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Uncertainty and Economic Activity: Does it Matter for Thailand?

by

Tosapol Apaitan, Pongsak Luangaram and Pym Manopimoke

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Uncertainty and Economic Activity: Does it Matter for Thailand?*

Tosapol Apaitan Pongsak Luangaram Pym Manopimoke†

Abstract

This paper investigates the role of domestic and foreign uncertainty shocks for macroeconomic dynamics in Thailand. We construct and compare various indicators of economic and policy uncertainty, including macroeconomic and financial uncertainty, as well as monetary policy, fiscal policy, and political uncertainty. We find that while all uncertainty measures display countercyclical behavior, they generate heterogenous effects on real GDP and its components depending on the type of shock. In general, the magnitude of real activity decline in response to economic and policy uncertainty shocks are on the scale of 1-2 percent, with most of the transmission occurring through investment and trade flows rather than consumption demand. In terms of persistence, Thai macroeconomic uncertainty shocks generate sudden impacts, while the effect of other shocks on the economy are more gradual. Despite being a small open economy, we find that domestic uncertainty shocks can be as prominent as uncertainty shocks that spillover from abroad. Thai monetary policy shocks generate declines in real activity that are as large and persistent as US financial uncertainty shocks, whereas the impact of both Thai fiscal policy uncertainty and US economic policy are both rather short-lived. Furthermore, we find that uncertainty is a key driver of fluctuations in domestic output, with certain types of uncertainty being able to explain up to 40 percent of the variation in real activity, even in the long run. Finally, we observe asymmetry in the effects of downside versus upside economic uncertainty shocks, but no difference between uncertainty of short versus long horizons.

Keywords: economic, policy, uncertainty, emerging market, spillovers.

JEL Classifications: D81, E32, F42

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†Apaitan: Section Head, Puey Ungphakorn Institute for Economic Research, Bank of Thailand, E-mail: TosapolA@bot.or.th; Luangaram: Assistant Professor, Department of Economics, Chulalongkorn University, E-mail: pluangaram@gmail.com; Manopimoke (Corresponding Author): Section Head, Puey Ungphakorn Institute for Economic Research, Bank of Thailand, E-mail: PymM@bot.or.th.

1 Introduction

During recent years, economic and policy uncertainty and their macroeconomic effects have gained widespread attention. Policymakers often cite heightened levels of uncertainty as a key factor in the Great Recession and its subsequent weak recovery (FOMC, 2009; Balta et al., 2013). Despite being an intuitive concept, measuring uncertainty is notoriously difficult because it is not directly observable. Furthermore, uncertainty comes in various forms, ranging from macroeconomic, financial, geopolitical, policy to firm-level uncertainty. Nevertheless, various measures have been proposed in the recent literature, and their countercyclical effects on real activity have been well documented (see Bloom, 2009; Bachmann et al., 2013; Jurardo et al., 2015; Rossi and Sekposyan, 2015; Baker et al., 2016, Ludvigson et al., 2016; Carriero et al. 2018, among others).

In this paper, we adopt well-known approaches to construct proxies of uncertainty for Thailand, and analyze its dynamic impact on the economy. Our contributions to the literature are threefold. First, existing work that examines the effects of uncertainty tends to focus on the experiences of advanced economies. A few exceptions include, for example, Ahir et al. (2018), where the authors construct a world uncertainty index covering 143 countries by text-mining the Economist Intelligence Unit country reports. Carrière-Swallow et al. (2013) investigate the effect of a global uncertainty shock as proxied by the VXO index, and show that emerging countries experiences more detrimental and prolonged declines in investment and consumption when compared to advanced economies due to reasons such as stronger credit constraints in the face of more shallow financial markets. Another study in similar spirit to ours is Cerda et al. (2018), where they construct an uncertainty measure for an emerging country, namely Chile, and analyzes its effects on real activity. They find that as an emerging country, increases in uncertainty delivers relatively large declines for real economic activity, even in the long-run. To enhance our overall understanding about the role and propagation mechanism of uncertainty shocks in different country settings, our goal is to add to this literature evidence from Thailand, an emerging, small open-economy in Asia.

Second, the bulk of past studies often focus on analyzing the effects of a particular type of uncertainty shock on a single real activity measure, making it difficult to draw any comparisons across the various types of uncertainty shocks and their impact on macroeconomic aggregates. At most, a few authors examine the distinctive effects of macroeconomic versus financial uncertainty (Redl, 2017; Ludvigson et al. 2018). Here, we aim to provide a highly comprehensive view of uncertainty by constructing as many proxies for uncertainty as possible for Thailand, covering macroeconomic, financial, and policy uncertainty shocks along different dimensions including monetary policy, fiscal and political uncertainty. We then compare how RGDP and its components respond to innovations from these various indicators to gain a deeper understanding about the behavior and propagation mechanism of uncertainty shocks. Finally, to bring an even more holistic view to our study, we also investigate differences between the term structure of uncertainties, asymmetries that might exist between upside and downside uncertainty, as well as performing forecast error variance decompositions to examine the share of macroeconomic fluctuations that can be explained by uncertainty at short, medium, and long-run horizons.

Last, against the backdrop of rapid globalization in trade and financial markets, growing concerns have also been voiced regarding the spillover effects of economic and policy uncertainty in advanced countries towards the boom-bust cycle of emerging market economies (Colombo, 2013; IMF, 2013; Berger et al. 2016). Thailand is a small open economy that is highly susceptible to external shocks, thus making it a natural candidate to study the effects of foreign uncertainty shocks on the economy. Therefore in this study, a few important questions that we focus on are, how relevant are foreign uncertainty shocks for the economy vis-à-vis country-own shocks, and does the type of uncertainty shock matter? While there have been some research along this direction, most focus on the Euro area. For example, Colombo (2013) finds that US policy uncertainty shocks have a deeper spillover effect on real activity in the Euro area than Euro area policy uncertainty itself. Nevertheless, very few similar attempts have been made for emerging market economies, and even those that do only focus on the impact of foreign uncertainty alone (see Carrière-Swallow et al., 2013, Bhattarai et al., 2019). As a result, there is no comparison on how the magnitude of these foreign uncertainty shocks compare to within-country ones, thus making it difficult to draw any insight on how domestic monetary policy should handle as well as prioritize their response to uncertainty shocks of different types.

A preview of our main results are as follows. First, all of our uncertainty measures are countercyclical with respect to real economic activity. In general, the decline in RGDP is approximately one percent for all shocks, with investments and exports contracting more in response to an uncertainty shock by about one to two percent, and consumption less so by about half a percentage point. Second, the persistence of the decline in real activity varies to a large extent depending on the type of shock. Domestic macroeconomic uncertainty shocks cause real activity to fall immediately upon impact, while other uncertainty shocks effect the economy more gradually. Third, neither domestic nor foreign shocks are more or less malignant for real activity - it is the type of shock that matters. Both US financial uncertainty and Thai monetary policy uncertainty shocks generate equally large and long-lasting effects on real activity. On the other hand, the impact of a US EPU shock and a domestic fiscal policy shock are more or less benign for the economy as their effects are rather fleeting. Fourth, uncertainty is a key driver of economic fluctuations in both the short and long run. Depending on the type of shock, the share of variation explained can be as high as 40 percent even in the long-run. Finally, real activity responds to short versus long run uncertainty in the same way, but its response is asymmetric towards downside versus upside uncertainty.

The remainder of the paper is organized as follows. Section 2 provides an overview of the various methods we adopt to construct uncertainty measures for Thailand, while Section 3 compares the various indicators and analyzes their overall properties. Section 4 outlines the empirical set up, and discusses the impact of the various types of uncertainty shocks for real economic activity. Section 5 presents the forecast error variance decomposition results, and discusses the role of uncertainty as an important driver of economic fluctuations. Section 6 concludes.

2 Measuring Uncertainty

Uncertainty is inherently unobservable, thus its measurement is a challenging task. Furthermore, uncertainty manifests itself in many forms - macroeconomic, financial, geopolitical, and policy uncertainty. Earlier measures of uncertainty are mostly financial-based, made popular by the influential work of Bloom (2009), whom advocated the use of implied and realized stock market volatilities. However, these measures have been criticized on the grounds that it may also be capturing changes in sentiment or risk aversion of investors. Subsequent studies also propose measuring uncertainty from the cross-sectional dispersion of survey-based forecasts (Bachmann et al., 2013). Survey measures however, have been shown to be an imperfect proxy for evaluating uncertainty (see Rich and Tracy, 2010; Abel et al. 2016), and are often constructed based on a single economic indicator, making it difficult to generalize to the aggregate economy.

More recently, there has been a growing number of improved measures of uncertainty. For example, Jurardo et al. (2015) (hereafter JLN) introduced a broad-based measure of aggregate uncertainty, extracted from a large number of macroeconomic and financial time series based on a diffusion index and stochastic volatility models. The model defines uncertainty as the common variability in the purely unforecastable component of the future value of these variables, thus unlike previous measures, it appropriately captures uncertainty as the second rather than first moment shock[1]. Another advantage of the JLN approach is that it is able to produce uncertainty measures for various future forecasting horizons, creating a distinction between short and long term uncertainty. Rossi and Sekhposyan (2015) (hereafter RS) developed a measure of uncertainty based on the position of the realized forecast error in the historical forecast error distribution obtained from surveys of professional forecasters. Since the forecast error can lie on either side of the mean of the distribution, they are able to distinguish between 'upside' and 'downside' uncertainties. Finally, based on textual analysis, Baker et al. (2016) (hereafter BBD) propose a novel economic policy uncertainty (EPU) measure from the frequency count of 'uncertainty-related' keywords in newspaper articles.

In this section, we apply the abovementioned approaches to Thai data and construct four types of uncertainty measures for Thailand with details as outlined below. The first three are classified as *economic uncertainty* and include (i) aggregate macroeconomic and financial uncertainty based on the JLN approach (ii) an index reflecting the Bank of Thailand's (BOT) uncertainty outlook on GDP growth based on the RS approach, and (iii) overall uncertainty measured as the first principal component of economic, financial and survey-based proxies of uncertainty. As the final measure we construct (iv) newspaper-based *economic policy uncertainty* indices in similar spirit to BBD, in which we construct separate indices for monetary policy, fiscal policy, and political uncertainty.

(i) Aggregate Economic Uncertainty

JLN propose a methodology to measure aggregate uncertainty for the US economy as the conditional variance of the unforcastable component common to a large number of macroeconomic and financial variables. Their measure is based on the premise that what matter for agents' decisions is not whether particular economic indicators have become more or less variable or disperse, but whether the economy has become more or less predictable. In this way, their measure of uncertainty is different from existing approaches since it is defined as a deterioration in predictability rather than just volatility. Also, in contrast to previous measures of uncertainty that is often based on a single (or a few) economic indicators, JLN's measure is common to a large set of economic time series that spans many markets and segments.

[1] This is a distinction that earlier measures of uncertainty such as survey-based ones often fail to address. First moment shocks can be thought of as a deterioration in the expected outcome which is not uncertainty, just bad news. Second moment shocks on the other hand is uncertainty, and is defined as a greater range of expected outcomes. Disentangling the two can be difficult, especially since market participants tend to become more pessimistic in the face of greater uncertainty.

Following JLN, several studies construct measures of aggregate uncertainty for countries in the Euro area (see Redl, 2017; Meinen and Roehe, 2017). Here, we apply the JLN methodology to construct aggregate measures of uncertainty for Thailand. We construct two types of aggregate uncertainty measures - macroeconomic and financial. While readers should refer to JLN for full details of the econometric approach, the authors' methodology is briefly summarized here for ease of reference.

First, let y^C_{jt} be a variable in either the macro or financial category. Its forecast, $E[y^C_{jt+h}|I_t]$ can be estimated from the following factor augmented forecasting model:

$$y^C_{jt+1} = \phi^y_j(L)y_{jt} + \gamma^F_j(L)\mathbf{\hat{F}_t} + \gamma^W_j(L)\mathbf{W_t} + v^y_{jt+1} \tag{1}$$

where $\phi^y_j(L), \gamma^F_j(L), \gamma^W_j(L)$ are finite-order polynomials. The factors $\mathbf{\hat{F}_t}$ are drawn from the information set I_t which is approximated by the full data set which contains both macroeconomic and financial time series variables[2]. $\mathbf{W_t}$ contains additional predictors that are meant to capture possible nonlinearities such as the squares of the first component of $\mathbf{\hat{F}_t}$. In the model, the prediction error for $y^C_{jt+1}, \mathbf{\hat{F}_t}, \mathbf{W_t}$ are permitted to have time-varying volatility $\sigma^y_{jt+1}, \sigma^F_{kt+1}, \sigma^W_{lt+1}$ respectively, which generates time-varying uncertainty in the overall series y^C_{jt}.

From Eq (1), we compute the forecastable component $E[y^C_{jt+h}|I_t]$ which form the basis of our uncertainty measures. More specifically, we calculate the forecast error as $V^{y^C}_{jt+h} = y^C_{t+h} - E[y^C_{jt+h}|I_t]$, where the conditional volatility of this forecast error $E[(V^{y^C}_{jt+h})^2|I_t]$ is then generated based on a parametric stochastic volatility model for the one-step-ahead prediction errors in y^C_{jt} and the factors. Then, using a recursive method, we can estimate $E[(V^{y^C}_{jt+h})^2|I_t]$ for future horizons $h > 1$. As discussed in JLN, the stochastic volatility modelling approach allows for shocks to the second moment of a variable to be independent from the first moment, consistent with theoretical models of uncertainty which presumes the existence of an uncertainty shock that independently affects y_j.

