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What drives fluctuations in exchange rate growth in emerging markets – A multi-level dynamic factor approach

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ABSTRACT

Historically, exchange rates in many emerging economies have been volatile. We use a dynamic hierarchical factor model to investigate the driving forces behind these fluctuations in exchange rate growth and find that in recent years, especially since the Great Recession, the common (world) factor has become more important. We also find that, since 2009, US monetary policy and Chinese economic growth have had much greater effects on emerging market exchange rate growth fluctuations. The historical decomposition indicates that 18.8% and 23% of the variations in the world factor after 2009 can be explained by US monetary policy shock and Chinese industrial production shock, respectively.

1. Introduction

The foreign exchange market, though highly volatile, sometimes witnesses co-movement of exchange rates among certain countries, especially emerging markets, which are more prone to being affected. The Argentine Peso, South African Rand, Russian Ruble, and Turkish Lira, for example, simultaneously plunged by 23%, 7.5%, 7%, and 6%, respectively, in the opening month of 2014. It was the ‘single biggest sell off in emerging market currencies since 2009’. Despite domestic factors had been identified as the triggers, analysts also pointed to some outside forces such as the withdrawal of stimulus by the US Federal Reserve to prop up its own economy. The devaluation was contagious and spread across continents, providing the first hint of our primary concern: are there any global factors, beyond national or regional economic conditions, that induce co-movement of exchange rates in emerging markets?

To address this question, we use a dynamic hierarchical factor model proposed by Moench et al. (2013). It uses multi-level factor models to characterize within- and between-block variations as well as idiosyncratic noise in dynamic panels. We extract the components common to all emerging market economies from local components, including regional factors, specific to each continent as well as country-specific factors. We find that, for the period from 1996 to 2014, local components were the major driving forces of exchange rate changes in emerging market economies. The common component (which we also refer to as the world or global factor), in the meantime, only accounts for less than 20% of the variations in the exchange rates fluctuations of emerging market economies on average. However, in recent years, the effect of the common component has become more prominent, accounting for almost 40% of the variations on average.

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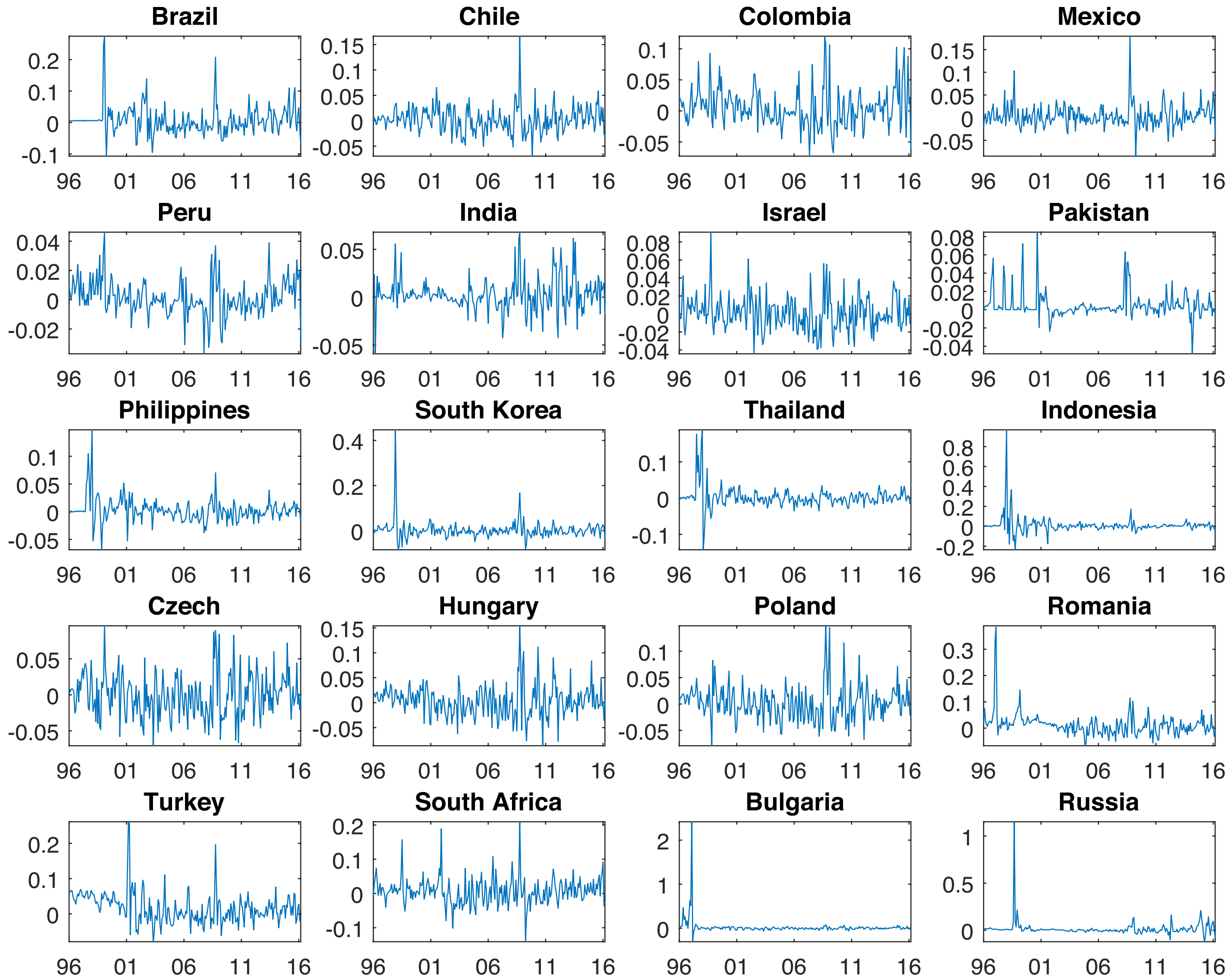

Fig. 1. Fluctuations in nominal exchange rates of emerging market countries: 1996–2016.

Given the role of common components, a follow-up question arises: what are the economic forces behind the world factor? Bearing in mind that driving forces and shocks that influence exchange rate changes in emerging markets are vast and sophisticated, we do not intend to dig out all possible explanations. Our main focus is the effect of the US and Chinese economy, especially that of the US monetary policy shocks and China's economic slowdown. As two leading economies, the policies and economic conditions of the United States and China do have spillover effects on the rest of the world. As an example, in the quantitative easing (QE) phrase, much of the capital the Federal Reserve injected into the economy flowed to emerging markets, and the tapering off of QE thus meant that liquidity was drying up. Furthermore, the performance of economic growth in China may affect the volatility of exchange rates in emerging markets, because China is not only the world's largest emerging market economy, but also the chief buyer of exports from other emerging market countries.

We thus use a vector autoregressive (VAR) model to investigate whether, and how, the US and Chinese economies affect the world factor of the exchange rate changes in emerging market economies. We look at both the magnitude of the influence as well as the differential effect on the world factor across time. We find that since the end of 2008, shocks to US monetary policy and the Chinese economy exert considerable influence on the fluctuations of the world factor, thereby affecting changes in emerging markets' ex-changes rates. The historical decomposition shows that 18.8% and 23% of the variations in the world factor after 2009 can be explained by US monetary policy shock and Chinese industrial production shock, respectively. The variance decomposition further indicates that, since 2009, US and Chinese shocks each account for 12% of the fluctuations in the world factor. Further, 3%(9%) of the forecast error of the world factor can be explained by US monetary policy shocks, and 7%(12%) can be explained by Chinese shocks in the short run(long run). These numbers are significantly larger than those before 2009. The results imply that the US monetary policy and Chinese economic performance matter in terms of common exchange rate fluctuations in emerging markets. The difference that we captured in their effect before and after 2009 is reinforced by our finding that the world factor becomes more critical in tracing the stimulus of exchange rate changes in emerging markets.

This study is related to four strands of literature. The first is literature investigating links between currency movements. In their seminal work, Baillie and Bollerslev (1989) find that a panel of seven currencies from industrialized economies are cointegrated,

Table 1
Summary statistics: the nominal exchange rates in emerging market countries.

