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Abstract

In this paper, we study the measurement and the consequences of monetary policy uncertainty in China. We propose a new measure of uncertainty about the monetary policy of the People's Bank of China (PBOC). The uncertainty index is extracted from the reporting about the PBOC's monetary policy in international newspapers. We show that a shock to Chinese monetary policy uncertainty has significant effects on real economic activity, investment and asset prices in mainland China. Moreover, this shock has spillover effects on other Asian economies, leading to a fall in asset prices and GDP. Particularly, an increase in uncertainty leads to a drop in stock prices throughout the region. Hence, uncertainty about the PBOC's monetary policy is an additional channel of transmission that coexists with the transmission of the PBOC monetary policy itself. Finally, we show that our index contains information over and above what is already incorporated in monetary policy uncertainty indices based on mainland newspapers.

JEL classification: E58; E32; F42
Keywords: monetary policy uncertainty, China, VAR, spillover, newspapers, emerging markets

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1. Introduction

Monetary policy uncertainty has been increasingly found as an additional channel for monetary policy transmission. Many factors contribute to this policy uncertainty. One reason could be that the market is not sure about the reaction function of the central bank such as the exact weight on growth and inflation. Another reason could be that timely economic data are not available and that the economy and financial market move fast, which makes the assessment of economic fundamentals difficult. In addition, members of policy decision board could have a different view not only on the assessment of economy, but also on the emphasis such as inflation or employment. There could also be different interpretations of the central bank communications. The uncertainty about monetary policy has consequences for real economic variables as well as financial market variables over and above the effects of monetary policy itself. Research for the US has found that monetary policy uncertainty has quantitatively important real effects (e.g. Husted et al, 2019) and weakens the transmission of monetary policy shocks (Tillmann, 2020). In this paper, we study the measurement and the consequences of monetary policy uncertainty in China.

Researchers investigating the consequences of policy uncertainty face two difficulties. First, uncertainty is an unobservable, latent variable. We need to find a proxy that is correlated with the true extent of uncertainty and can be used as an input in empirical models. Second, monetary policy uncertainty is related to factors such as monetary policy itself, the business cycle or the financial cycle, it is an endogenous variable and must be disentangled from these factors.

In this paper, we make three contributions. First, we provide a new index of monetary policy uncertainty, which we derive from the reporting about the PBOC's monetary policy in international newspapers. We follow the literature on newspaper-based uncertainty measures (e.g. Baker et al., 2016) and count the number of articles that contain references to the PBOC and, at the same time, reflect uncertainty about its policy. We rely on articles exclusively in leading international newspapers and avoid newspapers from mainland China. The existing research on monetary policy uncertainty in China is scarce. Huang and Luk (2020) use uncertainty measures as reflected in mainland newspapers. The evolution of our index is similar to the Huang and Luk (2020) index. There are, however, frequent

deviations between the two indices, which reflect an offshore-onshore differential in the perception of China's monetary policy uncertainty.

Second, we estimate a vector autoregressive (VAR) model of Chinese monetary policy uncertainty with a small set of variables in order to identify the component of monetary policy uncertainty that is orthogonal to China's business cycle and financial conditions. The series of monetary policy uncertainty (MPU) shocks is then used in a number of local projections for other variables from mainland China. We show that an increase in monetary policy uncertainty prompts the private sector in mainland China to curtail its investment. Real economic activity falls significantly following an increase in uncertainty. Hence, monetary policy uncertainty has sizable business cycle effects. Furthermore, we study the spillover effects of monetary policy uncertainty to other economies in Asia. We find that shocks to China's monetary policy uncertainty cause a strong fall in equity prices and a drop in real GDP growth in Asia. Hence, the consequences of monetary policy uncertainty are not limited to mainland China but spread throughout the region.

Finally, we revisit the spread between our MPU index and the index of Huang and Luk (2020). We show that a widening of the spread predicts an increase in uncertainty reflected in mainland newspapers' reporting, not the reporting in international newspapers. Hence, an increase in reporting about MPU in the *South China Morning Post*, Hong Kong's leading English-language newspaper, relative to the reporting in mainland newspapers contains valuable information. This information content is further illustrated when we put the spread into a local projection for equity prices in Asia. An increase in the offshore-onshore spread in reporting about uncertainty prompts a strong decline in stock prices. This evidence is predictive, not necessarily causal.

Our paper is related to a buoyant literature on general economic policy uncertainty that was initiated by the collection of newspaper-based indicators by Baker et al. (2016).[1] Husted et al. (2019) apply the methodology to *monetary* policy uncertainty in the US and show that an increase in uncertainty around Federal Reserve policy dampens real economic activity. As mentioned before, we add to this literature an index of monetary policy uncertainty based on international newspapers and contrast our findings with those of

[1] See www.policyuncertainty.com for the collection of these indicators.

Huang and Luk (2020). These authors show that uncertainty reduces equity prices, employment and output in mainland China. These results are broadly in line with the findings for other countries (Baker et al., 2016; Caldara et al., 2016). Huang and Luk (2020) also provide a broad index of economic policy uncertainty in China. This paper focuses on the measurement and the consequences of monetary policy uncertainty. We study the direct consequences of uncertainty shocks for real activity as well as financial markets. Another route would be to ask whether elevated levels of monetary policy uncertainty affect the transmission of monetary policy shocks to the real economy (see Tillmann, 2020; Lien et al., 2019).

Our paper is also related to recent attempts to estimate the effects of Chinese monetary policy. We contribute to this literature by adding uncertainty as another channel through which monetary policy of the PBOC affects the economy – both domestically as well as regionally. Modelling Chinese monetary policy is not straightforward since the PBOC simultaneously uses a multitude of policy instruments, e.g. changes in policy-controlled interest rates such as short-term repo rate or changes in reserve requirements. Therefore, we need to reduce the dimensionality of the PBOC policy in order to express the policy stance by a single variable in our empirical models. For that purpose, we use the index provided by Sun (2015, 2018), which summarizes the monetary policy stance in a single number. Other approaches to dimensionality reduction include Chen, Chow and Tillmann (2017) and Funke and Tsang (2019).[2] Chen, Ren and Zha (2018), in contrast, argue that exogenous changes in M2 are a good statistic that summarizes the changes to all monetary policy instruments in a given quarter.

Finally, our paper adds to the understanding of the interaction between financial markets and monetary policy in China. Recent event studies (McMahon et al., 2018; Kamber and Mohanty, 2018; Bennani, 2019; Sun, 2020) suggest that monetary policy surprises shift expectations and asset prices, respectively. We show that uncertainty about monetary policy is a separate driving force for asset prices.

The remainder of this paper is organized as follows. In section two, we introduce our monetary policy uncertainty index. Section three contains the identification of exogenous MPU

[2]Unfortunately, the Funke ad Tsang (2019) index is available since 2012 only, such that we cannot use it in this paper. Fernald et al. (2014) reduce the dimensionality of the information content of Chinese macroeconomic data by estimating latent factors for Chinese inflation and real economic activity, respectively.

shocks, which are used in section four to estimate a battery of local projection models. Section five takes a closer look at the difference between our monetary policy uncertainty index and the index provided in Huang and Luk (2020). Section six draws conclusions.

2. An index of monetary policy uncertainty in China

In this section, we introduce a new index of monetary policy uncertainty for China.[3] We will also compare our index with the existing index of Huang and Luk (2020). The conceptual framework follows the literature on newspaper-based indices of policy uncertainty (Baker et al., 2016): uncertainty is a latent variable, which is correlated with newspaper articles using a specific list of keywords. These keywords must be chosen carefully in order to derive a meaningful indicator.

Our index has two main properties: first, it is based on articles in English-speaking international newspapers. Second, it is supposed to reflect specific uncertainty about the policy of the PBOC. We base the index construction on the number of articles in the *South China Morning Post* (SCMP) and *The Financial Times* (FT). Both are leading outlets for foreign investors in China. The *SCMP* is Hong Kong's prime newspaper and has specific expertise in covering the Chinese economy and serving Hong Kong's expat-community of market participants. We access the two newspapers through the *Nexis* database, which allows us to search for articles that contain a series of search strings. The database does not, however, give us full-text access to each article. In the *Nexis* database, the *Financial Times* is split into its print edition and its online edition. We cover both branches. For the SCMP no such distinction is made in the database. In contrast to Huang and Luk (2020), we do not search mainland newspapers. This is based on the perception that foreign investors get information about China's monetary policy mainly from international newspapers. A language-barrier might prevent offshore investors from accessing mainland newspapers. In addition, mainland newspapers might not reflect the true degree of uncertainty uniformly over the sample period. We will study the difference between our index and the Huang and Luk (2020) index below.

[3]We restrict ourselves to *monetary* policy uncertainty. Baker et al. (2016) use newspaper articles from the South China Morning Post to construct a *general* economic policy uncertainty index for China available under https://www.policyuncertainty.com/scmp_monthly.html.

