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REVISITING EXCHANGE RATE SHOCKS ON MACROECONOMIC VARIABLES IN CHINA USING TIME-VARYING VAR MODEL

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ABSTRACT

In this study we analyze exchange rate shocks in China on its macroeconomic variables by apply TVP-VAR modeling approach. Three-dimensional impulse response functions reveal that GDP, CPI and interest rate are affected in the short run and long run. Our findings have important policy implications for the Chinese government conducting exchange rate policy.

Contribution/Originality: Rather than using regression analysis, we use three-dimensional impulse response functions to assess the short-run and long-run effects of exchange rate shocks on China's CPI, GDP, and interest rates.

1. INTRODUCTION

A country's exchange rate is the most important macro variable that links domestic economy to the rest of the world. As such, any change in the exchange rate can affect almost all other macro variables. As far as China is considered, indeed, many studies have investigated the impact of changes in the value of Yuan on Chinese economy and its macro variables. Examples include (Bahmani-Oskooee, Bose, & Zhang, 2018; Bahmani-Oskooee, Bose, & Zhang, 2019; Chou, 2000; SaangJoon, 2008) who assessed impact of changes in the value of yuan on China's trade flows or trade balance in goods; Xu, Bahmani-Oskooee, and Karamelikli (2022) who investigated the link between Chinese trade in services and the value of yuan; Bahmani-Oskooee, Xi, and Bahmani (2016) who considered the link between value of the yuan and demand for money in China; Jeanneney and Hua (2001) who looked into the nexus between exchange rate and income inequality; and Hua (2007) who considered the link between the exchange rate and employment.

Bacchetta and Van Wincoop (2000) have argued that in order to improve a country's trade and welfare, one needs to have a stable exchange rate and China is no exception.

Prior to 2005, China was on a non-uniform managed float against the U.S. Dollar. In 2005, it was decided to peg the yuan to a basket of currencies. Since then, the yuan fluctuates and China managed its value and for that reason, the U.S. has blamed China for manipulating its currency. A developing country that seeks a higher growth is recommended to have more flexible exchange rate (Levy-Yeyati & Sturzenegger, 2003).

Most studies such as those mentioned above that assessed the impact of changes in the value of the yuan on China's economy, relied upon traditional method of estimating reduced form models through regression analysis. This paper attempts to investigate exchange rate shocks on macroeconomic performance of China over time through a dynamic impulse response function. In doing so we follow Tiwari, Cai, and Chang (2019) who argued that in considering exchange rate shocks we must pau close attention to their time-varying properties. Once we do that, we find that the macroeconomic performance of China is indeed time-varying. To show this, in Section II we present the TVP-VAR Vector Autoregression model that is followed by Section III in which we report our empirical results. The last section concludes the paper.

2. METHODOLOGY[1]

The literature supports two main approaches to investigate changes in the transmission mechanism over time. In the first approach is to estimate the model over two splatted samples. However, this approach embodies a problem in that it is not clear where to divide the sample. This issue is resolved in the second approach in which coefficients are allowed to change over the entire study period. As pointed out by Koop, Leon-Gonzalez, and Strachan (2009), it is more likely that economic conditions in a country changes gradually rather than abruptly, making the second approach more attractive.

Following the second approach, we use several VAR models to investigate changes in the exchange rate on the Chinese economy. Following Tiwari et al. (2019) we estimate a Bayesian TVP model that includes stochastic volatility. Tiwari et al. (2019) pointed out that ignoring heteroskedasticity of shocks may cause changes in the size of the shocks to be confounded with changes in the transmission mechanism which could produce inconsistent estimates. Following Tiwari et al. (2019) we consider the following Time-varying VAR model:

$$y_t = c_{t+}B_{1,t}y_{t-1} + \cdots + B_{p,t}y_{t-p} + \mu_t \tag{1}$$

In (1) y_t is an $n \times 1$ vector of endogenous variables, c_t is defined as an $n \times 1$ vector of intercepts that vary with time, $B_{i,t}$ (for $i = 1, \ldots, p$) is defined as an $n \times n$ matrices of VAR coefficients that also vary with time, and u_t are unobservable shocks with time-varying variance–covariance matrices Ω_t for $t = 1, \ldots, T$. As can be seen, coefficients as well as the error variances and the covariances are allowed to very over time. A triangular reduction of Ω_t will be employed such that

$$A_t \Omega_t A_t' = \Sigma_t \Sigma_t' \tag{2}$$

or, equivalently,

$$\Omega_t = A_t^{-1} \Sigma_t \Sigma_t' (A_t^{-1})' \tag{3}$$

where $A_t$is the lower triangular matrix and $\sum_t$ is the diagonal matrix. Thus, we have

$$y_t = c_t + B_{1,t}y_{t-1} + \cdots + B_{p,t}y_{t-p} + A_t^{-1}\textstyle\sum_t \varepsilon_t \tag{4}$$

where ε_t are independent and identically distributed errors with var$(\varepsilon_t) = I_n$. Following Tiwari et al. (2019) we rewrite Equation 4 as follows:

$$y_t = X' B_t + A_t^{-1}\textstyle\sum_t \varepsilon_t \tag{5}$$

[1] This section closely follows Tiwari et al. (2019).

where all of the coefficients from the right side of (4) are stacked in a vector $B_t$in (5). Additionally, in (5) $X' = I_n \otimes [1,\ y'_{t-1}, \cdots, y'_{t-p}]$., where$\otimes$denotes Kronecker product. Following Franta, Horváth, and Rusnak (2014) and Tiwari et al. (2019) we also employ a stochastic volatility framework by assuming a geometric random walk where we can specify the parameters are specified by:

$$B_t = B_{t-1} + \nu_t, \tag{6}$$

$$\alpha_t = \alpha_{t-1} + \zeta_t, \tag{7}$$

$$\log\sigma_t = \log\sigma_{t-1} + \eta_t. \tag{8}$$

Combined with Equation 5, we now have a state space model where Equations 6 – 8 reflect model's measurement equation and the state equations. The residuals $(\varepsilon_t, \nu_t, \zeta_t, \eta_t)$ are assumed to be jointly normal and they have the following variance–covariance matrix:

$$V = var\left(\begin{bmatrix}\varepsilon_t\\ \nu_t\\ \zeta_t\\ \eta_t\end{bmatrix}\right) = \begin{bmatrix} I_n & 0 & 0 & 0\\ 0 & Q & 0 & 0\\ 0 & 0 & S & 0\\ 0 & 0 & 0 & W\end{bmatrix}, \tag{9}$$

where I_n is an n-dimensional identity matrix and Q, S, and W are positive definite matrices. Here S is the block diagonal and the matrix W also diagonal.

We follow Tiwari et al. (2019) and chose the mean and the variance of B_0 to be the OLS point estimate and four times its variance of this OLS point estimate from the time-invariant VAR:

$$B_0 \sim N(\hat{B}_{OLS}, 4 \bullet var(\hat{B}_{OLS}))$$

The prior for A_0 is obtained in a similar manner:

$$A_0 \sim N(\hat{A}_{OLS}, 4 \bullet var(\hat{A}_{OLS}))$$

Next, we defined $log\ \sigma_0 \sim N(lo\hat{g}\ \sigma_{OLS}, 4 \bullet I_n)$ and the priors for the hyperparameters are established as:

$Q \sim IW(k_Q^2 \bullet \tau \bullet var(\hat{B}_{OLS}), \tau)$

$W \sim IG(k_W^2 \bullet (1 + dim(W)) \bullet I_n, (1 + dim(W)))$, and

$S_l \sim IW(k_S^2 \bullet (1 + dim(S_l)) \bullet var(\hat{A}_{l,OLS}), (1 + dim(S_l)))$,

where τ is the size of the training sample, S_l denotes the corresponding blocks of S, and $\hat{A}_{l,OLS}$represent the corresponding blocks of$\hat{A}_{OLS}$. The parameters k_Q,k_W, and k_S are specified below. Note that one plus the dimension of each matrix is selected as the degrees of freedom of the scale matrices for the inverse- Gamma prior distribution of the hyperparameters. Furthermore, following Cogley and Sargent (2001) degrees of freedom are multiplied by the OLS estimates on training sample to obtain the appropriate scale matrix. Paying a close attention to Chinese economy in which exchange rate changes affect all aspect of the economy, we impose some sign restrictions by assuming that exchange rate shocks on GDP, price level and interest rate are all negative, meaning that a depreciation is expected to boost net exports, hence the GDP. It is also expected to be inflationary and result in high interest rate.[2] Following Franta et al. (2014) and Tiwari et al. (2019), the sign of a response for output, price level and interest rate imposed for four quarters and exchange rate reaction is restricted to only the immediate impact of a shock. We use Givens rotations to implement identification restrictions. This approach is recommended by Fry and Pagan (2011) where the sign restrictions are important in transforming structural residuals into reduced-form residuals. For an orthonormal matrix Q, the following relation must hold:

$$A_t^{-1}\Sigma_t\varepsilon_t = A_t^{-1}\Sigma_t Q' Q\varepsilon_t \tag{10}$$

where $Q\varepsilon_t$ represents another vector of uncorrelated structural residuals with unit variance. Following Fry and Pagan (2011) and Tiwari et al. (2019), we demonstrate the Givens rotations by:

$$Q = Q_{12}(\theta_1) \times Q_{13}(\theta_2) \times Q_{14}(\theta_3) \times Q_{23}(\theta_4) \times Q_{24}(\theta_5) \times Q_{34}(\theta_6), \tag{11}$$

where

[2] Although the model is estimated using differences, the sign restrictions are imposed on levels.

$$Q(\theta_m)_{ij} = \begin{pmatrix} 1 & \cdots & 0 & \cdots & 0 & \cdots & 0 \\ \cdots & \ddots & \cdots & \cdots & \cdots & \cdots & 0 \\ 0 & \cdots & cos(\theta_m) & \cdots & -sin(\theta_m) & \cdots & 0 \\ \vdots & \vdots & \vdots & 1 & \vdots & \vdots & \vdots \\ 0 & \cdots & sin(\theta_m) & \cdots & cos(\theta_m) & \cdots & 0 \\ \cdots\cdots & \cdots & \cdots & \cdots & \ddots & \cdots & \\ 0 & \cdots & 0 & \cdots & 0 & \cdots & 1 \end{pmatrix} \quad (12)$$

Where the row and column of the matrix are denoted by i and j respectively. A uniform distribution on the interval (0, π) are used to draw the parameters of θ_m, m = 1...and 6 .[3]

3. DATA, EMPIRICAL RESULTS AND POLICY IMPLICATIONS

Quarterly data over the 996Q1-2016Q4 period are used to carry out the empirical exercise.[4] Except for interest rate, all of the remaining variables are transformed to log differences to render the variables as stationary.[5]

Exchange rates are said to affect output Gross Domestic Product (GDP) through two channels: the channel through which expenditures are switch from imports to domestically produced goods and the interest rate channel. The combined effects of exchange rate shocks on GDP, CPI, Consumer Price Index. and the interest rate are presented in Figures 1- 3 respectively. As can be seen, economic activity or output is weekend subsequent to exchange rate appreciation. We observe that exchange rate shocks have their strongest effects on GDP at approximately 4, 8 and 12 quarters subsequent to a shock Figure 1. However, effects on prices are long lasting Figure 2. Unlike Taylor (2000) who suggested that exchange rate pass-through declines over time, we do not find this trend in China. As for the impact on interest rate, we find that exchange rate appreciation results in lower interest rates Figure 3. Exchange rate appreciation is said to be anti-inflationary policy since it lowers cost of imported goods. This could reduce the burden of monetary policy. From Figure 1 we gather that at different time-horizon, the transmission of exchange rate shocks has become stronger over time, including during the period of the recent financial crisis. This effect is particularly evident for output (GDP). From Figure 2 we learn that reaction of prices to an exchange rate shocks has been stable over time. Figure 3 reveals that the reaction of interest rate appears to be more persistent in recent period than in the past. Our findings suggest that China has conducted an exchange rate policy that is designed to maintain economic stability consistent with economic growth in China.