Finally, uncertainty about the variable y^C_{jt} at horizon h can be computed as:

$$U^{y^C}_{jt}(h) \equiv \sqrt{E[(V^{y^C}_{jt+h})^2|I_t]} \tag{2}$$

[2]To provide a guide for factor estimation, we use the Bai and Ng (2002) information criterion (IC) to select the number of factors. The IC suggests 3 factors which explains only 21 percent of the variation in the dataset, where the first three factors loads heavily on real activity measures such as retail sales and the manufacturing production index, the SET index and return on its components, and government bond rates respectively. Since the variation explained by the three factors are rather low we also consider extracting 18 factors which can explain at least half of the variation of series in the dataset. However, we find that whether using 3 or 18 factors provides aggregate uncertainty measures that are not statistically significantly different, thus we use 3 factors in our empirical investigation.

which measures uncertainty as the conditional volatility of the purely unforecastable component of the h-step-ahead realization of each underlying macroeconomic and financial time series based on available information at time t. We follow JLN and assume equal weights $w_j = \frac{1}{N_C}$ to arrive at the aggregate uncertainty measure[3]:

$$U_t^{y^C}(h) \equiv plim_{N\to\infty} w_j U_{jt}^{y^C}(h). \tag{3}$$

Based on Eq (3), we compute the macroeconomic and financial uncertainty measures by aggregating the conditional variances of the unforecastable components over variables that either belong to the macroeconomic or financial categories. For both measures, we compute uncertainty for the forecasting horizons $h = 1, 4$, and 8 quarters, where we henceforth refer to these indices as $M1, M4, M8, F1, F4$, and $F8$ respectively. The underlying dataset for these indices comprise of quarterly macroeconomic and financial data obtained from the Bank of Thailand and the Stock Exchange of Thailand databases over the 2002Q1-2018Q4 sample. Readers are referred to Appendix A for details on the full dataset, transformations employed to ensure stationarity, as well as the classifications for macroeconomic and financial based variables.

(ii) Bank of Thailand's Economic Uncertainty

The Bank of Thailand gives an explicit account of its uncertainty estimate around the economic outlook for main macroeconomic variables such as GDP and inflation by publishing its forecasts in the form of a fan chart and and a table revealing the probability density of forecasts (pdf) in quarterly Monetary Policy Reports. Table 1 shows an example of GDP growth projections from the September 2017 forecast round, where each row represents the probability that the realized outcome will fall within a given range.

We translate series of these quarterly fan charts into BOT uncertainty measures. In doing so, we first uncover the underlying forecast distribution from the fan chart according to a method described in Appendix B, then apply the method of RS[4]. According to the RS approach, macroeconomic uncertainty is quantified by comparing the realized forecast error to the percentile in the historical distribution of

[3]Other weighting schemes are also possible such as by employing the principal component analysis (PCA) approach. We follow JLN and construct these measures as part of our robustness checks, and find that final indices do not differ significantly.

[4]The original index of RS is based on the the Survey of Professional Forecasters' (SPF) forecasts of Real Gross Domestic Product (RGDP) for the US. However, SPF data for RGDP in Thailand only covers a short sample range which is insufficient to build a reliable pdf. Therefore, we rely on the distribution of forecast errors as implied by the BOT's fan chart for RGDP that is published in the BOT's Monetary Policy Report instead.

Figure 1: Probability Distribution of the Bank of Thailand's GDP Growth Forecasts

Table: Probability distribution of GDP growth forecast

Percent	2017		2018				2019	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
10-12	0	0	0	0	0	0	1	1
8-10	0	0	1	2	2	3	4	5
6-8	2	9	10	10	12	12	13	13
4-6	37	39	32	27	26	25	24	23
2-4	51	38	35	31	29	28	26	25
0-2	9	12	18	20	19	20	19	18
(-2)-0	0	1	4	8	8	9	10	10
< (-2)	0	0	1	2	3	4	4	5

Source: Bank of Thailand 2017Q3 Monetary Policy Report.

forecast errors. If the realized forecast error fall in the tails of the ex-ante forecast error distribution, it represents a macroeconomic environment that is very uncertain. Note that since the RS approach considers the entire distribution of forecast errors in constructing the uncertainty index, similar to JLN, it is able to separate out the 'second moment' of the forecast error distribution from the mean or the 'first moment'.

Based on the underlying pdf of forecasts, the cumulative density of realized forecast errors can be calculated as:

$$U_{t+h} = \int_{-\infty}^{e_t+h} p(e)de \tag{4}$$

where $e_{t+h} = y_{t+h} - E_t(y_{t+h})$ denotes the actual realized forecast error of output for the $h-$step-ahead horizon, and $p(e)$ is the pdf which could either be defined as the unconditional density of the whole sample (ex-post) or the density of the real-time data (e.g. the data up to forecasting period). Note that by construction, U_{t+h} will fall between zero and one, where a value closer to one denotes a positive 'shock' since the difference between the realized and expected value or the mode of the forecast distribution is large (eg. higher GDP than expected). By similar logic, a value closer to zero represents a negative 'shock' (eg. lower GDP than expected). Consequently, upside and downside uncertainty can be measured as:

$$U^{+}_{t+h} = \frac{1}{2} + max\{U_{t+h} - \frac{1}{2}, 0\} \tag{5}$$

$$U^{-}_{t+h} = \frac{1}{2} + max\{\frac{1}{2} - U_{t+h}, 0\} \tag{6}$$

where by construction, these measures will always be between one-half and one. Finally, the overall index can be written as:

$$U^*_{t+h} = \frac{1}{2} + |U_{t+h} - \frac{1}{2}|. \quad (7)$$

For Thailand, we construct the BOT's positive and negative economic uncertainty measures according to Eqs. (5) and (6) for the $h = 1, 4$, and 8 quarter-ahead forecasting horizons (henceforth referred to as $BOT^{+}1, BOT^{+}4, BOT^{+}8$ and $BOT^{-}1, BOT^{-}4$, $BOT^{-}8$ respectively) as well as an overall measure according to Eq. (7) (henceforth referred to as $BOT^{*}1, BOT^{*}4, BOT^{*}8$ respectively). Due to limitations in the availability of data from BOT fan charts, the BOT uncertainty series span 2002Q2-2017Q3.

(iii) Principal Component Economic Uncertainty

Despite variation among proxies of uncertainty, past studies show that different measures tend to move together, suggesting the existence of a strong common component. Therefore, another popular approach to gauge the level of uncertainty as carried out by Haddow et al. (2013), Forbes (2016) and Redl (2017), among others, is to extract the first principal component (PC) from a swathe of proxies for uncertainty. This approach has the advantage of being able to capture overall uncertainty in an economy along a number of dimensions.

To construct a PC-based measure for Thailand, we extract the first principal component from both macroeconomic and financial based uncertainty measures (henceforth referred to as TPCA), which include: (i) our JLN-based measure of macroeconomic and financial uncertainty (we use the one-quarter ahead indices, $M1$ and $F1$), (ii) the Thai consumer confidence index (CCI), meant to capture the uncertainty outlook of households (iii) the Thai business sentiment index (BSI), meant to capture the uncertainty outlook of firms, (iv) uncertainty in the currency market, measured as the 3-month moving-average of the US dollar to Thai baht exchange rate option implied volatility (USDTHBVOL), and (v) uncertainty in the Thai stock market, proxied by the 60 day moving-average of the Stock Exchange of Thailand (SET50) historical volatility index (SETVOL)[5]. The reason why we exclude our constructed measure of BOT uncertainty from the PC-based index is because unlike other measures, BOT indices are bounded between 0.5 and 1.

[5]Many studies proxy uncertainty with implied volatility of stock returns and exchange rates. The premise of proxying uncertainty with option-implied volatility of equity prices is that it reflect investors' subjective uncertainty about the future outlook of the stock market, as higher uncertainty drives up demand and hence prices for option contracts. Similarly, option-implied volatility of the exchange rate can provide a guide of companies' uncertainty about export receipts or the costs of imported inputs. Unfortunately for Thailand, option-implied volatility measures for equity prices are not available, thus we resort to a moving-average of the historical volatility of the SET50.

(iv) News-based Economic Policy Uncertainty

BBD propose a novel approach to compute US economic policy uncertainty (EPU) based on a frequency count of news stories that are related to uncertainty about the economy or macroeconomic policy. The index is based on the frequency of articles in leading US newspapers that contain the key terms "economic" or "economy"; "uncertain" or "uncertainty" and selected policy terms such as "congress", "deficit", and the "Federal Reserve". To deal with the issue that the overall volume of articles varies across newspapers and time, the raw counts are scaled by the total number of articles in the same newspaper and month, then standardized and averaged across all newspapers before normalizing the series to a mean of 100 over the sample period. Based on a similar approach, the authors also develop EPU indices for various other major economies, which forms the basis of a global economic policy uncertainty index[6]. Many of these indices are for European countries, but EPU indices for advanced Asian economies also exist including those for China, Japan, Australia and Hong Kong (see Baker et al., 2013; Arbatli et al., 2017; Moore, 2017; Luk et al., 2017).

In similar spirit to BBD, we construct news-based uncertainty measures for Thailand. To our knowledge, these will be the first set of news-based policy uncertainty measures for a small developing country in Asia. We extract Thai EPUs from five local newspapers in Thai language, namely Bangkok Biz News, Post Today, Daily News, Matichon and Thairath. Unfortunately, the news database sample is short and only spans 2006M6-2018M5. Although a longer sample exists for English-based news archives from Bloomberg and the Bangkok Post, we opt to use the Thai news archive because unlike the English one, we have access to all text in the articles. The advantage of having access to this wide availability of content is important, because it allows us to construct topic-based EPUs for different types of policy uncertainty such as monetary, fiscal and political. Were we to construct EPU indices from the English-based archives, we would have to rely on keyword searches alone which may not give an accurate and complete representation of policy uncertainty along the different dimensions.

To construct topic-based EPU measures, we follow Azqueta-Gavaldon (2017) and employ the Latent Dirichlet allocation (LDA) method, an unsupervised machine learning algorithm developed by Blei et al. (2003) to help uncover the underlying topics in the full corpus. The steps that we follow are as outlined below:

(i) Select articles in the economics and business section that contain at least two of the following keywords: {"uncertain(ty)", "delayed", "conflict", "crisis", "post-

[6] These measures can be found at http://www.policyuncertainty.com.

pone", "procrastinate"}.

(ii) Screen out articles that are too short (less than 50 words) or too long (more than 1000 words), which leaves us with a total of 13,603 remaining news articles.

(iii) Employ the LDA approach to uncover underlying topics. The LDA assumes a generative process with the following joint distribution:

$$p(\theta, z, w|\alpha, \beta) = p(\theta|\alpha) \prod_{n=1}^{N} p(z_n|\theta) p(w_n|z_n, \beta),$$

where θ is a set document-topic probability, $\beta = \{\beta_1, ..., \beta_k\}$ is a topic-word probability of K topics, α is a parameter governing concentration of the Dirichlet distribution, and $z = \{z_1, ..., z_N\}$ and $w = \{w_1, ..., w_N\}$ are sets of N topics and words respectively. While K and α are given, the model infers θ and β from the data. In this study we use $K = 15$ and all weights in α are equally distributed.

(iv) Construct the EPU index for each topic based on the amount of news describing uncertainty for each topic. More specifically, we first label each article d with its most likely topic (the topic with the highest probability θ_d). The EPU index is then the raw count of the number of articles for each topic within a quarter.

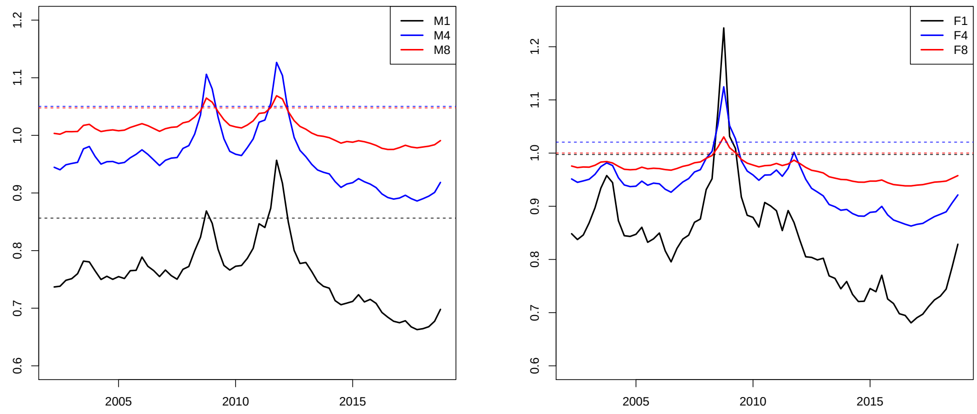
3 Uncertainty Measures for Thailand

In this section, we assess the overall properties of our constructed uncertainty measures. To preserve as much data as possible for the empirical analysis, economic and policy uncertainty indices span different sample periods. Since the sample over which raw data for economic indices are more or less similar, we restrict all economic indices to the same sample period, 2002Q2-2017Q3. The news archive is slightly shorter than this sample, thus topic-based EPUs span 2006Q3-2018Q1.

