北京大学中国经济研究中心
China Center for Economic Research

讨论稿系列
Working Paper Series

E2018012 **2018-04-01**

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Key words: Macroeconomic uncertainty; Spillover effect; Granger causality

JEL: C30, D80, F40

The Spillover of Macroeconomic Uncertainty between the U.S. and China

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1. Introduction

Since the seminal work of Bloom (2009), measuring aggregate macroeconomic uncertainty and examining its impacts on economies and financial markets have received increasing attention. Jurado et al. (2015) construct a U.S. macroeconomic uncertainty index from a large dataset of economic variables and find that high levels of macroeconomic uncertainty have negative effects on major economic variables. Using different measures, Caggiano et al. (2014) and Baker et al. (2016) reach a similar conclusion.

Studies have also documented the spillover effect of macroeconomic uncertainty across economies (see Balli et al., 2017; Mumtaz and Theodoridis, 2017; Antonakakis et al., 2018; Mumtaz, 2018). It is important for researchers and policymakers to understand and quantify the spillover between China and the U.S. in particular, as the largest two economies in the world. As there are no widely used measures of macroeconomic uncertainty in China that are based on real economic variables, Fontaine et al, (2017) use the economic policy uncertainty (EPU) index developed by Baker et al. (2016), which is constructed by counting word frequencies from the media. The China EPU is exclusively calculated from articles published by the South China Morning Post. Fontaine et al. (2017) find evidence that Chinese uncertainty significantly affects U.S. economic activity only during recession periods.

We aim to investigate the spillover effects of macroeconomic uncertainty between China and the U.S. to fill this research gap. First, we follow the method of Jurado et al. (2015) to construct a monthly aggregate macroeconomic uncertainty index for China from 224 economic variables, which aims to reflect the comprehensive uncertainty of macroeconomic fundamentals in China. We then apply vector autoregression (VAR) and the Granger causality test to a macroeconomic uncertainty series for China and the US. The empirical results suggest a unidirectional spillover of macroeconomic uncertainty from the U.S. to China. Furthermore, U.S. uncertainty has significant dynamic effects on China's major economic variables that are even larger than the effects of China's own uncertainty.

2. Construction of a macroeconomic uncertainty index for China

2.1 Method

The macroeconomic uncertainty (MU) index for China is constructed following Jurado et al. (2015). The h-period ahead uncertainty index $\mathrm{MU}_t(h)$ is defined as the aggregation of $\mathrm{u}_{jt}^{y}(h)$, which is the uncertainty in series $y_{jt} \in Y_t = (y_{1t}, \dots, y_{N_y t})'$,

$$\mathrm{MU}_t(h) \equiv \mathrm{plim}_{N_y \to \infty} \sum_1^{N_y} w_j \mathrm{u}_{jt}^{y}(h) \equiv E_w[\mathrm{u}_{jt}^{y}(h)], \tag{1}$$

$$\mathrm{u}_{jt}^{y}(h) = \sqrt{E[(y_{j,t+h} - E[y_{j,t+h}|I_t])^2|I_t]} \quad , \tag{2}$$

where $w_j = \frac{1}{N_y}$ is the weight and $E[\cdot\,|I_t]$ is the expectation based on information I_t available at time *t*.

$\mathrm{MU}_t(h)$ is estimated with three steps. First, to estimate $E\left[y_{j,t+h}\middle|I_t\right]$, we use a large set of predictors $\{X_{it}, i = 1,2, \dots N\ \}$ to approximate the information set I_t, and assume that X_{it} has a factor structure

$$\mathrm{X}_{it} = \Lambda_i^{F\prime} F_t + e_{it}^{X}, \tag{3}$$

where F_t is a vector of the latent common factors that can be extracted from information sets using principal component analysis. Second, define the h-step ahead forecast error as $v_{j,t+h}^{y} = y_{j,t+h} - E[y_{j,t+h}|I_t]$ and build a stochastic volatility model for $v_{j,t+h}^{y}$ to estimate its conditional volatility $\mathrm{u}_{jt}^{y}(h)$. Third, aggregate $\mathrm{u}_{jt}^{y}(h)$ to obtain $\mathrm{MU}_t(h)$.