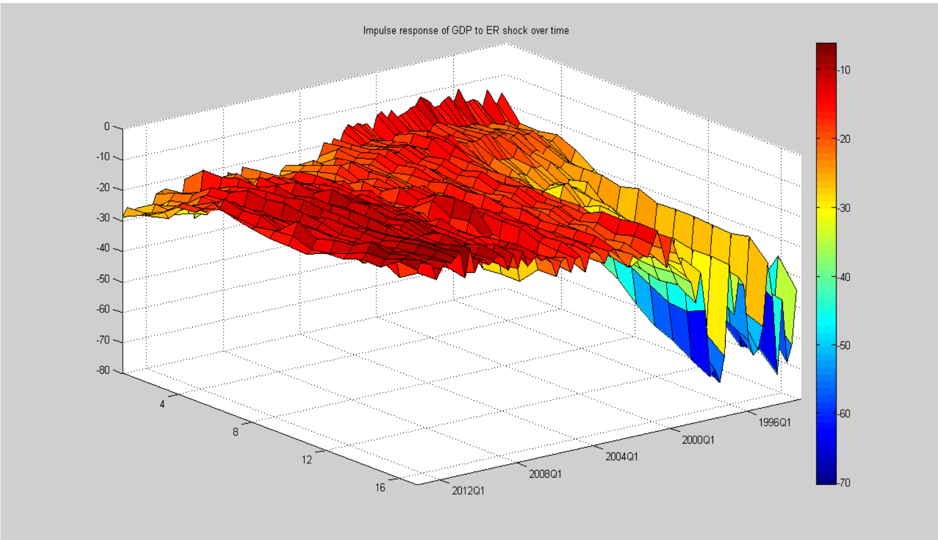

Figure 1. Exchange rate shock to GDP.

[3] For more details see Fry and Pagan (2011) and Franta et al. (2014).

[4] The data are adjusted for seasonal variation using X11 technique in Eviews 9.5.

[5] Due to space constraints, we do not report conventional unit test results. Results are available upon requests.