We select the newspaper articles according to two criteria, which have to be met jointly. The first is that each article contains one of the terms: "PBoC", "PBC", "Peoples Bank of China" or "People's Bank of China". The second criterion is that each article contains one of the words "uncertain", "uncertainty", "concern", "not certain", "unknown", "unpredictable", "unclear", "unstable" or "volatile". The first criterion selects only those articles that deal with monetary policy conducted by the PBOC. Huang and Luk (2020), in contrast, would classify an article that contains the word "inflation" as an article on monetary policy, even though it does not mention the PBOC. Hence, our index is more narrowly defined than the Huang and Luk (2020) index. All articles that fulfil the second criterion are supposed to be about uncertainty.

For each outlet (*SCMP*, *FT* print and *FT* online), we sum the number of articles per quarter that fulfil both criteria over the sample period 2000Q1 to 2018Q4. We aggregate the data at a quarterly frequency for two reasons. First, in the early years of the sample, some months have entries of zero. Using quarterly aggregates avoids this problem. Second, we are interested in the real effects of monetary policy uncertainty. Hence, we ultimately need to analyze the index with macroeconomic variables such as GDP, which is available at a quarterly frequency only. We manually compare the articles on *FT* print and *FT* online in order to avoid double-counting articles that appeared both in print and online.

For each media outlet, we then divide the number of articles selected by the total number of articles on the PBOC in a quarter, i.e. the number of articles that fulfil the first criterion but not the second. Hence, we normalize the number of articles by the overall reporting on the PBOC. This should control for the fact that the global media interest in the PBOC and monetary policy in China grew over time.

As a final step, we weight the relative number of articles in each media outlet by the inverse of their sample standard deviation. This avoids one of the three outlets having a higher weight in the final index because it is more volatile.

The final MPU index is shown in the upper panel of Figure 1. The figure also shows the Huang and Luk (2020) index. To facilitate a comparison, we express both indices in standard deviations from their respective mean. We find that both indices evolve similarly over time. This is what we expected as the reporting in mainland newspapers should not deviate too much and too long from the reporting in international newspapers. Monetary policy uncertainty increases around the global financial crisis in 2008/2009 and remains at

an elevated level throughout the sample period. The correlation between the two series is 0.70.

While the overall evolution of policy uncertainty is similar, we spot several periods of relatively large deviations between the two alternative indices. The lower panel of Figure 1 depicts the difference between the two indicators expressed as our MPU index minus the MPU index of Huang and Luk (2020). Hence, a positive gap reflects an underreporting of uncertainty in mainland newspapers relative to international newspapers. These deviations vary between plus and minus two standard deviations. The graph also highlights four important episodes of Chinese monetary policy. The first three vertical lines highlight the three exogenous shifts of the PBOC towards a policy tightening as identified by Sun (2013). The dates for these shifts are 2004Q2, 2008Q1 and 2011Q1. The fourth date indicated in the graph by a vertical line is the unexpected devaluation of the RMB in August 2015. Except for the tightening shift in 2004, all other dates exhibit a positive gap between the two indicators. Hence, there is a higher degree of uncertainty reflected in international newspapers about monetary policy in China compared to the uncertainty expressed in mainland newspapers. It seems that despite the overall similarity to the existing index, our index contains information that is particularly reflecting the uncertainty around major shifts in monetary policy.

As policy uncertainty is an elusive concept we should discuss the limitations of our approach to measuring monetary policy uncertainty. For instance, our approach is unable to reflect the intensity by which monetary policy uncertainty is reported in the news. We count the number of articles, but do not quantify the content of each article. This also implies that we cannot take the context into account in which the reporting of uncertainty takes place. An article that mentions the words “uncertainty” and “PBOC” in the context of new GDP number for China might be interpreted differently from an article that uses the same words in an article on the future of the RMB as an international currency. Despite these limitations, we believe that the approach taken here is informative precisely because of its simplicity. We do not need to calibrate more complicated text-analytical models, thus obtain a measure of policy uncertainty that does not hinge on model calibrations or other discretionary choices.

In principle, it would be desirable to include a larger number of newspapers in the construction of the uncertainty index. Both the *FT* and the *SCMP* are certainly the most relevant newspapers for China-focused investors. Nevertheless, including outlets such as *The Wall Street Journal* or other regional newspapers besides the *SCMP* would reduce some of the noise included in our index. Additional newspapers would also reduce the effect of changes in editorial policies of one of the outlets on the resulting MPU index. However, we do not have access to the archives of relevant newspapers other than the *FT* and the *SCMP* and leave this extension for future research.

In the following, we plan to use our MPU index in empirical time series models to estimate the economic consequences of a sudden change in policy uncertainty. The main obstacle is that shifts in monetary policy uncertainty as reflected in changes in our MPU index are not necessarily exogenous shifts in uncertainty. These changes could merely reflect changes in business cycle conditions, the evolution of financial markets in China or the stance of monetary policy itself. Hence, we need to identify exogenous shifts in monetary policy uncertainty that are orthogonal to other factors. This is the subject of the following section.

3. Shocks to monetary policy uncertainty

In this section, we estimate a vector autoregressive (VAR) model in order to identify a shock to monetary policy uncertainty that is orthogonal to other variables such as real activity and the stock market. As a matter of fact, the identification of uncertainty shocks requires imposing additional identifying assumptions. We will discuss the identification below after we have introduced the set of endogenous variables.

The vector of quarterly endogenous variables, Y_t, follows a VAR process with q lags and contains four variables. It looks as follows

$$Y_t = [ccat_t \quad MP_t \quad \Delta stockp_t \quad MPU_t]' ,$$

where $ccat_t$ is the China Cyclical Activity Tracker constructed by Fernald et al. (2019) and is provided on the website of the Federal Reserve Bank of San Francisco. This series summarizes several variables and is a reliable proxy for the Chinese business cycle.

We need to include a variable that summarizes monetary policy. As the PBOC simultaneously uses a plethora of different instruments, selecting one of them over many others does not reflect the monetary policy stance as a whole. Therefore, we use the indicator provided by Sun (2018), who constructs a summary stance of monetary policy in a single

variable. Since stock prices are particularly sensitive to monetary policy and the uncertainty about monetary policy, we include the percentage change of the log-level of the main Shanghai stock price index, $\Delta stockp_t$. The final variable is the monetary policy uncertainty index introduced in the previous section, MPU_t.

To identify the component of monetary policy uncertainty that is orthogonal to the business cycle, the stance of monetary policy and the evolution of the stock market, we rely on a recursive identification scheme. This implies that we restrict the contemporaneous interaction of the variable according to the order of the variables in the vector of endogenous variables. In a given quarter, monetary policy uncertainty is allowed to be sensitive to the three other variables in the VAR model. Shocks to monetary policy uncertainty, in contrast, do not affect the three other variables contemporaneously. To summarize, we identify the part of monetary policy uncertainty that is orthogonal to monetary policy, stock prices and the business cycle. This type of recursive ordering is used by several papers in the literature (Husted et al., 2019, Baker et al., 2016, and many more) in order to identify uncertainty shocks. Monetary policy shocks are allowed to affect stock prices within the same quarter, while the PBOC is assumed to respond to stock price dynamics with a lag of one quarter. The VAR model is estimated with *q=3* lags and Bayesian methods.

As the model is Bayesian, it relies on a specification of priors. Many papers use a variant of the Minnesota prior, which assumes that the variance-covariance matrix is known. We use a Normal-Wishart prior instead, which assumes that neither the VAR coefficients nor the variance-covariance matrix is known. We believe this specification is more appropriate as it imposes fewer constraints on the model. [4] We derive impulse responses based on 10000 draws, from which the first 5000 draws are discarded as a burn-in sample.

Figure 2 presents the resulting impulse response function following a shock to monetary policy uncertainty. The shock corresponds to an exogenous increase in policy uncertainty one standard deviation in size. We also show probability bands around the median corresponding to 68% of all draws. A shock to monetary policy uncertainty raises the MPU index. Furthermore, real economic activity contracts following the uncertainty shock. The

[4]We use the BEAR toolbox 4.2 for estimation, which is available at https://www.ecb.europa.eu/pub/research/working-papers/html/bear-toolbox.en.html.

probability band around this fall in economic activity, however, includes a response of zero. The stance of monetary policy as summarized by the Sun (2018) indicator falls, which implies an easing of monetary policy conditions. Stock returns are also sensitive to policy uncertainty. The increase in uncertainty leads to a drop in stock returns by one percentage point.

Figure 3 plots the median of all draws of the structural MPU shock, expressed in standard deviations. In the following, we use this identified uncertainty shock in a series of local projections to estimate the domestic effects of uncertainty as well as the spillover effects to neighbouring Asian economies.