First, we plot measures of economic uncertainty. Figure 2 shows JLN-based macroeconomic and financial uncertainty indicators at forecasting horizons: $h = 1, 4,$ and 8 quarters. Examining the spikes that occur 1.65 standard deviations above the mean (horizontal dotted line), all series appear to capture heightened economic uncertainty episode during the GFC. In fact, the financial uncertainty proxy displays only one major peak during this time, while the macroeconomic uncertainty indices displays a second, slightly more striking peak during the second half of 2011. During this period, Great floods in Thailand led to severe disruptions in supply chains and production sectors.

We also observe that both macroeconomic and financial uncertainty measures increase with the forecasting horizon h except for at the peaks where uncertainty at shorter horizons dominate and in general, display steeper increases. As the forecasting horizon increases, the variability of aggregate uncertainty also declines. Across the two types of aggregate uncertainty, financial uncertainty indices are slightly more volatile, especially at the short-term horizon, which is not surprising given that financial variables are generally known to exhibit more variability.

Figure 2: Aggregate Economic Uncertainty



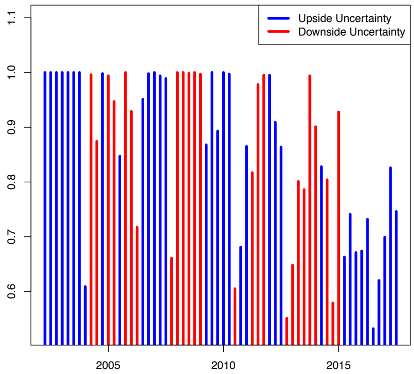
(a) Macroeconomic Uncertainty

(b) Financial Uncertainty

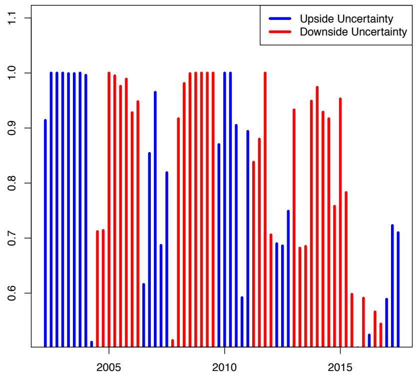
Note: The left and right panels show JLN-based 1, 4 and 8 quarter-ahead macroeconomic and financial uncertainty series ($M1, M4, M8$ and $F1, F4, F8$ respectively). Dashed horizontal lines represent 1.65 standard deviations above the mean for each corresponding uncertainty series.

Next, we examine economic uncertainty extracted from the BOT's published fan charts for GDP growth forecasts. Figure 3 plots upside and downside uncertainty for the horizons h =1, 4, and 8 quarter horizons. Examining upside uncertainty first, we find that upside uncertainty for the Thai economy according to the BOT's forecasts are slightly more pronounced at shorter horizons. Positive uncertainty that remained consistently strong across all forecasting horizons include the pre 2005 period, which was a time of strong economic stability, ample liquidity in financial markets and economic growth exceeding 5 percent. Downside uncertainty on the other hand, appeared consistently over all three horizons during 2006, 2008, and 2013-2015. In 2006, political turmoil led to a military coup towards the end of the year, inducing policy measures to reduce pressure on a rapidly appreciating exchange rate. The 2008 episode corresponds to a severe contraction in real economic activity due to the GFC. The Thai economy also slowed in 2013 inducing a series of policy cuts by the BOT, partly due to weak domestic demand, expired government stimulus measures, and sluggish recovery in exports. Interestingly, upside and downside uncertainty as implied by BOT forecasts are quite distinct when compared to JLN-based measures, highlighting the many dimensions of economic uncertainty.

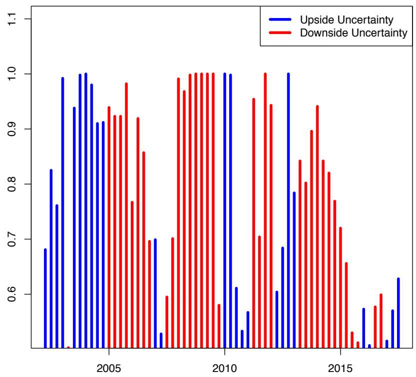
Figure 3: BOT Economic Uncertainty



(a) h=1



(b) h=4

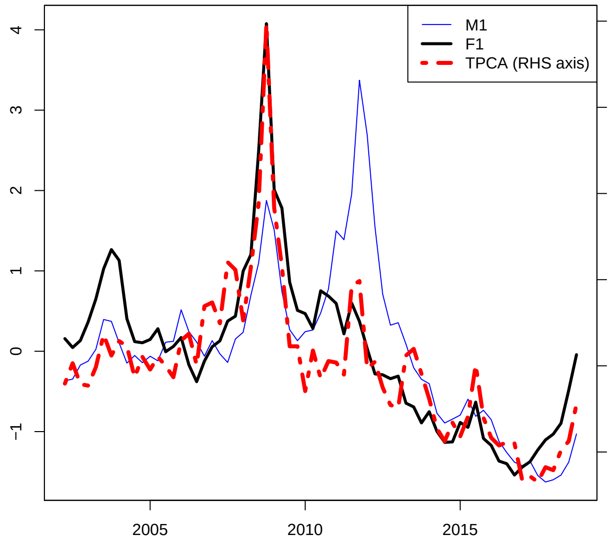


(c) h=8

Note: Plotted are upside and downside uncertainty extracted from BOT fan charts for GDP growth forecasts according to the RS approach. Estimates are reported for h= 1, 4, 8 quarter-ahead forecasting horizons ($BOT^{+}1, BOT^{+}4, BOT^{+}8, BOT^{-}1, BOT^{-}4, BOT^{-}8$ respectively).

Finally, we plot the PC-based measure of overall economic uncertainty in Figure 4. Alongside, we plot aggregate economic uncertainty $M1$ and $F1$ for comparison purposes. Upon first glance, TPCA movements are strikingly similar to $F1$, with both containing only one distinct peak during the GFC. Nonetheless, it also comoves to a significant degree with $M1$, except during the Great Floods period in 2011. Based on Table 1, TPCA is strongly correlated with its other components as well, implying that various uncertainty measures for Thailand typically comove and have a strong 'common' component. One exception is the CCI, which we suspect that this is because the CCI is the only measure that did not exhibit large swings during the GFC (see Figure 5).

Figure 4: Principal Component Economic Uncertainty

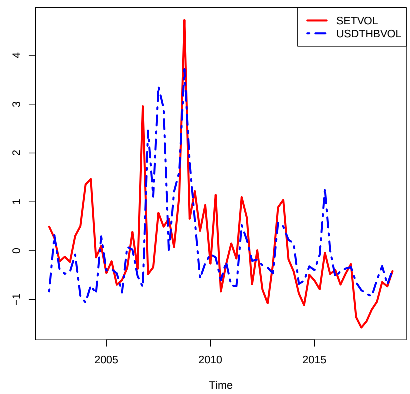


Note: Plotted is the first principal component (TPCA) of six uncertainty proxies: one-quarter-ahead macroeconomic uncertainty (M1), one-quarter-ahead financial uncertainty (F1), the business sentiment index (BSI), the consumer confidence index (CCI), 3-month moving average option implied volatility of the USDTHB exchange rate (USDTHBVOL) and 60 days moving-average historical volatility of the SET50 index (SETVOL).

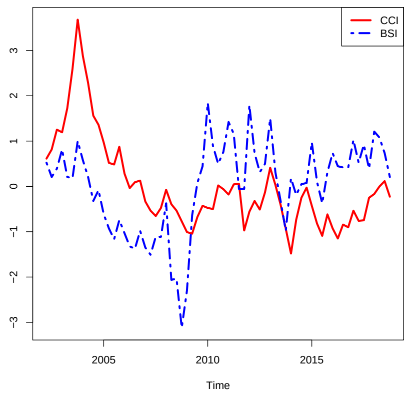
Finally, we examine news-based EPU measures for Thailand. Utilizing the LDA approach, we identify four word clouds that correspond to topics that reflect policy uncertainty in Figure 6. The first three are domestic-based while the final one captures policy uncertainty from the US. Bolded keywords that occur frequently within each word cloud are as follows: (i) monetary policy uncertainty (MPU): {'interest rates', 'economy', 'Bank of Thailand', 'decrease', 'rate'}; (ii) fiscal policy uncertainty (FPU): {'government', 'budget', 'public', 'project'}; (iii) political uncertainty (PU): {'country', 'politics', 'government', 'Thai' }; and (iv) US economic policy uncertainty (USEPU):{'US', 'economy', 'rate', 'dollar'}.

Figure 7 plots the four topic-based EPU indicators. Judging from the labelled graph, the key events that occurred during spikes correspond well to actual policy uncertainty episodes in Thailand and the US. Compared with previous economic uncertainty measures, policy uncertainty indicators appear to be more volatile, with peaks occurring more frequently. This feature of EPU measures are consistent with those observed for other countries. Given the way in which they are constructed, authors have argued that media citations can be highly volatile, which may explain

Figure 5: Market and Survey-based Uncertainty



(a) Stock and Currency Markets



(b) Household and Firms

Note: The left panel plots the the 60-day moving average of the SET50 historical volatility and the 3-month moving average option implied volatility of the USDTHB exchange rate (USDTHBVOL). The right panel plots the Thai consumer confidence index (CCI) and the Thai business sentiment index (BSI).

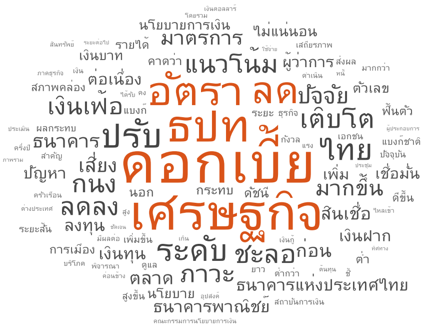
why such measures tend to have weaker relationships with key economic variables (see Forbes, 2016; Caldara et al., 2018).

Table 1: Correlation Among Proxies of Uncertainty

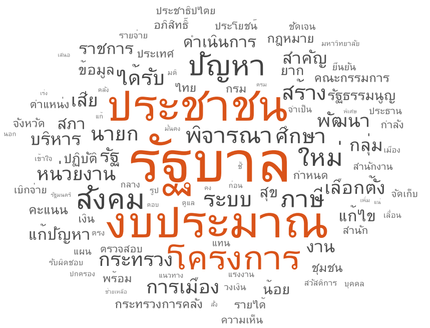
Correlation	M1	F1	BSI	CCI	USDTHBVOL	SET60VOL	TPCA
M1	1						
F1	0.67	1					
BSI	-0.22	-0.47	1				
CCI	0.04	0.26	0.14	1			
USDTHBVOL	0.31	0.48	-0.65	-0.32	1		
SETVOL	0.47	0.70	-0.44	0.13	0.47	1	
TPCA	0.69	0.88	-0.71	0.01	0.75	0.81	1

Note: Reported are correlation coefficients between one-quarter-ahead macroeconomic uncertainty (M1), one-quarter-ahead financial uncertainty (F1), the business sentiment index (BSI), the consumer confidence index (CCI), the 3-month moving average option implied volatility of the USDTHB exchange rate (USDTHBVOL), the 60-day moving average of the SET50 historical volatility, and the principal component based measure of economic uncertainty (TPCA).

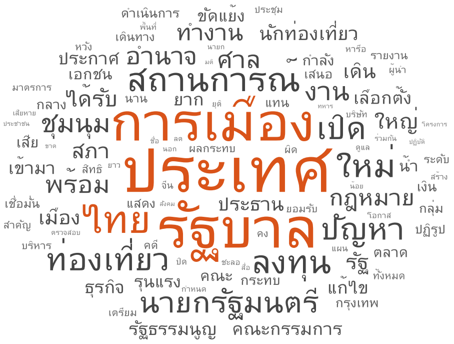
Figure 6: Word Cloud for Topic-based Economic Policy Uncertainty



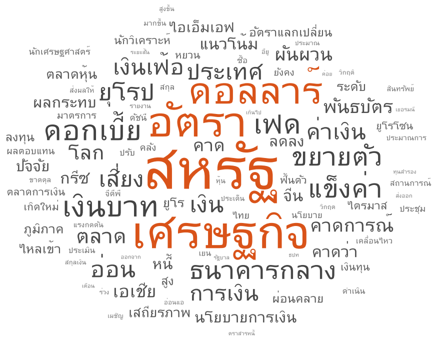
(a) Monetary Policy



(b) Fiscal Policy

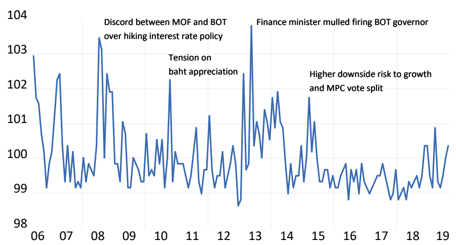


(c) Political

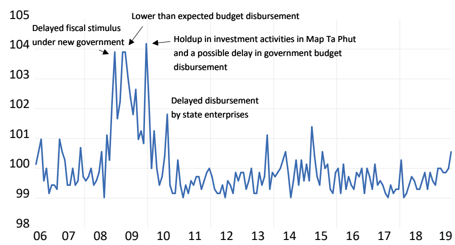


(d) US

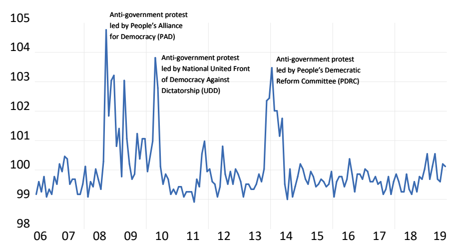
Figure 7: Word Cloud for Topic-based Policy Uncertainty



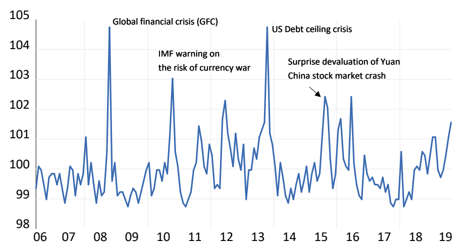
(a) Monetary Policy



(b) Fiscal Policy



(c) Political



(d) US

Note: Plotted are topic-based policy uncertainty measures extracted from Thai local newspapers based on the LDA approach.

