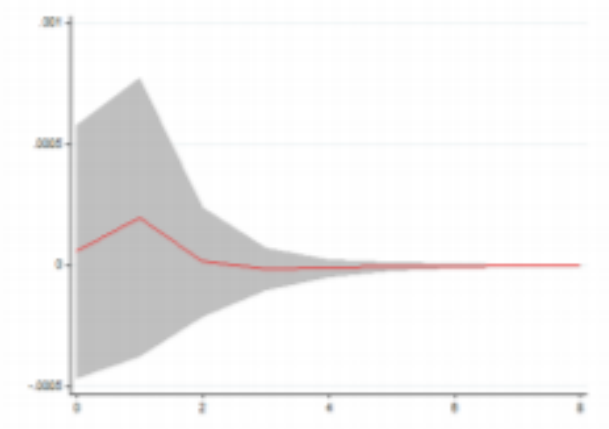
Consumer price index responses to an uncertainty shock.



(a) Global EPU index



(b) Mexico EPU index



(c) Mean uncertainty index