Region	Country	Mean (%)	Standard deviation	Exchange rate arrangement
America	Brazil	0.64	0.04	Independently floating
	Chile	0.24	0.03	Independently floating
	Colombia	0.52	0.03	Independently floating
	Mexico	0.37	0.02	Independently floating
	Peru	0.16	0.01	Managed floating
Asia	India	0.28	0.02	Managed floating
	Isreal	0.11	0.02	Independently floating
	Pakistan	0.47	0.01	Managed floating
	Philippines	0.26	0.02	Independently floating
	Korea	0.25	0.04	Independently floating
	Thailand	0.18	0.03	Managed floating
	Indonesia	1.00	0.08	Managed floating
Europe and Africa	Czech	0.01	0.03	Managed floating
	Hungary	0.34	0.03	Pegged with ± 15% bands
	Poland	0.23	0.03	Independently floating
	Romania	1.22	0.04	Crawling bands
	Turkey	1.72	0.04	Independently floating
	South Africa	0.67	0.04	Independently floating
	Bulgaria	2.04	0.17	Currency board
	Russia	1.35	0.08	Managed floating

1. Data: nominal exchange rates of emerging markets against US dollar from 1995M1 to 2016M3. The original data is transferred to the growth rate of exchange rates (log-difference).
2. Countries are grouped according to continent. Each block contains countries in one continent. The first column is the abbreviation of continents: America, Asia, Europe, and Africa.

which is consistent with the hypothesis that there is one long-run relationship among these exchange rates. After examining five currencies in the ASEAN countries, Lee and Azali (2010) find that there are two cointegrating relationships in the post-crisis period, while the currencies are not cointegrated in the pre-crisis period. Frankel and Rose (1996) construct a panel of annual exchange rate data for over 100 developing countries and investigate the factors that contribute to a currency crisis. Besides national factors, their results point out the important role of foreign interest rates, which affect capital flows substantially. Similarly, Phylaktis and Ravazzolo (2005) test for cointegration among a group of Pacific Basin countries over the period 1980–1998, and find that stock and foreign exchange markets are positively related to the US stock market, regardless of the adoption of foreign exchange restrictions. The currency links among emerging markets are potentially facilitated by regional financial integrations, a process which authorities in Asia, in particular, are taking steps to accelerate (García-Herrero and Wooldridge, 2007).

Second, there is a vast body of literature on exchange rate forecasting. Engel et al. (2015) construct factors from a cross-section of exchange rates and use the idiosyncratic deviations from these factors to forecast exchange rates. Balke et al. (2013) start with the asset pricing approach of Engel and West, and then examined the degree to which fundamentals can explain exchange rate fluctuations. Verdelhan (2012) study the share of systematic variation in bilateral exchange rates. To the best of our knowledge, our study is the first to investigate the co-movement of emerging market exchange rates and the main forces behind them.

Third, the methodology used in this study belongs to the body of literature investigating dynamic factor models. Kose et al. (2003) use multilevel factor models to investigate international business cycles, and Stock and Watson (1989) adopt a similar methodology to analyse national and regional factors in housing construction. Different from the top-down approach taken by Kose et al. (2003), however, Moench et al. (2013) undertake a bottom-up application without making an assumption that requires that level components be orthogonal to the global factor.

Fourth, this study is also related to the literature on the spillover effect of US monetary policy on emerging markets. Mackowiak (2007) investigates whether external shocks are an important source of macroeconomic fluctuations in emerging markets and finds that 'when the US sneezes, emerging markets catch a cold'. Chen et al. (2016) study the effect of US quantitative easing (QE) on both emerging and advanced economies, and find that the effects of QE are sizeable and vary across economies. Ho et al. (2018) use a FAVAR approach to examine how the unconventional US monetary policy affected the Chinese economy. Different from their works, our study focuses on the spillover effect of US monetary policy on exchange rate fluctuations in emerging markets.

The remainder of this paper is structured as follows. Section 2 introduces the methodology. Section 3 describes the data. Section 4 reports the empirical results, and Section 5 concludes and discusses findings.

2. Methodology

2.1. Dynamic factor model

We adopt a two-step empirical analysis approach in this study. By first using a statistical model to extract the common component for exchange rate fluctuations in emerging markets, we further investigate factors affecting the common component. Particularly, we

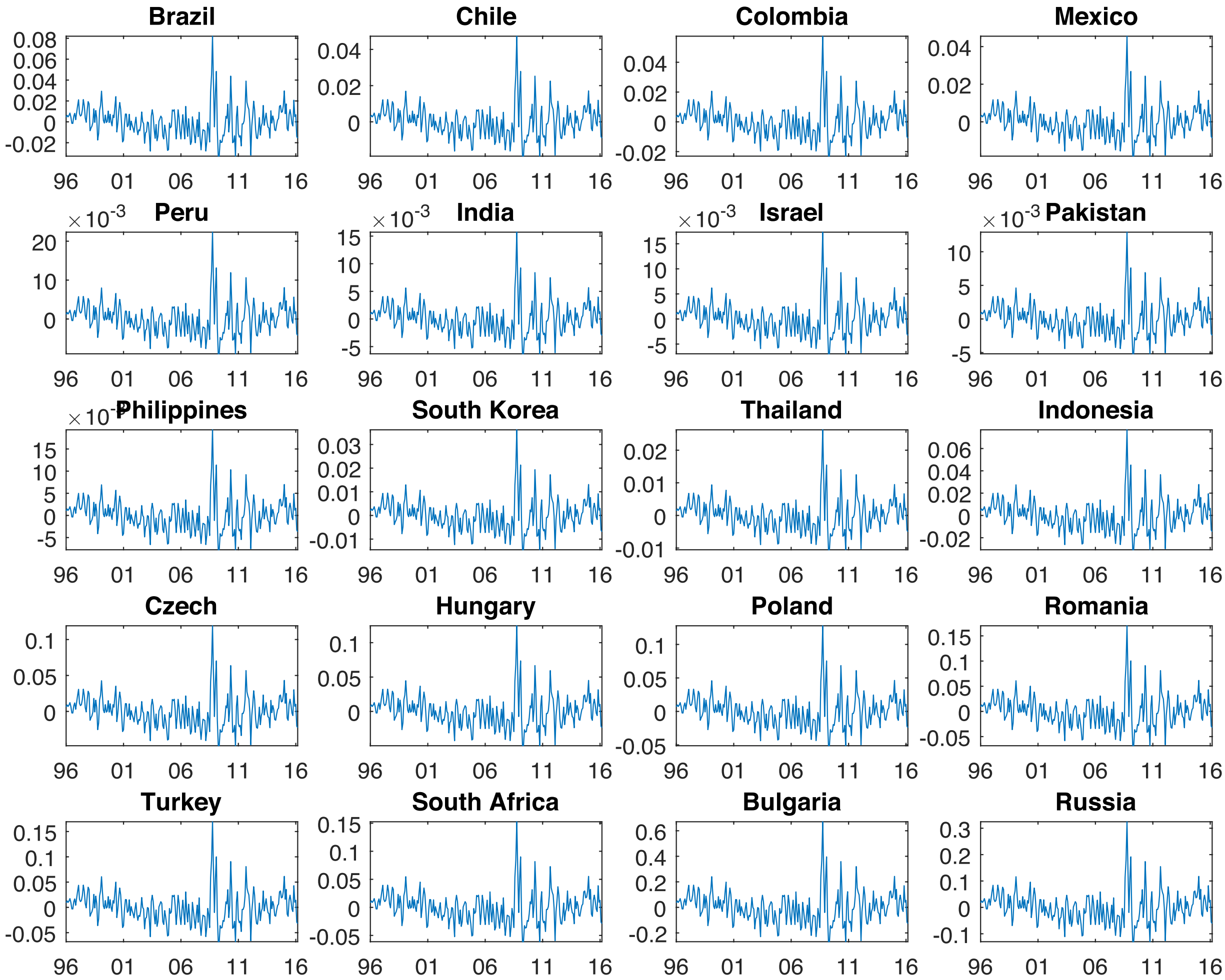

Fig. 2. Impacts of the world factor on nominal exchange rates of emerging market countries: 1996–2016.

focus on the effects of the US and Chinese economy on the exchange rate fluctuations in emerging markets, especially that of US monetary policy and the Chinese economic slowdown.

