



Research article

Time-varying impact of U.S. financial conditions on China's inflation: a perspective of different types of events

Yanhong Feng¹, Shuanglian Chen^{2,*}, Wang Xuan³ and Tan Yong⁴

¹ School of Economics and Statistics, Guangzhou University, Guangzhou 510006, China

² Guangzhou International Institute of Finance and Guangzhou University, Guangzhou 510006, China

³ Xingxiang school, Xiangtan University, Xiangtan 411105, China

⁴ Department of Accounting Finance and Economics, Huddersfield Business School, University of Huddersfield, Queensgate, HD1 3DH, W Yorkshire, UK

* **Correspondence:** Email: chensl@gzhu.edu.cn.

Abstract: In recent years, the frequency adjustment of U.S. monetary policy has a dynamic and global impact on other countries' economy. Based on the financial conditions index (FCI), the paper employs the time-varying parameter vector autoregressive model with stochastic volatility (TVP-VAR-SV) and spillover index respectively to investigate the time-varying impact of U.S. financial conditions (UFCI) on China's inflation (CINF) and its impact mechanisms. Some results are achieved as follows: first, the impacts of UFCI on CINF vary greatly over time both in the dimension of action duration and time point. Second, the effects of UFCI on CINF directly relate to different types of major events, and they are heterogeneous in action duration, degree, direction as well as the trend and range of fluctuations. In addition, UFCI can work on CINF through trade flow and China's financial market, and the China's financial market plays a main conductive role, and its conductive effect changes over time.

Keywords: U.S. financial conditions; China's inflation; time-varying impact; types of events; impact mechanism

JEL Codes: E31, E44

1. Introduction

The frequency adjustment of U.S. monetary policy plays an important role in the volatility of China's economy. Evidence that "when the U.S. sneezes, emerging markets catch a cold" is provided by previous studies (Bi and Anwar, 2017; Chen et al., 2016; Dedola et al., 2017; Evgenidis et al., 2019; Maćkowiak, 2007; Tillmann, 2016). These studies mainly take into account three kinds of monetary policy indicators: quantitative, priced and unconventional monetary policy indicators. For example, Bi and Anwar (2017) employ the money supply growth rate and short-term interest rate to quantify the impact of U.S. monetary policy changes on inflation in China. The results show that a positive shock to the money supply growth rate of U.S. initially has a positive push on China's inflation rate, while a positive shock to the U.S. short-term interest rate reduces China's inflation rates. Maćkowiak (2007) selects the Federal Funds rate to investigate the effect of U.S. money policy shock on inflation in some EMEs. They point out that U.S. monetary policy is an important source of price level fluctuations in a typical emerging market. Chen et al. (2016) test the impact of U.S. quantitative easing (QE) on EMEs' inflation utilizing the term spread and corporate spread respectively. They find that U.S. monetary policy shock leads to rising inflation in several EMEs. As an export-oriented emerging economy, external shocks are a critical determinant of China's price level.

However, the dynamic spillover from U.S. financial conditions (UFC) to China's economy is not received enough attentions. Indeed, some characteristics facts prove that China's economy responses differently to the U.S. financial shocks as soon as the internal or external environments changes. For instance, when the US Federal Reserve raised the interest rate several times in different times, when it implemented quantitative easing (QE), even when it talked about "tapering" or revised downward expectations, we saw that international capital flowed from America to China every time, and further caused the economy of emerging countries to overheat quickly. Moreover, during the financial crisis of 2008, the serious drop in exports that caused by insufficient external demand (Dooley and Hutchison, 2009; Frank and Hesses, 2009), has a sizable impact on China's economy. However, mostly existing studies used with various constant parameter model or different sample period cannot completely capture the dynamic impact (Bi and Anwar, 2017; Chen et al., 2016; Maćkowiak, 2007; Tillmann, 2016). As price stability is one of primary goal of China's monetary policy, the paper aims at investigating the time-varying impact of UFC on China's inflation.

It is important to be clear, against the instantaneous shocks of the different types of major events how China's price level reacts to UFC. Although some financial phenomenon indicates that the dynamic impact of UFC on China's inflation relates to some major events, the heterogeneous effect between different types of events is still not clear. In fact, the different react processes of China's inflation to UFC shocks at special time points when different types of major events happened, might link to the transmission mechanism. For instance, the shock of global financial crisis has a considerable impact on the China's financial market (Dooley and Hutchison, 2009; Frank and Hesses, 2009), China's accession to WTO mainly contributes to the China's trade flow (Buthe and Milner, 2008; Grant and Lambert, 2008), and the reform of RMB system is directly related to international capital flow because economics with more flexible exchange rate regimes attract more capital inflows (Magud et al., 2014). Thus, it results in the various effects of UFC on China's inflation under the instantaneous shocks of different events. Therefore, it is of great reference value to make clear how China's economy fluctuates in response to UFC volatility, facing different types of major events. On the one hand, it helps to make targeted response policy when a major emergency like global finance crisis occurs again. On the other hand, it provides reference basis to carry on major reform policy, such as further internationalization of the RMB and opening-up of China's capital accounts.

Then, we ask: how does UFC transmit to China's inflation in different period? On the one hand, early studies argue that the international monetary policy has different transmission mechanisms under different environment (Bernanke and Mihov, 1995; Canova and De Nicrolo, 1999, 2000; Canova and Marrinan, 1998). On the other hand, several previous studies pay a special attention on the specific transmission channels such as credit (Kazi et al., 2013), money policy (Von Borstel et al., 2016), trade and capital (Anaya et al., 2017). However, the previous evidence is not directly informative about the time-varying and heterogeneous characteristics of transmission channels. What's more, under the background of closer and closer relationship between U.S. and China, understanding the impact mechanism is helpful for policy making. Therefore, it is necessary to identify the transmission channels and their time-varying feature.

The financial market of a country involves various information such as currency, assets and credit. In a seminal study, Goodhart and Hofmann (2000) proposed a financial conditions index (FCI), which has commonly been used as a composite measure of the stance of a country's monetary policy and the aggregate state of financial market (Angelopoulou et al., 2013; Goodhart and Hofmann, 2000). Hence, based on the FCI, this paper hopes to solve the following questions: first, using a time-varying parameter vector autoregressive model with stochastic volatility (TVP-VAR-SV), this paper attempts to investigate the time-varying characteristics of the impact of UFC, which is different with the common regression methods (Hosen et al., 2020). Second, this paper specially analyzes the heterogeneity of the time-varying characteristics under the instantaneous shocks of different major events. Third, this paper further tries to identify the transmission channels and their time-varying characteristics by the spillover index.

The contributions can be summarized as follows. First, this paper analyzes the time-varying characteristics of the impact of UFC on China's inflation. On the one hand, some characteristics facts prove that China's economy responses differently to the U.S. financial shocks as soon as the internal or external environments changes, but it is not clear how the effect changes over time. On the other hand, previous studies examine the impact of some U.S. monetary policy indicators separately on some EMEs' inflation and the empirical results are controversial. Hence, this paper investigates the time-varying impact of the aggregate state of U.S. financial conditions on China's prices level in a time-varying framework and from the perspective of composite index. The empirical results show that the responses of China's inflation to UFC shocks show an inverted "V" in the response dimension and a "W" in time dimension respectively. In addition, the time-varying characteristics is directly relevant to some major events.

Second, this paper analyzes the heterogeneity of the time-varying characteristics under the instantaneous shocks of different major events. There are some evidences that China's inflation responses differently to U.S. financial shocks at special time points when different types of major events happened. However, it is not clear what are the specific differences and it leads to the lack of reference for policymaker. Therefore, this paper focuses on the instantaneous shocks of different major events. Our results highlight that the instantaneous impacts of UFC on China's inflation under major events are different in event types. Specially, the heterogeneity of the instantaneous impacts under different types of events is reflected in length, speed and degree.