4 Uncertainty and Real Economic Activity

Dating back to at least Keynes (1937), numerous studies argue that uncertainty can have a negative association with economic growth. Theoretically, it is well-known that the contractionary effects of uncertainty works through the real-options effect, whereby heightened uncertainty delays investing and hiring decisions of firms because factors such as adjustment costs makes decisions more costly to reverse (Bernanke, 1983; McDonald and Siegel, 1986). This 'wait-and-see' approach applies to consumption behavior as well, with periods of high uncertainty making consumers more cautious about buying durables (Caroll and Dunn 1997). Another channel for uncertainty to impact real activity is through the the precautionary savings effect whereby a rise in uncertainty may induce households to increase their precautionary savings to draw on during periods of temporarily low income if they are risk averse, leading to a reduction in consumption (Kimball, 1990; Carroll, 1997).

Empirically, there is an increasing consensus on the countercyclical effects of uncertainty on real activity. Most studies however, tend to focus on analyzing the impact of an uncertainty shock on a single activity variable. Among them, investment has received the most attention, and it is believed to be the most important channel by which uncertainty influences the business cycle due to its heavy reliance on opinions about future events (see Bloom, 2017). However, for Thailand, which is a small open economy with heavy reliance on international trade, we believe that uncertainty could also have a large bearing through the export channel as well. Therefore, we are interested in examining the effects of uncertainty across multiple real activity variables including real gross domestic product (RGDP) and its selected components - namely consumption (C), investment (I), and exports (X). By doing so, we hope to gain a better understanding on how the impact of uncertainty compares between the various channels as well as propagates to RGDP.

Finally, another interesting aspect of uncertainty is that of cross-country spillovers. With Thailand being a small open economy, we are interested in separately analyzing the effects of *domestic* versus *foreign* uncertainty shocks on real economic activity to examine the extent in which shocks from abroad may matter towards explaining economic fluctuations in Thailand. To achieve this, we split our analysis into two parts, one that includes an analysis of only domestic variables as the baseline case, and one that is augmented to also include foreign measures of uncertainty to examine the relative impact of domestic versus foreign shocks. Since foreign economic and policy uncertainty measures that are constructed in the same way as our Thai indicators are only available for the US, our proxy of foreign uncertainty are only those originating from the US. Details on our approach and the empirical findings are discussed below.

4.1 Data and Empirical Set Up

The common approach to examine dynamic relationships between uncertainty and real activity are based on structural vector autoregressions (SVARs). We adopt this approach and estimate empirical SVARs that examine the responses of RGDP, C, I, and X to economic and policy uncertainty shocks originating in Thailand as well as those that spillover from the US. Recall that all estimations related to economic uncertainty span 2002Q2-2017Q3, whereas the empirical investigation for news-based policy uncertainty covers the shorter 2006Q3-2018Q1 period.

Based on the standard approach in the uncertainty literature, orthogonal shocks are uncovered in the SVAR based on a Cholesky decomposition. For the baseline SVAR, the domestic uncertainty shock is identified by using a similar ordering to BBD: $\{U_t$, the log of the SET50 index, the policy rate, the log of the consumer price index (CPI) and the log of the real activity measure$\}$[7]. U_t is the uncertainty index that represents all proxies: $\{M1, M4, M8, F1, F4, F8, BOT^{+}1, BOT^{+}4, BOT^{+}8, BOT^{-}1, BOT^{-}4, BOT^{-}8, BOT^{*}1, BOT^{*}4, BOT^{*}8, TPCA, MPU, FPU, PU\}$, which are included one at a time to the SVAR. Real activity variables consists of the log of RGDP, C, I and X, also added one at a time to the SVAR. All data is obtained from the Bank of Thailand database.

Next, to investigate the relative importance of Thai versus US uncertainty shocks, we augment the baseline SVAR to include JLN-based US macroeconomic and financial uncertainty measures at the 1 quarter-ahead horizon ($M^{*}1$ and $F^{*}1$, made available by JLN), as well as a news-based US economic policy uncertainty index ($USEPU$) that we have constructed via the LDA approach (see Figure 7d). The foreign SVAR is then the domestic SVAR with foreign uncertainty measures (U_t^{*}) of a related type added as the first variable in the empirical specification. More specifically, for each real economy indicator, we estimate foreign SVARs with the following foreign and domestic uncertainty pairs: (i) $\{M^{*}1, M1\}$, (ii) $\{F^{*}1, F1\}$, to investigate the impact of economic uncertainty, and (iii)$\{USEPU, MPU\}$, $\{USEPU, FPU\}$, $\{USEPU, PU\}$ to examine the impact of policy uncertainty.

Finally, in both domestic and foreign SVAR specifications, we control for international trade by including the log of world imports as an exogenous or control

[7]Alternatively, U_t can be added second as in Bloom (2009), or last, as in JLN. We performed robustness checks according to these alternative orderings, and also experimented with adding additional economic variables such as the nominal effective exchange rate to the empirical specification. However, we did not find that these alternate specifications changed the results in a qualitatively meaningful way. Due to space considerations, results are available upon request.

variable. We use the information criterion to determine the number of lags appropriate for each SVAR, but due to the short sample, we report the results based on a SVAR with only one lag for all variables. Our findings are however, robust to longer lag specifications. Robustness test results are available upon request.

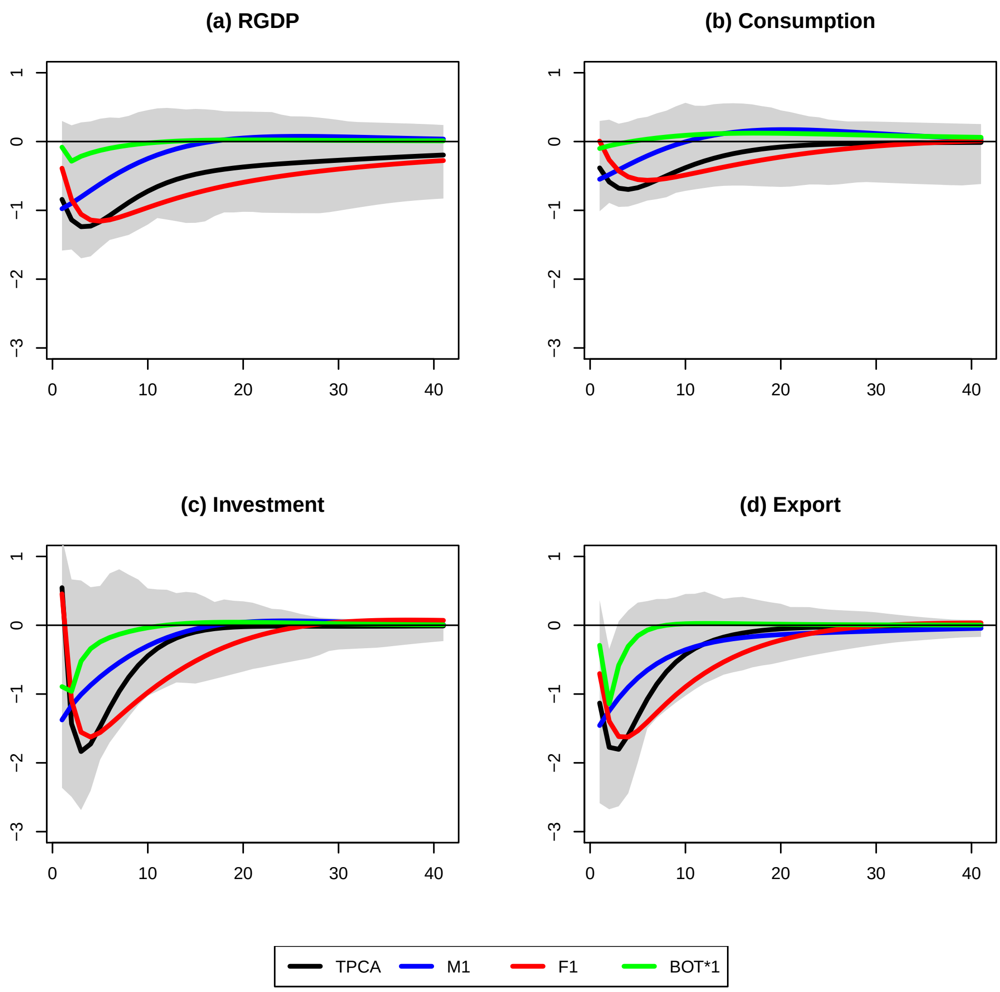
4.2 Domestic SVAR Analysis

We first investigate the response of real economic activity variables to Thai economic uncertainty shocks. As shown in Figure 8, we find that as expected, economic uncertainty shocks are contractionary. A one standard deviation uncertainty shock leads to a decline in RGDP by about 1 percent with the main channels being investments and exports (-1 to -2 percent) since the effect on consumption is rather muted (-0.5 percent). Of the different types of uncertainty, the overall PC-based and financial uncertainty shocks lead to largest declines in real activity while the BOT uncertainty shock is the least contractionary.

To compare the effects of an uncertainty shock with other countries, a direct comparison would be difficult due to differences in sample periods and specifications of the empirical SVAR. However, our results are suggestive that the impact for Thailand may be stronger than those of advanced economies. For example, in the UK, the peak impact of a one standard deviation PC-based uncertainty shock on the level of GDP is only around -0.5 percent (Haddow et al., 2013), while for Australia, various types of uncertainty shocks produce about one sixth of a percentage point decline in employment and retail sales growth (Moore, 2017). For Euro-area countries, Meinen and Roehe (2017) find that the amplitude in the drop of investment falls within the range of 0.5 to 1 percent following an uncertainty shock. This finding partially supports Carriere-Swallow and Céspedes (2013), whom find that emerging market countries suffer a median fall in investment approximately four times as large as found in developed countries. They suggest that the heterogeneity in results across countries may hinge upon the quality of business institutions, depth of the local financial sector, and degree of dollarization.

Turning to examine the dynamics of the impulse responses, we do not find evidence of an overshooting effect. This stands in contrast to evidence presented by Bloom (2009) for the US and Gourio et al. (2013) for G7 countries, whereby they report that the initial drop in real activity is followed by a swift recovery and subsequent overshoot that surpasses its trend due to firms catching up on hiring decisions that were delayed by uncertainty. These studies however, use volatile implied or realized financial market volatility measures as proxies for uncertainty, whereas when alternative proxies are used for similar countries, JLN and Cuaresma et al. (2019)

Figure 8: Impulse Responses of RGDP and Components to Economic Uncertainty Shocks



Note: Plotted are the impulse responses to a PC-based economic uncertainty shock (TPCA), aggregate macroeconomic and financial uncertainty shocks at the 1 quarter horizon (M1 and F1) and the BOT's economic uncertainty shock at the 1 quarter horizon (BOT*1). The recursive VAR has the uncertainty measure ordered first, followed by the log of the SET50, the policy rate, the log of the CPI, and the log of the real activity measure. Shaded regions correspond to 90 percent standard error bands. The data is quarterly and spans 2002Q2-2017Q3.

find no such effect. Thus, the rebound effect may depend on the type of uncertainty measure used. Alternatively, it may depend upon cross-country differences or the sample period under investigation. Carriere-Swallow and Céspedes (2013) offer evidence that real activity tends to occur in the medium run for developed economies, while emerging economies do not display a similar pattern. Cagiiano et al. (2014) show that if the sample period includes the GFC where most developed central banks switched to unconventional monetary policy measures in the presence of the effective zero lower bound, the overshoot vanishes.