We use the dynamic hierarchical factor model introduced by Moench et al. (2013), which characterizes within- and between-block variations and also idiosyncratic noise in dynamic panels. Herein we consider a three-level model. Let N_r denote the number of countries in region $r = 1, \ldots, R$, and let $N = N_1 + \cdots + N_R$ be the total number of countries. The length of the time series for each country is T. In the model, the observed variable, the changes in exchange rates in emerging markets, y_{rnt}, depends on several latent factors, including the world factor, F_t, the regional or continent-specific factors, $G_{rt} = (G_{r1t}, \ldots, G_{rK_{Gr}t})$, where K_{Gr} is the number of regional factors for Region r, and the country-specific factor, e_{yrnt}:

$$y_{rnt} = \lambda^{n}_{Gr}(L)G_{rt} + e_{yrnt}, \tag{1}$$

$$G_{rjt} = \lambda^{j}_{Fr}(L)F_t + e_{Grnt}, \tag{2}$$

where λ^{n}_{Gr} and λ^{j}_{Fr} are distributed lag of loadings on the continent-specific factors and the world factor, e_{Grnt} is the continent variations.

To close the model, the country-specific, the continent-specific, and world factors are assumed to follow stationary, normally distributed autoregressive processes of the order q_{yrn}, q_{Gr}, and q_F, respectively. That is,

$$\begin{aligned}
&\Psi_F(L)F_t = \epsilon_{Ft} \quad \epsilon_F \sim N(0, \sigma_F^2),\\
&\Psi_{G.rj}(L)e_{Grnt} = \epsilon_{Grjt} \quad \epsilon_{Grj} \sim N(0, \sigma^2_{Grj})\ j = 1, \ldots, K_{Gr},\\
&\Psi_{y.rn}(L)e_{yrnt} = \epsilon_{yrnt} \quad \epsilon_{yrn} \sim N(0, \sigma^2_{yrn})\ n = 1, \ldots, N_r.
\end{aligned}$$

Factors are extracted by using the Markov Chain Carlo method, and the main steps are:

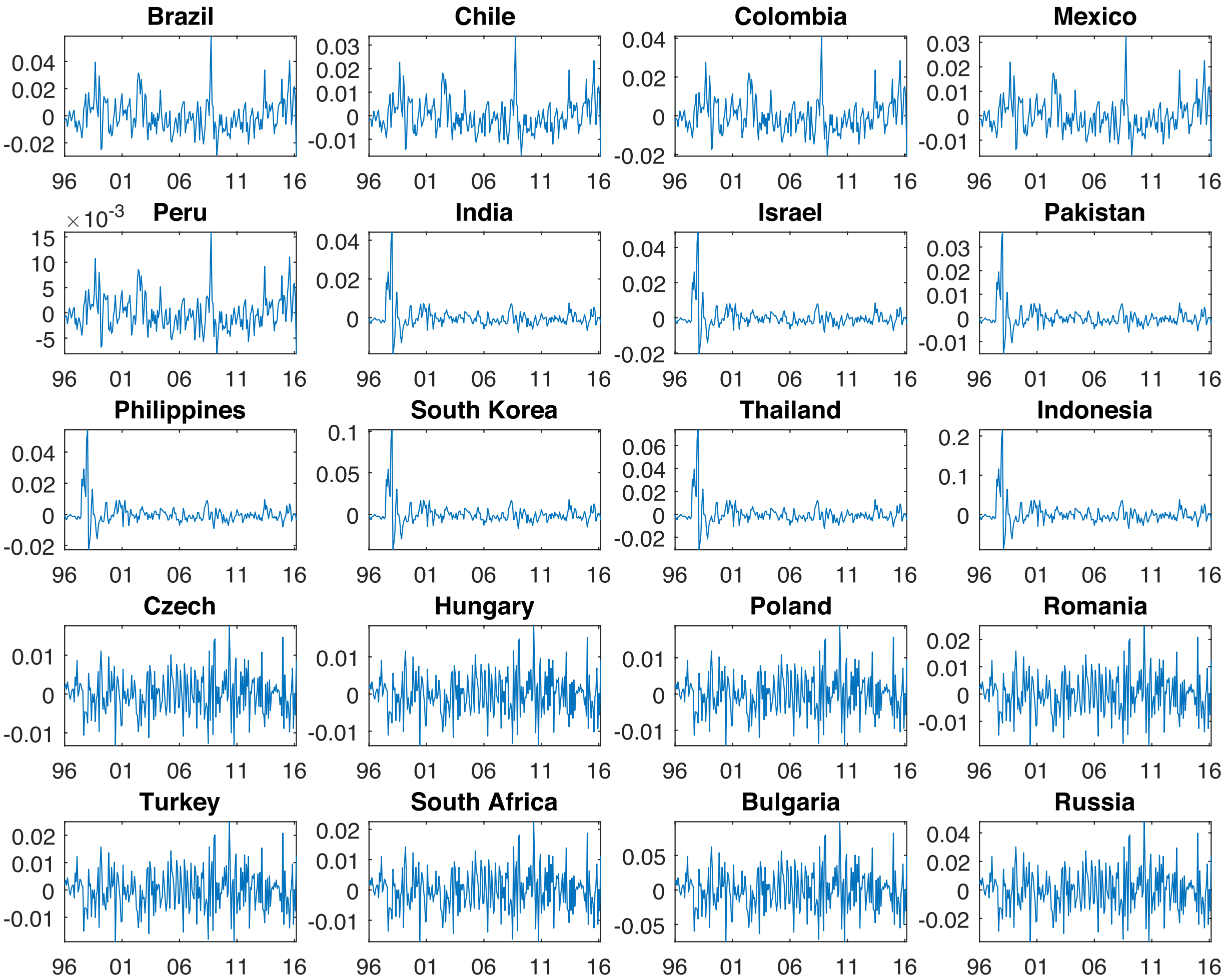

Fig. 3. Impacts of regional factors on nominal exchange rates of emerging market countries: 1996–2016.

1. Organize the data into blocks. Obtain initial values for $\{F_t\}$ and $\{G_t\}$ using principal components, and produce initial values for $\Lambda = (\Lambda_G, \Lambda_F)$, $\Psi = (\Psi_G, \Psi_F, \Psi_Y)$, and $\Sigma = (\Sigma_G, \Sigma_F, \Sigma_Y)$,.
2. Conditional on Λ, Ψ, Σ, $\{F_t\}$, and the data y_{rnt}, draw $\{G_t\}$.
3. Conditional on Λ, Ψ, Σ, and $\{G_t\}$, draw $\{F_t\}$.
4. Conditional on $\{F_t\}$ and $\{G_t\}$, draw Λ, Ψ, and Σ.
5. Return to 2.

The total unconditional variance for each individual variable, y_{rnt}, can be decomposed according to

$$\mathrm{Var}(y_{\mathrm{rn}}) = \gamma'_{F.\mathrm{rn}}\mathrm{vec}(\mathrm{Var}(F)) + \gamma'_{G.\mathrm{rn}}\mathrm{vec}(\mathrm{Var}(e_{\mathrm{Gr}})) + \mathrm{vec}(\mathrm{Var}(e_{\mathrm{yrn}})), \tag{3}$$

where the γs are functions of loadings on factors λs.