Third, this paper identifies the transmission channels and their time-varying characteristics. According to literature review, it can be inferred that the trade, capital, credit, interest rate and exchange rate etc. may play an critical role in transmitting UFC shocks to China's inflation (Bowman et al., 2015; Chor and Manova, 2012; Dahlhaus and Vasishtha, 2014; Goodhart and Hofmann, 2001; Lin and Ye, 2018; Rey, 2016). However, it is lack of empirical evidences that the transmission channels transform over time. Therefore, this paper firstly divides the possible transmission channels into three categories: capital flow, trade flow and China's financial market. Furthermore, this paper identifies the transmission

channels and their time-varying characteristic empirically. In the term of empirical methodology, this paper adopts the dynamic spillover based on TVP-VAR model, which allows for interactions between variables and can remove the reverse effect (Antonakakis et al., 2018). Through empirical analysis, the results show that China's financial market and trade are transmission channels through which UFCI affects China's inflation, but capital is not. Moreover, the differences between the China's financial market channel and trade channel are manifested in the two aspects of time and degree.

The paper is organized as follows. The section 2 provides the research foundation, consisting of the variables and data. In this section, the focus is to measure whole financial market conditions of America and China. The time-varying characteristic analysis of the impact of U.S. financial conditions on China's inflation are presented in section 3. The examinations and analysis of the time-varying transmission mechanisms are provided in section 4. The last section presents the conclusions.

2. variables and data

2.1. Variables

This paper studies the time-varying impact and impact mechanism of aggregate U.S. financial conditions on China's inflation. According to the introduction, this paper involves five key variables, which are U.S. financial market condition, capital flow, trade flow, China's financial market and China's inflation. The China's inflation is measured by the monthly CPI growth rate. The trade flow is represented by the monthly export growth rate of China. Referring to a simple indirect measurement method of World Bank (1985) and considering the availability of data, the foreign exchange reserve accumulation minus the net-export is used to measure international capital flow. To ensure the stability, this paper further defines the rate of capital flow to GDP as the final proxy variable.

In particular, the measurement of U.S. and China's financial market are following the seminal studies of Goodhart and Hofmann (2000). Since been put forward, the FCI has got sustained and wide attention from academia, center bank and investors. In the existing literature, there are three common measurements for estimating the weights of the construction variables of FCI. They are reduced aggregate demand Equation (RADE), principal components analysis (PCA), and variant models of VAR (Alessandri and Mumtaz, 2017; Goodhart and Hofmann, 2001). Specially, the method of RADE is made up of a Phillips curve and IS equation. Due to the deep theoretical basis, RADE is contributed to distinguishing the effects of various potential factors on the real economy better. Therefore, this paper uses the IS equation to come up with the FCI. Referring to the seminal studies of Goodhart and Hofmann (Goodhart and Hofmann, 2000), FCI is constructed as follows:

$$FCI_t = \sum W_{it} (q_{it} - \bar{q}_{it}) = \sum W_{it} * qg_{it} \quad (1)$$

where FCI_t is the aggregate financial conditions index at time t , q_{it} is the price of asset i in period t , which includes the real interest rate gap, real exchange rate gap, real share price gap and real house price gap. \bar{q}_{it} is the long-run trend equilibrium value of the price of asset i in period t , qg_{it} is the gap of the price of asset i at time t , and ω_{it} is the relative weight given to the price of asset i at time t in the FCI. Moreover, we obtain the equilibrium term of the financial indicators employing the Hodrick-Prescott Filter, a widely used tool for economic research in deriving the variables' time-varying trends.

Following the pioneering contribution, we estimate a state-space model and use the dynamic coefficients to derive the time-varying weight of financial variables in the FCI. At first, based on IS curve, we construct a simple signal equation of the state space model as follow:

$$\begin{aligned} rog_t = & \alpha + c_1 rog_{t-1} + c_2 rig_t + c_3 rsg_t + c_4 rhg_t + \gamma_t * rog_{t-1} \\ & + \lambda_{1t} * rig_t + \lambda_{2t} * reg_t + \lambda_{3t} * rsg_t + \lambda_{4t} * rhg_t + \eta_t \end{aligned} \quad (2)$$

where, rog is the gap between real total output and equilibrium total output or potential total output. c_i is constant coefficient. λ_i is time-varying coefficient. rig , reg , rsg and rhg respectively donate the real interest rate gap, real exchange rate gap, real share price gap and real house price gap between its real value and equilibrium.

The state equation is defined according to the form of recursive functions:

$$\begin{aligned} \gamma_t = T_0 \gamma_{t-1}; \quad \lambda_{1t} = T_1 \lambda_{1,t-1}; \quad \lambda_{2t} = T_2 \lambda_{2,t-1}; \\ \lambda_{3t} = T_3 \lambda_{3,t-1}; \quad \lambda_{4t} = T_4 \lambda_{4,t-1}; \quad \eta_t = c_5 * \eta_{t-1} + [\text{var} = \exp(c_6)] \end{aligned} \quad (3)$$

Thus, the weights of FCI are present by

$$W_{it} = \frac{|\lambda_{it}|}{\sum_{i=1}^4 |\lambda_{it}|} \quad (4)$$

In addition, the proxy variables of FCI are following to the typical practice. First, the real interest rate is measured by over-night money market rate minus the change rate of consumer price index (CPI). Second, the real affective exchange rate index is used to as a proxy for the real exchange rate. Third, we select the real house price index and real stock price index from OECD to measure the real house price and the real stock price, respectively. To be clear, since the data of China's real house price index is a lot of missing, China's Estate Climate Index is used as a proxy variable for real house prices of China. Moreover, real output is represented by GDP after reduction.

2.2. Data and pretreatment

Overall, all the relative variables and their sources are shown in Table 1.

With regard to the measurement of FCI, considering the consistency and availability of data, we use the monthly data over the sample period 1999M1–2019M6 to calculate the U.S. FCI (UFCI) and China's FCI (CFCI). Most variable series are measured at a monthly frequency, with the remainder measured at quarterly frequencies. Before estimation, all quarterly series are converted to monthly frequency employing denton, a conversion method of low frequency to high frequency data¹. Furthermore, due to the strong seasonality in the GDP, seasonal adjustment is made for the variable by the method of Census X-12 before de-trending them. Last but importantly, the unit root test proves the stationary of the variables gap between their real value and equilibrium before estimating the state-space model.² The summary statistics of variables of FCI are presented in Table 2.

¹For GDP, a flow variable, we select match sum in denton conversion. For real house price index, an exponential sequence, we select match average in denton conversion.

²The unit root test and the parameter estimation of the state-space model are available upon request from the authors.

Table 1. Variables and data source.

Indicators	Proxy variables	Data source
real interest rate	Over-night money market rate minus CPI monthly rate of change	IMF, OECD data
real exchange rate	real effective exchange rate index	BIS
real stock price	real stock price index	OECD data
real house price	USA: real house price index	OECD data
	CHN: Estate Climate Index	Wind
real output	GDP	IMF
China's inflation	CPI monthly rate of change	Wind
capital flow	(foreign exchange accumulation minus the trade surplus and the net inflow of FDI)/GDP in China	Wind
trade flow	export growth rate of China	Wind

Table 2. Data summary statistics.

