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# Exchange rate movements in Emerging Economies Global *vs* Regional factors in Asia

Raphaël Chiappini\*      Delphine Lahet†

## Abstract

The aim of this article is to analyse the main determinants of emerging markets' exchange rate movements, particularly in Asia. For this purpose, we implement a dynamic latent factor model to investigate the drivers of 24 emerging countries' exchange rate movements and decompose the patterns into three components: a global common factor, a regional factor and a country-specific factor. Our results reveal that, in the whole period of 2000-2015, the common global factor is by far the most important determinant of exchange rate variations for Asian economies and, albeit to a lesser extent, for Latin America. However, after 2005, there is a strong increase in the explanatory power of the regional factor in Asia, from 5.6% to 45.1%, and to 49.7% in the period of 2011-2015, which shows that it is becoming the dominant factor in this area. Then, we use a Vector Autoregressive (VAR) model and an Autoregressive Distributed Lag (ARDL) model to show that the regional factor in Asia, estimated from the dynamic latent factor model, is mainly explained by Chinese economic variables. More particularly, our results highlight that the bilateral exchange rate of China, both the onshore and the offshore rates, and the macroeconomic climate in China greatly influence the regional factor in Asia in the long-run. These results give some evidence of a Renminbi zone in the long-run and are robust to the inclusion of two other major currencies in Asia, the Japanese Yen and the Korean Won, notably in the long run.

**Keywords:** Exchange rates, currencies internationalization, Renminbi bloc, dynamic latent factor model, Bayesian estimation, VAR and ARDL models

**JEL Classification:** C32, F15, F31, F36

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## Abstract

The aim of this article is to analyse the main determinants of emerging markets' exchange rate movements, particularly in Asia. For this purpose, we implement a dynamic latent factor model to investigate the drivers of 24 emerging countries' exchange rate movements and decompose the patterns into three components: a global common factor, a regional factor and a country-specific factor. Our results reveal that, in the whole period of 2000-2015, the common global factor is by far the most important determinant of exchange rate variations for Asian economies and, albeit to a lesser extent, for Latin America. However, after 2005, there is a strong increase in the explanatory power of the regional factor in Asia, from 5.6% to 45.1%, and to 49.7% in the period of 2011-2015, which shows that it is becoming the dominant factor in this area. Then, we use a Vector Autoregressive (VAR) model and an Autoregressive Distributed Lag (ARDL) model to show that the regional factor in Asia, estimated from the dynamic latent factor model, is mainly explained by Chinese economic variables. More particularly, our results highlight that the bilateral exchange rate of China, both the onshore and the offshore rates, and the macroeconomic climate in China greatly influence the regional factor in Asia in the long-run. These results give some evidence of a Renminbi zone in the long-run and are robust to the inclusion of two other major currencies in Asia, the Japanese Yen and the Korean Won, notably in the long run.

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## 1. Introduction

Following the 1990s' financial crises in Latin America and Asia, emerging countries aimed to develop and reform their economies while protecting against the volatility of foreign capital flows and exchange rates' instability. Some of them, notably in Asia, manage exchange rate regimes and impose capital controls. This was also the case in 2010 after the subprime crisis. At the same time, some emerging countries' currencies are becoming more internationalized. Currencies are internationalized when they are

increasingly used by non-residents for the composition of international reserves, foreign exchange interventions and operations, the payment and denomination of trade and financial transactions (Frankel, 2011, Maziad et al., 2011). Amongst these countries, China has distinguished itself through its economic growth, its geopolitical influence on Asia and on the world and the reforms that are underway, notably concerning the more flexible management of the exchange rate regime since 2005. China is a dominant country. In PPP terms, it represents 18.2% of the world GDP (IMF, 2018; the U.S. represents 15.3%) and it is the world's leading exporter (12.8% of world exports of merchandise) and the second-largest importer (10.2% of world imports of merchandise) in the world (WTO, 2018). Moreover, Asian countries are highly dependent on China in terms of growth, trade, and financial channels (Rafiq, 2016; Dizioli, Guajardo et al., 2016; Chen et al., 2014; Li and Whalley, 2017), and in terms of regional initiatives like the CMIM (The Chiang Mai Initiative Multilateralization, Eichengreen and Lombardi, 2015).

The emergence of China naturally leads to questions about the dominant role of the Renminbi (RMB) in Asia. Formally, no country is *de facto* pegging its currency to the RMB. However, for a trading partner, it is crucial to maintain the stability of its currency relative to the dominant country. One can observe that, in the 2000s, notably in 2015 following reforms of the daily fixing of the RMB, some Asian currencies seemed to move closely with the RMB (Shu et al., 2015; McCauley and Shu, 2018). Such a dominant-country position does not exist in Latin America, nor in Emerging Europe, for which the major questions are respectively the position relative to the U.S. and the condition of access to the Eurozone. Consequently, the literature is less interested in the status of the currencies of these countries and the currencies with which they may co-move.

The aim of this article is to analyse the determinants of emerging markets' exchange rate movements, particularly in Asia, with a two-fold approach. First, we decompose the evolutions of emerging markets' exchange rates into the contribution of a global common factor, a regional factor and a country-specific factor. The global factor is in the same vein of the push determinants of capital flows (US monetary policy, external shocks...); the regional factor refers to the recent literature on the existence of a *de facto* monetary bloc in Asia centred around the RMB; and the specific or idiosyncratic factor relates to domestic determinants. Second, we want to highlight the determinants of the regional factor in Asia and to investigate what the role of Chinese fundamentals would be, particularly the onshore and the offshore exchange rates. It could allow us to conclude on the existence of a *de facto* monetary zone around the RMB in the long run and to investigate if the launch of the offshore rate since 2010 in Hong Kong has increased the influence of China on the other Asian currencies. This could be a major contribution to the literature.

More globally, this topic is in line with the literature that concentrates on the currency internationalization process, on network effects (Lee, 2014; He and Yu, 2016) and on the potential of the RMB to challenge the U.S. dollar as the leading global currency. For another part of the literature, the RMB may be a leading regional currency that has

overtaken the U.S. dollar as the dominant reference currency in Asia<sup>1</sup>.

To shed light on this issue, we implement a dynamic latent factor model to investigate the determinants of 24 emerging countries' exchange rate movements and decompose the evolutions into the contribution of a global factor, a regional factor and a country-specific factor.