Of course, we could also extend the VAR model to include more than four variables. This would allow us to estimate the effects of policy uncertainty on other variables. The drawback, however, is that the number of estimated parameters increases strongly with more variables included. This is particularly problematic given the small number of observations for the sample period. Therefore, we choose a different route. We use the identified uncertainty shock and include it as an exogenous variable in a battery of estimated local projections.

Undoubtedly, monetary policy decision making at the PBOC as well as the transmission of PBOC policy to the rest of the economy have been subject to structural breaks. Changes in the RMB exchange rate arrangement, shifts in the leadership of the PBOC and structural changes in the Chinese economy, to name just a few, might have led to structural breaks in the relationships underlying the estimated VAR model. Since the estimation period is rather short, we cannot take potential structural breaks into account. Most tests of structural stability rely on large samples in order to provide reliable evidence on structural shifts. Nevertheless, we try to guard against problems of structural instability by keeping the estimated VAR model relatively small. Fewer estimated parameters should reduce the susceptibility with respect to breaks.

As a robustness check, we estimate the VAR model with the three-month deposit rate instead of the Sun (2018). The resulting shock series is also plotted in Figure (3). The baseline shocks series and the alternative shock are almost identical with a correlation coefficient of 0.92. If we estimate the local projections model, which we introduce below, with the alternative shock series, the results remain unchanged.

Before we proceed with the empirical analysis, we would like to add a cautionary note. The uncertainty shock we identified in the VAR model is the part of the MPU index that is

orthogonal to real economic activity, monetary policy and the stock market. The series does not lend itself to a structural interpretation. Hence, we do not take a stand on the precise nature of surprise changes of uncertainty reflected by the series, i.e. whether it is a shock about the second moment or a disagreement shock. For our purpose, it is enough to know that we have identified a fraction of newspaper-based monetary policy uncertainty that is orthogonal to the endogenous changes of the other three variables in the VAR system.

4. The domestic and regional effects of monetary policy uncertainty

Our aim is to quantify the effects of monetary policy uncertainty shocks on other macroeconomic and financial variables in China and in neighbouring Asian economies. We choose to estimate a series of local projections (Jordà, 2005) to accomplish this. There are several advantages of local projections over VAR models for our purpose. First, we need to estimate drastically fewer parameters as we estimate a single-equation model only. This is particularly advantageous as we deal with quarterly data and, thus, a limited number of observations. Second, local projections tend to be more robust to misspecifications than full VAR models. This is because misspecifications in one equation do not necessarily affect the quality of estimation of the remaining equations. The typical drawback of local projections is that the model does not allow us to identify structural shocks in the same way as VAR models would do. However, this is not a big concern for our purpose as we have already identified a monetary policy uncertainty shock in the previous section. Thus, we will use this shock series as the driving variable in our local projections.

Consider a dependent variable, y_t, which is driven by the monetary policy uncertainty shock, $\widehat{mpu}_t$. We regress the change between y_{t+h} and y_{t-1} on a constant, the monetary policy uncertainty shock and a set of control variables for $h = 0, 1, \dots, H$

$$y_{t+h} - y_{t-1} = \alpha_h + \beta_h \, \widehat{mpu}_t + \delta_h \boldsymbol{X}_t + \varepsilon_{t+h} \, .$$

The coefficient β_h measures the effect of monetary policy uncertainty on the dependent variable at time t for h periods ahead. Plotting β_h as a function of h provides us with an impulse response function, which we can interpret similarly to impulse responses resulting from a VAR model. The vector $\boldsymbol{X}_t$ contains control variables. We include the following variables: the level of monetary policy uncertainty in period *t-1*, the level of economic policy uncertainty in the US as reflected by the Baker et al. (2016) EPU index, the cyclical

activity indicator used in the VAR model before and the stance of monetary policy as expressed in the Sun (2018) index. The latter variable is supposed to capture the absolute level of uncertainty, whereas the driving variable of the local projections, $\widehat{mpu}_t$, is the surprises component. When we use the model to explain variables in Asian economies, we also include country-specific GDP growth and inflation rates.
The specification introduced before is appropriate for dependent variables in log-levels. We will include asset prices such as the stock price index or the exchange rate in levels.

However, we will include macroeconomic variables such as GDP and investment in annualized year-on-year growth rates. This is because the macroeconomic variables, in contrast to asset prices, exhibit a strong seasonal component, which also reflects the holidays around the lunar New Year. Since standard methods of seasonal adjustment might struggle with filtering the seasonal component, we include the macroeconomic time series as growth rates. For these series, the estimated model is

$$\Delta y_{t+h} = \alpha_h + \beta_h \, \widehat{mpu}_t + \delta_h \boldsymbol{X}_t + \varepsilon_{t+h} \, ,$$

where Δy_{t+h} is the year-on-year growth rate. In this case, the vector of control variables also includes the dependent variable in *t-1*.
The model is estimated by OLS. In each local projection, we use Newey-West corrected standard errors and allow for up to two lags of the control variables.

We estimate the model for a set of variables that we believe are particularly sensitive to Chinese monetary policy uncertainty. The first set contains Chinese macroeconomic and financial time series. We use the growth rate of real investment and various measures of aggregate real economic activity. Investment is either fixed asset investment or gross fixed capital formation. Each series is available either for private investment, thus including SOE investment, or non-SOE investment. We chose to study the response of real investment because in their analysis of monetary policy uncertainty in the US, Husted at al. (2019) stress the transmission of monetary policy uncertainty to firm investment. The source of the investment data is the Atlanta Fed's time series database on China.

The variables reflecting aggregate real economic activity in China are also drawn from the Atlanta Fed database. We use the growth rate of real GDP, the growth rate of real value added, the growth rate of real value added of SOEs and the growth rate of real value added

of share-owned firms. The distinction between SOE and share-owned value added allows us to study sectoral differences in the effect of monetary policy uncertainty.

We also estimate the model for neighboring Asian economies that are particularly susceptible to Chinese monetary policy because of their strong trade and financial ties with mainland China. The economies we include are South Korea, Taiwan, Singapore and Hong Kong SAR. For each of these economies, we use the main stock price index and GDP growth as dependent variables. Hence, we want to assess whether monetary policy uncertainty originating from China affects financial markets and the real economy, respectively.

The resulting impulse response functions for private investment in China are shown in Figure 4. We find that investment falls after an increase in monetary policy uncertainty. All responses other than the response of private gross fixed capital formation are significantly different from zero. The growth rate of investment falls by about two to three percentage points in the first year after the occurrence of the monetary policy uncertainty shock. Interestingly, non-SOE investment, either fixed asset investment or gross fixed capital formation, is more sensitive to monetary policy uncertainty than private investment, which includes SOE investment. This finding is consistent with the notion that SOEs are either better informed than private firms about future monetary policy or have preferential access to the capital market, which allows them to smooth fluctuations in investment more easily.[5] The high sensitivity of private investment to policy uncertainty is consistent with the findings of Husted et al. (2019) about US investment in response to shocks in uncertainty about Federal Reserve policy. Moreover, the findings are in line with the results of Wang et al. (2014), who show that Chinese corporate investment declines as a result of an increase in general economic policy uncertainty.

Our index of monetary policy uncertainty is essentially forward-looking. It is not based on the past monetary policy decisions such as the variation of past policy rates. Instead, it is based on the international newspaper's reporting about the future monetary policy of the PBOC. This is similar to the implied volatility of the Fed fund futures in the US. The shock derived from our MPU index controls for the influence of real business cycle activity, stock price and monetary policy itself. It could reflect the uncertainty of the future economic data or reflect the uncertainty on the views of the monetary policy decision committee.

[5] See Chen, Li and Tillmann (2019) for further evidence on the differences in the monetary transmission to SOE and non-SOE firms.

Given its forward-looking nature, it is not surprising that it will affect investment the most since investment in general is the most forward-looking variable.

Figure 5 reports the estimated impulse response functions for four alternative measures of real economic activity in China. All four measures exhibit a significant decline following an increase in monetary policy uncertainty. Thus, changes in uncertainty about the PBOC has real consequences. Activity falls by about one percent one year after the shock hits the economy. In contrast to the responses of private investment shown before, the sectoral measures of value added, i.e. value added of SOEs and value added of share-owned companies, does not exhibit significant differences.

We now turn to the spillover effects of Chinese monetary policy uncertainty to other Asian economies. Figure 6 shows the responses of the main stock market indices (in logs) of South Korea, Taiwan, Singapore and Hong Kong SAR to an MPU shock originating in China. Stock prices drop significantly following an increase in uncertainty. In Hong Kong SAR, for example, stock prices start to fall soon after the MPU shock occurred. With a decline in stock prices by about seven to eight percent, the Chinese uncertainty shocks has a somewhat stronger effect compared to policy uncertainty shocks in other regions. Caldara et al. (2016), for example, estimate the maximum effect of a policy uncertainty shock on US stock prices of three to four percent. Hristov and Roth (2019) find a drop of equity indices by about four to five percent. The response peaks eight quarters after the shock, with a drop in stock prices by about seven percent. The shape and the magnitude of the responses are roughly similar across all four Asian economies. This degree of similarity is unexpected given that countries differ with respect to their exposure to China. We expected Hong Kong SAR to be most exposed to China with mainland firms having a large representation in the Hong Kong stock market index. Overall, we find that changes in monetary policy uncertainty in China are a key factor driving asset prices throughout the region.