	Variables	Mean	Median	Maximum	Minimum	Std.Dev.
U.S.	RI	-0.24	-0.67	3.947	-3.790	1.74
	REE	109.93	111.20	129.03	93.06	9.47
	RS	78.54	74.96	124.24	44.24	20.58
	RH	99.82	98.63	118.57	80.78	11.18
	RG	5,200.69	5,202.22	6,345.35	4,129.29	581.46
China	RI	0.31	0.39	7.68	-6.41	2.17
	REE	103.08	99.18	130.93	81.84	14.57
	RS	64.64	60.15	155.98	28.20	24.30
	RH	100.70	101.45	106.59	92.43	3.5683
	RG	32,743.76	30,955.35	64,307.58	11,257.86	16,162.40

Note: This table summarizes descriptive statistics (sample mean, maximum, minimum, standard deviation) of real interest rate (RI), real effective exchange rate (REE), real share prices (RS), and real house prices (RH) for U.S. and China, respectively. The sample period is from January, 1999 to June, 2019.

Because the measured weight of FCI is 0 at the first 5 time points, the dataset in the VAR framework covers the period ranging from 1999M6 to 2019M6. Variables included in the VAR framework are: UFCI, CF, CINF, TF and CF. The description statistics of these variables are displayed in Table 3. In addition, the dynamic correlation graphs based on DCC-GARCH model in the Figure A1 to Figure A3 in appendix A, show that the relationship between variables is time-varying.

Table 3. variables descriptive statistics.

	Mean	Median	Maximum	Minimum	Std. Dev.
UFCI	-0.0671	0.0033	3.7068	-4.4754	1.3348
CFCI	0.0626	-0.3199	45.651	-23.501	9.6115
CINF	2.0938	1.9000	8.7000	-2.6800	2.0624
TF	0.0015	0.0020	0.0551	-0.0755	0.0235
CF	15.3291	15.4000	51.7000	-28.0000	16.9702

Furthermore, in order to get the reliable estimates of the TVP-VAR model, we need to test the stability of variables. The univariate properties of time series were tested by the ADF test and PP test, two common methods of unit root tests. In Table 4, it can be seen that the results of method are less than the critical values at 10%. It indicates that all of these tests reject the null hypothesis of the unit root. In other words, all variables are stationary in levels at least 10%.

Table 4. Unit root test results.

	UFCI	CFCI	CINF	TF	CF
ADF(k)	-4.1628(1)	-4.2909(1)	-3.5055(1)	-2.7027(1)	-4.2317(1)
PP(K)	-3.7662 (1)	-3.7662(1)	-3.4653(1)	-2.6027(1)	-3.7562(1)

Notes: The critical values for the ADF and PP tests at the 1%, 5% and 10% significance level are -3.61, -2.94 and -2.58 respectively. (k) is the lag order of the model used for unit root test.

3. Time-varying impact of UFCI on CINF: impulse response analysis

3.1. TVP-VAR-SV model

The impact of UFC on China's inflation changes with the external and internal environment. Especially, in recent years, the Federal Reserve frequently adjust the money policy, which results in a significantly dynamic impact on China's economy. Almostly existing literature employed various models with constant coefficients to investigate the international spillover of U.S. financial shocks to EMEs' inflation, such as global vector auto regression (GVAR) model (Bi and Anwar, 2017), global vector error correction model (GVECM) (Chen et al., 2016), structural vector auto regression (SVAR) model (Maćkowiak, 2007), and Qual vector auto regression (VAR) model (Tillmann, 2016). However, these models didn't take unobserved time-varying nature into consideration.

The TVP-VAR-SV model is extended from the traditional VAR model by adopting a state space representation with measurement equation (Primiceri, 2005). It serves as a useful tool for investigating the dynamic linkage between the variables underlying structure shocks over time in a flexible and robust manner (Nakajima et al., 2009). Therefore, following the contribution of Primiceri (2005) and Nakajima et al. (2009), this select the TVP-VAR-SV model to capture the time-varying impact of UFC on China's inflation.

The volatility of China's price level is not only generated from external financial shocks, but also from the changes of internal financial conditions. In addition, the China's financial conditions is influenced easily by the American's financial conditions, through capital flow and international trade flow. Hence, we set a five-variable framework model. Furthermore, according to the exogenous order of the variables, we set their order to be: UFC, CFC, CF, TF and CINF. Let

$\{(UFCl_t, CF_t, TF_t, CFCl_t, CINFl_t)'\}$ be the data set, where $UFCl_t$ and $CFCl_t$ denote the U.S financial conditions and China's financial conditions at time t respectively, $CINFl_t$ denotes China's inflation at time t .

Consider the time-varying parameter regression model specified by:

$$y_t = X_t \beta_t + A_t^{-1} \Sigma_t \varepsilon_t, \quad t = s+1, \dots, n, \quad \varepsilon_t \sim N(0, I_K) \quad (5)$$

where $y_t = (UFCl_t, CFCl_t, CF_t, TF_t, CINFl_t)'$, $X_t' = I_k \otimes (y'_{t-1}, \dots, y'_{t-s})$, y_t and ε_t are 5×1 vectors, the coefficients β_t , and the parameters A_t , and Σ_t are 5×5 diagonal matrices, σ_{jt} is the diagonal elements of Σ_t . As Primiceri (2005) suggested, to capture the time-varying nature of the underlying structure in economies, it is assumed that the parameters in the TVP-VAR-SV model obey random-walk processes. Let $a_t = (a_{21}, a_{31}, a_{32}, a_{41}, \dots, a_{k,k+1})'$ represent a stacked vector of the lower-triangular elements in A_t . and $h_t = (h_{1t}, h_{2t}, \dots, h_{kt})'$ with $h_{jt} = \log \sigma_{jt}^2$, for $h_{jt} = \ln \sigma_{jt}^2 (j = 1, 2, \dots, k; t = s+1, \dots, n)$.

Thus,

$$\begin{pmatrix} \beta_{t+1} \\ a_{t+1} \\ h_{t+1} \end{pmatrix} = \begin{pmatrix} \beta_t \\ a_t \\ h_t \end{pmatrix} + \begin{pmatrix} u_{\beta t} \\ u_{a t} \\ u_{h t} \end{pmatrix}, \quad \begin{pmatrix} \varepsilon_t \\ u_{\beta t} \\ u_{a t} \\ u_{h t} \end{pmatrix} \sim N \left(0, \begin{pmatrix} I & 0 & 0 & 0 \\ 0 & \Sigma_\beta & 0 & 0 \\ 0 & 0 & \Sigma_\alpha & 0 \\ 0 & 0 & 0 & \Sigma_h \end{pmatrix} \right) \quad (6)$$

For $t = s+1, \dots, n$, where $\beta_{s+1} \sim N(u_{\beta 0}, \Sigma_{\beta 0})$, $a_{s+1} \sim N(u_{a 0}, \Sigma_{a 0})$ and $h_{s+1} \sim N(u_{h 0}, \Sigma_{h 0})$.

Further, we assume that shocks are not related to the time-varying parameters and the covariance matrices Σ_β , Σ_α , Σ_h are supposed to be diagonal.

In the frame of the Bayesian, the estimation of the model can be constructed using the Markov Chain Monte Carlo (MCMC) methods which is appropriate for several reasons. First, the model includes the nonlinear state equations of stochastic volatility, which solves the problem of the intractability of the likelihood function. Second, this method makes full use of the uncertainty of the unknown parameters to infer the state variables and estimate the function of the parameters. Lastly, these estimates are more efficient if focusing on the time varying nature of the unobservable states, which is the case for the issues we address in this paper. Following Nakajima (2011), we make use of the following priors: $\Sigma_\beta \sim IW(25, 0.01I)$, $(\Sigma_\alpha)_i^{-2} \sim \text{Gamma}(4, 0.02)$, $(\Sigma_h)_i^{-2} \sim (4, 0.02)$, $\mu_{\beta_0} = \mu_{\alpha_0} = \mu_{h_0} = 0$ and $\Sigma_{\beta_0} = \Sigma_{\alpha_0} = \Sigma_{h_0} = 10 \times I$.