First of all, the results indicate that, in the whole period of 2000-2015, the common global factor is by far the most important determinant of exchange rate variations for Asian economies (70%) and, albeit to a lesser extent, for Latin America (53%) and all other countries in the sample (49.6%). If we decompose the whole period into sub-periods, the results are quite different. The 2000-2005 sub-period shows the predominance of the global common factor as the main explanation of exchange rate movements, especially for Asian countries (73%). However, after 2005, there is a strong increase in the explanatory power of the regional factor in Asia, from 5.6% to 45.1%, indicating that it is becoming the dominant factor in this area. We find evidence, in line with the Chinese dominance hypothesis in the literature, of the increasing influence of the regional factor in the evolution of exchange rates in Asia to the detriment of the common global factor. This is not the case for the other emerging zones. Moreover, when we split the period of 2006-2015 into two sub-periods, namely 2006-2010 and 2011-2015, to take into account the launch of the offshore exchange rate (CNH) in Hong Kong in 2010, the explanatory power of the regional factor in Asia is the highest for the period of 2011-2015 (49.7%), with respect to the explanatory power for the period of 2006-2010 (47.2%) and for the whole period of 2006-2015 (45.1%). We assert that this regional influence could be linked to the internationalization of the RMB and to the more flexible management of the Chinese exchange rate regime since 2005 and after the launch of the offshore rate in 2010. Afterwards, to investigate this issue in the short-run, we use a Vector Autoregressive model (VAR). We find that the regional factor in Asia, estimated by the dynamic latent factor model, is mainly explained by Chinese economic variables. Indeed, our results highlight that both the onshore and the real effective exchange rates of China, and the macroeconomic climate in China influence the regional factor in Asia. We also find that other determinants, such as the Barclays Emerging Market Asia Index, are important for explaining changes of the factor. Then, we use an ARDL model to take a long-run view of the issue. The results give some evidence of a strong influence of both the onshore and the offshore exchange rates of China and, therefore, support the hypothesis of a RMB zone in Asia. The results are robust to the inclusion of two other major currencies in Asia, the Japanese Yen and the Korean Won, notably in the long run, and they give support to the major driving role of the Chinese currency on the other Asian currencies.

Our contribution to the literature is four-fold. First, we use a new methodology with respect to the Frankel and Wei method, to precisely pinpoint the determinants

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<sup>1</sup>Rajan and Prakash, 2010; Eichengreen, 2011 ; Frankel, 2011 ; Subramanian, 2011; Maziad et al., 2011 ; Kenen, 2012 ; Kim and Suh, 2012; Rhee, 2012; Ehlers and Packer, 2013; Padmanabhan, 2013; Park and Shin, 2012 ; Gao and Yu, 2012 ; Ma and Villar, 2014; Lee, 2014; He et al., 2015; Eichengreen and Lombardi, 2015; Aizenman, 2015; Chinn and Ito, 2015; Reiss, 2015; Lahet, 2017.

of exchange rates' movements and the influence exerted by one currency on another one. Second, we supplement the existing literature on a regional *de facto* monetary bloc in Asia with evidence of the contribution of a regional factor in the exchange rates' movements in Asia after 2005 and following the 2010 offshore rate launch. Third, we complete the rather sparse literature on the influence of the offshore rate on changes in other Asian currency rates. Finally, our results are in line with the literature on a multi-polar (or tri-polar) international monetary system, considering that the reliance of the International Monetary System on a single dominant currency issued by a country responsible for a global economic crisis may engender its own fragility (Benassy-Quéré and Pisany-Ferry, 2011; Tovar and Nor, 2018).

The rest of the paper is organized as follows. In Section 2, we present the literature review. The data and the empirical model are analysed in Section 3. Section 4 presents the results and the robustness checks, and Section 5 offers a discussion and conclusion.

## 2. Literature review

Explaining the exchange rate movements in emerging countries is in line with the topic of internationalization *vs* regionalization of emerging markets' currencies that has mainly concerned the Asian currencies from three perspectives.

First, Ehlers and Packer (2013), by studying the FX Turnover<sup>2</sup> of emerging markets' currencies from the BIS Triennial Central Bank Survey, show that the offshore trading of Asian currencies is regional and done via a regional centre (Hong Kong), which is not the case for Latin American currencies.

Second, by studying the ability to fulfil some of the functions of money globally, the literature focuses mainly on the RMB regarding its degree of internationalization: large, at an international level, or close, at a regional level (Dobson and Masson, 2009; Eichengreen, 2011; Gao and Yu, 2012; Eichengreen and Lombardi, 2015).

Third, different methodologies have been used to enquire about the existence of a regional *de facto* monetary bloc in Asia; but the conclusions disagree because the findings are sensitive to the methodologies used. There are three types of methods. First, the traditional methodology proving the influence of an exchange rate on other exchange rates or co-movements is the linear regression à la Frankel and Wei (1994). It is the most used on this topic. For example, the evolution of an Asian local currency vis-à-vis the Swiss Franc, for example, (sometimes the U.S. Dollar or the DTS) may be explained by the evolution of the following exchange rates: RMB/Swiss Franc, U.S. Dollar/Swiss Franc, Yen/Swiss Franc, or Euro/Swiss Franc. This allows for the highlighting of the dominant reference currency in Asia: the RMB (Subramanian and Kessler, 2013; Eichengreen and Lombardi, 2015; Shu et al., 2015; McCauley and Shu, 2018). Nevertheless, other articles emphasize multicollinearity problems in this method and, to tackle them, propose using the exchange rates of currencies measured against the New Zealand dollar, which is the currency of a small open economy managing a floating exchange rate without capital

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<sup>2</sup>Trading share of a currency (purchase and sale) in the total amount of transactions in global FX markets.

control (Huang et al., 2014; Kawai and Pontines, 2014; Kawai and Pontines, 2016; Ito, 2017; Tovar and Nor, 2018). If these articles conclude that there is an increasing influence of the RMB on other Asian exchange rates, notably after 2005 (the year of the implementation of liberalization reforms in China) or after 2008 (following the subprimes crisis in the U.S.), then they do not conclude the existence of an Asian RMB monetary bloc. Second, another methodology consists in quantifying the responses of exchange rates to shocks on the RMB (VAR (Chow-Tan, 2014; Shu et al., 2016) or event analysis (Ito, 2017)). These articles demonstrate the increasing influence of the RMB on the other Asian currencies after 2008, but there is no conclusion about a monetary bloc. Third, an alternative method (convergence with unit roots test: first, second and third generations (Figuière et al., 2013)) proves the convergence of some Asian exchange rates on regional targets, notably RMB-Won-Yen and RMB-Yen in the most recent periods. These conclusions support the thesis of an Asian monetary bloc with a crucial role for the RMB<sup>3</sup>.