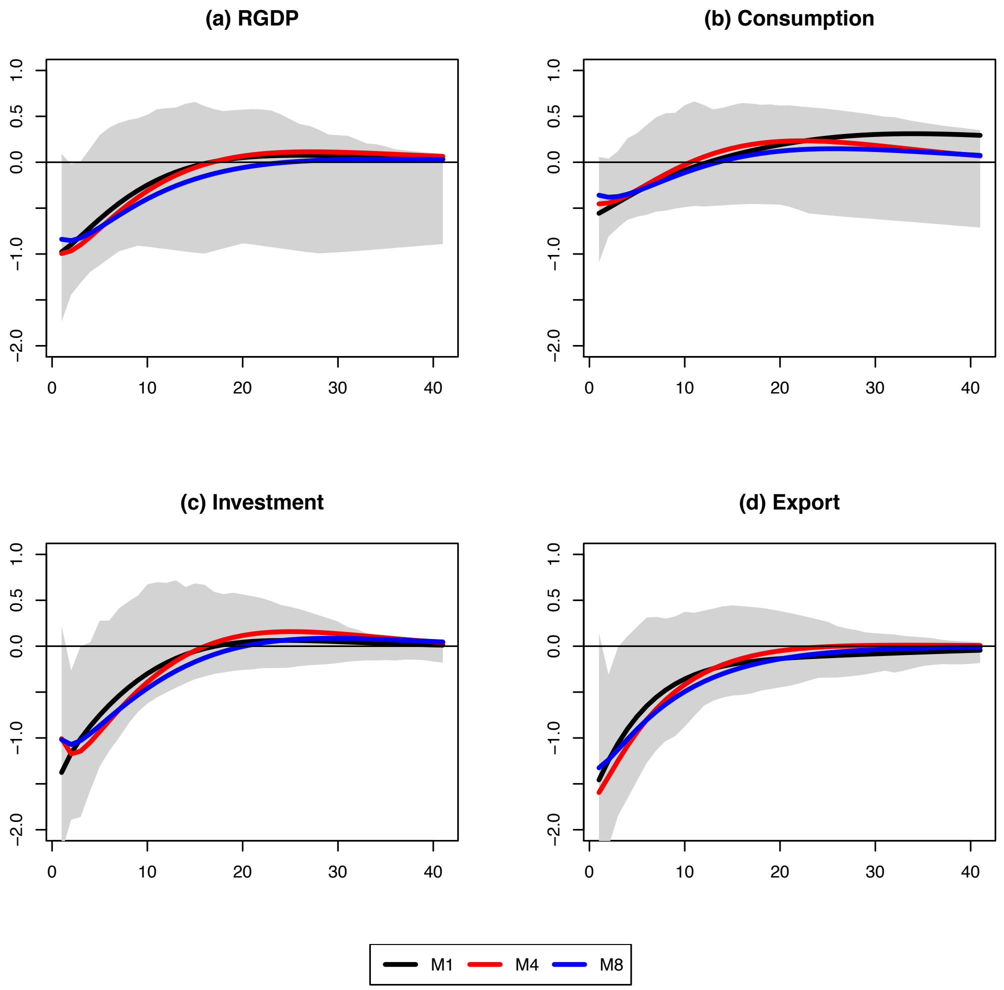
Finally, there are important differences across uncertainty shocks in terms of persistence. We find the response of real activity to a financial uncertainty shock to be the most persistent, followed by the PC-based, macroeconomic, and the BOT uncertainty shock. For example, it takes about a year for the impact of the financial uncertainty shock to bottom out and approximately 30 quarters for its effect to fully dissipate. On the other hand, the impact of a macroeconomic uncertainty shock is sudden, and its effect on real activity lasts for less than 20 quarters. This difference in impact and mechanism in which shocks of various types amplify and drives output fluctuations is in itself interesting. Our findings contrast with Ludvigson et al. (2019) where they find that US financial uncertainty shocks lead to sharp declines in activity whereas macroeconomic ones do not play such a large role. As a result, they argue that financial uncertainty is an exogenous impulse that drives output fluctuations whereas macroeconomic uncertainty are endogenous responses to output fluctuations. While a more rigorous examination is needed to come to such a conclusion, our findings at least highlight that uncertainty shocks of different types for Thailand have distinct origins as well as propagation mechanisms for output.

Thus far, we have found that not only does uncertainty matter for real economic activity in Thailand, but so does the 'type' of uncertainty shock. Next, we investigate the effect of uncertainty along other dimensions. First, we ask whether the agents' forecasting horizon matter for the magnitude and persistence of shocks? To answer this question, we plot the impulse responses of RGDP and its components to one standard deviation JLN-based macroeconomic and financial uncertainty shocks at the horizons $h = 1, 4$, and 8 quarters. According to Figures 9 and 10, the term structure of uncertainty does not appear to matter for real activity in Thailand[8]. These findings, where short versus long run uncertainty appear to play similar roles

[8] We reach the same conclusion when examining BOT uncertainty shocks at the various forecasting horizons. Due to space considerations, we do not display our results here.

for real economic activity are consistent with the findings of JLN for the US[9].

Figure 9: Impulse Responses of RGDP and Components to Macroeconomic Uncertainty Shocks

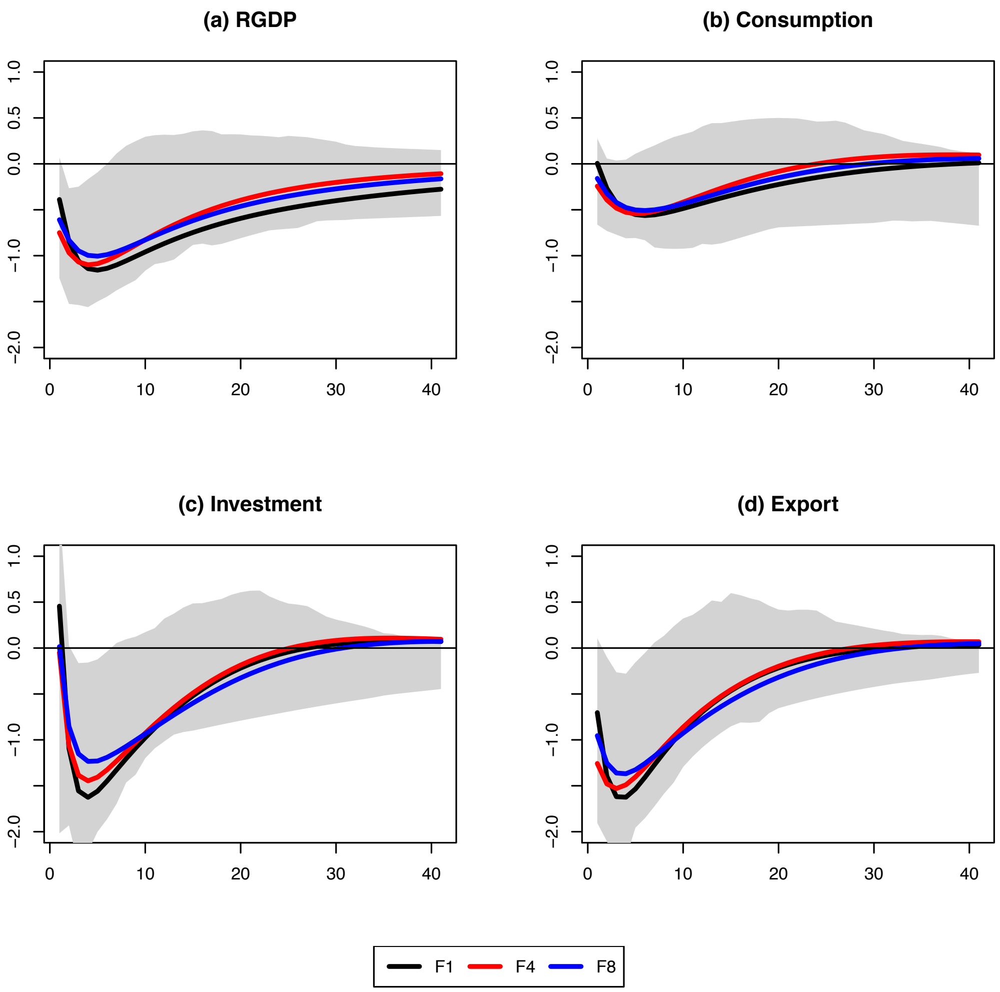


Note: Plotted are the impulse responses to JLN-based macroeconomic uncertainty shocks for Thailand at horizons $h = 1, 4$, and 8 quarters. The recursive VAR has the uncertainty measure ordered first, followed by the log of the SET50, the policy rate, the log of the CPI, and the log of the real activity measure. Shaded regions correspond to 90 percent standard error bands. The data is quarterly and spans 2002Q2-2017Q3.

Next, we explore whether there are any differences between the effects of upside versus downside uncertainty as opposed to the overall BOT uncertainty shock. Figure 11 plots the response of real activity measures to positive, negative and total one-quarter ahead BOT economic uncertainty shocks $(BOT^{+}1, BOT^{-}1, BOT^{*}1)$.

[9] Although this result may hold true at the aggregate level, there may be differences between uncertainty of the various horizons that is worth exploring at the micro level. For example, using firm-level data, Barrero et al. (2017) exploits information in the term structure of uncertainty across options of different durations and show that short versus long run uncertainty has different impacts on firm policies such as R&D and hiring.

Figure 10: Impulse Responses of RGDP and Components to Financial Uncertainty Shocks



Note: Plotted are the impulse responses to JLN-based financial uncertainty shocks for Thailand at horizons $h = 1, 4$, and 8 quarters. The recursive VAR has the uncertainty measure ordered first, followed by the log of the SET50, the policy rate, the log of the CPI, and the log of the real activity measure. Shaded regions correspond to 90 percent standard error bands. The data is quarterly and spans 2002Q2-2017Q3.

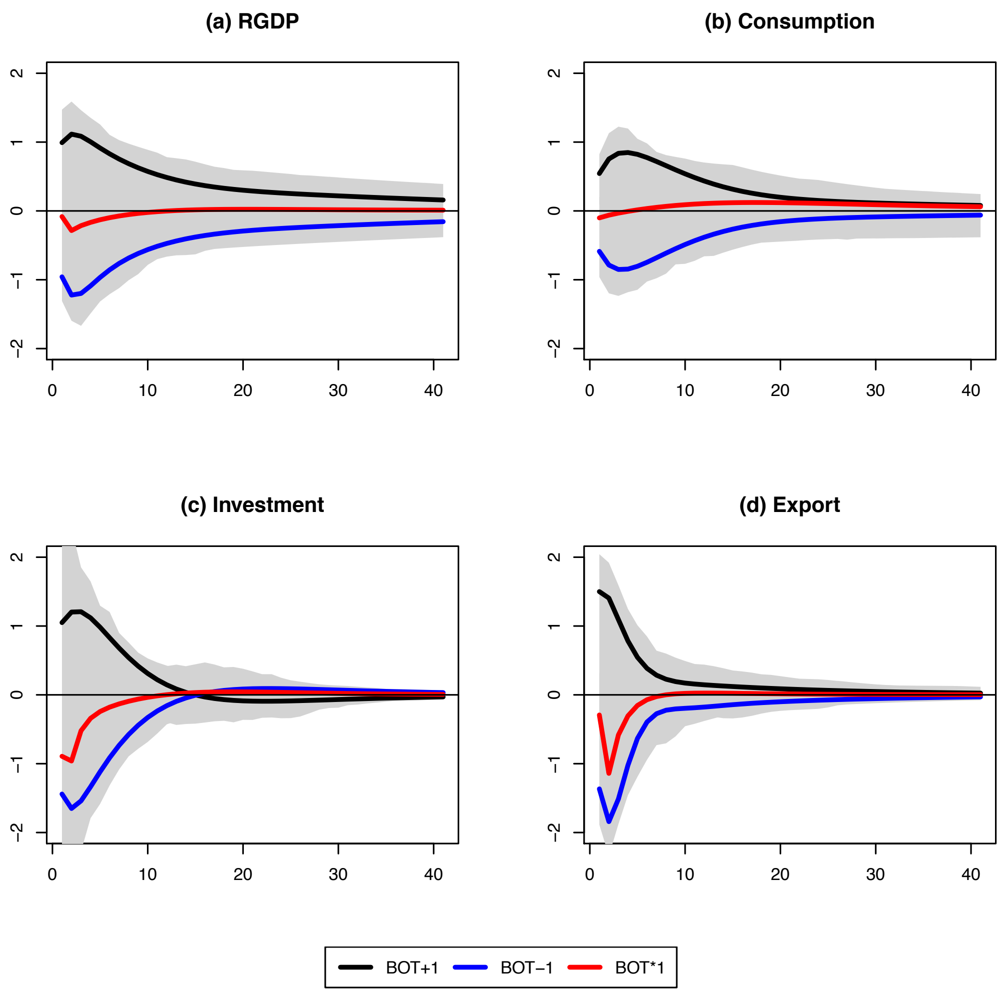
We find that upside and downside uncertainty shocks have larger effects on real activity than the overall index, and as expected, upside uncertainty is expansionary while downside uncertainty is contractionary for all real activity measures[10]. In terms of absolute magnitude, we do not find evidence of asymmetry in downside versus upside uncertainty for RGDP, and there is only little asymmetry for investments and exports where the impact of downside uncertainty is larger by about half a percentage point. Overall, this finding is similar to RS for the US and underscores the importance of distinguishing between uncertainty in both directions.

Finally, we turn to examine how policy uncertainty shocks affect real activity. Figure 12 contains plots for the impulse responses of RGDP and its components to monetary policy, fiscal policy and political uncertainty shocks. Readers are reminded that the sample period for policy uncertainty is shorter than economic uncertainty, and are thus cautioned on making a direct comparison between the impulse response functions. Broadly speaking however, we find that similar to the case of economic uncertainty, all policy uncertainty shocks are contractionary, and its impact on RGDP works largely through investment and exports rather than consumption.