An interesting question is whether the spillovers from uncertainty about monetary policy in China are larger or smaller than the spillovers from Chinese monetary policy itself. To address this question, we modify the local projection for Asian stock prices and use the monetary policy shock, which has been identified in the VAR model before, as a second

driving variable. Hence, we can now plot the response to monetary policy uncertainty and the response to a monetary policy shock, respectively, in the same graph. Figure 7 shows this comparison. We find that a one standard deviation change in policy uncertainty has a larger effect on Asian stock prices than a tightening of monetary conditions in China by one standard deviation. In the latter case, the stock price responses outside China, with the exception of Hong Kong SAR, show hardly any significant reaction. Thus, the policy uncertainty seems to be a more important channel of policy spillovers from mainland China.

Turning back to the analysis of uncertainty shocks, we need to acknowledge that our series of shocks identified in the auxiliary VAR model is conditional on the ordering of the variables. We ordered the MPU index last, such that we can identify uncertainty shocks as changes in uncertainty for given levels of real activity, monetary policy and stock prices. This is not the only possible ordering. In fact, the literature also suggests ordering policy uncertainty first (e.g. Carrière-Swallow and Céspedes, 2013; Leduc and Liu, 2016). Other papers, most notably Husted et al. (2019) order monetary policy uncertainty after the macroeconomic variables but before the financial variables. To assess the robustness of our previous findings, we estimate the auxiliary VAR model again with MPU either ordered first or ordered third before stock prices. For each model, we extract the MPU shock series as the median across all draws and put the shock series into our local projections. In Figure 8, we show the resulting impulse responses of Asian stock price indices to the baseline shock as well as the two alternative shock series. Clearly, all three impulse responses are similar and lie inside the confidence band around the baseline impulse response function. From that we conclude our results are very robust with respect to the ordering of the variables in the VAR model.

Figure 9 contains the impulse response functions of GDP growth in neighboring Asian economies. Again, we find strong spillovers of monetary policy uncertainty in the mainland on other economies. Throughout the region, GDP growth falls strongly after an increase in policy uncertainty. Not surprisingly, Hong Kong SAR exhibits the strongest and fastest response with GDP growth being one percentage point lower one year after the uncertainty shock.

Finally, we also look at the responses of exchange rates. For all four Asian economies, we focus on the real effective exchange rate provided by the BIS, which is the real exchange rate against the narrowly defined group of each economy's main trading partners. An increase in this variable corresponds to a real appreciation of the domestic exchange rate. We expect the real effective exchange rate to be an important channel through which policy uncertainty in China affects the local economies. Figure 10 depicts the resulting impulse response functions. Following the surprise increase in monetary policy uncertainty, Korea, Taiwan and Hong Kong SAR exhibit a real depreciation. Singapore, in contrast, responds by a significant real appreciation of its currency.

5. Revisiting the gap between alternative MPU indices

Our index is based on the reporting in international newspapers and our selection of keywords reflecting uncertainty is narrower than the corresponding list used in Huang and Luk (2020). Therefore, differences between the two indices could be due to an over- or underreporting of uncertainty in mainland versus international newspapers or could be due to the slight differences in the dictionaries. In the following, we study the information content of the gap between the two MPU indicators. We ask whether the gap itself effects asset prices in the region which go over and above the effect of uncertainty as reflected by the Huang and Luk (2020) index.

To understand the information content of the difference between the two alternative uncertainty indices, we take the difference between them

$$mpu_t^{gap} \equiv MPU_t - MPU_t^{Huang\ \&\ Luk},$$

where we use the standardized indices to make sure that both indicators fluctuate around zero and have the same standard deviation.

In a first step, we assess whether the gap contributes to forecasting monetary policy uncertainty. For that purpose, we regress each MPU indicator on four lags of itself and the gap in *t-1*. A significant coefficient on the gap variable would imply that the gap today helps predicting tomorrow's level of MPU over and above the lagged values of MPU. The results of these simple forecasting regressions are reported in Table 1. We find that the lagged gap between the uncertainty indices does not contribute to the explanation of today's realization of our MPU index. Interestingly, the gap has forecasting power for the index provided by Huang and Luk (2020). The estimated coefficient is positive and highly

significant. Hence, a widening of the gap predicts a future increase in policy uncertainty reflected in mainland newspapers. Thus, a widening gap implies that monetary policy uncertainty is underreported in mainland newspapers relative to international newspapers, and that future reporting about uncertainty will increase in mainland newspapers.

In a second step, we ask whether the uncertainty gap contains information that is valuable for investors. We return to the local projections introduced in the previous section, but replace the MPU shock as the driving variable by the gap between the alternative MPU indices

$$y_{t+h} - y_{t-1} = \alpha_h + \beta_h \, mpu_t^{gap} + \delta_h \boldsymbol{X}_t + \varepsilon_{t+h} \, .$$

Thus, the estimated coefficient β_h reflects the impact of a larger coverage of uncertainty in international newspapers relative to mainland newspapers or an underreporting of uncertainty in mainland newspapers relative to international newspapers. We estimate the model for stock prices in Asian economies, where the information gap between the reporting about the PBOC in internationals newspapers compared to mainland newspapers is particularly relevant. Note that we include the level of the Huang and Luk (2020) MPU index as a control variable.

The results are depicted in Figure 11. When interpreting the figure, keep in mind that the estimated coefficient reflects the impact of an increase in the gap by one unit, i.e. by one standard deviation, which is a large increase. Hence, the responses of stock prices tend to be sizeable. Since the model is linear, however, the effects could easily be scaled to reflect increases in the MPU gap smaller than one standard deviation. We find that an increase in the gap between the two uncertainty indices leads to a strong fall in stock price valuation. Stock price indices (in levels) drop by about 10 to 15 percent. Put differently, an offshore-onshore differential in the reporting about uncertainty has a strong effect on asset prices that augments the effects of the Huang and Luk (2020) index itself. This supports the notion that (i) the spillovers of policy uncertainty are substantial and (ii) investors pay close attention to international newspapers when evaluating the future monetary policy. It should be noted, however, that the effect of the uncertainty gap on stock prices is predictive only, but not necessarily causal.

6. Conclusions

This paper showed that shocks to monetary policy uncertainty lead to a significant decline in real economic activity, investment and asset prices in mainland China. In addition, these shocks have significant spillover effects to other Asian economies. Spillovers of uncertainty about monetary policy coexist with spillovers of monetary policy itself. Indeed, we find that Asian stock prices are more sensitive to an increase in uncertainty about Chinese monetary policy than to a tightening of monetary conditions in China. We derived this finding from a new index of monetary policy uncertainty, which is based on the reporting of international newspapers about the PBOC.

The results have several implications for the design of monetary policy as well as for central bank watchers and investors alike. First, monetary policy uncertainty may lead to undesirable outcomes. In order to avoid unwarranted side effects on real economic activity and financial markets, it is important for the central bank to consider measures to reduce policy uncertainty. More effective communications with the public and financial professionals would certainly contribute to that effect.[6]

Second, we derive the effects of policy uncertainty from international newspapers. The existing literature, most notably Huang and Luk (2020), provides an index of policy uncertainty based on mainland newspapers. Our findings suggest that the reporting about policy uncertainty in international newspapers has real effects. We also show that the difference between our index and that of Huang and Luk(2020) can predict theirs. Hence, to gauge the extent of monetary policy uncertainty in China, international investors can rely on English newspapers.

This research leaves several interesting broad questions unanswered. One open issue is the structural source of uncertainty. On the one hand, markets could be certain about the future development of the macroeconomy but uncertain about how the central bank responds to economic developments. Hence, there could be uncertainty about the the central bank's reaction function. On the other hand, markets could be certain about the reaction function, but uncertain about the prospects of the macroeconomy. Both types of uncertainty are observationally equivalent in the indices of monetary policy uncertainty currently used in the literature. Future research could try to disentangle the structural sources of policy uncertainty. In addition, the newspaper-based approach to monetary

[6]McMahon et al. (2018) make a number of recommendations for the central bank to consider.

policy uncertainty is necessarily silent on the horizon of uncertainty, i.e. whether observers are uncertain about the central bank's immediate actions or its long-term goals. Finally, more sophisticated computer-linguistic methods such as natural language processing tools could be used to exploit not just the number of articles, but also the content. The index used in this paper follows the literature in relying on simple word-count techniques. We do not quantify the intensity by which a given newspaper article discusses policy uncertainty.