The variance share of the world factor is denoted by $Share_{WF}$, and measured as

$$\mathrm{Share}_{\mathrm{WF}} = \frac{\gamma'_{F.\mathrm{rn}}\mathrm{vec}(\mathrm{Var}(F))}{\mathrm{Var}(y_{\mathrm{rn}})}. \tag{4}$$

A more direct way to express the decomposition of movements in $y_{n,t}$ into world, regional, and country-specific factors follows Del Negro and Otrok (2007, JME):

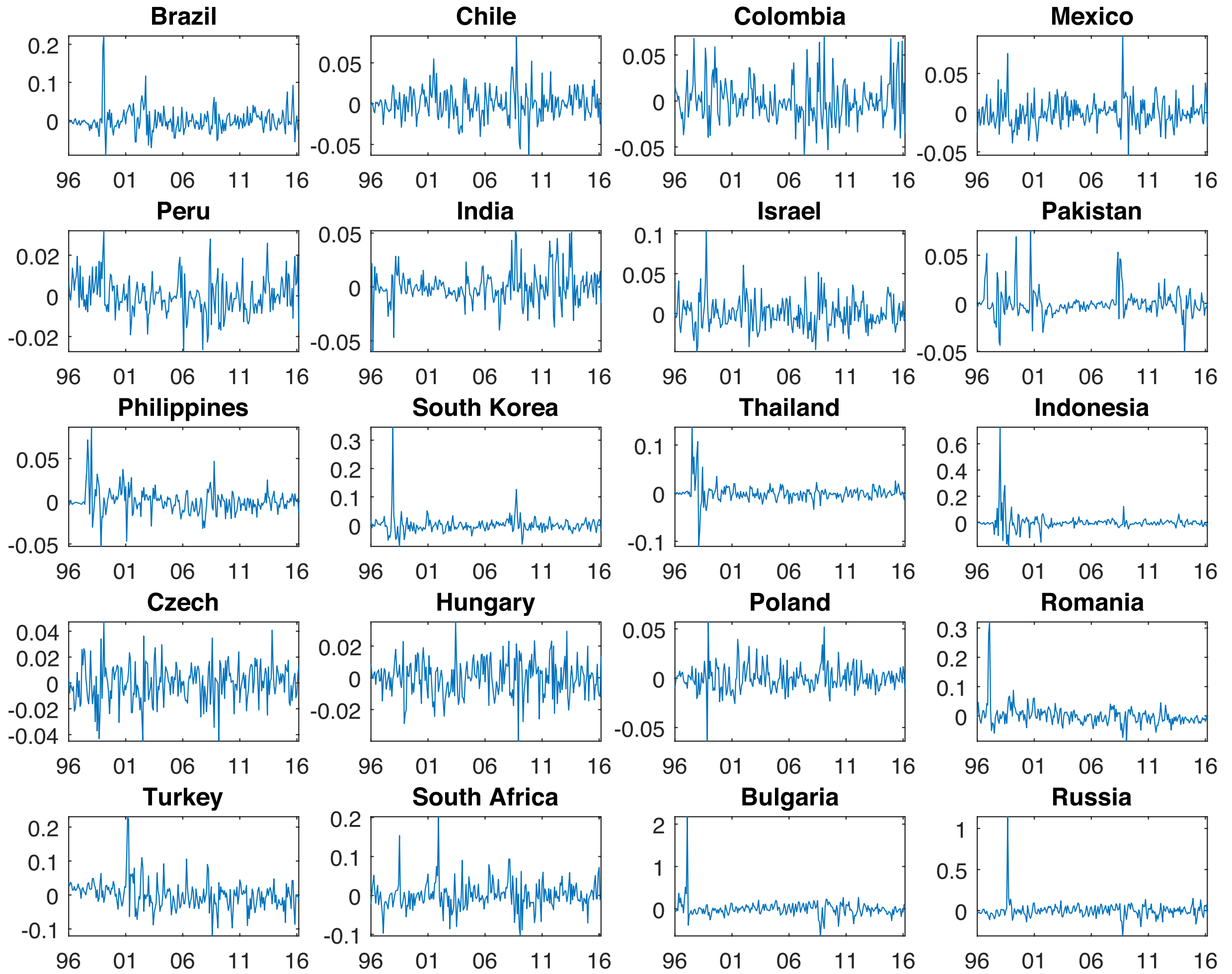

Fig. 4. Impacts of country-specific factors on nominal exchange rates of emerging market countries: 1996–2016.

$$v_n(t_0,\, t_1)) = \frac{\sum_{t=t_0}^{t_1} (\lambda_{G.r}^{n} \lambda_{F.r}^{j} F_t)^2}{\sum_{t=t_0}^{t_1} (\lambda_{G.r}^{n} \lambda_{F.r}^{j} F_t)^2 + \sum_{t=t_0}^{t_1} (\lambda_{G.r}^{n} e_{\mathrm{Grt}})^2 + \sum_{t=t_0}^{t_1} (e_{\mathrm{yrnt}})^2}. \tag{5}$$

This variance decomposition is computed for each country both for the full and sub-samples.

2.2. VAR analysis

After extracting the world factor of the exchange rate changes in emerging market countries, we turn to VAR to analyse the forces that influence the world factor. At the beginning of 2014, an announcement of the tapering of QE by the Federal Reserve was followed by emerging market exchange rate swings. This turbulence in emerging countries currency markets naturally gives us the impression that US monetary policy has a significant effect on the value of emerging market currencies. Is this conclusion correct? The Chinese economic slowdown may be an alternative to explain the co-movement of emerging market exchange rate fluctuations. How important is the Chinese economy in terms of these fluctuations? We use the Bayesian vector autoregression (BVAR), proposed by Sims and Zha (1998), with a one-month lag (chosen according to AIC and BIC statistics). There are 9 variables in the BVAR system in the following order: US industrial production growth ($IND_{US,t}$), US CPI inflation ($CPI_{US,t}$), US effective Federal funds rate or shadow rate (the zero lower bound (ZLB))(FFR_t), Chinese industrial production growth ($IND_{CN,t}$), Chinese CPI inflation ($CPI_{CN,t}$), Chinese money supply ($M2_{CN,t}$), emerging market industrial production index ($IND_{EM,t}$), emerging market inflation ($CPI_{EM,t}$), and the world factor of the emerging markets' exchange rate (F_t).

The VAR system proceeds as follows:

Table 2
Variance share of world factor.

Region	Country	1996M1–2016M3	1996M1–2008M11	2008M12–2016M3
America	Brazil	0.16	0.10	0.29
	Chile	0.21	0.13	0.20
	Colombia	0.20	0.13	0.20
	Mexico	0.22	0.13	0.19
	Peru	0.17	0.11	0.21
	Average	0.19	0.12	0.22
Asia	India	0.03	0.02	0.03
	Isreal	0.01	0.01	0.05
	Pakistan	0.00	0.01	0.07
	Philippines	0.13	0.02	0.15
	Korea	0.08	0.02	0.11
	Thailand	0.14	0.02	0.26
	Indonesia	0.09	0.02	0.31
	Average	0.07	0.02	0.14
Europe and Africa	Czech	0.60	0.55	0.77
	Hungary	0.70	0.72	0.80
	Poland	0.67	0.64	0.83
	Romania	0.21	0.26	0.71
	Turkey	0.11	0.23	0.54
	South Africa	0.18	0.27	0.50
	Bulgaria	0.04	0.18	0.48
	Russia	0.03	0.17	0.49
	Average	0.32	0.38	0.64
All average		0.20	0.19	0.36

1. The full sample variance share of nominal exchange rates fluctuations explained by the world factor is calculated according to Eq. (4).
2. The average share of nominal exchange rate fluctuations explained by world factor, regional factor and country-specific factors in subsample period $[t_0, t_1]$ using the following Eqs. (5).
3. Continent average statistics are reported at the end of each block, and average statistics of all the emerging markets are reported in the last row.

Table 3
Explaining power of the world factor.

Region	Country	R^2
America	Brazil	0.21
	Chile	0.27
	Colombia	0.24
	Mexico	0.23
	Peru	0.23
Asia	India	0.21
	Isreal	0.18
	Pakistan	0.03
	Philippines	0.12
	Korea	0.17
	Thailand	0.12
	Indonesia	0.06
Europe and Africa	Czech	0.59
	Hungary	0.68
	Poland	0.70
	Romania	0.28
	Turkey	0.20
	South Africa	0.23
	Bulgaria	0.04
	Russia	0.05

1. The R^2 is obtained by regressing each country's exchange rate change on the world factor extracted from the dynamic hierarchical factor model.