2.2 Data

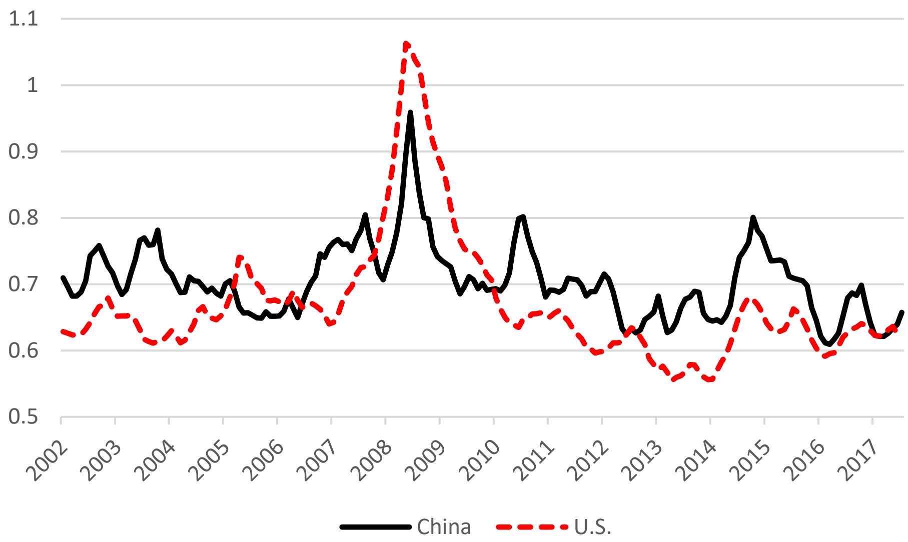
The MU index is constructed using 224 monthly variables from January 2002 to December 2017. The data include 159 Chinese economic variables used to measure uncertainty, and 65 control variables comprising 42 financial variables, 15 U.S. economic variables and 8 global commodity indices. These series are selected to represent various economic activities, including real output, investment, real estate, consumer spending, trade, bond and stock markets, the foreign exchange market, public finance, price indices and international economic indicators. Details are given in the data appendix.

2.3 China's MU index

Figure 1 presents the Chinese and U.S. MU indices. The U.S. MU index is taken from Jurado et al. (2015). The Chinese macro uncertainty in general is higher than its U.S. counterpart except the

2008-2009 global financial crisis period. Chinese MU is at the second highest level in 2015 (the stock market crash). Other spikes appear during the SARS outbreak (2002-2003) and periods of frequent macroeconomic adjustments by the government (2003-2004, 2007-2008, 2010-2011). Overall the Chinese MU appears to capture macroeconomic uncertainty in China very well.

Figure 1 China and U.S. MU indices



3. Interaction of macroeconomic uncertainty between U.S. and China

The correlation coefficient for these two series is 0.63, implying co-movements and possible spillover effects of economic uncertainty between U.S. and China. Granger causality test is applied to evaluate the direction of the possible spillover[2]. The test statistics indicate that the U.S. MU is the Granger cause of the Chinese MU, but not vice versa (Table 1).

Table 1 Granger causality test for the China and the U.S. MU indices

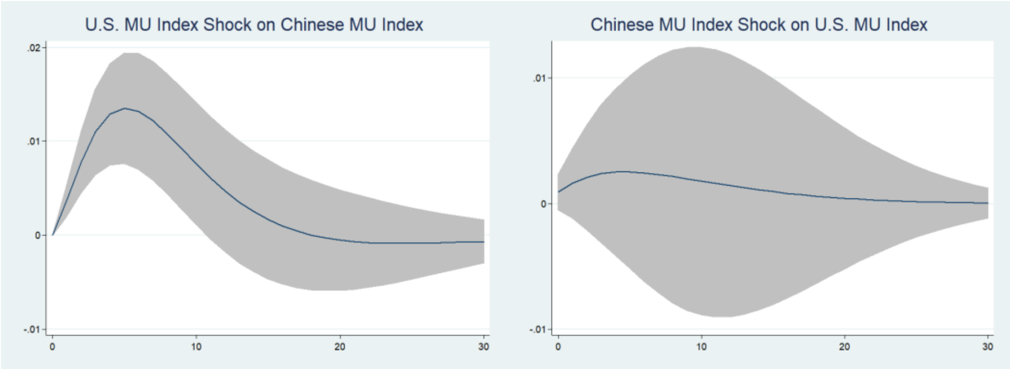
Null Hypothesis	$\chi^2(2)$	P-value	Rejection
U.S. does not Granger-cause Chinese uncertainty	23.34	0.000	Yes
China does not Granger-cause U.S. uncertainty	0.009	0.995	No

We then estimate a VAR model with lag order 2 (selected by AIC) and present the impulse responses in Figure 2. This figure shows that the Chinese MU increases significantly when the U.S. MU is shocked by one standard deviation. No significant movement occurs to the U.S. series when

[2] The ADF test statistics reject non-stationarity of the MU series.

the Chinese MU is shocked. To summarize, U.S. economic uncertainty has a strong spillover effect on China but not the vice versa.