Across the different types of policy uncertainty indicators, we also observe sizable differences in terms of the magnitude as well as the persistence of shocks. Monetary policy uncertainty shocks appear to have the largest impact on real activity with highly persistent effects, especially on investment demand. The impact of political uncertainty shocks are also rather pronounced, again with long-lasting impacts on investment. The nature of fiscal policy uncertainty shocks however, are different. While its magnitude is as large as the monetary policy uncertainty shock upon initial impact, its effects dissipate rather quickly within about a year. Again, these findings reiterate that the dynamic impact of uncertainty shocks hinge largely upon its 'type', highlighting the necessity for being able to differentiate between the various types of uncertainty shocks towards designing appropriate policy responses.

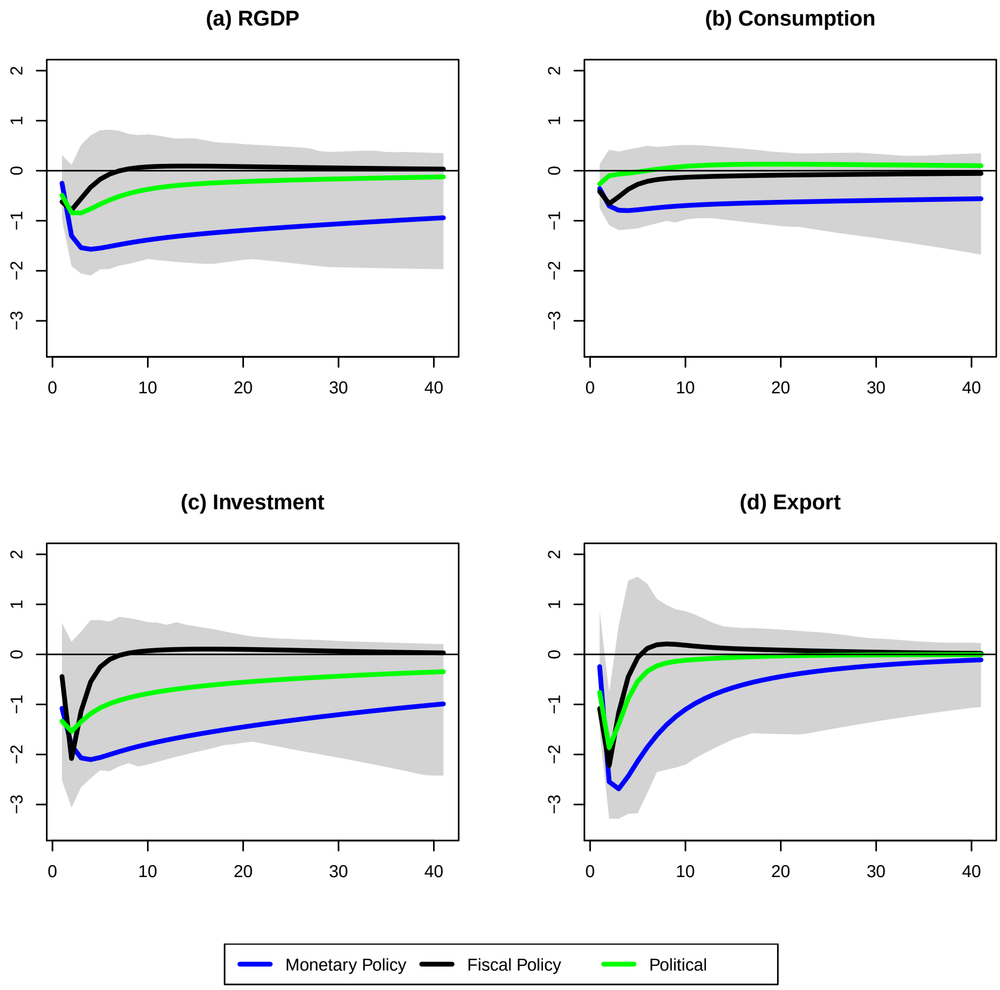
[10]A related literature examines the different effects of uncertainty on real activity during good and bad times. Based on a nonlinear VAR, Caggiano et al. (2017) finds that industrial production and employment for the US falls sharply when uncertainty shocks hits the economy during recessions. Dahlhaus and Sekhposyan (2018) find that downside and upside uncertainty (defined as the federal funds rate being higher and lower than expected, respectively), strongly correspond to periods of monetary policy tightening and easing, and they find that periods of monetary policy tightening turn out to be more recessionary.

Figure 11: Impulse Responses of RGDP and Components to BOT Economic Uncertainty Shocks



Note: Plotted are the impulse responses to one-quarter-ahead positive, negative and total BOT economic uncertainty shocks for Thailand. The recursive VAR has the uncertainty measure ordered first, followed by the log of the SET50, the policy rate, the log of the CPI, and the log of the real activity measure. Shaded regions correspond to 90 percent standard error bands. The data is quarterly and spans 2002Q2-2017Q3.

Figure 12: Impulse Responses of RGDP and Components to Thai News-based Uncertainty Shocks



Note: Plotted are the impulse responses to Thai news-based policy uncertainty shocks. The recursive VAR has the uncertainty measure ordered first, followed by the log of the SET50, the policy rate, the log of the CPI, and the log of the real activity measure. Shaded regions correspond to 90 percent standard error bands. The data is quarterly and spans 2006Q3-2018Q1.

4.3 Foreign SVAR Analysis

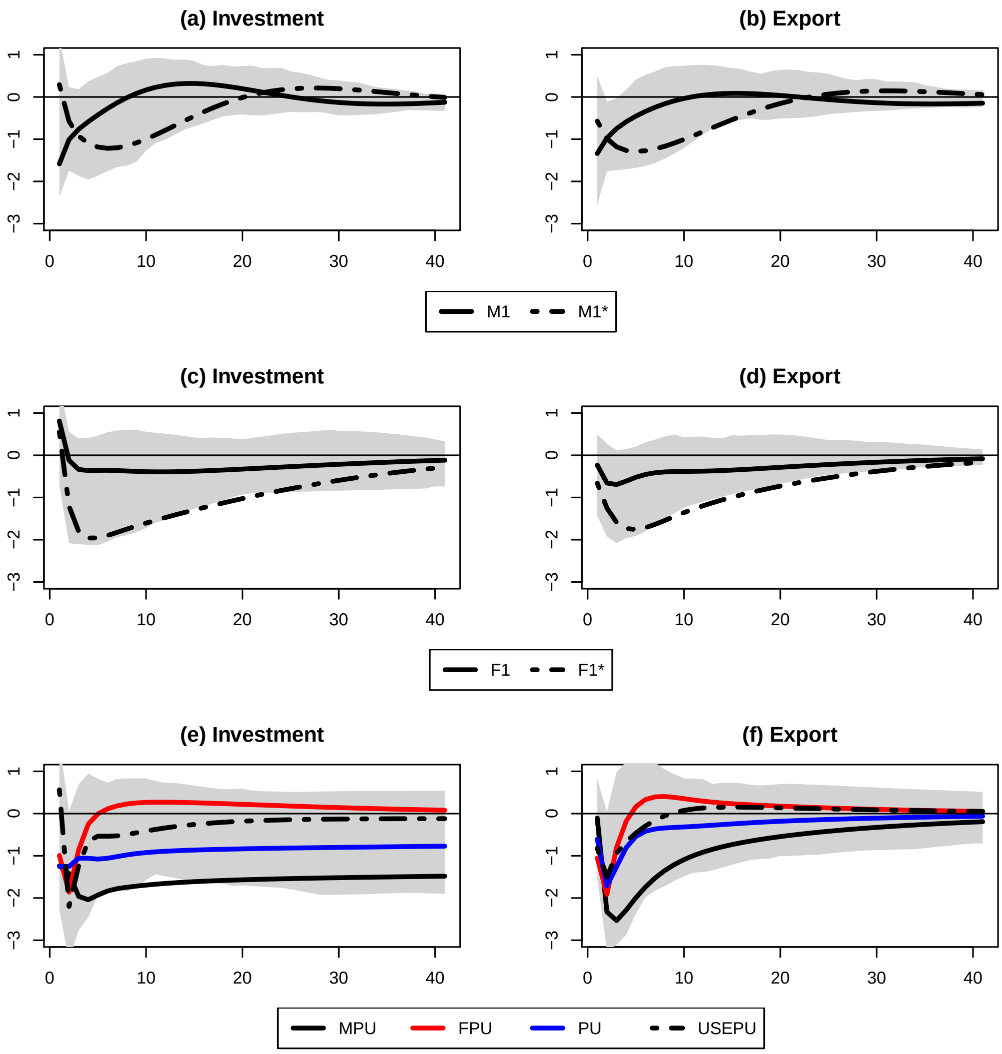
We have established that domestic uncertainty shocks can lead to sizable contractions in real economic activity. However, Thailand is a small open economy that can be highly susceptible to foreign uncertainty shocks. Also, with measures of domestic and foreign uncertainty being correlated (the comovement between JLN-based domestic and foreign macroeconomic and financial uncertainty pairs are as high as 0.37 and 0.71 respectively), it is possible that the large responses of real activity to domestic uncertainty shocks may merely be picking up the spillover effects of uncertainty shocks from abroad. Thus, it would be of interest to investigate whether domestic uncertainty shocks are still relevant after the inclusion of the foreign uncertainty shocks in the SVAR specification.

The estimation results from the foreign SVARs are plotted in Figure 13. Due to space considerations, we only report the impulse responses for investment and export since the contraction in real output is driven primarily by these two variables. First, we examine the dotted lines across all plots, which represent the impulse responses of real activity to US uncertainty shocks. Consistent with Thailand being a highly open economy, we find the impact of all US shocks on real activity to be significant and large, with full magnitude effects that are at least as large as its domestic counterpart (-2 percent for US financial and policy uncertainty shocks and -1 percent for macroeconomic uncertainty shocks). In fact, compared to its Thai counterpart, US economic uncertainty shocks are more persistent, as they take longer to bottom out and a longer time to fully dissipate (5 and 10 years for macroeconomic and financial uncertainty shocks respectively). The effect of the USEPU shock on the other hand, is relatively short-lived as real activity rebounds in about one year.

Does the introduction of the US shock in the SVAR alter the response of domestic shocks? To answer this question we compare the results in Figure 13 to Figures 8 and 12. Since the impulse response of real activity to domestic macroeconomic and policy uncertainty shocks are the same regardless of whether the US shock is in the SVAR, it can be inferred that these two types of shocks are largely independent from the ones originating from the US. On the other hand, the effect of the Thai financial uncertainty shock ($F1$) declines substantially once the US $F^{*}1$ measure is added to the SVAR, implying that shocks in the Thai financial market mostly spillover from the US. Given that the contractionary effect of the US financial uncertainty shock is largest and most persistent, this finding highlights the need for policymakers to give special consideration to measuring and monitoring this type of shock from abroad.

The findings in this section contributes to a growing literature that examine

Figure 13: Impulse Responses of Investment and Export to Foreign and Thai Economic and Policy Uncertainty Shocks



Note: Plotted are the impulse responses to foreign and domestic macroeconomic, financial and economic policy uncertainty shocks. The recursive VAR has the US uncertainty measure ordered first, followed by the corresponding Thai uncertainty measure, the log of the SET50, the policy rate, the log of the CPI, and the log of the real activity measure. Shaded regions correspond to 90 percent standard error bands. The data is quarterly and spans 2002Q2-2017Q3 for the macroeconomic and financial uncertainty SVARs (first two rows) and spans 2006Q3-2018Q1 for the policy uncertainty SVAR (third row).

the effects of global uncertainty and its spillover effects on domestic real activity. According to existing research, findings on the importance of global uncertainty largely focus on the experiences of advanced economies, with overall empirical results that are quite mixed. For example, Colombo (2013) and Belke and Osowski (2017) find that the effect of a shock to US EPU on Euro-based macroeconomic aggregates are quantitatively larger than the ones exerted by Euro area news-based shocks. Similarly, Berger et al. (2016) reports that global uncertainty is the major driver of macroeconomic performance in most countries with the impact of national uncertainty being small and frequently insignificant. On the other hand, based on a measure of global uncertainty that is extracted via a dynamic factor approach from a large set of cross-country macroeconomic and financial data, Mumtaz and Theodoridis (2017) and Mumtaz and Musso (2018) find that country-specific uncertainty is more important than global uncertainty in explaining real output volatility in a large number of countries. We add evidence from a small open economy, Thailand. We show that foreign uncertainty shocks from the US have strong cross-border effects, but we also provide evidence that the dynamic impact depends to a large extent on the 'type' of foreign uncertainty shock.

5 Forecast Error Variance Decompositions

A substantial body of work in the macroeconomic literature tries to understand the source of business cycle variation. Given the extraordinary events surrounding the "Great Recession", recent studies have cast considerable doubt on the traditional sources of macroeconomic disturbances. In response, uncertainty shocks have been cited as alternative drivers of macroeconomic fluctuations. In this section, we conduct a forecast error variance decomposition (FEVD) to measure the relevance of uncertainty shocks as a source of economic fluctuations in Thailand. In doing so, we examine the share of variance in real activity that uncertainty shocks of different types can account for at short, medium, and long term horizons. We also investigate the relative contributions of domestic versus foreign uncertainty shocks as well.