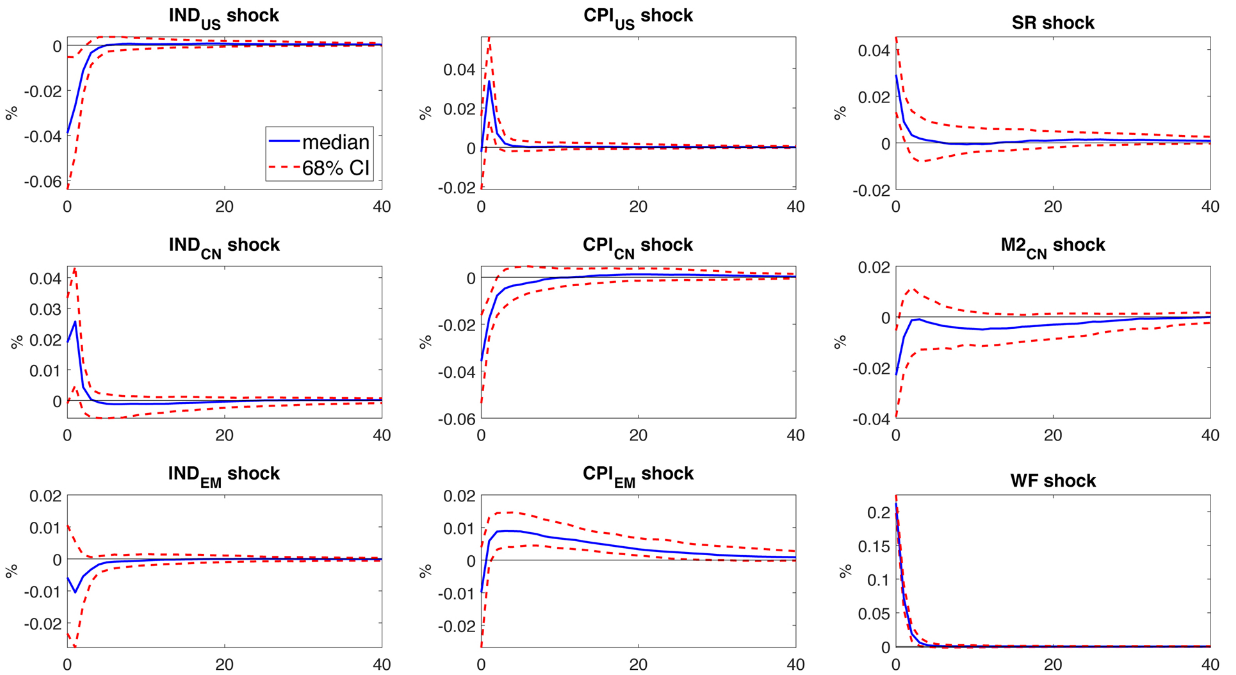

Fig. 5. Impulse responses of the world factor: 1996M1–2008M11. *Notes:* Impulse responses of the world factor to an 1% shock to US industrial production, US inflation, US federal funds rate, Chinese industrial production, Chinese inflation, Chinese monetary supply, emerging market production, emerging market inflation, and the world factor of the emerging market exchange rates, respectively. The blue solid lines represent median responses, and the red dashed lines represent the 68% confidence intervals for the estimated median responses. *X*-axis: time in quarters; *Y*-axis: percentage changes. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 4
Forecast error variance decomposition of the world factor: 1996M1–2008M11.

Horizon	IND_{US}	CPI_{US}	SR_{US}	IND_{CN}	CPI_{CN}	$M2_{CN}$	IND_{EM}	CPI_{EM}	WF
1M	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.91
6M	0.02	0.05	0.02	0.02	0.01	0.01	0.01	0.01	0.80
12M	0.02	0.05	0.02	0.02	0.01	0.02	0.01	0.01	0.77
18M	0.02	0.05	0.03	0.02	0.02	0.03	0.01	0.01	0.76
24M	0.02	0.05	0.03	0.02	0.02	0.03	0.01	0.01	0.75
30M	0.02	0.05	0.03	0.02	0.02	0.03	0.01	0.01	0.75
36M	0.02	0.05	0.03	0.02	0.02	0.03	0.01	0.01	0.75
42M	0.02	0.05	0.03	0.02	0.02	0.03	0.01	0.01	0.75
48M	0.02	0.05	0.03	0.02	0.02	0.03	0.01	0.02	0.75

1. This table presents the result of decomposing the forecast error variance of the world factor into nine shocks at the selected horizons based on data from 1995M11 to 2008M11. All the statistics is measured in percentage point.
2. The nine shocks are US industrial production shock (IND_{US}), US price shock (CPI_{US}), US monetary policy shock (FFR_{US}), Chinese industrial production shock (IND_{CN}), Chinese price shock (CPI_{CN}), Chinese monetary policy shock ($M2_{CN}$), emerging markets industrial production shock (IND_{EM}), emerging markets price shock (CPI_{EM}), and world factor shock (WF).

$$\begin{bmatrix} \mathrm{IND}_{\mathrm{US},t} \\ \mathrm{CPI}_{\mathrm{US},t} \\ \mathrm{FFR}_t \\ \mathrm{IND}_{\mathrm{CN},t} \\ \mathrm{CPI}_{\mathrm{CN},t} \\ M2_{\mathrm{CN},t} \\ \mathrm{IND}_{\mathrm{EM},t} \\ \mathrm{CPI}_{\mathrm{EM},t} \\ \mathrm{WF}_t \end{bmatrix} = A(L) \begin{bmatrix} \mathrm{IND}_{\mathrm{US},t-1} \\ \mathrm{CPI}_{\mathrm{US},t-1} \\ \mathrm{FFR}_{t-1} \\ \mathrm{IND}_{\mathrm{CN},t-1} \\ \mathrm{CPI}_{\mathrm{CN},t-1} \\ M2_{\mathrm{CN},t-1} \\ \mathrm{IND}_{\mathrm{EM},t-1} \\ \mathrm{CPI}_{\mathrm{EM},t-1} \\ \mathrm{WF}_{t-1} \end{bmatrix} + e_t. \tag{6}$$

We identified structural shocks using the Cholesky decomposition with the assumption that variable's shocks do not affect the variables ordered ahead contemporaneously.

Table 5
Forecast error variance decomposition of the world factor into three groups: 1996M1–2008M11.

Horizon	US_{all}	CN_{all}	EM_{all}
1M	0.03	0.01	0.92
6M	0.09	0.04	0.82
12M	0.09	0.05	0.79
18M	0.10	0.06	0.78
24M	0.10	0.06	0.77
30M	0.10	0.06	0.77
36M	0.10	0.07	0.77
42M	0.10	0.07	0.77
48M	0.10	0.07	0.77

1. This table presents the result of decomposing the forecast error variance of the world factor into three groups shocks at the selected horizons based on data from 1995M11 to 2008M11. All the statistics is measured in percentage point.
2. The three groups of shocks are the US shocks (US_{All}), including US industrial production shock (IND_{US}), US price shock (CPI_{US}), and US monetary policy shock (FFR_{US}), Chinese shocks (CN_{All}), including Chinese industrial production shock (IND_{CN}), Chinese price shock (CPI_{CN}), and Chinese monetary policy shock ($M2_{CN}$), and emerging markets shocks (EM_{All}), including emerging markets industrial production shock (IND_{EM}), emerging markets price shock (CPI_{EM}), and world factor shock (WF).

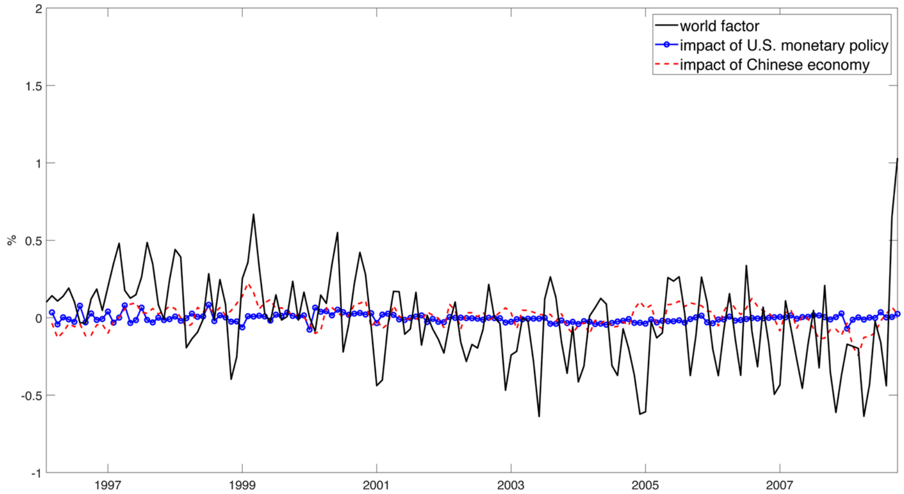

Fig. 6. Historical decomposition of the world factor: nominal exchange rate, 1996M1–2008M11.