3.2. Continuous responses of CINFL to UFCI shock

A three-variable TVP-VAR model with stochastic volatility, consisting of UFCI, CFCl and CINFL, is estimated for monthly data from the period 1999M6 to 2019M6. The SC (Schwarz information criterion) is used to select the VAR lags and the number of the VAR lags is 1. To compute the posterior estimates, we set $M = 10,000$ times, discarding the initial 1000 samples of the MCMC algorithm. To investigate the dynamic characteristics of UFC impact on China's inflation from different action duration and time point [Time dimension refers to the occurrence time of UFC impact, while response dimension refers to the duration of impact on China's inflation.], we draw a three-dimensional impulse response diagram, as shown in Figure 1. Where, the X-axis represents the duration of response of

China's inflation to UFC shocks, the Y-axis represents the time of UFC shocks, and the Z-axis represents the response degree of China's inflation to UFC shocks.

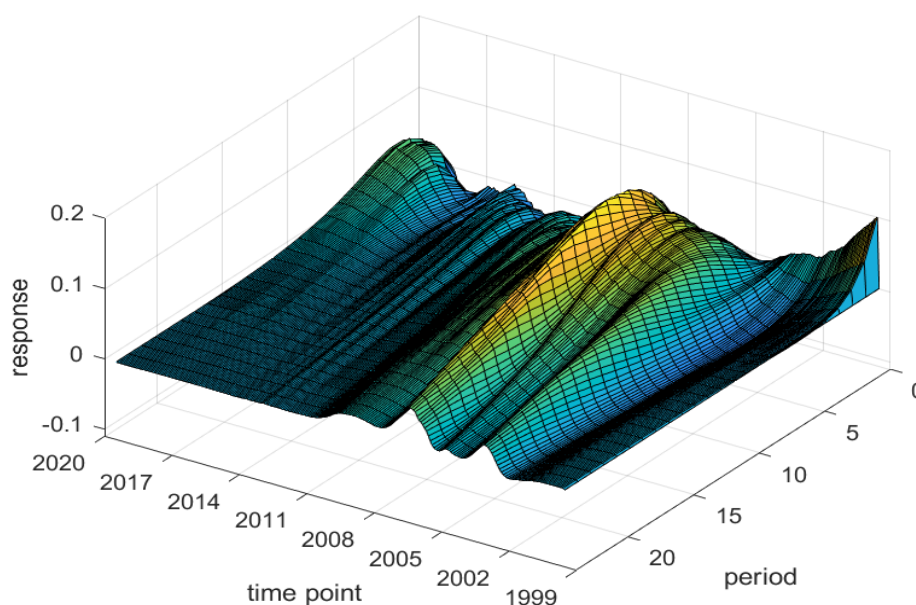


Figure 1. Time-varying continuous responses of CIN to UFC shocks.

As can be seen from the three-dimensional impulse response Figure 1, the impact of UFC on China's inflation on the whole has the following characteristics:

First, the responses of China's inflation to UFC shocks is time-varying in the response dimension. In general, the significant characteristic is that the degree of the impact of UFC on China's inflation increases first and then quickly decreases to zero at mostly time points. However, there exists something specific. First, in the short period of 1999M6–2002M12, the responses China's inflation to UFC shocks show an overall downward trend. It means that during the period of low openness and trade dependence, the impacts of UFC fall of rapidly. Second, during the global financial crisis of 2007–2009, European sovereign debt crisis of 2010–2014 and the global economic boom of 2005–2006, the action duration of UFC on China's inflation lasts longer. It reveals that the impact of UFC on China's inflation is mainly in the short and medium term, but in the period of some major events, the UFC has a longer lasting effect on China's inflation.

Second, the impacts of UFC on China's is time-varying in the time dimension. Since the impacts are more obvious in the short term, this paper taken the short term as an example. Overall, these obvious time-varying characteristics are mainly manifested in two aspects. On the one hand, it is reflected in trends and fluctuations. From the perspective of trend, the impact of UFC on China's inflation changes as a “W” in time dimension. More specifically, the impact of UFC on China's inflation decreases from 1999 to 2001, then increases from 2002 and reach the peak at 2008, after that, it falls down until 2017, and then rises again. This indicates that the impact of UFC during the global financial crisis are relatively large, which is quite similar to previous research (Dooley and Hutchison, 2009; Frank and Hesses, 2009). The possible explanation is, with China's accession to WTO and increasing trade dependence, the impacts of UFC show increase trend first in time dimension. And then, after global financial crisis, with the deepening of China's economic transformation,

internationalization of RMB and regulation of financial risk, China's economic is relying less and less on the export and dollar (Bowles and Wang, 2013; Hung, 2013). Hence, the impact of UFC on China's inflation then declines. But the increased Sino-America trade frictions causes the impact of UFC rises again. It can be further deduced that the time-varying characteristics are relevant to some major events. From the perspective of fluctuation, the impact of UFC shows the characteristics of periodic fluctuation. Obviously, the shocks show time-varying characteristics with large jump fluctuations before 2012, while show time-varying characteristics with small continuous fluctuations after 2012. It attributes to the structural mutation of the China's inflation at 2012. The volatility of China's inflation is significant before 2012, while that is relatively stable after 2012. (see Figure A3 in Appendix A). On the other hand, the direction of the impact of UFC on China's inflation changes in time dimension. In general, it reveals that UFC is an important of source of the inflationary pressure at most of time. Even though the positive responses of CINF to UFC shock prevail, there are periods where UFC lead to decreased CINF. Clearly, throughout the sample period, during 2001–2003, the negative values of responses are relatively large. It mainly owes to the own factors of China. On the one hand, during that time, the low financial openness in China restricted the international capital inflow. On the other hand, the fixed exchange rate made the exchange rate fluctuate in a small range and the policy uncertainty kept relatively small (Eichengreen et al., 1996). Thus, these factors eased the pressure of China's inflation which is caused by the fast and multiple rate cuts in response to internet bubble in U.S.

3.3. *Heterogeneous effects between different types of major events*

It has been observed from the section 3.2 analysis that UFC's impact on China's is not only time-varying in the time dimension and response dimension, but also directly relates to some major financial and economic events at home and abroad. In order to further study the time-varying characteristics of instantaneous shocks of UFC on China's inflation at different time points, this paper selects typical time points of different types of events which are relevant to different transmission channels. First, the reform of RMB exchange rate system, as a major mark of financial reform of China, has a considerable influence on capital flow. Thus, it impacts the shock of UFC on China's inflation. Second, the global financial crisis has a directly negative shocks on China's financial market. Ordinarily, when a country's finance is in a bad situation, its economy is more easily influenced by external shocks (Dong et al., 2019). Therefore, the event of global financial crisis affects the transmission from UFC shocks to China's inflation. Third, the Sino-US trade war with more American tariffs on Chinese imports, has a direct impact on the channel of trade flow. Thus, it affects the impact of UFC on China's inflation. For a better illustration of the heterogeneous effects of UFC on China's inflation under the shocks of different events, we choose 2005M7, 2008M9 and 2018M7 three special time points to analyze. In July, 2005, the People's Bank of China announced the reform of RMB exchange rate. In September, 2008, the Lehman Brothers bankruptcy marked the outbreak of a global financial crisis. Moreover, 2018M7 represents the outbreak of the Sino-US trade war. According to the parameter estimation results, the instantaneous impact of UFC on China's inflation at the time of three major events is plotted into Figure 2.