In light of these divergent conclusions on the regional influence of the RMB due to the methodologies used, we decide to use the dynamic factor model methodology (Kose et al., 2003) to examine the movements of emerging markets' exchange rates and to decompose them into a global factor, a regional factor or a country-specific component. This methodology has already been applied to examine the degree of co-movement of gross capital inflows (Fratzscher, 2012; Forster et al., 2014; Shirota, 2015; Cerutti et al., 2015), of inflation (Neely and Rapach, 2011; Forster and Tillmann, 2014) and of commodity prices (Yin and Han, 2015; Delle Chaie et al., 2018). To the best of our knowledge, this methodology has not yet been used for exchange rates. The contribution of this article is to test another methodology in order to investigate the potential regional component of exchange rates' movements for Asian currencies.

### 3. Econometric methodology and data

#### 3.1 A dynamic latent factor model for exchange rates

In this paper, we apply the dynamic latent factor model proposed by Kose *et al.* (2003) to tackle the issue of co-movements of exchange rates in emerging economies. It is a three level model allowing us to decompose the dynamics of exchange rates in our data into three different categories: world, regional and country components.

Let us suppose that  $e_{i,t}$ , is the demeaned logarithm of the bilateral exchange rate of country  $i$  ( $i = 1, \dots, N$ ) vis-à-vis the New Zealand dollar. This bilateral exchange rate responds to different driving forces. Indeed, a first dynamic factor ( $f_t^{world}$ ) is common to all countries we consider in our analysis ( $N = 24$ ). Then, countries are grouped into

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<sup>3</sup>Alongside this topic, one can scarcely find a gravity model to investigate the determinants of the geographical (and regional) distribution of international currencies in global financial market transactions and FX transactions (He et al., 2015). Moreover, Garcia-Herrero and Xia (2013) and Eichengreen and Lombardi (2015) investigate the determinants of the bilateral financial swaps of China with a gravity model. Their results differ about the regional preference of China.

R regions ( $R = 3$ ), and all countries in each of the R specific regions share a common factor ( $f_{rt}^{region}$ ), representing the regional common factor. Finally, purely national influences on exchange rate are captured by  $\epsilon_{i,t}$ , which represents the country-specific or idiosyncratic component. The model can be expressed as:

$$e_{i,t} = \beta_i^{world} f_t^{world} + \beta_i^{region} f_{r,t}^{region} + \epsilon_{i,t} \quad (1)$$

where  $\beta_i^{world}$  and  $\beta_i^{region}$  are factor loadings, which captures the impact of an individual country's exchange rate on changes in world and regional factors, respectively. As in Kose *et al.* (2003) and Neely and Rapach (2011), we assume that the evolution of each factor follows an AR(p) process:

$$f_t^{world} = \rho_1^{world} f_{t-1}^{world} + \dots + \rho_p^{world} f_{t-p}^{world} + u_t^{world} \quad (2)$$

$$f_{r,t}^{region} = \rho_{r,1}^{region} f_{r,t-1}^{region} + \dots + \rho_{r,p}^{region} f_{r,t-p}^{region} + u_{r,t}^{region} \quad (r = 1, \dots, R) \quad (3)$$

where:

$$\begin{aligned} u_t^{world} &\sim \mathcal{N}(0, \sigma_{world}^2) \\ u_{r,t}^{region} &\sim \mathcal{N}(0, \sigma_{r,region}^2) \\ E(u_t^{world} u_{t-k}^{world}) &= E(u_{r,t}^{region} u_{r,t-k}^{region}) = 0 \text{ for } k \neq 0 \end{aligned}$$

The idiosyncratic errors (e.g. the country-specific factors) are assumed to be normally distributed and to follow an AR(q) process:

$$\epsilon_{i,t} = \rho_{i,1} \epsilon_{i,t-1} + \dots + \rho_{i,q} \epsilon_{i,t-q} + u_{i,t} \quad (4)$$

Where  $u_t \sim \mathcal{N}(0, \sigma^2)$  and  $E(u_{i,t} u_{i,t-k}) = 0$  for  $k \neq 0$ . Notice that, as in Neely and Rapach (2011) and Yin and Han (2015), we assume that all factors are orthogonal and set the orders of the AR processes, p and q, to 2.<sup>4</sup>

As in the seminal paper of Kose *et al.* (2003), we rely on the following conjugate prior to implementing Bayesian analysis:

$$(\beta_i^{world}, \beta_i^{region})' \sim \mathcal{N}(0, I_2), \quad (i = 1, 2, \dots, N) \quad (5)$$

$$(\rho_{i,1}, \dots, \rho_{i,q})' \sim \mathcal{N}[0, \text{diag}(1, 0.5, \dots, 0.5^{q-1})], \quad (i = 1, 2, \dots, N) \quad (6)$$

$$(\rho_1^{world}, \dots, \rho_p^{world})' \sim \mathcal{N}[0, \text{diag}(1, 0.5, \dots, 0.5^{p-1})], \quad (i = 1, 2, \dots, N) \quad (7)$$

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<sup>4</sup>We test other values for p and q and find very similar results.



$$\left(\rho_{r,1}^{region}, \dots, \rho_{r,p}^{region}\right)' \sim \mathcal{N}\left[0, \text{diag}\left(1, 0.5, \dots, 0.5^{p-1}\right)\right], \quad (r = 1, \dots, R) \quad (8)$$

$$\sigma_i^2 \sim IG(6, 0.001), \quad (i = 1, 2, \dots, N) \quad (9)$$

where  $IG()$  denotes the inverse-gamma distribution. Note that the prior for the idiosyncratic shock is fairly diffuse and that the AR processes in equations (2), (3) and (4) are assumed to be stationary (Neely and Rapach, 2011). As a consequence, we use the first difference of exchange rates rather than the level, as all bilateral exchange rates in our sample are  $I(1)$  processes<sup>5</sup>.

Finally, this method also allows us to measure the extent of regional influences on countries' exchange rates expressed in New Zealand dollar by computing the regional factor's contribution to the total variability in a country's exchange rate:

$$\theta_i^{region} = \left(\beta_i^{region}\right)^2 \frac{\text{var}\left(f_{r,t}^{region}\right)}{\text{var}(e_{i,t})} \quad (10)$$

Where:

$$\text{var}(e_{i,t}) = (\beta_i^{world})^2 \text{var}(f_t^{world}) + (\beta_i^{region})^2 \text{var}(f_{r,t}^{region}) + \text{var}(\epsilon_{i,t}), \quad (i = 1, \dots, N) \quad (11)$$

$\theta_i^{region}$  is the proportion of the total variability in country  $i$ 's exchange rate which comes from the regional factor. The same variance decomposition can be drawn for the world factor. Note that to estimate the model, a Markov Chain Monte Carlo (MCMC) method is applied and that the results of this study are based on a chain of length 10000 with 1000 burn-in replications.<sup>6</sup>

## 3.2 Investigating short and long-run relationships

### 3.2.1 Short-run analysis

In this paper, we aim to investigate the driving forces behind the regional factor in Asia. More particularly, we want to evaluate whether this factor is connected with the growing influence of the RMB in Asia.