Considering the larger explanatory ability of world factors in co-movements in the emerging market exchange rate fluctuations since 2008, with the advent of ZLB period of US monetary policy and the normalized slowdown of Chinese economic growth, we split the full sample into two sub-samples, one covering the 'before-ZLB' period – 1996M1–2008M11 – and the other covering the 'ZLB' period – 2009M1–2016M3.

3. The data

We identify 20 emerging markets according to the International Monetary Fund (IMF) classification. Among them, one is from Africa; seven are from Europe; five are from Latin America, and the remaining seven are from Asia. We use the monthly change in nominal exchange rates of these markets against the US dollar from 1996M1 to 2016M3 as the observed variables. The data source was the IMF IFS database. Fig. 1 plots the growth rates, that is, the log difference of nominal exchange rates of all 20 countries. Table 1 reports the mean and standard deviation of the growth rate of the exchange rate for each currency.

In the three-level model for country-level exchange rate growth, the bottom level is the country level. Each country belongs to a continent, and the continents constitute the block level. The world factor is extracted from the data for all the countries in the sample, the regional factors are extracted within each continent, and the leftovers are the idiosyncratic or country-specific factors.

We also use a set of variables for the VAR analysis, which includes the US industrial production, US inflation, US effective federal funds rate measured by the Wu-Xia shadow rate during the ZLB period as in Wu and Xia (2016), Chinese industrial production, Chinese CPI, Chinese money supply measured by $M2$, the emerging economy industrial production index, and the emerging market inflation index.

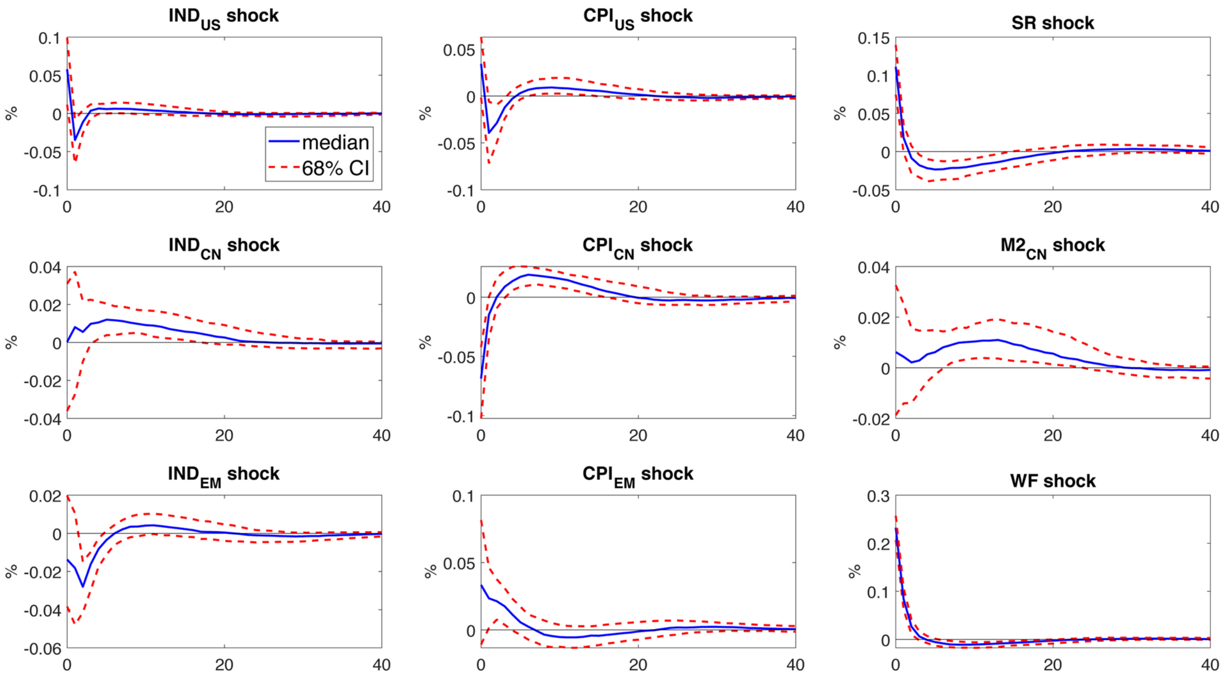

Fig. 7. Impulse responses of the world factor: 2008M12–2016M3. *Notes:* Impulse responses of the world factor to an 1% shock to US industrial production, US inflation, US federal funds rate, Chinese industrial production, Chinese inflation, Chinese monetary supply, emerging market production, emerging market inflation, and the world factor of the emerging market exchange rates, respectively. The blue solid lines represent median responses, and the red dashed lines represent the 68% confidence intervals for the estimated median responses. *X*-axis: time in quarters; *Y*-axis: percentage changes. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 6
Forecast error variance decomposition of the world factor: 2008M12–2016M3.

Horizon	IND_{US}	CPI_{US}	SR_{US}	IND_{CN}	CPI_{CN}	$M2_{CN}$	IND_{EM}	CPI_{EM}	WF
1M	0.01	0.01	0.06	0.01	0.00	0.01	0.02	0.01	0.80
6M	0.03	0.05	0.06	0.03	0.02	0.03	0.08	0.02	0.61
12M	0.04	0.05	0.08	0.03	0.03	0.03	0.09	0.03	0.57
18M	0.03	0.05	0.08	0.03	0.04	0.03	0.09	0.03	0.54
24M	0.03	0.05	0.09	0.03	0.04	0.04	0.08	0.03	0.52
30M	0.03	0.05	0.09	0.04	0.04	0.04	0.08	0.03	0.52
36M	0.03	0.05	0.09	0.04	0.04	0.04	0.08	0.03	0.51
42M	0.03	0.05	0.09	0.04	0.04	0.04	0.08	0.03	0.51
48M	0.03	0.06	0.09	0.04	0.04	0.04	0.08	0.03	0.51

1. This table presents the result of decomposing the forecast error variance of the world factor into nine shocks at the selected horizons based on data from 2009M1 to 2016M3. All the statistics is measured in percentage point.
2. The nine shocks are US industrial production shock (IND_{US}), US price shock (CPI_{US}), US monetary policy shock (FFR_{US}), Chinese industrial production shock (IND_{CN}), Chinese price shock (CPI_{CN}), Chinese monetary policy shock ($M2_{CN}$), emerging markets industrial production shock (IND_{EM}), emerging markets price shock (CPI_{EM}), and world factor shock (WF).

4. Empirical results

4.1. Exchange rate fluctuations and factors

From Fig. 1, we observe that the exchange rate changes in emerging market countries, as represented by solid lines, were highly volatile before 2004, followed by a relatively ‘peaceful period’ from 2005 to 2008, which then jumped into a new volatile phase (more volatile than the ‘peaceful period’ but still less volatile than the period before 2004) after the end of 2008. Figs. 2–4 show the effects of the world, regional and country-specific factors on each country's exchange rate growth. Because of the infeasibility of finding direct economic interpretation for each factor itself, we shift our emphasis to find out how elements can be interpreted as components of exchange rate changes in country n_j attributed to the factors. ‘Effect of world factor’ in Fig. 2 is factor F_t multiplied by the loadings in Eqs. (1) and (2), $\lambda^j_{\mathrm{Fr}}\lambda^n_{\mathrm{Gr}}F_t$. Although there is only one common world factor for all countries, the loading before the world factors is specific to each country, so in Fig. 2, each country has its own world factor line. Local factors (either the regional or

Table 7
Forecast error variance decomposition of the world factor into three groups: 2008M12–2016M3.