It can be seen from Figure 2 that when different types of major events occur, the instantaneous impact characteristics of UFC on China's inflation are shown as following:

Under different types of events, there are significant differences in length, speed and degree of the instantaneous impact of UFC on China's inflation. First, from the perspective of the duration, the instantaneous shock at 2018M7 (Sino-US trade war) lasts shorter lengths of time, and disappears in the next 10 phases. In contrast, the instantaneous shocks at 2005M7 (reform of RMB exchange rate)

and 2008M9 (global financial crisis) persist longer. It reflects that the impact of trade frictions on the transmission from UFC to China's inflation is relatively limited, because of the transformation of China's economic structure. Second, from the perspective of speed, the absolute impact of UFC on China's inflation at 2018M7 reaches the peak in the next 2 phases, while that at 2005M7 and at 2008M9 reaches the maximum in the next 5 phases and 6 phases respectively. This means that when different types of major events occur, the impact of UFC on China's has a difference in the rate of absorption of the events. Third, the degree of the shock fluctuations is different. The shock at 2008M9 fluctuates most, followed by the shock at 2005M7, and the shock fluctuation at 2018M7 is smallest. In addition, to test the robustness of the results, we change the order of variables in the TVP-VAR-SV model. The new order of variables is as follow: UFCI, CFCI, CF, TF, and CINF. The result of robustness test is shown in Figure A4 in appendix A. It can be seen that, after changing the order of variables in the model, the results of heterogeneity analysis don't change much.

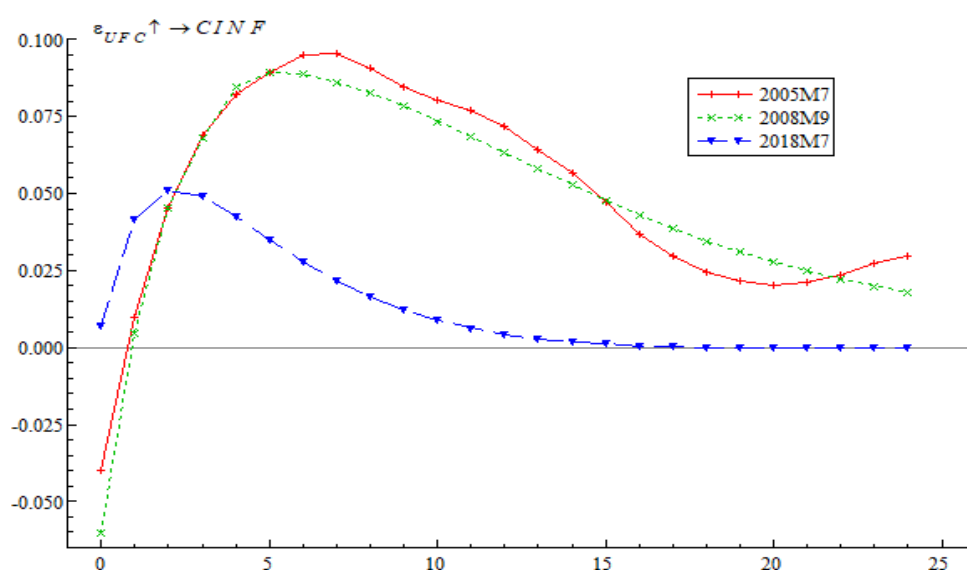


Figure 2. The responses of CINF to UFCI shocks at special points.

Overall, the time-varying characteristics of instantaneous impact of UFC is different in type of event. Compared with the events of Sino-US trade war, the instantaneous impacts of UFC on China's inflation under the global financial crisis and reform of RMB exchange rate system are more significant and durable. The possible cause is that the event of global financial crisis and reform of exchange rate has more profound and wide impacts on China's economic (Abbate et al., 2016). In term of the reform of RMB exchange rate system, the appreciation of the RMB caused by the reform brings great chance for the international transmission of financial factors. In term of the global financial crisis, the event not only leads to huge volatility of UFC, but also impacts the China's financial market which play an important role in transmitting UFC shocks to China's inflation.

4. Transmission channel of UFCI shocks on CINF volatility: spillover index

4.1. Theoretical analysis of transmission mechanism

Due to different pathways, constraint and environment, the conductive effects of different transmission channels change over time. Through the literature review, the shocks of UFC might transmit to inflation in China by three channels: trade, capital and financial market.

First, via trade channel, U.S. financial conditions could influence China's inflation through two pathways of the net-export effect and import-price effect. In term of net-export effect, the sound financial conditions in U.S. gives rise to the U.S. demand for the China's exports (Chor and Manova, 2012; Lin and Ye, 2018). Thus, it has an influence on inflation in China. Meanwhile, the increase of net-export makes the RMB strengthen, and makes exports less competitive, and lowers China's export, and lowers China's aggregate demand, and finally holds up China's inflation. In addition, due to the fluctuation of UFC, the change of exchange rate of U.S. dollar forms international payment surplus or deficit, and further causes the beggar-thy-neighbor negative effect or lose win positive effect (Kim, 2001). Then it leads to the corresponding changes of other countries' exports and total demand, and finally results in inflation volatility. In term of import-price effect, the cost of import trade is one of channels. The changes in U.S. monetary policy impact the cost prices of other countries' imports like crude oil and farm products (Anzuini et al., 2012; Rosa, 2014; Wang and Chueh, 2013; Wen et al., 2019). Further, the fluctuation of raw materials and farm prices cause the volatility of raw materials in other countries. Facing the changes of cost, manufacturers have to adjust commodity price, thus influence the whole consumer market price (Evgenidis et al., 2019; Gelos and Ustyugova, 2017; Rafiq, 2014). This can be called cost-push inflation.

Second, UFC impacts China's inflation via capital channel and the conductive effect is realized through the cost of capital effect. Due to the capital profitability, the international capital will influx in China as soon as the U.S. financial conditions deteriorates or the loose monetary policies of U.S. implement. Then, on the one hand, the inflow capital lowers China's long-term interest rate and pushes the asset prices, thus lowers the capital cost, and further stimulates business investment, and finally improves the total production capacity and lowers the long-term marginal cost. Thus, it relieves the upward pressure on price of imported competitive commodity and other goods and services, and eases China's inflation. On the other hand, under the current exchange rate system and foreign exchange settlement and sale system, the inflow capital leads to the increase of Position for Forex Purchase, thus increases domestic liquidity, and further increases the upward pressures on price level of China.

Most importantly, UFC impacts China's inflation via China's financial market. UFC affects China's financial market (Rey, 2016) and it can be proved from the perspective of the relevance of monetary policy between U.S. and EMEs. First, U.S. monetary policy shocks affect the initiative adjustment of EMEs' monetary policy by herd behavior (Caputo and Herrera, 2016; Chadwick, 2019; Chang et al., 2019; Krokida et al., 2020). In other words, there exists "import" U.S. Fed policies (Edwards, 2015). Second, the U.S. monetary policy shock has significant effects on some important macro financial variables in EMEs, such as interest rate, exchange rate and asset prices (Angelopoulou et al., 2013; Bowman et al., 2015; Bräuning and Ivashina, 2019; Edwards, 2015; Goodhart and Hofmann, 2000, 2001). Moreover, U.S. monetary policy has an impact on EMEs' credit conditions through the balance sheet of global banks (Bräuning and Ivashina, 2019; Rey, 2016). Meanwhile, China's financial market has a strong effect on its domestic inflation levels (Alessandri and Mumtaz, 2017; Anaya et al., 2017). On the one hand, China's financial market affects the investment and consumption, thus impacts domestic demand conditions, and further affects aggregate price level

(Goodhart and Hofmann, 2001). On the other hand, the fluctuations of asset prices lead to a change of consumption and investment through wealth effect (Modigliani, 1971), Tobin Q effect (Tobin, 1969), balance sheet effect (Bernanke and Gertler, 1989), expectations and credit channels, thus affect aggregate demand, and further influence aggregate prices level.