For this purpose, we, first, develop a VAR model. The equation of the VAR is expressed as follows:

$$\begin{bmatrix} F_t \\ X_t \end{bmatrix} = B(L) \begin{bmatrix} F_t \\ X_t \end{bmatrix} + u_t \quad (12)$$

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<sup>5</sup>We use both ADF and KPSS tests to evaluate the stationarity of our exchange rate series.

<sup>6</sup>We use the MATLAB code provided by Dave Rapach (<http://sites.slu.edu/rapachde/home/research>), which is based on the GAUSS code from Christoph Otrok.

where  $F_t$  represents the Asian regional factor identified using the dynamic latent factor model, the matrix  $X_t$  contains the determinants retained in our analysis,  $B(L)$  is the lag polynomial and  $u_t$  represents the error term. In this paper, we retain several key drivers of exchange rate dynamics in Asian economies.

Some retained variables are Chinese to precisely measure the influence of China : exchange rate, production and economic sentiment. It seems relevant to test trade variables to take into account the potential effects of the openness of China during the 2000's. Owing to the data frequency, we test the export-to-import ratio of China as a trade measure. We also use Asian drivers to capture a more regional effect (market return), and external ones, such as U.S. monetary policy and global stress. Using Chinese exchange rate is a way to test the liberalization process since 2005 and the existence of a *de facto* monetary zone in Asia. As Shu et al. (2015) and Liang et al. (2019) assert, one of the important events of the RMB liberalization is also the launch of the offshore exchange rate (CNH) in Hong Kong in September 2010, following by reforms in the two RMB markets. Consequently, we test both the influence of the Chinese onshore rate and of the offshore rate.

- The bilateral exchange rate of the Chinese RMB (Onshore), expressed in New Zealand dollars (or the real effective exchange rate of China);
- The offshore bilateral exchange rate of the Chinese RMB, expressed in New Zealand dollars<sup>7</sup>;
- The Chinese Industrial Production Index (IPI);
- The Macroeconomic Climate Index of China;
- A trade variable reflected by the export-to-import ratio of China;
- The Barclays Emerging Markets Asia Statistics Index (in U.S. dollar);
- The U.S. FED funds shadow rate (in %)<sup>8</sup>;
- The volatility index of the U.S. market (VIX).

Note that in all VAR models estimated, we control for the reform of central parity formation mechanism launched in China in 2015, the first of a series of reforms (Liang et al. (2019)), by adding a dummy variable that takes the value one from August 2015 to December 2015 and zero otherwise.

In this paper, we implement the Generalized Impulse Response functions (GIRF) developed by Koop *et al.* (1996) and Pesaran and Shin (1998) rather than the Cholesky

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<sup>7</sup>Data start in October 2010.

<sup>8</sup>We prefer the shadow rate to the effective rate, as the latter is set to 0 between 2009 and 2015. Tests with the effective rate show a weaker impact.

impulse responses because GIRF are not affected by the ordering of variables in the VAR, and therefore, are not subject to the orthogonality critique of the Cholesky decomposition. Note that we also use the Local Projection (LP) method proposed by Jordà (2005, 2009) to compute IRFs as a robustness check. Indeed, local IRF has the advantage of being robust to the misspecification representation of the data generating process (DGP). In this case, the DGP is not represented by a VAR, but LP consists of a set of predictive regressions that explained the variables on a structural shock for different predictions horizons. This method does not impose any underlying dynamics on the variables in the system, contrary to VAR models.

### 3.2.2 ARDL models and long-run analysis

In this study, we employ the Autoregressive Distributed Lag (ARDL) bounds testing procedure developed by Pesaran and Shin (1999) and Pesaran *et al.* (2001). This method has important advantages compared to standard cointegration tests. First, the method can be applied to a set of regressors that are a mixture of I(0) and I(1) variables (Pesaran *et al.*, 2001). Second, the method is robust in the case of small samples whereas other methods suffer from size distortion and low power in this case (Cheung and Lai, 1993). Third, the bound testing approach developed by Pesaran *et al.* (2001) provides unbiased long-run estimates and valid t-statistics even if one or more regressors are endogeneous (Narayan, 2005).

The bound testing approach is based on the estimation of the following conditional error correction model:

$$\Delta F_t = \alpha + \beta F_{t-1} + \sum_{i=1}^p \gamma_i \Delta F_{t-i} + \phi X_{t-1} + \sum_{j=1}^{m_k} \psi_j \Delta X_{k,t-j} + \epsilon_t \quad (13)$$

where  $F_t$  is the regional factor in Asia in  $t$ ;  $X_t$  is the matrix of the  $k$  determinants retained in our analysis in  $t$ , and  $\epsilon_t$  is the errors of the model supposed to be modelled by a white noise. Note that the number of lags in the model is selected according to the Akaike Information Criterion (AIC).

Then, the null hypothesis of no cointegration relationship between retained variables is tested based on an F-test:

$$H_0 : \beta = \phi = 0 \quad (14)$$

It is important to note that two sets of critical value are computed by Pesaran *et al.* (2001) for this test. One set if all variables in the ARDL model are supposed to be I(0) and one set if all variables in the ARDL model are supposed to be I(1). Therefore, this test provides critical value bounds for all regressors. If the F-statistic is higher than the upper bound, the null hypothesis can be rejected and there exists a long-run relationships between all the variables. If the F-statistic is lower than the lower bound, the null hypothesis cannot be rejected and there is no long-run relationship between all the

variables. Finally, if the F-statistic falls between the two bounds, the test is inconclusive and it is necessary to implement unit root tests. Note that ARDL models suppose only one cointegrating vector.

### 3.3 Data

Monthly data on exchange rates from January 2000 to December 2015 are taken from the Datastream database except those for Estonia, Latvia, Lithuania, Slovakia and Slovenia which come from Eurostat. These local currencies have been measured against the Euro after its adoption. The offshore exchange rate CNH from October 2010 to December 2015 also comes from Datastream. All exchange rates are finally expressed in New Zealand dollars following Kawai and Pontines (2014, 2016).