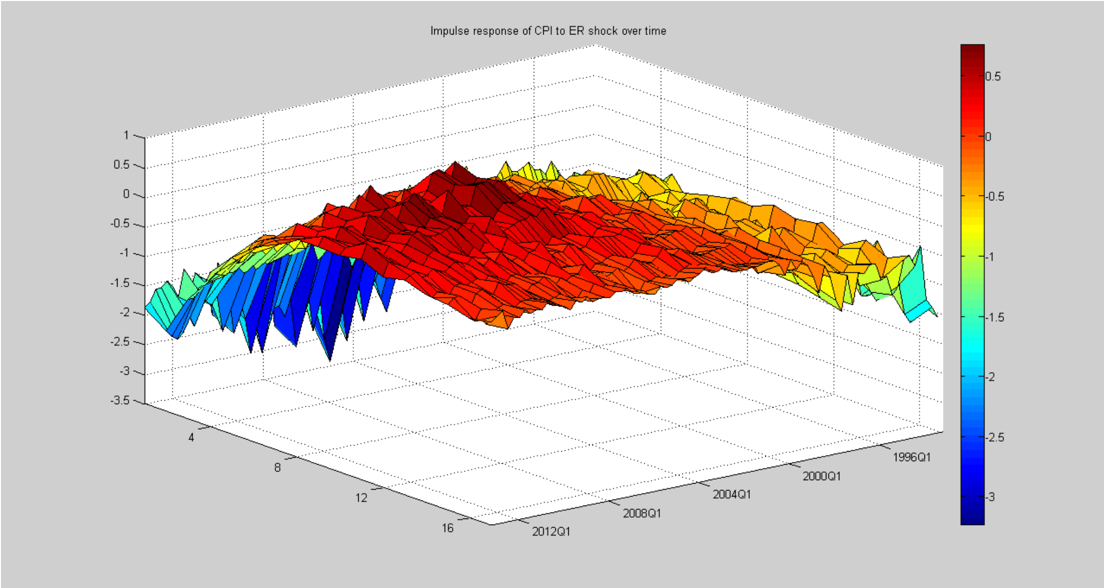

Figure 2. Exchange rate shock to price level.

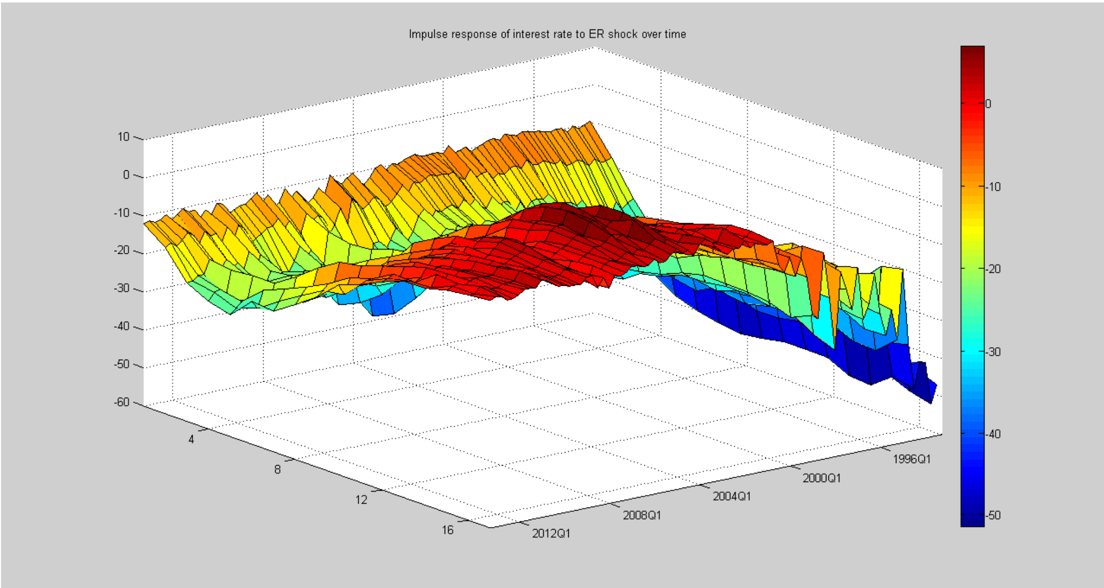

Figure 3. Exchange rate shock to interest rate.

4. CONCLUSIONS

One of the most powerful policies to combat inflation or to fight recession and promote economic growth is to manipulate the supply of money or change the interest rates. Central banks reduce money supply or raise interest rates to fight inflation. They also do the opposite to fight recessions. Assessing the impact of such policies on macro variables will depend on the time-varying properties of these variables. Recently, Tiwari et al. (2019) investigated the impact of monetary policy in China on a few macro variables by using a TVP-VAR model. In this paper we adopt their approach to assess the effects of China's exchange rate shocks on its GDP, CPI, and interest rates. Estimates of three-dimensional impulse response functions revealed that exchange rate shocks did affect output (GDP), price level (CPI) and interest rates in a stable manner, both in the short run and long run in China.[6] The implication of our findings is that in conducting an exchange rate policy to maintain economic stability and growth in China, policy makers better account the nature of time-varying properties of the economy and hence, macro variables. It is shown

[6] Note that this conclusion would have been relatively stronger if we used monthly data which is subject to more variation relative to quarterly data.

that once we account for time-varying properties, the outcome is more accurate and consistent with our theoretical expectation, meaning that a stable yuan will result in stable GDP, CPI, and interest rate.

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