Horizon	US_{all}	CN_{all}	EM_{all}
1M	0.08	0.02	0.83
6M	0.14	0.07	0.72
12M	0.16	0.09	0.68
18M	0.17	0.10	0.66
24M	0.17	0.11	0.64
30M	0.17	0.12	0.63
36M	0.18	0.12	0.63
42M	0.18	0.12	0.63
48M	0.18	0.12	0.63

1. This table presents the result of decomposing the forecast error variance of the world factor into three groups shocks at the selected horizons based on data from 2009M1 to 2016M3. All the statistics is measured in percentage point.
2. The three groups of shocks are the US shocks (US_{All}), including US industrial production shock (IND_{US}), US price shock (CPI_{US}), and US monetary policy shock (FFR_{US}), Chinese shocks (CN_{All}), including Chinese industrial production shock (IND_{CN}), Chinese price shock (CPI_{CN}), and Chinese monetary policy shock ($M2_{CN}$), and emerging markets shocks (EM_{All}), including emerging markets industrial production shock (IND_{EM}), emerging markets price shock (CPI_{EM}), and world factor shock (WF).

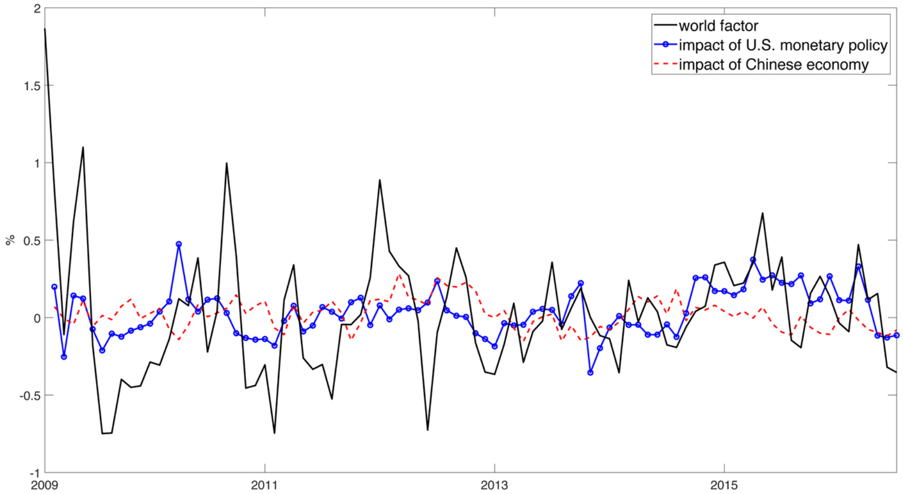

Fig. 8. Historical decomposition of the world factor: 2008M12–2016M3.

country-specific factors) affecting exchange rates are beyond the sphere of our study because each country has its own economic condition, political situation, institutional design, and other features. All these differences ought to have significant effects on the exchange rate. Among the 20 countries, several countries drew our special attention. In 2013, Morgan Stanley declared the Brazilian Real, the Indonesian Rupiah, the South African Rand, the Indian Rupee, and the Turkish Lira as the ‘Fragile Five’, or the troubled emerging market currencies under the most pressure against the US dollar. ‘High inflation, weakening growth, large external deficits, and in some cases, exposure to the China slowdown, and high dependence on fixed income inflows leave these currencies vulnerable,’ wrote Morgan Stanley analysts in an August 2014 research note. We find that during the Asian Financial Crisis, the Indonesian Rupiah suffered badly. Because this crisis was not worldwide, the estimated world factor did not capture the wild swings in the Indonesian Rupiah, whereas regional and country-specific factors took effect. The Brazil Real experienced an irregular appreciation period round 1994 and then dropped back, mainly because of the introduction of the modern Real on 1 July, 1994. Shortly after that, the Real unexpectedly gained value against the US dollar, following large capital inflows in late 1994 and in 1995. During that period, it attained its highest dollar value ever, approximately US$1.20. Between 1996 and 1998, however, the exchange rate was tightly controlled by the Central Bank, resulting in a slow and smooth depreciation of the Real against the dollar, dropping from near 1:1 to approximately 1.2:1 by the end of 1998. This appreciation is mainly affected by country-specific factors. Through investigating the factors and fluctuations of the ‘Fragile Five’ exchange rates, we become confident that the dynamic hierarchical factor model does a good job of capturing the fluctuations in exchange rate growth and distinguishing common components from local ones.

Comparing Figs. 2–4, we find that local factors, including regional and country-specific factors, play relatively more important roles in the exchange rate fluctuations than the world factor. However, the effect of the world factor becomes larger from 2009, and it also spiked at the end of 2008. As for the five currencies, despite the increase of the importance of the world factor since the Great Recession, its explanatory power is still weak in these five countries compared with that in other emerging markets.

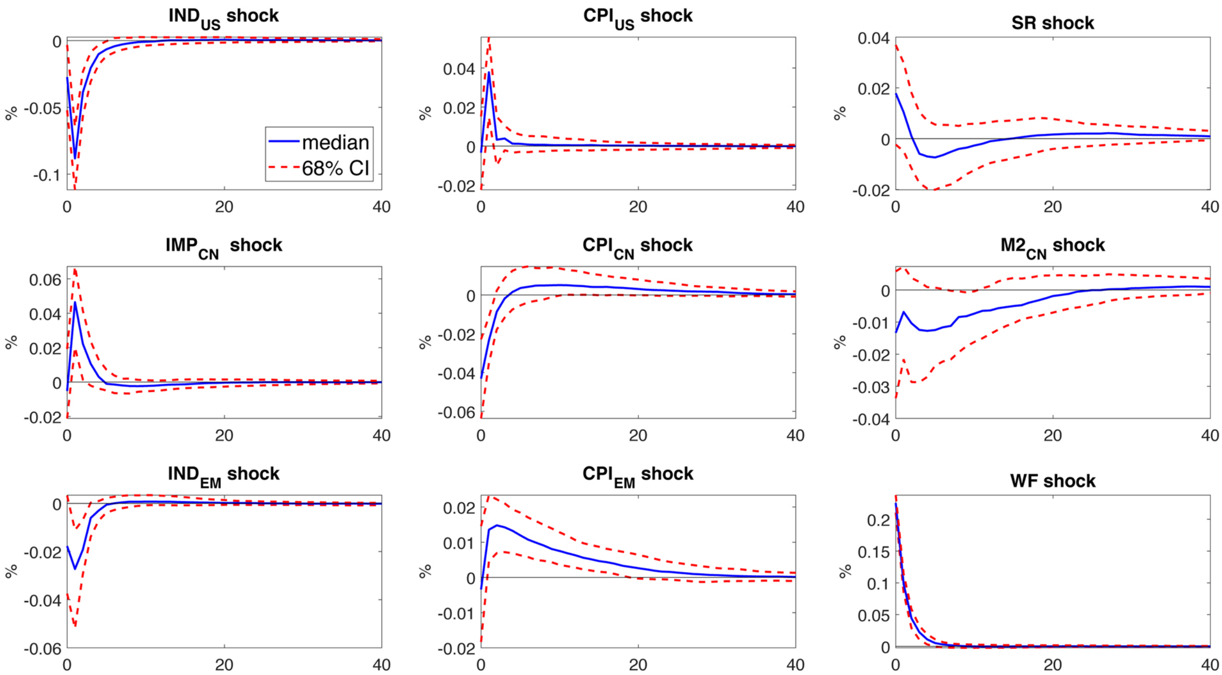

Fig. 9. Impulse responses of the world factor: 1996M1–2008M11. *Notes:* Impulse responses of the world factor to an 1% shock to US industrial production, US inflation, US federal funds rate, Chinese import, Chinese inflation, Chinese monetary supply, emerging market production, emerging market inflation, and the world factor of the emerging market exchange rates, respectively. The blue solid lines represent median responses, and the red dashed lines represent the 68% confidence intervals for the estimated median responses. *X*-axis: time in quarters; *Y*-axis: percentage changes. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