The analysis covers 24 countries from three different emerging areas: India, Indonesia, Malaysia, the Philippines, South Korea, Thailand, and Vietnam<sup>9</sup> (Asian economies); Argentina, Brazil, Bolivia, Chile, Colombia, Mexico, Peru, and Venezuela (Latin American economies); Poland, Romania, Hungary, the Czech Republic, Estonia, Latvia, Lithuania, Slovakia, and Slovenia (Eastern European economies)<sup>10</sup>.

We also rely on the Bank for International Settlements (BIS) database for the construction of monthly real effective exchange rates indices (broad index, basis 100 in 2010), and on Bloomberg for The Barclays Emerging Markets Asia Statistics Index. The other variables come from Datastream.

Table 1 gives summary statistics for the variation of the exchange rates relative to the New Zealand dollar for all countries considered in our analysis. We can remark that the Latin American area has experienced the highest average volatility of exchange rates during the studied period, with the strongest values for variations recorded for Argentina and Venezuela.

## 4. Results

### 4.1 Identifying world, regional and idiosyncratic factors

In Figure 1, we present the mean of the posterior distribution of the world factor and the regional factors (Asia, Latin America and Eastern Europe).

First, it is important to note that, in the dynamic factor model, world and regional factors are orthogonal. As a consequence, the results of the world factor do not depend on the regional grouping. The global factor extracted from the dynamic latent factor

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<sup>9</sup>We exclude China from the sample because the objective is to measure the potential dominant role of the RMB on other exchange rates in Asia.

<sup>10</sup>Table A.1 in the Appendix summarizes all countries covered by our study.

Table 1: Descriptive statistics for country exchange rates' variation (in New Zealand dollar, 2000-2015)

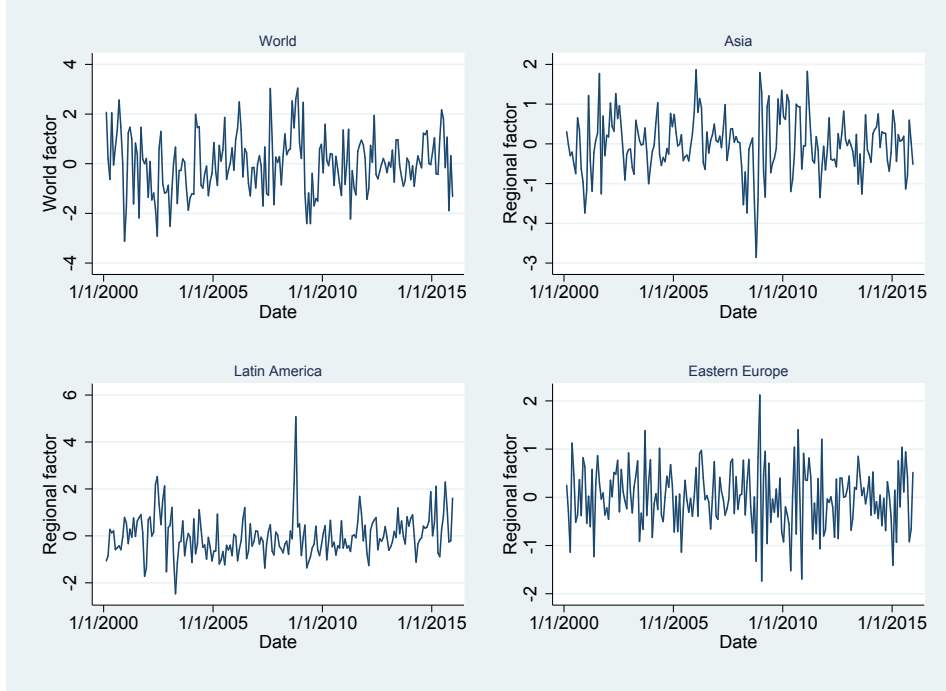
|  | Mean   | Std. Dev. | Minimum | Maximum |
|--|--------|-----------|---------|---------|
| <i>Panel A. Asian economies</i>            |        |           |         |         |
| India                                      | -0,004 | 0,028     | -0,071  | 0,075   |
| Indonesia                                  | -0,005 | 0,033     | -0,096  | 0,141   |
| Korea                                      | -0,002 | 0,027     | -0,123  | 0,061   |
| Malaysia                                   | -0,002 | 0,027     | -0,072  | 0,071   |
| Philippines                                | -0,002 | 0,029     | -0,075  | 0,075   |
| Thailand                                   | -0,001 | 0,027     | -0,067  | 0,091   |
| Vietnam                                    | -0,004 | 0,032     | -0,076  | 0,094   |
| <i>Panel B. Latin American economies</i>   |        |           |         |         |
| Argentina                                  | -0,014 | 0,056     | -0,359  | 0,068   |
| Brazil                                     | -0,005 | 0,038     | -0,153  | 0,107   |
| Bolivia                                    | -0,002 | 0,032     | -0,078  | 0,097   |
| Chile                                      | -0,003 | 0,030     | -0,092  | 0,099   |
| Colombia                                   | -0,004 | 0,031     | -0,110  | 0,079   |
| Mexico                                     | -0,004 | 0,030     | -0,096  | 0,076   |
| Peru                                       | -0,001 | 0,028     | -0,073  | 0,077   |
| Venezuela                                  | -0,013 | 0,064     | -0,526  | 0,095   |
| <i>Panel C. Eastern European economies</i> |        |           |         |         |
| Poland                                     | -0,001 | 0,029     | -0,092  | 0,059   |
| Romania                                    | -0,006 | 0,030     | -0,091  | 0,074   |
| Hungary                                    | -0,002 | 0,029     | -0,088  | 0,071   |
| Czech Republic                             | 0,000  | 0,029     | -0,062  | 0,085   |
| Estonia                                    | -0,001 | 0,034     | -0,094  | 0,104   |
| Latvia                                     | -0,002 | 0,035     | -0,094  | 0,105   |
| Lithuania                                  | 0,000  | 0,036     | -0,094  | 0,121   |
| Slovakia                                   | 0,001  | 0,035     | -0,094  | 0,110   |
| Slovenia                                   | -0,002 | 0,034     | -0,094  | 0,104   |

model reflects the movement of exchange rates since 2000. We can notice a strong decline after the 2007/2008 financial crisis.

While the world factor is common to all regions studied, we can observe strong discrepancies among regional factors. Indeed, we see that the regional factor for Latin America has exhibited a stronger increase during the financial crisis. Therefore, the pattern of exchange rates' co-movements changes substantially during severe global crises.

To have a better representation of the relative importance of global and regional factors in the evolution of exchange rates, we present, in Table 2, the decomposition of the variance of the changes in exchange rates over different periods of time.