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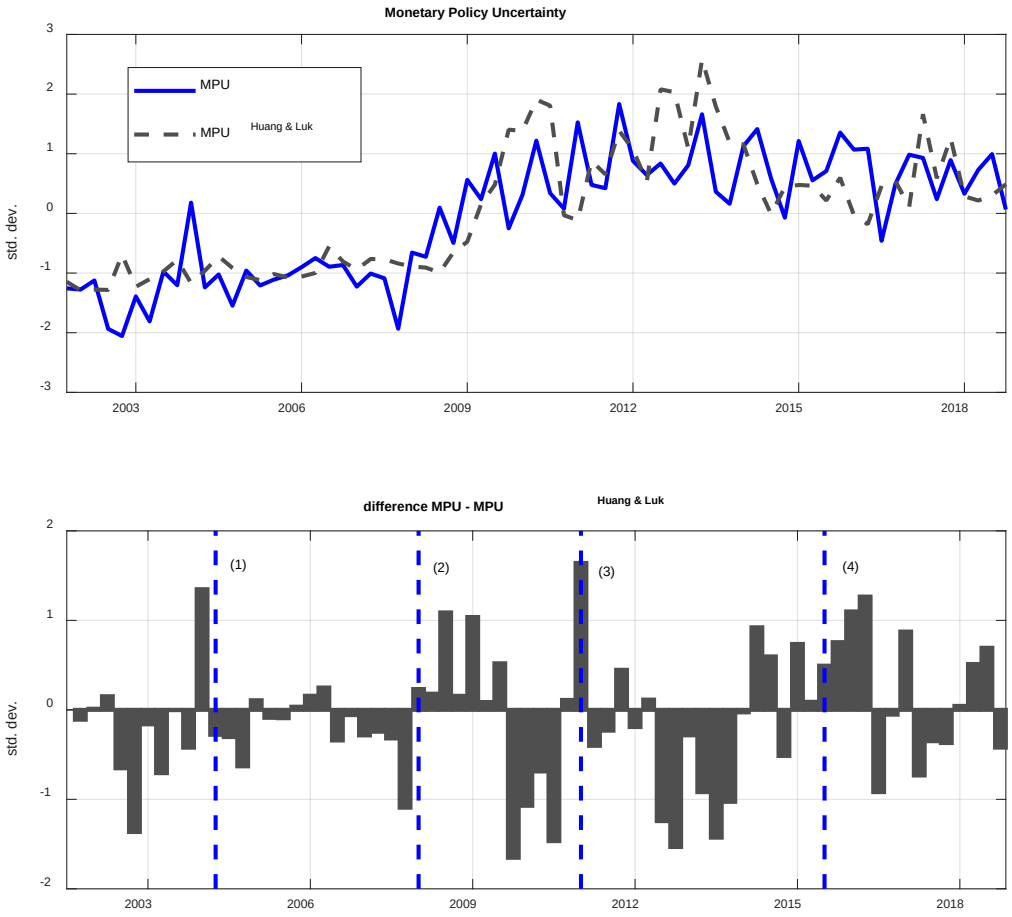
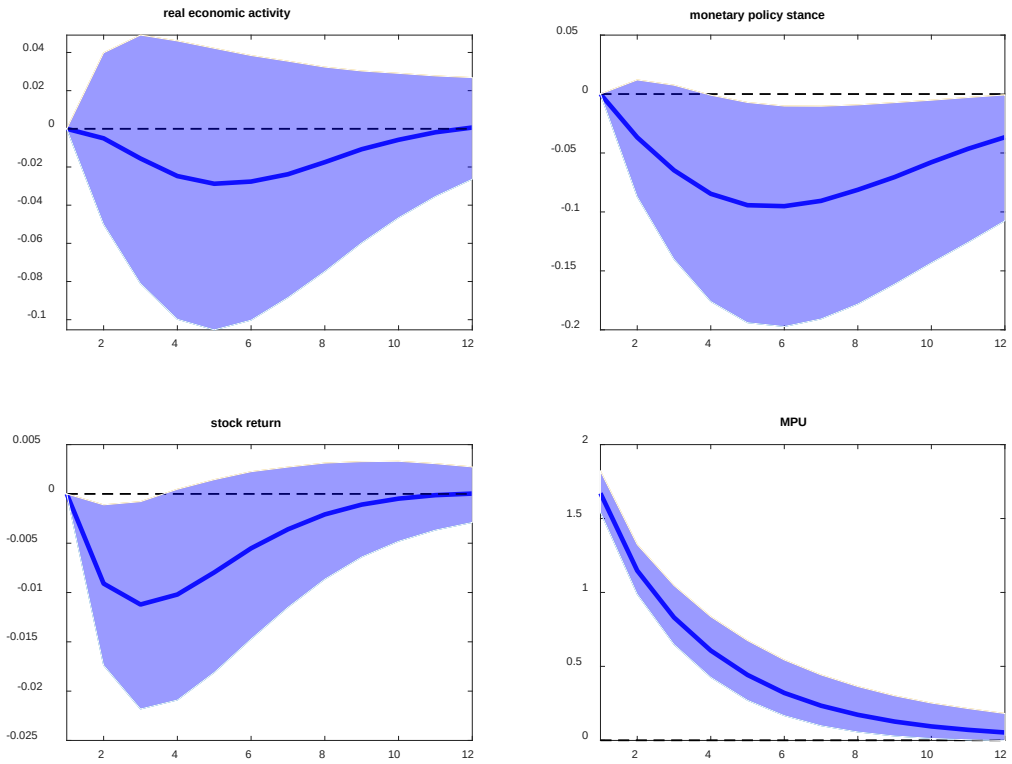
Figure 1: Indicators of monetary policy uncertainty in China



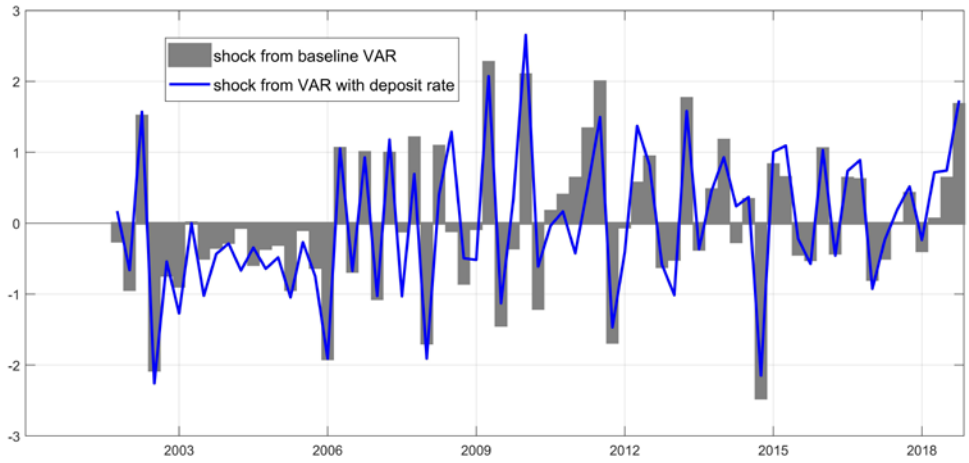
Notes: The upper panel shows the MPU index proposed in this paper and the MPU index provided by Huang and Luk (2020). The latter is based on mainland China newspapers. Both indices are standardized. The lower panel shows the difference between both MPU indices (bars). The graph also depicts four important episodes of recent PBOC policy (vertical dashed lines). The first three are the tightening shifts identified by Sun (2013). These occur in 2004Q2, 2008Q1, and 2001Q1. The fourth episode is the RMB devaluation in 2015Q3.