Figure 2. Impulse responses of the Chinese and U.S. MU indices



Note: Impulse responses result from a one standard deviation increase in the MU index

4. Impact of the U.S. MU on China's major macroeconomic variables

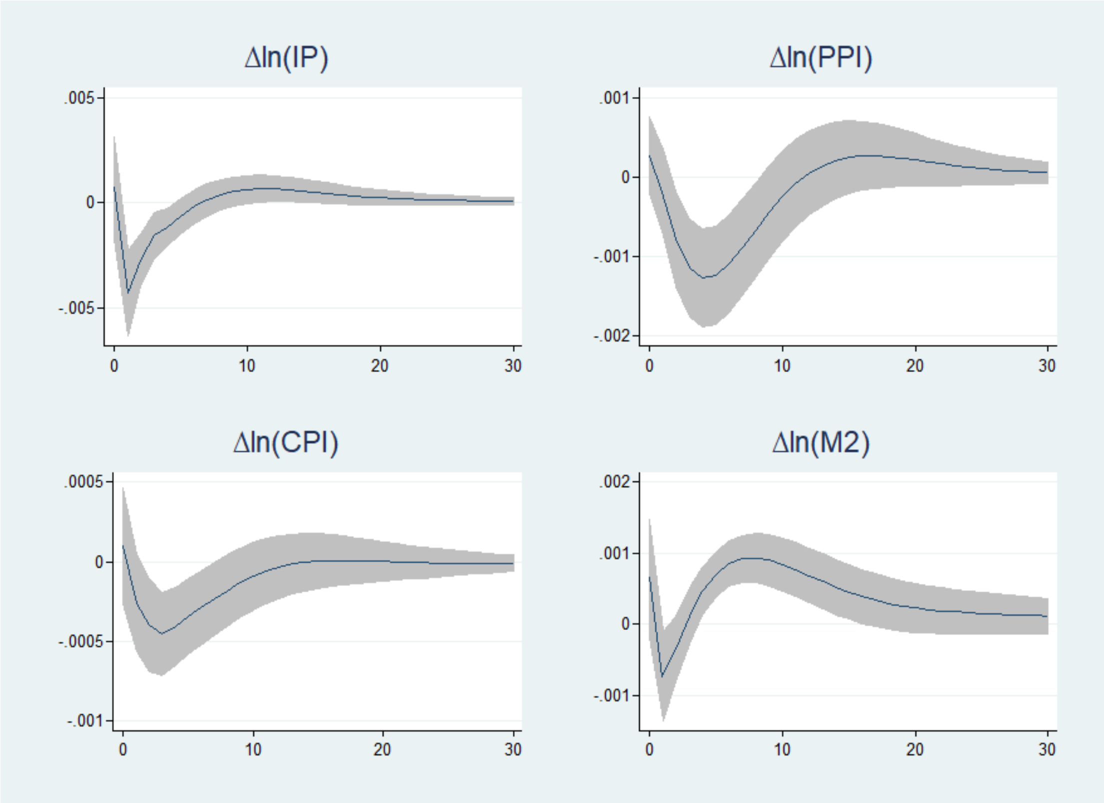
To further explore how the U.S. MU influences the Chinese MU, we control major macroeconomic variables in the structural VAR model. Following Fontaine et al. (2017), we define

$$Y_t = \left(MU^{US}, MU^{China}, \Delta\ln\left(IP^{China}\right), \Delta\ln\left(CPI^{China}\right), \Delta\ln\left(PPI^{China}\right), \Delta\ln\left(M2^{China}\right)\right),$$

where the last four variables correspond to the growth rates of industrial production[3], the consumer price index, the producer price index and M2 in China. The selected lag order is two using AIC. Figure 3 displays the impacts of a one-unit decrease in the U.S. MU index on China's macroeconomic variables. When U.S. economic uncertainty decreases, China's industrial production drops by up to -0.4% within one month of the shock and then recovers slowly. This negative effect is possibly due to the export orientation of this sector. The responses of price indices are also negative: the PPI and CPI drop by -0.13% and -0.04%, respectively, four months after the shock. China's M2, however, initially declines but increases in three months, reaching a maximum of around 0.093%, suggesting that stimulus policies are implemented in reaction to decreased U.S. uncertainty.