Figure 1: World and regional factors, 2000-2015



*Note: The solid lines represent the mean for the posterior distributions for the world and regional factors.*

The results for the whole period (2000-2015) reveal that the common global factor is by far the most important determinant of exchange rates' variations for Asian economies (70%) and, albeit to a lesser extent, for Latin American economies (53%). For Eastern European economies, the regional factor is responsible for most of the overall variation of exchange rates during the period of 2000-2015 (41.7%). Note that, for all regions, the idiosyncratic factor plays an important role in explaining exchange rate variations (between 25% and 37% of overall variation).

If we decompose the whole period into two sub-periods, the first one from 2000 to 2005 and the second one from 2006 to 2015, the results are very different, especially concerning the regional factor<sup>11</sup>. We choose 2005 as breakpoint because it represents the beginning of the internationalization of the RMB with a more flexible management of the exchange rate regime. The results of the first sub-period confirm the predominance of the global common factor as the main explanation of exchange rates' movements (37% to 73%), especially for Asian economies (73%). However, the results exhibit strong discrepancies after 2005, even if the global factor remains the most important when studying the whole sample (43.4%) despite a decrease. Indeed, we find a strong increase (+703%)

<sup>11</sup>The same is true if the breakpoint is 2007, the beginning of the subprime crisis.

Table 2: Variance decomposition

|  | 2000-2015    |              |              | 2000-2005    |              |              | 2006-2015    |              |              |
|--|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
|  | World        | Reg.         | Idios.       | World        | Reg.         | Idios.       | World        | Reg.         | Idios.       |
| <i>Panel A. Asian economies</i>            |              |              |              |              |              |              |              |              |              |
| India                                      | 0,762        | 0,037        | 0,202        | 0,924        | 0,003        | 0,074        | 0,266        | 0,456        | 0,278        |
| Indonesia                                  | 0,266        | 0,092        | 0,641        | 0,104        | 0,151        | 0,745        | 0,172        | 0,325        | 0,503        |
| Korea                                      | 0,529        | 0,115        | 0,355        | 0,694        | 0,093        | 0,213        | 0,263        | 0,206        | 0,530        |
| Malaysia                                   | 0,862        | 0,008        | 0,129        | 0,971        | 0,001        | 0,029        | 0,317        | 0,501        | 0,183        |
| Philippines                                | 0,811        | 0,029        | 0,160        | 0,751        | 0,069        | 0,180        | 0,267        | 0,605        | 0,128        |
| Thailand                                   | 0,824        | 0,009        | 0,167        | 0,782        | 0,074        | 0,145        | 0,301        | 0,576        | 0,124        |
| Vietnam                                    | 0,867        | 0,016        | 0,117        | 0,893        | 0,003        | 0,104        | 0,283        | 0,489        | 0,229        |
| <i>Panel B. Latin American economies</i>   |              |              |              |              |              |              |              |              |              |
| Argentina                                  | 0,408        | 0,022        | 0,570        | 0,257        | 0,049        | 0,694        | 0,206        | 0,541        | 0,253        |
| Brazil                                     | 0,235        | 0,390        | 0,375        | 0,313        | 0,360        | 0,327        | 0,103        | 0,070        | 0,827        |
| Bolivia                                    | 0,932        | 0,013        | 0,055        | 0,971        | 0,001        | 0,028        | 0,313        | 0,565        | 0,122        |
| Chile                                      | 0,474        | 0,135        | 0,392        | 0,513        | 0,209        | 0,279        | 0,209        | 0,230        | 0,560        |
| Colombia                                   | 0,350        | 0,168        | 0,482        | 0,698        | 0,097        | 0,205        | 0,092        | 0,098        | 0,810        |
| Mexico                                     | 0,581        | 0,097        | 0,322        | 0,780        | 0,019        | 0,201        | 0,189        | 0,271        | 0,540        |
| Peru                                       | 0,896        | 0,001        | 0,103        | 0,933        | 0,002        | 0,065        | 0,324        | 0,540        | 0,136        |
| Venezuela                                  | 0,335        | 0,003        | 0,663        | 0,403        | 0,125        | 0,472        | 0,107        | 0,171        | 0,722        |
| <i>Panel C. Eastern European economies</i> |              |              |              |              |              |              |              |              |              |
| Poland                                     | 0,201        | 0,124        | 0,675        | 0,364        | 0,009        | 0,627        | 0,459        | 0,335        | 0,205        |
| Romania                                    | 0,414        | 0,131        | 0,455        | 0,540        | 0,020        | 0,440        | 0,617        | 0,142        | 0,241        |
| Hungary                                    | 0,162        | 0,221        | 0,618        | 0,302        | 0,111        | 0,587        | 0,484        | 0,287        | 0,229        |
| Czech Republic                             | 0,239        | 0,206        | 0,555        | 0,239        | 0,079        | 0,682        | 0,600        | 0,209        | 0,191        |
| Estonia                                    | 0,321        | 0,666        | 0,013        | 0,293        | 0,679        | 0,028        | 0,973        | 0,008        | 0,018        |
| Latvia                                     | 0,421        | 0,538        | 0,041        | 0,551        | 0,376        | 0,073        | 0,967        | 0,009        | 0,024        |
| Lithuania                                  | 0,383        | 0,564        | 0,053        | 0,463        | 0,421        | 0,116        | 0,973        | 0,008        | 0,018        |
| Slovakia                                   | 0,291        | 0,649        | 0,059        | 0,287        | 0,599        | 0,114        | 0,953        | 0,004        | 0,043        |
| Slovenia                                   | 0,328        | 0,658        | 0,014        | 0,299        | 0,670        | 0,031        | 0,973        | 0,008        | 0,018        |
| <b>Asia</b>                                | <b>0,703</b> | <b>0,044</b> | <b>0,253</b> | <b>0,731</b> | <b>0,056</b> | <b>0,213</b> | <b>0,267</b> | <b>0,451</b> | <b>0,282</b> |
| Latin America                              | 0,526        | 0,103        | 0,370        | 0,608        | 0,108        | 0,284        | 0,193        | 0,311        | 0,496        |
| Eastern Europe                             | 0,307        | 0,417        | 0,276        | 0,371        | 0,329        | 0,300        | 0,778        | 0,112        | 0,110        |
| All  | 0,496        | 0,204        | 0,301        | 0,555        | 0,176        | 0,269        | 0,434        | 0,277        | 0,289        |

in the explanatory power of the regional factor in Asia. Between 2006 and 2015, the regional factor accounts for more than 45.1% of the variation in exchange rates in Asian economies, whereas this factor only explains 5.6% of the variation between 2000 and 2005. This result provides evidence of the increasing influence of the regional factor in Asia on the evolution of exchange rates to the detriment of the common global factor. We assess that the increasing impact of the regional factor could be linked to the in-

ternationalization of the RMB since 2005. The Chinese currency can now be seen as one of the main drivers of other Asian currencies. For the Latin American economies, the influence of the regional factor has increased by 188%, but the idiosyncratic factor has the highest explanatory power (49.6%). For both of these regions, the influence of the world factor has decreased by approximately 66%. In contrast, the influence of the world factor has increased in Eastern European economies by 110%, from 37% to 77.8%, which can mainly be explained by European integration and the adoption of the Euro in a floating exchange rate regime by almost all Eastern European economies in our sample. Moreover, as currencies are measured against the Euro, an international currency, it makes sense that the world factor is determinant, notably over the recent period because there are no more fluctuation bands.