Figure 2: Responses to a shock to monetary policy uncertainty



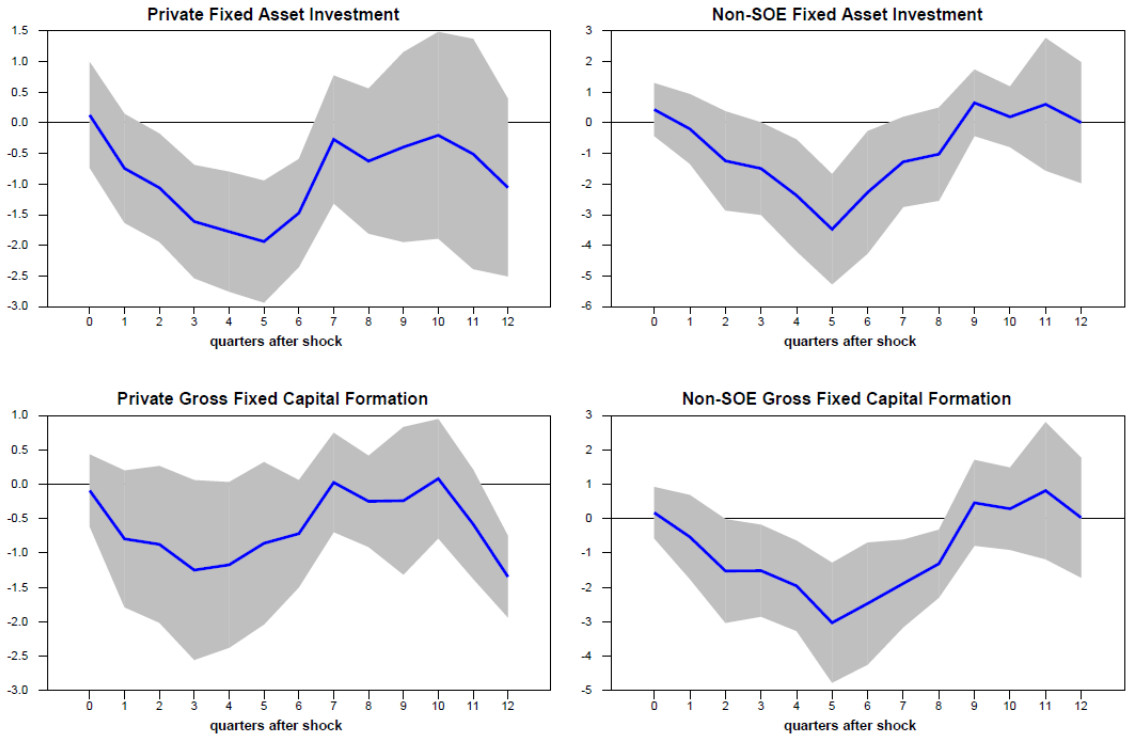
Notes: The graph shows the response to a monetary policy uncertainty shock in China obtained from a Bayesian VAR model. The shock is identified recursively by assuming that MPU shocks do not have a contemporaneous impact on the three other variables. Hence, the MPU shock is orthogonal to changes in the three other variables. Real economic activity is measured by the China Cyclical Activity Tracker (Fernald et al., 2019). The monetary policy stance is the summary indicator provided by Sun (2018). The shaded areas reflect 68% probability bands.

Figure 3: Identified shocks to monetary policy uncertainty



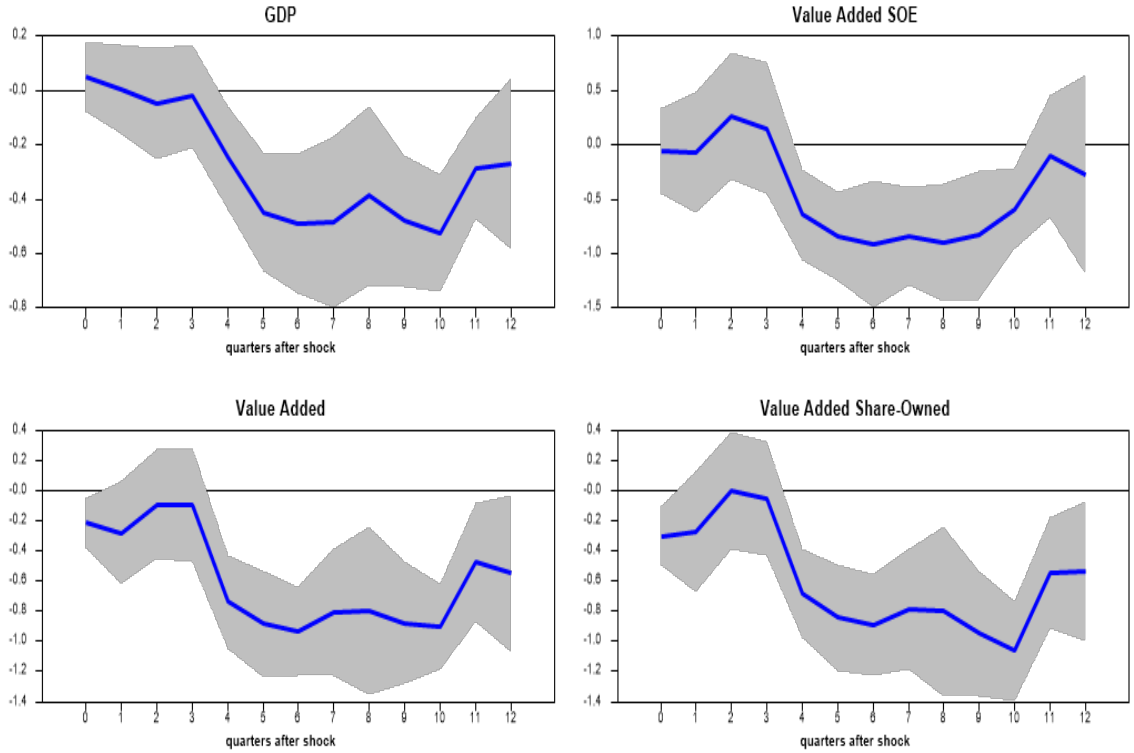
Notes: The graph shows the time series of the monetary policy uncertainty shocks obtained from the estimated Bayesian baseline VAR model (dark bars) and the alternative VAR model with the deposit rate as the policy instrument (blue line). The correlation between the shocks is 0.92. We show the median draw of all draws. The shocks are measured in standard deviations.

Figure 4: The response of Chinese investment



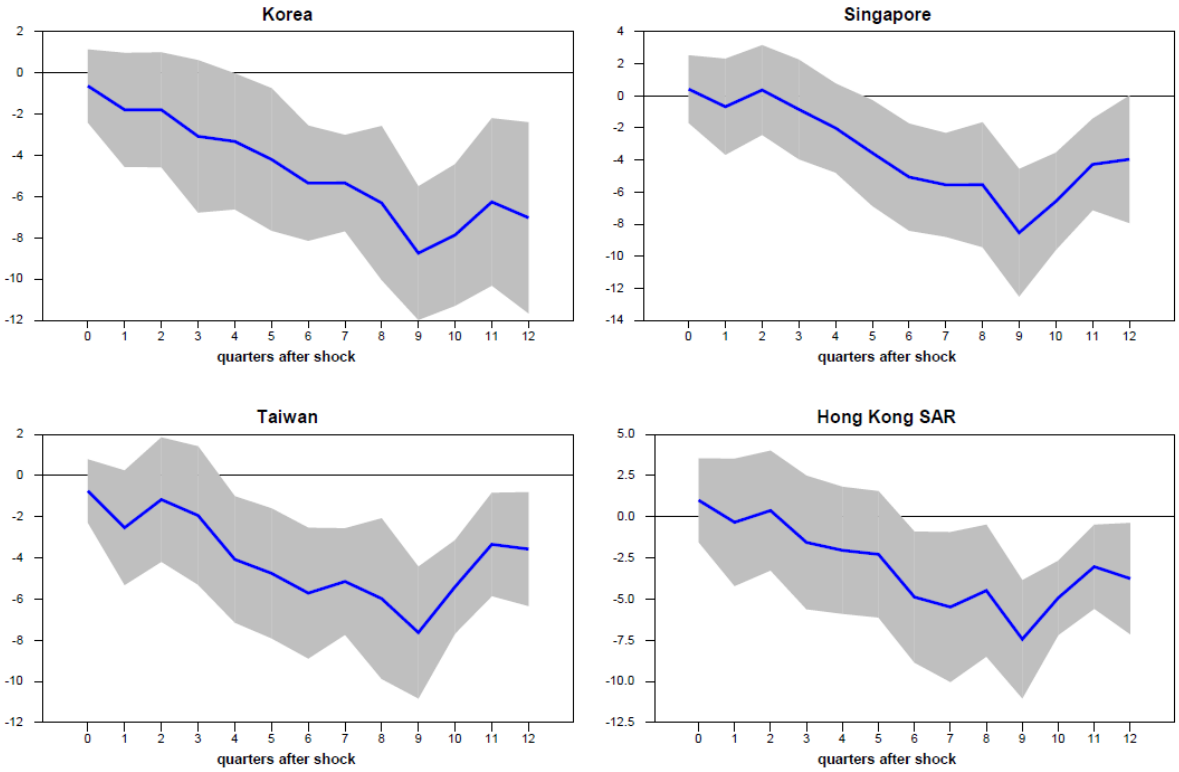
Notes: The graphs show the responses of alternative measures of private investment in China to a monetary policy uncertainty shock. The impulse responses are obtained from estimated local projections, i.e. they reflect the mean response. The dependent variables are included in y-o-y growth rates. The shaded areas reflect 90% confidence bands.