4.2. Dynamic spillover index

The transmission of UFC to China's inflation is not isolated and there exists interaction relationship between U.S. financial factors and domestic relative factors. In order to investigate the transmission of UFC on China's inflation empirically, we adopt the methodology of spillover index suggested by Antonakakis et al. (2018). This method is different from the common static spillover measurement method in the paper of Zhong et al. (2019). On the one hand, the methodology considers the interaction relationship between variables. On the other hand, the measurement of spillover index that based on TVP-VAR model instead of the rolling-window estimation (Ferrario et al., 2018), can adjust immediately to events. Based on the net pairwise volatility spillover, we can determine the bidirectional relationships between variables, and further identify the transmission channels and the time-varying feature of them.

First, this paper set a stationary five-variable TVP-VAR with stochastic volatility model. It encompasses U.S. financial conditions (UFC), capital flow (CF), trade flow (TF), China's financial market (CFC) and China's inflation (CINF). The general form of TVP-VAR model has shown in the section 3.1.

The time-varying vector moving average (VMA) is the foundation of the spillover index proposed by Diebold and Yilmaz (2014), employing generalized impulse response function (GIRF) and the generalized forecast error variance decomposition (GFEVD) (Keep et al., 1996). In order to calculate the spillover index, we transform the VAR to the form of VMA, which is given by $y_t = \sum_{j=0}^{\infty} A_{jt} \varepsilon_{t-j}$. Where $y_t = (UFC_t, CF_t, TF_t, CFC_t, CINF_t)'$, ε_t donates an 5×1 conditional volatilities vectors, $A_{j,t}$ is a 5×5 recursively matrices. $A_{jt} = \beta_{1,t} A_{j-1,t} + \dots + \beta_{p,t} A_{j-p,t}$. Where $A_{0,t} = I$.

Then, in the generalized VAR framework, the H-step-ahead generalized forecast error variance decomposition GFEVD is calculated as follow

$$\tilde{\phi}_{ij,t}^g(H) = \frac{\sum_{t=1}^{H-1} \Psi_{ij,t}^{2,g}}{\sum_{j=1}^N \sum_{t=1}^{H-1} \Psi_{ij,t}^{2,g}} \quad (7)$$

where, i , j represent different variables in the network. With $\sum_{j=1}^N \tilde{\phi}_{i,j,t}^g(H) = 1$ and $\sum_{i,j=1}^N \tilde{\phi}_{i,j,t}^g(H) = N$. Based on the GFEVD, we can compute the net pairwise volatility spillover (NPSV) from i to j

$$NPVS_{ij,t}(h) = \frac{\tilde{\phi}_{ji,t}^g(h) - \tilde{\phi}_{ij,t}^g(h)}{N} * 100, \quad (8)$$

The net pairwise volatility spillover can be used to examine the time-varying bidirectional relationship between two variables. If the net pairwise spillovers from variable i to variable j is greater than 0, it indicates that variable i determines variable j (Antonakakis et al., 2018; Gabauer

and Gupta, 2018). Based on the feature of the net pairwise volatility spillover, we can use it to identify the transmission channels by which UFC impacts China's inflation.

To help understand, we take the identification of capital flow channel as an example. If the net pairwise volatility spillover $NPDC_{UFC\ CF,t}(h) > 0$, it means UFC determines capital flow. Likewise, if $NPDC_{CF\ CINF,t}(h) > 0$, capital flow determines China's inflation. If $NPDC_{UFC\ CINF,t}(h) > 0$, UFC determines China's inflation. Taken together, if $NPDC_{UFC\ CF,t}(h) > 0$, $NPDC_{CF\ CINF,t}(h) > 0$ and $NPDC_{UFC\ CINF,t}(h) > 0$ are simultaneous, it can infer that capital flow is a transmission channel through which UFC impacts China's inflation.

4.3. time-varying feature of transmission channel

According to the Bayesian Information Criterion (BIC), the stationary TVP-VAR (1) is estimated. Then, we calculate the net pairwise volatility spillovers between the UFC, CF, TF, CFC and CINF from the generalized variance decomposition approach with the 10-step-ahead. The net pairwise volatility spillovers calculated are shown in the Figure 3.

In order to show the difference, the Figure 3 lists the three net pairwise volatility spillovers from UFC to CF, from CF to CINF and from UFC to CINF in the left; the three net pairwise volatility spillovers from UFC to TF, from TF to CINF and from UFC to CINF in the middle; the three net pairwise volatility spillovers from UFC to CFC, from CFC to CINF and from UFC to CINF in the right. Overall, Figure 3 shows three facts.

First, China's financial market and trade flow are transmission channels through which UFCI affects China's inflation, but capital flow is not. The left column of Figure 4 displays that the periods with the three net pairwise volatility spillovers from UFC to CF, from CF to CINF and from UFC to CINF greater than 0 are different. The period with net pairwise volatility spillover from UFC to capital flow greater than 0 is concentrated in 2002–2009, while the period with net pairwise volatility spillovers from capital flow to China's inflation and from UFC to China's inflation greater than 0 is 2010–2019. Therefore, it can infer that capital is not a transmission channel. It attributes to China's system of capital controls. Since China's capital account has not been fully opened, the transmission of capital flow channels is relatively limited. In contrast, the middle column of Figure 3 displays that there is common period with three net pairwise volatility spillovers from UFC to TF, from TF to CINF and from UFC to CINF greater than 0. Likewise, the right column of Figure 4 displays that there is common period with three net pairwise volatility spillovers from UFC to CFC, from CFC to CINF and from UFC to CINF greater than 0. Hence, China's financial market and trade flow are transmission channels.