The growing influence of the regional factor in Asia is confirmed in Figure 2, where we decompose the sample into three different sub-samples. We split the period of 2006-2015 into two sub-samples to question the impact of the introduction in 2010 of the offshore rate on other Asian currencies. The decomposition confirms the explanatory power of the regional factor for Asia. Indeed, it remains the dominant factor for the two sub-periods (47.2% (2006-2010), 49.7% (2011-2015)), with an increase by 5.2% between the two sub-periods. At the same time, the world factor decreases by 26.5% from 27% to 19.8%.

More precisely, we can remark that, after 2010, the effect of the regional factor has increased in Asian economies. The highest values recorded are for the Philippines (67%), Thailand (64%), and Indonesia (51%). The global common factor (i.e., the factor potentially affecting all countries whatever the region retained), has, after 2010, a very small impact on exchange rates' variations in Asia (less than 23% in each Asian economy). Therefore, in almost two decades in Asia, the global common factor has lost importance in explaining exchange rates' variations, whereas the regional factor has gained importance. The regional factor is, after 2006 and notably after 2010, the most important factor explaining exchange rates' movements in almost all countries in Asia. Our results are in line with the existing literature, notably Huang et al. (2014) for the increasing role of regional integration and the regional role of the RMB after 2005, Figuière *et al.* (2013), Chow-Tan (2014), Shu et al. (2016) and Ito (2017) for its growing influence after 2007, and Shu et al. (2015) for the important impact after 2010. The liberalization of the Chinese exchange rate regime after 2005 and 2010 allowed Asian central banks to give more weight to the RMB in the management of their exchange rates. Following the subprime crisis, Asian economies wanted to be less dependent on the U.S. dollar's fluctuations and concentrate on their economic region.

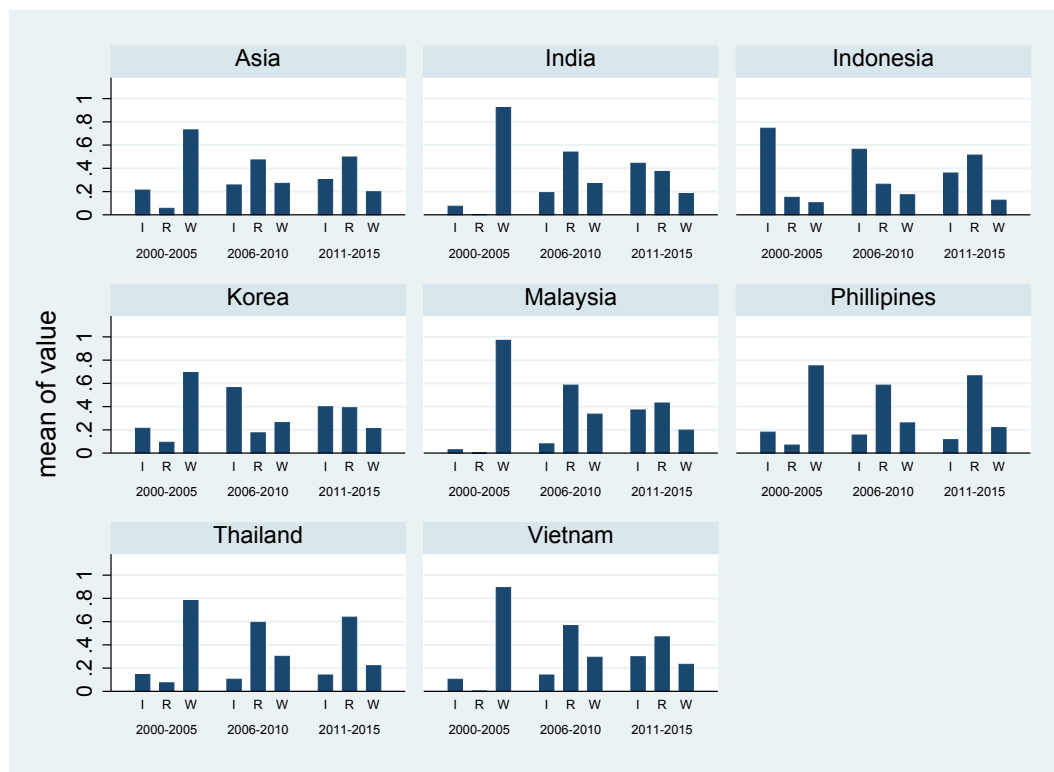
As a robustness check, we have applied the same methodology to real effective exchange rates<sup>12</sup> rather than nominal bilateral exchange rates. In this case, Vietnam and Bolivia are excluded from the analysis due to a lack of data. As depicted in Table A.2 and Figure A.1 in the Appendix, the analysis of real effective exchange rates seems to

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<sup>12</sup>Data come from the BIS database.



Figure 2: Variance decompositions for country exchange rate variations, 2000-2005, 2006-2010, 2011-2015 sub-samples, Asian economies



Note: I, R, W represents respectively the idiosyncratic factor, the regional factor and the world factor.

corroborate our previous results about the regional factor in Asia. Indeed, we can observe an increase of the effect of the regional factor in Asia after 2005, from 11.3% to 24.7% (+118%), even if the idiosyncratic factor remains the most important one for the four groups of countries during the three periods. This illustrates the construction of the real effective exchange rate based on bilateral time-varying trade weights, and on inflation differentials between trading partners. Nevertheless, this country factor has lost importance in the second sub-period for the four groups of countries. The regional factor in Latin America has less power (from 17.3% to 14.4%). At the same time, the regional factor in Asia has gained importance. The increase in the regional factor in Eastern Europe (from 11.2% to 33.7%), contrary to the results in Table 2, comes from the construction of the real effective exchange rate and from bilateral trade that has increased during this period in the European area. The explanatory power of the regional factor in Asia is confirmed in Figure A.1, when we split the period of 2006-2015 into two sub-periods (2006-2010; 2011-2015), notably for Indonesia and Thailand, even if, as previously indicated, the idiosyncratic factor remains the most important.