Figure 5: The response of Chinese real economic activity



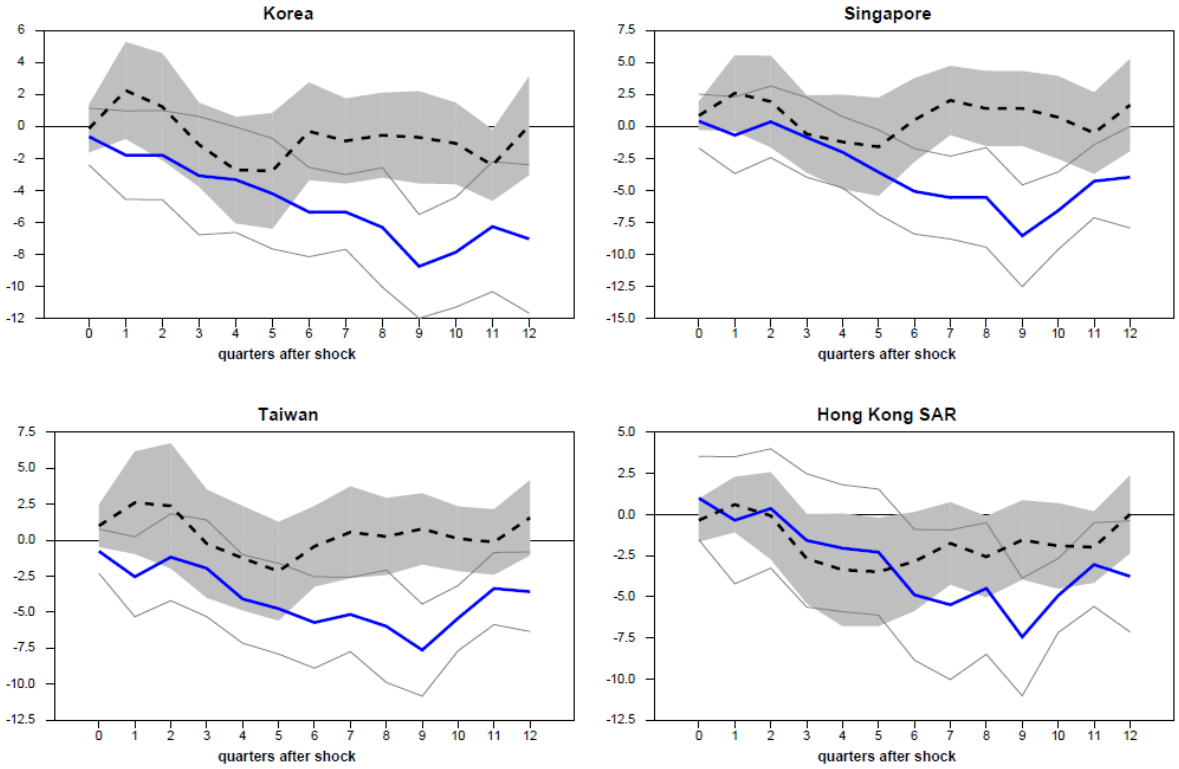
Notes: The graphs show the responses of alternative measures of real economic activity in China to a monetary policy uncertainty shock. The impulse responses are obtained from estimated local projections. The dependent variables are included in y-o-y growth rates. The shaded areas reflect 90% confidence bands.

Figure 6: The response of stock prices in Asian economies



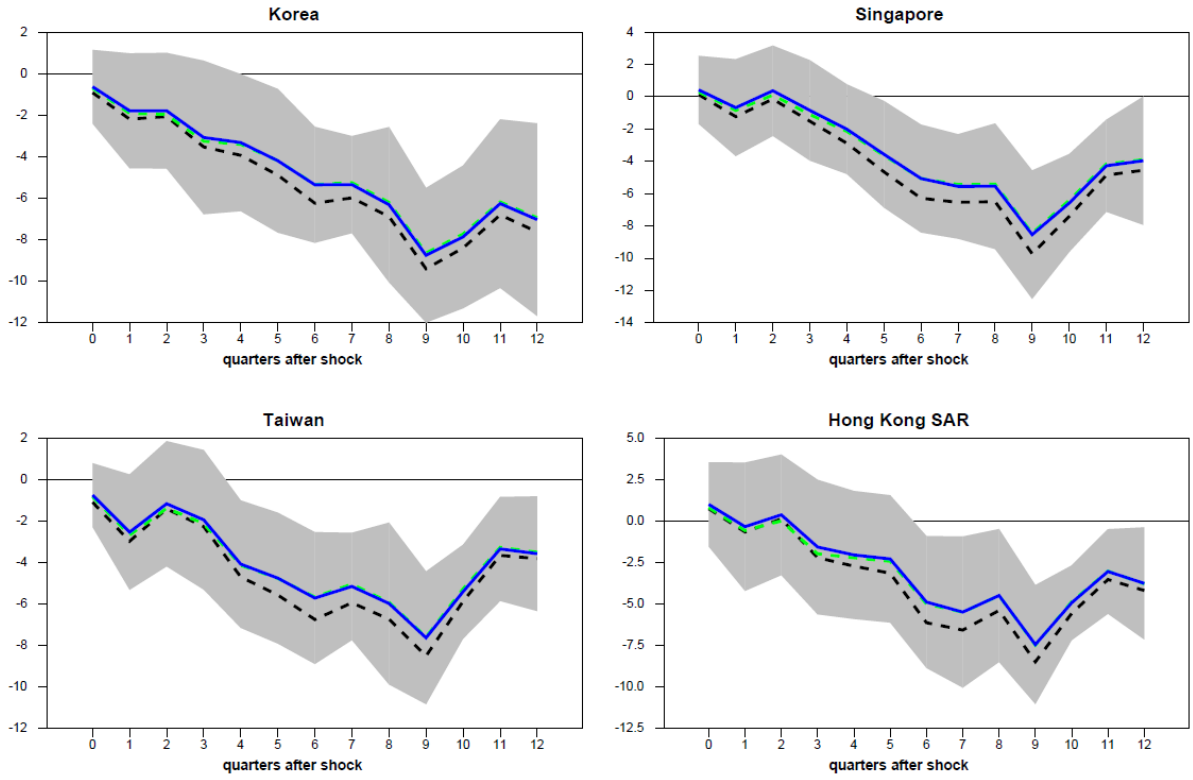
Notes: The graphs show the responses of the main stock price index in selected Asian economies to a monetary policy uncertainty shock. The impulse responses are obtained from estimated local projections. The dependent variables are included in log-levels. The shaded areas reflect 90% confidence bands.

Figure 7: The response of stock prices in Asian economies to monetary policy and monetary policy uncertainty shocks



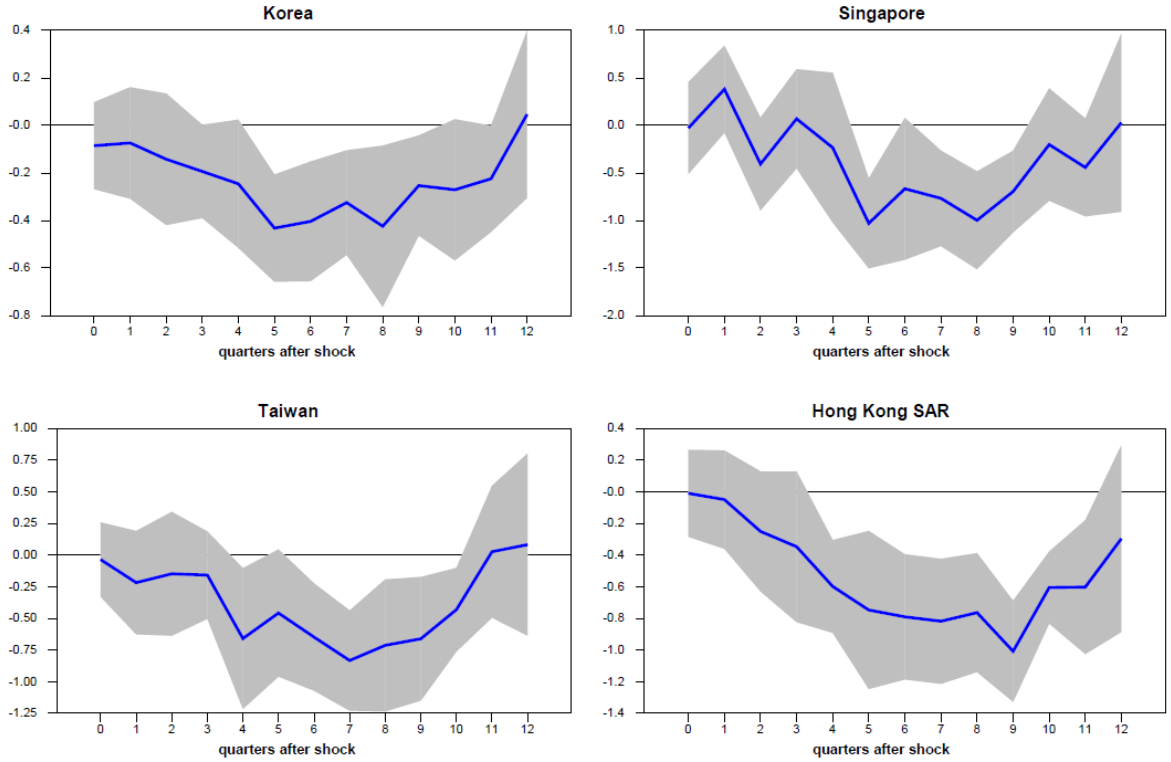
Notes: The graphs show the responses of the main stock price index in selected Asian economies to a monetary policy uncertainty shock (blue line) and to a monetary policy shock (black, dashed line). The impulse responses are obtained from estimated local projections. A positive shock indicates a tightening in monetary policy or an increase in uncertainty. The dependent variables are included in log-levels. The shaded areas reflect 90% confidence bands.