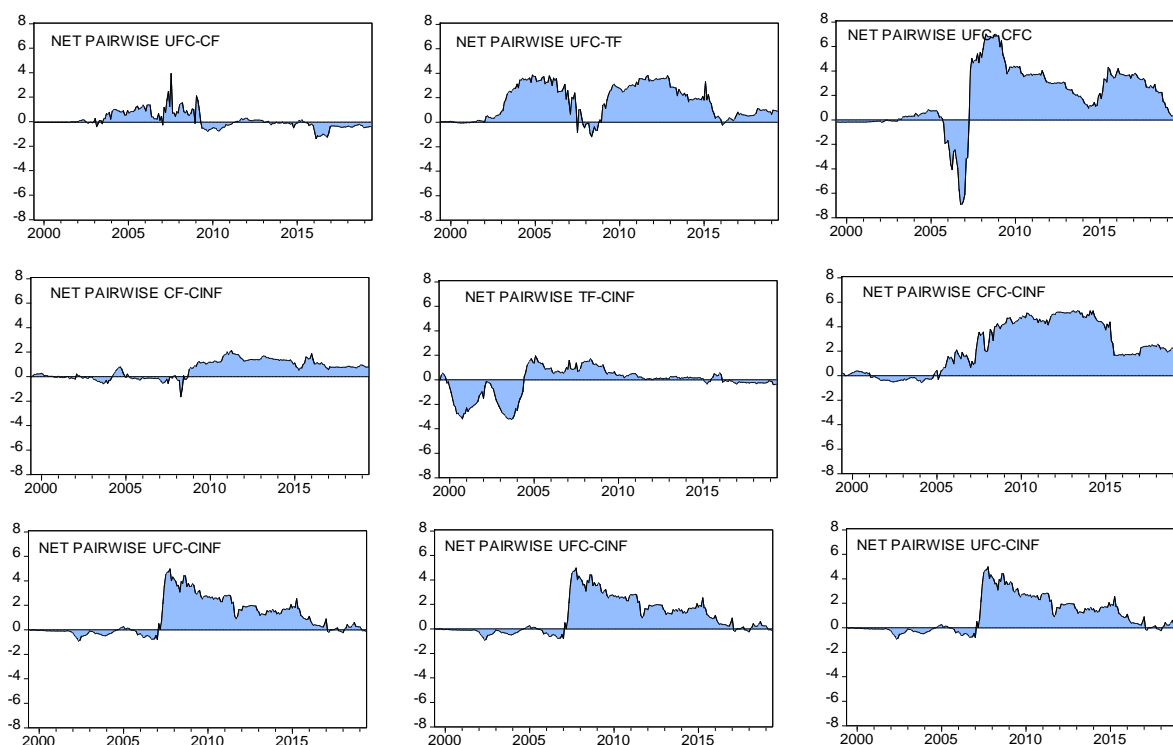


Figure 3. The net pairwise spillover from UFC, CF, TF, CFC and CINF (%). Notes: the net pairwise spillover represents the net spillover from variable i to variable j . For instance, NET PAIRWISE UFC-CF in the Figure 3 means the net pairwise spillover from UFC to CF. UFC, CF, TF, CFC and CINF represent U.S. financial conditions, capital, trade, China's financial market and China's inflation respectively.

Second, there are differences between the China's financial market channel and trade channel. The differences are manifested in the two aspects of time and degree. On the one hand, the conducive period of the China's financial market channel is wider than trade flow. As shown in Figure 4, the common period with three net pairwise volatility spillovers from UFC to TF, from TF to CINF and from UFC to CINF greater than 0 is concentrated in 2009–2016. It indicates that the period of the conducive effect of the trade flow channel is 2009–2016. While the common period with three net pairwise volatility spillovers from UFC to CFC, from CFC to CINF and from UFC to CINF greater than 0 is from 2009 to 2019. On the other hand, the conducive degree of China's financial market channel is significantly greater than the trade channel. As Figure 4 shown, in the conduction period, the areas of the shaded region of the diagrams in the right column are obviously greater than that in the middle column. This means that the China's financial market plays a main conducive role in the impact of UFC on China's inflation. For the reason, it most possibly relates to the broad pathways of China's financial market in transmitting UFC shocks to China's inflation, which includes credit, interest rate, foreign exchange and asset, etc.

In addition, the conducive effects of China's financial market channel and trade flow channel is most obvious during the financial crisis. It is useful to explain the conclusion in section 3.1 that why the impact of UFC on China's inflation is greatest in the financial crisis.

5. Conclusions

This paper investigates the time-varying impact of the aggregate U.S. financial conditions (UFC) on China's inflation (CINF). Based on the empirical analysis, we have the following findings:

First, the time-varying impacts of UFC on China's inflation in both response and time dimensions are directly relevant to major events. On the one hand, the impact of UFC on China's inflation changes as an inverted "V" and is mainly in the short and medium term. In particular, in the period of some major events, the UFC has a longer lasting effect on China's inflation. On the other hand, the impacts of UFC on China's is time-varying in the time dimension. The obvious time-varying characteristics in the short term are mainly manifested in the trend and fluctuation. From the perspective of trend, the impact of UFC on China's inflation changes as a "W" in time dimension, and it reaches the peak at the time point during the global financial crisis. From the perspective of fluctuation, the impact of UFC on China's inflation shows the characteristics of periodic fluctuation, which attributes to the structural mutation of the China's inflation at 2012. Overall, it reveals that the time-varying characteristics is directly relevant to major events.

Second, the instantaneous impacts of UFC on China's inflation under major events are different in event types. On the one hand, the jump points of the impact of UFC on China's inflation correspond to major events, such as the reform of RMB exchange rate system, global financial crisis and Sino-US trade war etc. This means that the time-varying effect of UFC on China's inflation directly relates to different types of major events. On the other hand, although when different types of major events occur, the instantaneous impact of UFC on China's inflation shows a consistent trend, there are significant differences in length, speed and degree. In general, compared with the events of Sino-US trade war, the instantaneous impacts of UFC on China's inflation at the time point of the global financial crisis and the reform of RMB exchange rate are more significant and durable.

In addition, two transmission channels and their differences in time and degree are identified. First, China's financial market and trade flow are transmission channels through which UFCI affects China's inflation, but capital flow is not. Second, the differences between the China's financial market channel and trade channel are manifested in the two aspects of time and degree. On the one hand, the conductive period of the China's financial market channel is wider than trade flow. On the other hand, the conductive degree of China's financial market channel is significantly greater than the trade channel. Third, the conductive effects of China's financial market channel and trade flow channel is most obvious during the financial crisis.

In summary, the policy implications of our paper are as follow: First, since China becomes more open and more dependent on trade, in order to better stabilize the domestic price level, policy-makers should further promote the transformation of economic structure. Second, China should persist in advancing the process of RMB internationalization, thus improve the competitive advantage of RMB pricing, and further reduce the inflationary pressure or deflation risk brought by input factors.

Acknowledgments

This work was supported by Projects of the National Science Foundation of Guangdong Province [grant number 2020A1515010747].

Conflict of interest

All authors declare no conflicts of interest in this paper.

References

- Abbate A, Eickmeier S, Lemke W, et al. (2016) The Changing International Transmission of Financial Shocks: Evidence from a Classical Time-Varying FAVAR. *J Money Credit Bank* 48: 573–601.
- Alessandri P, Mumtaz H (2017) Financial conditions and density forecasts for US output and inflation. *Rev Econ Dyn* 24: 66–78.
- Anaya P, Hachula M, Offermanns CJ (2017) Spillovers of US unconventional monetary policy to emerging markets: The role of capital flows. *J Int Money Financ* 73: 275–295.
- Angelopoulou E, Balfoussia H, Gibson HD (2013) Building a financial conditions index for the euro area and selected euro area countries what does it tell us about the crisis. *Econ Model* 38: 392–403.
- Antonakakis N, Gabauer D, Gupta R, et al. (2018) Dynamic connectedness of uncertainty across developed economies: A time-varying approach. *Econ Lett* 166: 63–75.
- Anzuini A, Lombardi MJ, Pagano P (2012) The impact of monetary policy shocks on commodity prices. Available from: <http://dx.doi.org/10.2139/ssrn.2030797>.
- Bernanke B, Gertler M (1989) Agency Costs, Net Worth, and Business Fluctuations. *Am Econ Rev* 79: 14–31.
- Bernanke BS, Mihov I (1995) Measuring Monetary Policy. National Bureau of Economic Research Working Paper Series.
- Buthe T, Milner HV (2008) The politics of foreign direct investment into developing countries: Increasing FDI through international trade agreements? *Am J Polit Sci* 52: 741–762.
- Bowles P, Wang BT (2013) Renminbi Internationalization: A Journey to Where? *Dev Change* 44: 1363–1385.
- Bowman D, Londono JM, Sapriza H (2015) US unconventional monetary policy and transmission to emerging market economies. *J Int Money Financ* 55: 27–59.
- Von Borstel J, Eickmeier S, Krippner L (2016) The interest rate pass-through in the euro area during the sovereign debt crisis. *J Int Money Financ* 68: 386–402.
- Bi Y, Anwar S (2017) US monetary policy shocks and the Chinese economy: a GVAR approach. *Appl Econ Lett* 24: 553–558.
- Bräuning F, Ivashina V (2019) U.S. monetary policy and emerging market credit cycles. *J Monetary Econ* 112: 57–76.
- Canova F, Marrinan J (1998) Sources and propagation of international cycles: Common shocks or transmission? *J Int Econ* 46: 133–166.
- Canova F, De Nicolo G (1999) On the Sources of Business Cycles in the G-7. *J Int Econ* 59: 77–100.
- Canova F, De Nicolo G (2000) Stock Returns, Term Structure, Inflation and Real Activity: An International Perspective. *Macroecon Dyn* 4: 343–372.
- Chor D, Manova K (2012) Off the cliff and back? Credit conditions and international trade during the global financial crisis. *J Int Econ* 87: 117–133.
- Chen Q, Filardo A, He D, et al. (2016) Financial crisis, US unconventional monetary policy and international spillovers. *J Int Money Financ* 10: 62–81.
- Caputo R, Herrera LO (2016) Following the leader? the relevance of the FED funds rate for inflation targeting countries. *J Int Money Financ* 71: 25–52.
- Chadwick MG (2019) Dependence of the “Fragile Five” and “Troubled Ten” emerging market financial systems on US monetary policy and monetary policy uncertainty. *Res Int Bus Financ* 49: 251–268.