Table 2 shows the FEVD results from the baseline VAR that contains only domestic uncertainty and real activity variables. As shown, it is striking that in general, domestic uncertainty shocks are capable of explaining up to approximately a third of the total variation in real output. Across all real activity variables, the role of F1, BOTNEG1 and TPCA uncertainty shocks appear most prominent and are more or less comparable, with some exceptions such as F1 not being such a strong driver of consumption. Among policy uncertainty measures, it is clear that MPU explains the largest share of variance in real activity, while the role of the other policy shocks are rather muted, especially at longer horizons. While in general we find that uncertainty matters more for economic fluctuations at shorter horizons, in many cases their role in the long-term can still be substantial. For example, F1, BOTNEG1, TPCA, and MPU all explain at least one fifth of the variation in RGDP even at the 40Q horizon.

Table 2: Variance Decomposition of RGDP and its Components to Macroeconomic, Financial and Policy Uncertainty Shocks

Horizon	M1	F1	BOTNEG1	TPCA	MPU	FPU	PU
a. RGDP							
4Q	23.20	25.81	36.08	37.19	32.31	7.80	11.90
20Q	10.61	33.79	24.55	30.99	30.93	2.41	5.02
40Q	9.09	30.33	20.90	27.05	29.00	2.10	3.92
b. Consumption							
4Q	13.65	8.44	34.40	22.16	20.92	11.75	1.10
20Q	4.89	13.38	22.96	15.00	20.78	3.85	0.71
40Q	5.06	10.55	17.73	11.73	19.35	2.77	0.94
c. Investment							
4Q	10.87	14.24	18.11	18.04	25.80	12.23	15.46
20Q	9.78	26.80	17.55	20.57	32.07	5.06	9.61
40Q	9.44	25.74	17.00	19.94	30.79	4.77	7.90
d. Export							
4Q	22.45	29.48	30.10	36.83	38.19	15.34	14.75
20Q	15.04	35.23	18.76	28.81	29.83	7.46	6.75
40Q	14.00	32.90	17.40	26.99	28.67	7.18	6.35

Note: Reported are the percentages of the variation in real economic activity explained by economic and policy uncertainty shocks at short (4Q), medium (20Q) and long-run (40Q) horizons.

How does the role of domestic versus foreign uncertainty shocks compare in explaining fluctuations in real activity? Table 3 offers the FEVD results from the foreign SVAR with Thai and US-based economic and policy uncertainty shocks. First, we find that while macroeconomic uncertainty shocks from both within-country and abroad appear equally important towards explaining the variability in real activity in the short-run, US macroeconomic shocks becomes the prominent driver of fluctuations in the medium and long-run. For financial uncertainty shocks, the role of US shocks are even more pronounced. Domestic financial uncertainty shocks are insignificant drivers of real activity fluctuations, while shocks from the US explain up to 40 percent of the variability in the medium and long-run. The importance of foreign uncertainty shocks for economic fluctuations, particularly since they can be long-lasting, highlight the importance of monitoring risks and uncertainty shocks that spillover from abroad.

Table 3: Variance Decomposition of RGDP and its Components to Domestic and Foreign Economic and Policy Uncertainty Shocks

Horizon	M1 (M*1)	F1 (F*1)	MPU	FPU	PU	(USEPU)
a. RGDP						
4Q	14.52 (13.47)	3.44 (31.68)	25.82	5.50	6.74	(17.08)
20Q	6.65 (15.51)	4.70 (40.13)	26.22	2.51	3.68	(9.93)
40Q	6.72 (14.20)	4.84 (39.23)	24.95	2.49	3.20	(7.87)
b. Consumption						
4Q	10.76 (3.65)	1.36 (21.71)	20.11	9.61	1.00	(2.33)
20Q	9.45 (6.96)	1.43 (25.41)	20.53	2.71	0.29	(1.99)
40Q	10.24(8.12)	1.39 (20.98)	19.55	1.81	0.22	(1.40)
c. Investment						
4Q	9.64 (5.37)	2.02 (19.48)	21.63	10.08	10.77	(13.85)
20Q	7.55 (17.68)	2.91 (41.73)	28.92	4.83	10.72	(5.89)
40Q	7.76 (17.68)	3.19 (41.12)	28.71	4.64	10.05	(4.29)
d. Export						
4Q	14.64 (17.26)	4.92 (27.58)	32.89	10.94	11.82	(8.90)
20Q	7.13 (27.54)	4.60 (41.38)	27.52	6.29	6.52	(4.35)
40Q	7.14 (25.97)	4.71 (40.06)	26.44	6.13	6.17	(4.14)

Note: Reported are the percentages of the variation in real economic activity explained by economic, policy, and foreign (in parentheses) uncertainty shocks at short (4Q), medium (20Q) and long-run (40Q) horizons.

On the other hand, Table 3 shows that domestic-based policy uncertainty shocks are more important than EPU shocks from the US. In particular, monetary policy uncertainty shocks are by far the most prominent driver of real activity fluctuations, explaining up to almost one third of its variability. Fiscal and political policy shocks however, play a rather muted role. US EPU shocks although important for RGDP and investment, can explain only about 15 percent of its variability in the short-run. To our knowledge, our study is the first to compare the different effects of policy uncertainty shocks on real activity by category. While BBD also provides a decomposition of their US EPU index into various components (eg. fiscal policy, monetary policy, healthcare, national security, trade policy), they do not study their effects on real activity. Thiem (2018) provides a further analysis of BBD's categorical indices, but their focus is on examining the degree and directional spillover effects across categories. They show that category-specific uncertainties are indeed closely interrelated.

Compared to existing studies, the role that we find for uncertainty shocks in explaining output fluctuations in Thailand is rather high. In South Korea, Cheng (2017) finds that Korean EPU shocks do not explain more than 10 percent of output variation in the short and medium run. For the US, studies find that domestic uncertainty shocks only explain approximately 10 percent of the long-run variation in real activity (see Bachmann et al., 2013; Jurardo et al., 2015; Caldara et al., 2016; Cascaldi-Garcia and Galvao, 2018; and Carriero et al., 2018). The impact of foreign shocks are on a similar scale. Cheng (2017) finds that US EPU shocks can explain about one fifth of the variation in Korean GDP and exports. Mumtaz and Musso (2018) extract a global uncertainty measure from a large set of financial and macroeconomic variables common to 22 OECD countries and finds that global uncertainty explains about 15 percent of the volatility of real economic activity growth across countries. These studies however, typically study the role of a single type of aggregate shock. In our study, we show that not all types of uncertainty shocks explain similar shares of variation in macroeconomic aggregates. Thus, when analyzing the role of uncertainty for economic fluctuations, it may be important for future studies to consider uncertainty shocks at a more disaggregated level.

6 Conclusion

This paper constructs new uncertainty measures for Thailand and provides an analysis of their impact on real gross domestic product and its components. We provide a comprehensive analysis of the effects of a wide array of domestic and foreign uncertainty shocks including macroeconomic, financial, economic policy, and an overall index that captures the common component of a wide range of uncertainty proxies including sentiment indices and financial market volatilities.

Our findings suggest that the notion of uncertainty is complex and that there are various dimensions of uncertainty. While uncertainty of different types are correlated, they deliver varying impacts on the real economy, both in terms of magnitude and persistence. Our key findings are that in general, economic and policy uncertainty shocks, whether originating from Thailand or the US, causes real activity to contract on the scale of 1 to 2 percent, with investments and exports seeing larger declines than consumption. However, the nature and propagation mechanism of each type of shock varies to certain extent. For example, domestic macroeconomic uncertainty shocks causes the most sudden declines in real activity, while US financial and Thai monetary policy uncertainty shocks deliver the largest and most persistent contractions. Similarly, the degree in which uncertainty shocks can explain economic fluctuations in Thailand depends on the type of shock as well. US financial uncertainty shocks are capable of explaining the largest share of real activity variability - as high as 40 percent even in the long-run. Thai fiscal and political uncertainty shocks on the hand, play a rather muted role.

The implications of our results are that policymakers should pay close attention to uncertainty as an important driver of fluctuations in real activity, for both the short and long run horizons. It is also important to recognize that uncertainty could have multifaceted effects on an economy through diverse channels, with certain types of uncertainty being more malignant than others. For this reason, future research that tries to properly measure as well as understand the nature of various types of uncertainty shocks are highly encouraged. Studies such as Orlik and Veldkamp (2014) and Kozeniauskas et al. (2018) that tries to uncover the origins of uncertainty shocks are encouraging work in this direction. In addition, it would be fruitful to investigate the various other channels in which uncertainty shocks could propagate, such as through labor markets (Arellano et al., 2012) and credit markets (Gilchrist et al., 2014; Allesandri and Bottero, 2017). Finally, the implication of our results for small developing countries is that it is not enough to just monitor uncertainty shocks from abroad. While we show that the spillover effects of US-based shocks do matter, certain domestic uncertainty shocks can lead to comparably larger declines in real activity, highlighting the need to also measure and closely monitor within-country uncertainty shocks.

7 Appendix A

The dataset used to construct the Thai macroeconomic and financial uncertainty indices according to JLN are monthly and quarterly series that span 2002-2018. Macroeconomic time series data are taken from the Bank of Thailand database while financial variables are from the Stock Exchange of Thailand. This appendix lists the name of each series in the dataset, as well as the transformation applied to each series to achieve stationarity. In total, we have 199 macroeconomic series that represent broad categories that describe the macroeconomy (Groups 1-10) and 22 financial series (Group 11), which are described in the table below. Each series has a corresponding transformation code, which follows either one of the following possible transformations:

Macroeconomic time series transformations:

1: $X_{it} = X_{it}^A$
2: $X_{it} = X_{it}^A - X_{it-1}^A$
3: $X_{it} = \Delta^2 X_{it}^A$
4: $X_{it} = ln(X_{it}^A)$
5: $X_{it} = ln(X_{it}^A) - ln(X_{it-1}^A)$

6: $X_{it} = \Delta^2 ln X_{it}^A$
7: $X_{it} = (X_{it}^A - X_{it-1}^A)/X_{it-1}^A$

where X_{it} denotes the transformed variable i, and X_{it}^A is the actual or raw data series. Note that we use the notation $\Delta = 1 - L$ and $LX_{it} = X_{it-1}$.

Financial time series transformations:

For the first five financial time series with transformation code 8, we follow the method as described below.

- $D\_log(DIV)$: $\Delta log D_t^*$
- $D\_log(P)$: $\Delta log P_t$
- $D\_DIVreinvest$: $\Delta log D_t^{re,*}$
- $D\_Preinvest$: $\Delta log P_t^{re,*}$
- d-p: $log(D_t^*) - log(P_t)$

Note that to obtain the dividend and price series, (D_t^* and P_t), we first construct the return series with dividends ($RETD_t$) and excluding dividends ($RETX_t$) as: $RETD_t = \frac{P_{t=1}+D_{t+1}}{P_t}$ and $RETX_t = \frac{P_{t+1}}{P_t}$, and produce a normalized price series based on the recursive rule: $P_0 = 1, P_t = P_{t-1}RETX_t$. A dividend series can then be constructed as: $D_t = P_{t-1}(RETD_t - RETX_t)$ where $D_t^* = (D_t + D_{t-1} + D_{t-2} + D_{t-3})$.

For dividends and prices under reinvestment, (D_t^{re*} and P_t^{re*}), we use the recursion $P_0^{re} = 1, P_t^{re} = P_{t-1}RETD_t$. Then, dividends under reinvestment can be defined as $D_t^{re} = P_{t-1}^{re}(RETD_t - RETX_t)$ where as before, $D_t^{re*} = (D_t^{re} + D_{t-1}^{re} + D_{t-2}^{re} + D_{t-3}^{re})$.

Finally, for the remaining 17 financial time series which are industry portfolios, the portfolio returns are constructed from the price and dividend yield series as follows:

$$R_{it} = \frac{P_{t+1} + D_{t+1}}{P_t}.$$

Table A1: List of Macroeconomic and Financial Variables

No.	Name and Description	Tcode
Group 1: National Account Data (Quarterly Series)		
1	Real Gross Domestic Product	5
2	Consumption	5
3	Government Consumption	5
4	Investment	5
5	Exports of goods and services	5
6	Imports of goods and services	5
Group 2: Output and Income (Monthly Series)		
7	PI:Personal Income	5
8	MPI: Manufacturing Production Index	5
9	MPI_10: Manufacture of food products	5
10	MPI_12: Manufacture of tobacco products	5
11	MPI_13: Manufacture of textiles	5
12	MPI_14: Manufacture of wearing apparel	5
13	MPI_15: Manufacture of leather and related products	5
14	MPI_19: Manufacture of coke and refined petroleum products	5
15	MPI_20: Manufacture of chemicals and chemical products	5
16	MPI_22: Manufacture of rubber and plastic products	5
17	MPI_23: Manufacture of other non-metallic mineral products	5
18	MPI_24: Manufacture of basic metals	5
19	MPI_25: Manufacture of fabricated metal products, except machinery and equipment	5
20	MPI_26: Manufacture of computer and electronic products	5
21	MPI_29: Manufacture of motor vehicles, trailers and semi-trailers	5
22	CAPU_10: Capital utilization of food products	2
23	CAPU_13: Capital utilization of textiles	2
24	CAPU_14: Capital utilization of wearing apparel	2
25	CAPU_15: Capital utilization of leather and related products	2
26	CAPU_17: Capital utilization of paper and paper products	2
27	CAPU_19: Capital utilization of coke and refined petroleum products	2
28	CAPU_20: Capital utilization of chemicals and chemical products	2
29	CAPU_22: Capital utilization of rubber and plastic products	2
30	CAPU_23: Capital utilization of other non-metallic mineral products	2
31	CAPU_24: Capital utilization of basic metals	2
32	CAPU_25: Capital utilization of fabricated metal products, except machinery and equipment	2
33	CAPU_26: Capital utilization of computer and electronic products	2
34	CAPU_29: Capital utilization of motor vehicles, trailers and semi-trailers	2
Group 3: Labor Markets (Monthly Series)		
35	Help Wanted	5
36	Help wanted/unemp	2
37	Emp (Total): Employed Total (Thousand)	5
38	Emp_nonag: Civilian Labor Force: Employed, Nonagricultural Industries	5
39	Unemployment Rate: Unemployment Rate: All workers	2
40	U_dr1m: Unemployment with duration less than 1 month	5
41	U_dr3m : Unemployment with duration between 1-2.9 months	5
42	U_dr6m: Unemployment with duration between 3-5.9 months	5
43	U_dr9m: Unemployment with duration between 6-8.9 months	5
44	U_dr12m: Unemployment with duration between 9-11.9 months	5
45	U_drmore12m: Unemployment with duration more than 1 year	5
46	Emp total-agri :Total employment in agricultural sector	5
47	Emp privatemanu: Private employment in manufacturing sector	5
48	Emp total-cons:Total employment in construction	5
49	Emp total_trade: Total Employment in Trade	5
50	Emp total_hotelrest:Total employment in hotel and restaurants	5
51	Emp private-fin:Private employments in financial sector	5
52	Private avg hour: Average working hours per weeks of private employees	5
53	Private earn_hr: Average earning per hour of private employees	5
54	Avg hr-private manu:Average working hours per weeks of private manufacturing workers	5
55	Avg wage-trade: Average earning per hour for private trade workers	5
56	Avg wage-fin : Average earning per hour for private financial workers	5
57	Avg wage-manu: Average earning per hour for private manufacturing workers	5