Figure 8: The response of stock prices in Asian economies - robustness



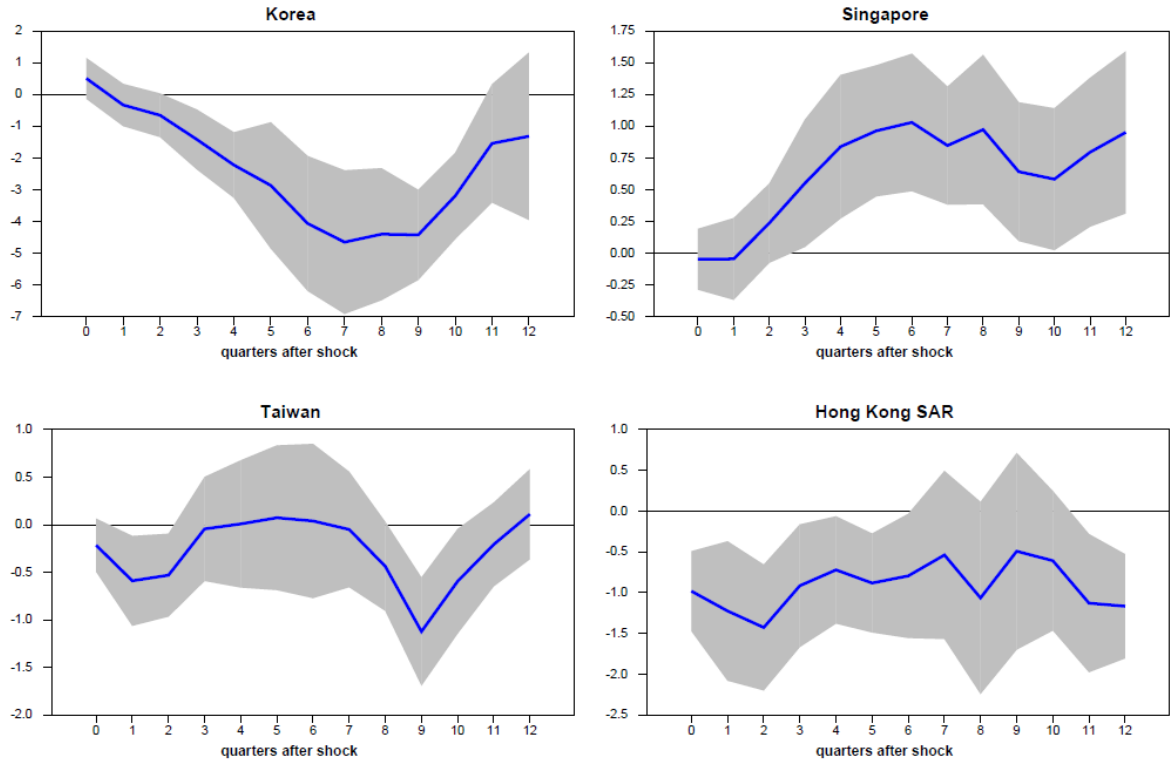
Notes: The graphs show the responses of the main stock price index in selected Asian economies to alternative monetary policy uncertainty shocks. The alternative shocks are derived from VAR models with different recursive orderings of the endogenous variables. The blue line is the response to the baseline shock obtained from a VAR with MPU ordered last. The black (green), dotted line is the response to an alternative shock obtained from a VAR with MPU ordered first (third). The impulse responses are obtained from estimated local projections. The dependent variables are included in log-levels. The shaded areas reflect 90% confidence bands.

Figure 9: The response of GDP in selected Asian economies



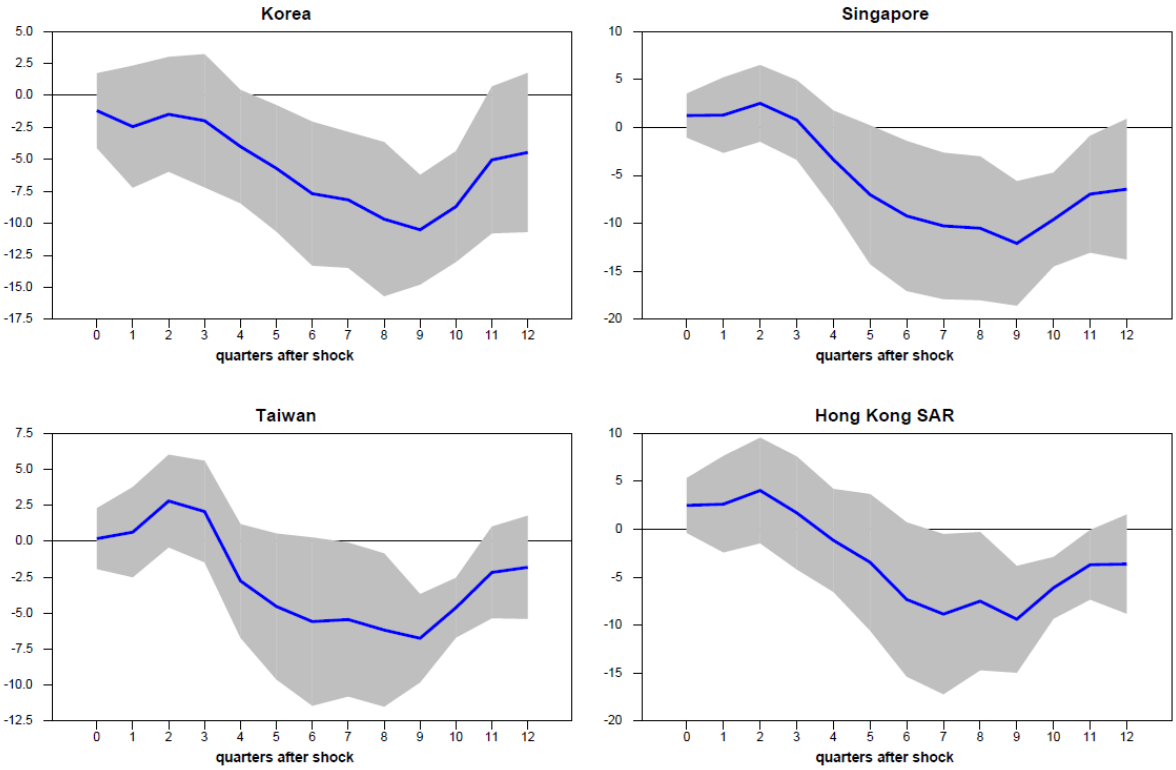
Notes: The graphs show the responses of GDP in selected Asian economies to a monetary policy uncertainty shock. The impulse responses are obtained from estimated local projections. The dependent variables are included in y-o-y growth rates. The shaded areas reflect 90% confidence bands.

Figure 10: The response of real exchange rates in selected Asian economies



Notes: The graphs show the responses of the real effective exchange rate of selected Asian economies to a monetary policy uncertainty shock. The impulse responses are obtained from estimated local projections. The dependent variables are included in log-levels and were drawn from the BIS database. The shaded areas reflect 90% confidence bands.

Figure 11: The response of stock prices in selected Asian economies to the gap between uncertainty indicators



Notes: The graphs show the responses of the main stock price index in selected Asian economies to the gap between the uncertainty index introduced in this paper and the Huang and Luk (2020) index. The impulse responses are obtained from estimated local projections. The dependent variables are included in log-levels. The shaded areas reflect 90% confidence bands.

Table 1: The information content of the gap between alternative MPU indices

	dependent variable	
	MPU_t	$MPU_t^{Huang\ \&\ Luk}$
constant	yes	yes
four lags	yes	yes
mpu_{t-1}^{gap}	0.032	0.256^{***}
	(0.114)	(0.089)
R^2	0.661	0.751
# obs.	72	72

Notes: The table reports the estimated coefficients and robust standard errors (in parenthesis) of a regression of either MPU index on a constant, four lags of itself and the lagged difference between the two monetary policy uncertainty indicators. A positive coefficient on the gap implies that today's differential between the alternative MPU indicators has forecasting power for tomorrow's level of policy uncertainty over and above the information contained in the lagged MPU levels. A significance level of 99% is indicated by ***.