- Chang CY, Shie FS, Yang SL (2019) The relationship between herding behavior and firm size before and after the elimination of short-sale price restrictions. *Quant Financ Econ* 3: 526–549.
- Dooley M, Hutchison M (2009) Transmission of the U.S. subprime crisis to emerging markets: Evidence on the decoupling–recoupling hypothesis. *J Int Money Financ* 28: 1331–1349.
- Diebold FX, Yilmaz K (2014) On the network topology of variance decompositions: Measuring the connectedness of financial firms. *J Econom* 182: 119–134.
- Dahlhaus T, Vasishtha G (2014) The Impact of U.S. Monetary Policy Normalization on Capital Flows to Emerging-Market Economies. Bank of Canada Working Paper, 2014-53.
- Dedola L, Rivolta G, Stracca L (2017) If the Fed sneezes, who catches a cold? *J Int Econ* 108: 23–41.
- Dong H, Liu Y, Chang JQ (2019) The heterogeneous linkage of economic policy uncertainty and oil return risks. *Green Financ* 1: 46–66.
- Eichengreen B, Rose AK, Wyplosz C (1996) Contagious Currency Crises. NBER Working Paper, No.5681.
- Edwards S (2015) Monetary Policy Independence under Flexible Exchange Rates: An Illusion? *World Econ* 38: 773–787.
- Evgenidis A, Philippas D, Siriopoulos C (2019) Heterogeneous effects in the international transmission of the US monetary policy: a factor-augmented VAR perspective. *Empir Econ* 56: 1549–1579.
- Frank N, Hesses H (2009) Financial Spillovers to Emerging Markets During the Global Financial Crisis. IMF Working Papers, 507–521.
- Ferrario A, Guidolin M, Pedio M (2018) Comparing in- and out-of-sample approaches to variance decomposition-based estimates of network connectedness an application to the Italian banking system. *Quant Financ Econ* 2: 661–701.
- Goodhart C, Hofmann B (2000) DO ASSET PRICES HELP TO PREDICT CONSUMER PRICE INFLATION? *Manch Sch* 68: 122–140.
- Goodhart C, Hofmann B (2001) Asset Prices, Financial Conditions, and the Transmission of Monetary Policy. Conference on Asset Prices, Exchange Rates, and Monetary Policy, Stanford University.
- Grant JH, Lambert DM (2008) Do regional trade agreements increase members' agricultural trade? *Am J Agric Econ* 90: 765–782.
- Gelos G, Ustyugova Y (2017) Inflation responses to commodity price shocks – How and why do countries differ? *J Int Money Financ* 72: 28–47.
- Gabauer D, Gupta R (2018) On the transmission mechanism of country-specific and international economic uncertainty spillovers: Evidence from a TVP-VAR connectedness decomposition approach. *Econ Lett* 171: 63–71.
- Hosen M, Broni MY, Uddin MN (2020) What bank specific and macroeconomic elements influence non-performing loans in Bangladesh? Evidence from conventional and Islamic banks. *Green Financ* 2: 212–226.
- Hung HF (2013) China: Saviour or Challenger of the Dollar Hegemony? *Dev Change* 44: 1341–1361.
- Keep G, Pesaran MH, Potter SM (1996) Impulse response analysis in nonlinear multivariate models. *J Econom* 74: 119–147.
- Kim S (2001) International transmission of U.S. monetary policy shocks: Evidence from VAR's. *J Monetary Econ* 48: 339–372.
- Kazi IA, Wagan H, Akbar F (2013) The changing international transmission of U.S. monetary policy shocks: Is there evidence of contagion effect on OECD countries. *Econ Model* 30: 90–116.

- Krokida SI, Makrychoriti P, Spyrou S (2020) Monetary policy and herd behavior: International evidence. *J Econ Behav Organ* 170: 386–417.
- Lin S, Ye H (2018) The international credit channel of U.S. monetary policy transmission to developing countries: Evidence from trade data. *J Dev Econ* 133: 33–41.
- Modigliani F (1971) Consumer Spending and Monetary Policy: The Linkages. Proceedings of a MONETARY CONFERENCE NANTUCKET ISLAND, ASSACHUSETTS, 9–84.
- Maćkowiak B (2007) External shocks, U.S. monetary policy and macroeconomic fluctuations in emerging markets. *J Monetary Econ* 54: 2512–2520.
- Magud NE, Reinhart CM, Vesperoni ER (2014) Capital Inflows, Exchange Rate Flexibility and Credit Booms. *Rev Dev Econ* 18: 415–430.
- Nakajima J, Kasuya M, Watanabe T (2009) Bayesian Analysis of Time-Varying Parameter Vector Autoregressive Model for the Japanese Economy and Monetary Policy. *J Jpn Int Econ* 25: 225–245.
- Nakajima J (2011) Time-Varying Parameter VAR Model with Stochastic Volatility: An Overview of Methodology and Empirical Applications. IMES Discussion Paper, Series 2011-E-9. Available from: <https://www.imes.boj.or.jp/research/papers/english/11-E-09.pdf>.
- Primiceri GE (2005) Time varying structure Vector Autoregressions and monetary policy. *Rev Econ Stud* 72: 821–852.
- Rosa C (2014) The high-frequency response of energy prices to U.S. monetary policy: Understanding the empirical evidence. *Energy Econ* 45: 295–303.
- Rafiq S (2014) What Do Energy Prices Tell Us About UK Inflation? *Economica* 81: 293–310.
- Rey H (2016) International Channels of Transmission of Monetary Policy and the Mundellian Trilemma. *IMF Econ Rev* 64: 6–35.
- Tobin J (1969) A General Equilibrium Approach To Monetary Theory. *J Money Credit Bank* 1: 15–29.
- Tillmann P (2016) Unconventional monetary policy and the spillovers to emerging markets. *J Int Money Financ* 66: 136–156.
- Wang YS, Chueh YL (2013) Dynamic transmission effects between the interest rate, the US dollar, and gold and crude oil prices. *Econ Model* 30: 792–798.
- Wen F, Zhao Y, Zhang M, et al. (2019) Forecasting realized volatility of crude oil futures with equity market uncertainty. *Appl Econ Lett* 51: 6411–6427.
- World Bank (1985) World development report 1985.
- Zhong JH, Wang MD, Drakeford BM, et al. (2019) Spillover effects between oil and natural gas prices: Evidence from emerging and developed markets. *Green Financ* 1: 30–45.



AIMS Press

© 2021 the Author(s), licensee AIMS Press. This is an open access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>)