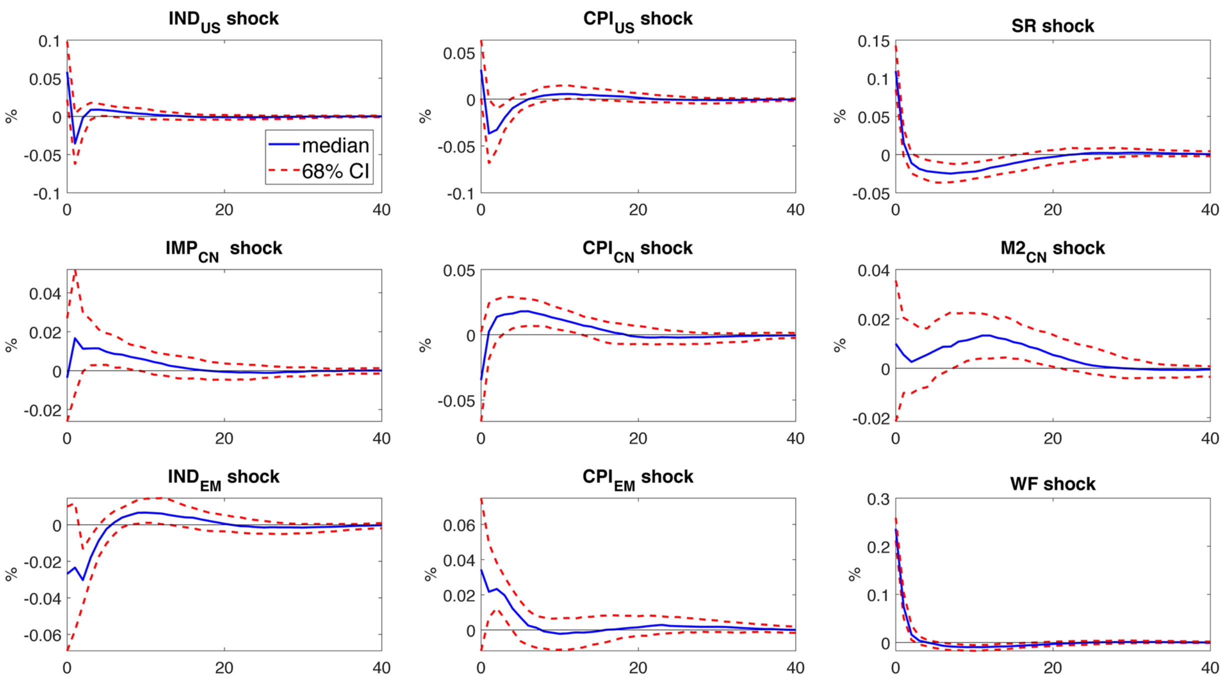

Fig. 10. Impulse responses of the world factor: 2008M12–2016M3. *Notes:* Impulse responses of the world factor to an 1% shock to US industrial production, US inflation, US federal funds rate, Chinese import, Chinese inflation, Chinese monetary supply, emerging market production, emerging market inflation, and the world factor of the emerging market exchange rates, respectively. The blue solid lines represent median responses, and the red dashed lines represent the 68% confidence intervals for the estimated median responses. *X*-axis: time in quarters; *Y*-axis: percentage changes. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

The variance share of the world factors supports our observation from Fig. 2. Table 2 gives the share of variations in the exchange rates explained by the world factor within different sample periods. The first column is the continent the country belongs to. The second column is the country name. The third column is the variance share of the world factor in the full sample results from 1996M1 to 2016M3 as calculated based on Eq. (4). The fourth and last column shows the results calculated from Eq. (5) using sub-samples from 1996 to 2008 and 2009 to 2016, respectively. Indeed, 20% of the fluctuations of all 20 countries from 1996 to 2016 can be explained by the world factor. Before the Great Recession, this number was only 19%, and since the Great Recession, this number has increased to 36%. A comparison between the last two columns shows that in recent years, the common factor accounts for more variation in the exchange rate fluctuations of the emerging economies. Therefore, generally speaking, the world factor became more important for exchange rate fluctuations in emerging markets after 2008 according to the variance decomposition,. This characteristic is retained for all the countries we studied. Besides the magnified effect caused by the time collapse, there are also cross-continental differences concerning the magnification of the world factor. The average variance share of the world factor in Europe reaches 32%, whereas that ratio for Asia is only 7%. Therefore, the exchange rates of Asian countries are more affected by local factors, including regional or country-specific factors. Table 3 reports the R^2 of the regression of exchange rates on the world factor. There are also many cross-country differences.

4.2. The US and Chinese Economies and the emerging market exchange rates

Fig. 5 indicates the impulse responses of the world factor to positive shocks in the VAR system, based on data from 1996M1 to 2008M11. The blue solid lines indicate the estimated median of the impulse responses, and the red dashed lines represent the 68% confidence intervals. Shocks to US variables do not have any significant effect on the world factor. However, Chinese CPI shocks do have a negative effect on the world factor.

Table 4 is the forecast error variance decomposition of the world factor in different horizons based on data from 1996M1 to 2008M11. Table 5 reports the result of grouping the shocks into US, Chinese, and emerging market shocks. During this time, US monetary policy and CPI shocks had almost no effect on the world factor. Using a 48-month horizon, US industrial production shocks accounts for 2% of the total fluctuations in the world factor, and all three US shocks account for only 10% of the total fluctuations. Meanwhile, Chinese shocks also account for only 7% of the total fluctuations in the 48-month horizon. However, different from the composition of the contribution of the US shocks, Chinese monetary policy shocks contributed more than Chinese industrial production shocks.

Fig. 6 indicates the historical decomposition of the world factor from 1996M1 to 2008M11. The black solid line is the world factor, the blue line with circles is the effect of the US monetary policy shock on the world factor, and the red dashed line is the effect of Chinese economy shocks on the world factor. Comparing the solid line and the line with circles, we find that the US monetary policy shock did not show much effect. The effect of Chinese economy shocks on the world factor is larger than that of US monetary policy shocks.

Fig. 7 shows the impulse responses of the world factor to positive shocks in the VAR system, based on data from 2009M1 to 2016M3. The impulse responses during the ZLB period are clearly very different from those for the previous period. US industrial production shocks had a significant effect of the world factor in the very short run (1–2 months), and the US monetary policy shocks had a significantly negative effect on the world factor from the second to the seventh month after a shock. Both the Chinese industrial production and the CPI shocks affected the world factor positively and in the opposite direction than in the previous period. The results mean that first, US monetary policy becomes more important for the emerging markets' exchange rate fluctuations, and second, the Chinese economy now matters for emerging markets. The reason might be China's changed role in emerging markets: for emerging markets, it has shifted from being a competitor to being a very important importer.

Table 6 is the forecast error variance decomposition of the world factor for different horizons based on data from 2009M1 to 2016M3. Table 7 reports the result of grouping the shocks into US, Chinese, and emerging market shocks. Both the US and China have become more important in terms of affecting the world factor, namely, 18% and 12% medium-run variations can be explained by the US shocks and Chinese shocks, respectively.

Fig. 8 is the historical decomposition of the world factor from 2009M1 to 2016M3. Compared with Fig. 6, the effects of the US monetary policy and Chinese economy shocks, represented by the blue lines with circles and red dashed lines, respectively, are larger on the world factor. US monetary policy plays a much more important role during this period compared with the pre-ZLB period. After 2014, the Chinese economy shocks mainly have negative effects on the world factor. The average historical contribution of US monetary policy and Chinese economy shocks during 2009 and 2016 are 18.8% and 23%, respectively.

These results imply that in recent years, US monetary policy has had a much larger influence on the changes of exchange rates in the emerging market countries, and the slowdown in the Chinese economy does have a significant spillover effect on other emerging market countries.

We also considered using the Chinese import growth to replace Chinese industrial production growth because international trade is the main channel through which the Chinese economy affects other emerging markets. Our main results remain unchanged. The impulse responses in Figs. 9 and 10 display similar patterns to those in Fig. 5 and Fig. 7, respectively.

5. Conclusion

The dynamic hierarchical factor model helps to disentangle the relative importance of the common component of the exchange rate changes in emerging markets and implies that the fluctuation in their exchange rates has historically mostly been driven by local factors. The common factor has become more important in recent years. The analysis of a VAR built to investigate how the US monetary policy and a slowdown in the Chinese economy affect the common component shows that US monetary policy and Chinese shocks did exert more influence on co-movements of the emerging markets exchange rate fluctuations since 2009.

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