Figure 3 Effects of a U.S. MU index shock on China

[3] Electricity production is used to approximate industrial production.



In Table 2 we compare the share of fluctuations in major macroeconomic variables that are explained by MU indices in the forecast error variance decomposition. For example, across a 24-month horizon, the U.S. MU index shock explains 10.4%, 23.6%, 9.5%, and 18.8% of the fluctuations in Chinese CPI, PPI, IP, and M2, respectively. In contrast, the Chinese MU index shock only explains 5.7%, 1.5%, 3.3%, and 0.7% of the fluctuations in U.S. variables, respectively. Therefore the U.S. MU appears to have has a larger short-run impact on China's macroeconomic variables than that of the Chinese MU.

Table 2 Forecast error variance decomposition: the U.S. and Chinese MU shocks

Horizon (in months)	Δln(CPI)		Δln(PPI)		Δln(IP)		Δln(M2)	
	U.S.	China	U.S.	China	U.S.	China	U.S.	China
1	0.1%	3.2%	0.6%	0.4%	0.1%	0.7%	1.3%	0.2%
6	8.5%	4.8%	16.2%	1.2%	8.6%	3.0%	5.1%	0.8%
12	10.4%	5.7%	22.5%	1.4%	8.9%	3.2%	15.6%	0.7%
18	10.4%	5.7%	23.1%	1.5%	9.4%	3.3%	18.4%	0.7%
24	10.4%	5.7%	23.6%	1.5%	9.5%	3.3%	18.8%	0.7%

Conclusion

We build an MU index for China following Jurado et al. (2015) and investigate the spillover of macroeconomic uncertainty between the U.S. and China since 2002. We find that the U.S. MU index is the Granger cause of the Chinese MU index, but the reverse does not hold. We also find that the impact of changes in U.S. MU on China's major macroeconomic variables is significant and is even larger than that of the Chinese MU.

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Appendix: Data used for the Chinese MU index

No.	**Variable Name**	No.	**Variable Name**
1	Industrial added value	64-65	Indices of stock market turnover rates
2	IP: electric energy	66-67	Indices of HML
3	IP: raw coal	68-69	Indices of Mkt-RF
4	IP: coke	70-71	Market value factors
5	IP: crude steel	72	ROE
6	IP: steel	73	Foreign exchange reserves
7	IP: crude	74	Real effective exchange rate index
8	IP: ethylene	75-78	Currencies: USD, EUR, JPY, GBP/CNY
9	IP: ten kinds of nonferrous metal	79	Public expenditure
10	IP: autos	80	Public revenue
11	IP: industrial boilers	81	Fiscal balance
12	IP: metal containers	82-84	M0, M1, M2
13-14	Indices of cargo passing through ports	85	Balance of loans
15	Rail freight traffic volume	86	Balance of deposits
16	Air freight volume	87-88	Indices of loans (different terms)
17-23	Indices of fixed asset investment (different types)	89	Loan-to-deposit ratio
24-31	Indices of real estate development enterprise	90	Total social financing
32	Commodity house prices	91-95	CPI (different types)
33	Real estate index	96-104	PPI (different types)
34	Consumer expectation index	105-108	CGPI (different types)
35	Consumer satisfaction index	109-118	IPI (different types)
36	Consumer confidence index	119-124	Seven indices of the interbank rate in China
37	Total retail sales of consumer goods	125	Deposit reserve ratio
38-43	Six indices of import and export volume	126-130	Five indices of the rediscount interest rate
44	Index of export prices	131-133	Three indices of the loan interest rate
45	Index of import prices	134-139	Six indices of the deposit interest rate
46	Terms of trade	140-148	Eight indices of the treasury yield
47	Ratio of exports to imports	149	Term spread (10Y-3M)
48-56	Indices of futures volumes and prices	150-159	Indices of China's bond market
57-58	Shanghai and Shenzhen stock indices	160-200	Factors of China's stock market
59	CSI300 stock index	202-216	Major US economic indicators
60	PE Ratios: Shanghai and Shenzhen Exchanges	217-224	Major global commodities indices
62-63	Trading volumes		

Note: No.1-159 are construction variables, No.160-224 are additional conditioning variables

Data source: Wind and CEIC.