No.	Name and Description	Trans Code
Group 4: Housing (Monthly Series)		
58	Fee: Juristic Act and Right Registration Fee for Immovable Property (Millions of Baht)	5
59	Land licen: Land Development Licences - Bangkok Metropolis	5
60	Construction Area: Construction Areas Permitted (1000 sqm.)	5
61	Land Trans: Land and building Transactions Nationwide (Millions of Baht)	5
62	building licen: Building license	5
63	bld licen-bkk: Building license in Bangkok	5
64	bld licen-others: Building license in other provinces	5
65	New hous: New Housing Project in Bangkok Metropolis and Vicinity (unit)	5
66	housing proj: New Housing in Bangkok Metropolis and Vicinity (unit)	5
67	apartment: New apartment in Bangkok Metropolis and Vicinity (unit)	5
68	self built housing: New selfbuilt housing in Bangkok Metropolis and Vicinity (unit)	5
69	credit outstanding: Property Credit Outstanding (Millions of Baht)	5
70	re credit: Real Estate Development Credit	5
71	personal housing credit:Personal Housing Credit	5
Group 5: Consumption, Orders, and Inventories (Monthly Series)		
72	bsi: Business survey index	2
73	bsi_perf: Business survey index Performance	2
74	bsi_order: Business survey index Total Order Book	2
75	bsi_invest: Business survey index Investment	2
76	bsi_employment: Business survey index Employment	2
77	bsi_cost : Business survey index Production Costs (Invert)	2
78	bsi_3 month: Expected Business survey index over 3 month horizon	2
79	Retail Sales Index	5
80	Retail: Motor: Retail sales of motor vehicles and automotive fuel	5
81	Retail: Nondu: Retail sales of non-durable goods	5
82	Retail: Du: Retail sales of durable goods	5
83	Retail: Store: Retail sales of department stores, supermarkets, and general stores	5
84	Wholesales Index	5
85	whole sale: non du: Wholesales of non-durable goods	5
86	whole sale: du: Wholesales of durable goods	5
87	whole sale: int : Wholesales of intermediate goods	5
88	VAT - Gross Value Added Tax at 2000 prices (Million baht)	5
89	Sales: Automotives: Domestic automobiles sales	5
90	Sales: Clothes: Retail sale of clothing, footware and leather articles	5
91	Sales: Food: Retail sale of food in specialized store	5
92	Sales: Bev: Retail sale of beverages in specialized store	5
93	Sales: Tobacco: Retail sale of tobacco products in specialized stores	5
94	Sales: Electronics appliances: Retail sale of electrical household appliances in specialized stores	5
95	PII: Private Investment Index	5
96	Sales: Construction: Construction material sales index	5
97	Import: Capital: Imports of capital goods at 2010 prices	5
98	Sales: Machine: Domestic machinery sales at 2010 prices	5
99	PCI : Personal Consumption Index	5
100	Sales: Passenger Cars: Sales of passenger cars (units)	5
101	Sales: Motorcycle Sales: Sales of motorcycles (units)	5
102	Sales: Commercial Cars: Sales of commercial cars (units)	5
103	Gas Index: Sales of benzene, gasohol and diesel index	5
104	Electricity: Household electricity consumption index	5
105	Import: Clothes: Import of textiles index	5
106	Domestic Car Sales: Domestic automobiles sales (units)	5
Group 6: Money and Credit (Monthly Series)		
107	M1: Narrow money	7
108	M2: Broad money	7
109	Currency: Currency held by the public	7
110	Banknotes in Circulation	7
111	Deposit	7
112	Narrow Money	7
113	Currency Held by Depository Corp. - Commercial Banks	7
114	Transferable Deposits at Depository Corp. - Commercial Banks	7
115	Quasi-money	7
116	MLR: minimum loan rate (Min)	2
117	MLR minimum loan rate (Max)	2

No.	Name and Description	Trans Code
118	MRR: minimum retail rate (Min)	2
119	MRR: minimum retail rate (Max)	2
120	Government bonds (Total)	6
121	Treasury bills (Total)	7
122	Promissory notes (Total)	7
123	State enterprise bonds (total)	6
124	BOT-bond : Bank of Thailand bonds	6
125	Government debt securities held by nonfinancial market mutual funds	6
126	Outstanding government debt security	6
127	Total deposits outstanding of Commercial Banks	6
128	Deposits turnover ratio of Commercial Banks	2
129	Government bonds Short-term 1 year	6
130	Government bonds Medium-term 1-5 years	6
131	Government bonds Long-term 5 year up	6
132	Government promissory notes	6
133	State enterprise bonds Short-term 1 year	6
134	State enterprise bonds Medium-term 1-5 years	6
135	State enterprise bonds Long-term 5 year up	6
136	State enterprise promissory notes Short-term 1 year	6
137	New issuances of domestic securities	6
138	New issuances of domestic public sector securities	6
139	New issuances of domestic private sector securities	6
140	Authorized Capital of Newly Registered Companies	6
Group 7: Bonds and Exchange Rate Measures (Monthly Series)		
141	NEER: Nominal effective exchange rate	5
142	REER: Real effective exchange rate	5
143	inter_overnight: Interbank overnight lending rates	2
144	repo_1day: Bilateral repurchase rate (1 day)	2
145	repo_7days: Bilateral repurchase rate (7 days)	2
146	repo_14days: Bilateral repurchase rate (14 days)	2
147	Thai Baht implied interest rate (1 month)	2
148	Thai Baht implied interest rate (3 months)	2
149	Thai Baht implied interest rate (6 months)	2
150	tThai Baht implied interest rate (12 months)	2
151	Government bond yield (1 year)	2
152	Government bond yield (2 years)	2
153	Government bond yield (3 years)	2
154	Government bond yield (5 years)	2
155	Government bond yield (7 years)	2
156	Government bond yield (10 years)	2
157	Government bond yield (12 years)	2
158	Government bond yield (14 years)	2
Group 8: Prices (Monthly Series)		
159	CPI : Consumer price index	5
160	CPI-food: Consumer price index food and non-alcoholic beverages	5
161	CPI-apparel: Consumer price index apparel and foodwear	5
162	CPI-housing: Consumer price index housing and furnishing	5
163	CPI-med: Consumer price index medical and personal care	5
164	CPI-trans: Consumer price index transportation and communication	5
165	CPI-recre: Consumer price index recreation and education	5
166	CPI-tobacco: Consumer price index tobacco and alcoholic beverages	5
167	CPI-rawfood: Consumer price index raw food	5
168	CPI-energy: Consumer price index energy	5
169	CPI-ex food energy: Consumer price index excluding food and energy	5
170	CPI-ex food energy rent: Consumer price index excluding energy and rent	5
171	PPI : Producer price index	6
172	PPI_agri: Producer price index agricultural products	6
173	PPI_mining: Producer price index mining products	6
174	PPI_manu: Producer price index manufactured products	6
175	price_cons: Price of construction materials index	6
176	price_wood: Price of construction materials_wood	6
177	price_cement: Price of manufacturing goods_mixed cement 50 kgs.	6
178	price_metal: Price of construction materials_metal	6
179	price_diesel: Price of manufacturing goods_diesel	6
180	price_fueloil: Price of manufacturing goods_fuel oil	6
181	price_sugar: Price of manufacturing goods_white sugar (1 kg.)	6
182	price_rice: Wholesale price of 100% rice in Bangkok Metropolis	6
183	price_rubber: Wholesale price of ribbed smoked sheet rubber in Bangkok Metropolis	6

No.	Name and Description	Trans Code
Group 9: Stock Market Indices (Monthly Series)		
184	SET index: Stock Exchange of Thailand Index	5
185	SET Food Index	5
186	SET Bank Index	5
187	SET Energy Index	5
188	SET 50: SET 50 Index	5
Group 10: Trade (Monthly Series)		
189	Ex-volume: Export volume	5
190	Im-volume: Import volume	5
191	Im-cons: Import - Consumer Goods: Volume	5
192	Im-rawmat: Import - Raw Materials: Volume	5
193	Im-cap: Import - Capital Goods: Volume	5
194	Ex-agri: Export - Agricultural Products: Volume	5
195	Ex-fish: Export - Fishery Products: Volume	5
196	Ex-mfgs: Export - mfgs: Volume	5
197	Import goods excluding gold	5
198	Occupancy Rate	5
199	Tourists	5
Group 11: Financial Variables (Monthly Series)		
200	D_log(DIV): Dividend series based on	8
201	D_log(P): Price series based on	8
202	D_DivReinvest: Dividend under reinvestment based on	8
203	D_Preinvest: Price under reinvestment based on	8
204	d-p: Dividend to price ratio based on	8
205	AutoReturn: Automotive industry portfolio	8
206	FoodReturn: Food industry portfolio	8
207	FashionReturn: Fashion industry portfolio	8
208	HomeReturn: Home industry portfolio	8
209	PersonReturn: Personal goods industry portfolio	8
210	FinanceReturn: Finance industry portfolio	8
211	InsuranceReturn: Insurance industry portfolio	8
212	PetroReturn: Petroleum industry portfolio	8
213	PKGReturn: Packaging industry portfolio	8
214	PropertyReturn: Property industry portfolio	8
215	ENERGReturn: Energy industry portfolio	8
216	CommReturn: Commerce industry portfolio	8
217	HELTHReturn : Healthcare industry portfolio	8
218	MEDIAReturn : Media industry portfolio	8
219	TourismReturn: Toursim industry portfolio	8
220	TranReturn: Transportation industry portfolio	8
221	ETRONReturn: Electronics industry portfolio	8

8 Appendix B

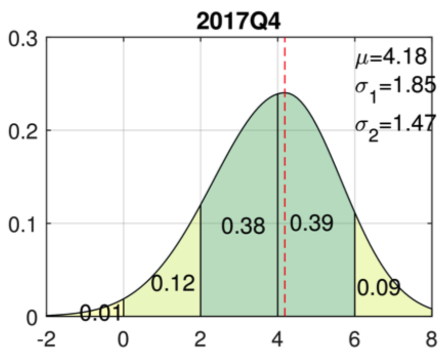
To uncover the underlying forecast distribution from the BOT fan chart, we assume that projections are constructed based on a two-piece or split normal distribution which is an approach quite common among central banks that publishes fan charts (Pońsko and Rybaczyk, 2016; Razi and Loke, 2017; Tay and Wallis, 2000). The split normal distribution has three parameters: a mode (μ), a left-hand-side standard deviation (σ_1), and a right-hand-side standard deviation (σ_1). Altogether, these parameters provide us with the following pdf:

$$f(x,\mu,\sigma_1,\sigma_2) = \begin{cases} Aexp(-\frac{(x-\mu)^2}{2\sigma_1^2}) & \text{if } x \leq \mu \\ Aexp(-\frac{(x-\mu)^2}{2\sigma_2^2}) & \text{otherwise} \end{cases}$$

where $A = \frac{\sqrt{2/\pi}}{\sigma_1+\sigma_2}$.

Based on the above specification, we draw a vast amount of random values for the three parameters and perform a grid search to find the best combination that gives us the closest match to the variable density in the fan chart. For example, from the fan chart in Figure 1, the split normal distribution that best describes the area under the density function for producing the forecast for 2017Q4 are governed by the parameters $\mu = 4.18$, $\sigma_1 = 1.85$ and $\sigma_2 = 1.47$ (see Figure B1). To obtain a series of forecast distributions that serve as inputs for the construction of the uncertainty measures according to RS, we perform such a process for every forecast round from 2000Q2 to 2017Q3.

Figure B1: Split Normal Distribution



Source: Authors' calculations.

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