## 4.2 What drives the regional factor Asia?

In the previous section, our results provided evidence of the growing influence of the regional factor in Asia (factor Asia) in explaining nominal bilateral exchange rates' variations over the period of 2000-2015, and notably over the period of 2010-2015. Now, we aim to determine what are the driving forces behind the regional factor in Asia, and particularly, if this factor is connected with the growing influence of the RMB in Asia. For that purpose, we question both the role of the onshore and offshore exchange rates.

### 4.2.1 Short-run analysis

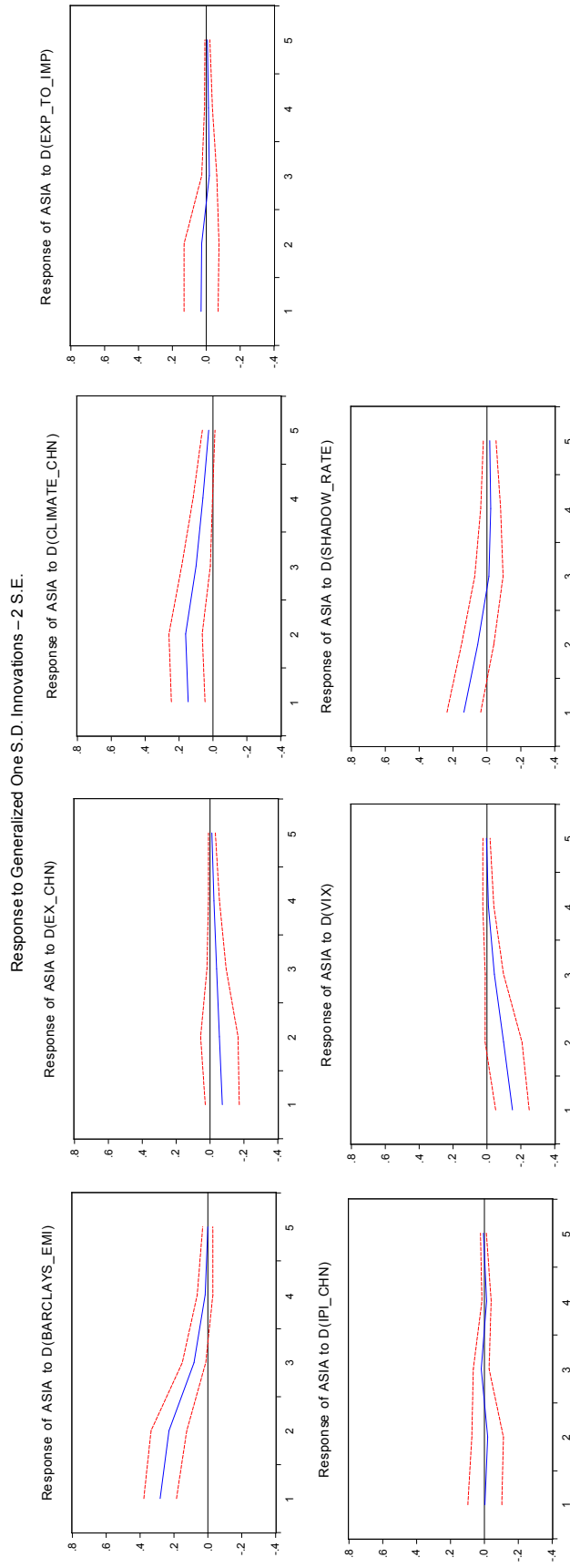
First, we test the time series properties of our different variables using the Augmented Dickey-Fuller (ADF) test. For a robustness check, we complement this test with the stationarity test developed by Kwiatkowski, Phillips, Schmidt and Shin (1992), which tests the null hypothesis of stationarity instead of the existence of a unit root, as in the ADF and PP tests. Using both kinds of tests is important because the ADF test has low power if the process is stationary but with a root close to the non-stationary boundary, and tends to reject the non-stationarity hypothesis too often. The KPSS complements the ADF test because contrary to the latter, which assesses the null hypothesis of the unit root, it tests the null hypothesis of stationarity. It is a very powerful test, but it cannot catch non-stationarity due to a volatility shift. Table A.3 in the Appendix reports the results of the unit root tests. The results confirm that the factor Asia is stationary, as we cannot reject the null hypothesis of stationarity using the KPSS test at the 10% level. All other variables are  $I(1)$ .

Figure 3 presents General Impulse Response Functions from the estimation of our VAR model<sup>13</sup> (i.e., the responses of the factor Asia to one standard deviation innovations of the explanatory variables).

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<sup>13</sup>One lag is selected according to the Aikake information criterion. Autocorrelation and heteroskedasticity tests are also implemented to check the accuracy of the estimated VAR model.

Figure 3: Determinants of the factor Asia using Generalized Impulse Response Functions (GIRF)



Note: Note: These graphs provide the response of the factor Asia (ASIA) to a generalized one standard deviation innovations in variation of bilateral onshore exchange rate of China ( $D(EX-CHN)$ ), Barclays EMI ( $D(BARCLAYS-EMI)$ ), macroeconomic climate in China ( $D(CLIMATE-CHN)$ ), VIX ( $D(VIX)$ ), the Fed shadow interest rate ( $D(SHADOW-RATE)$ ), IPI in China ( $D(IPI-CHN)$ ) and exports-to-imports ratio of China ( $D(EXP-TO-IMP)$ ). Also included are two asymptotic standard error bands (100000 Monte Carlo replications).

First, we find that a positive shock on the Barclays EMI leads to an immediate and significant increase in the factor Asia. This result illustrates the fact that an increase in the value of market securities in Asia increases capital inflows to the region and, therefore, leads to an appreciation of Asian currencies in the short run.

Second, we find that the factor Asia is influenced by Chinese economic variables. Indeed, an increase in the Chinese macroeconomic climate index, as a good signal on the region, leads to an immediate increase of the factor Asia, characterized by an appreciation of Asian currencies. However, our results show that a positive shock on the RMB (Onshore) rate (appreciation) entails a small, but not significant, decrease of the factor Asia (depreciation of Asian currencies), one month after the shock. It could have meant that an appreciation of the RMB would cause outflows from other Asian countries in the very short-term because loss of competitiveness in China may cause uncertainty over the Asian area due to the role of China in the region.

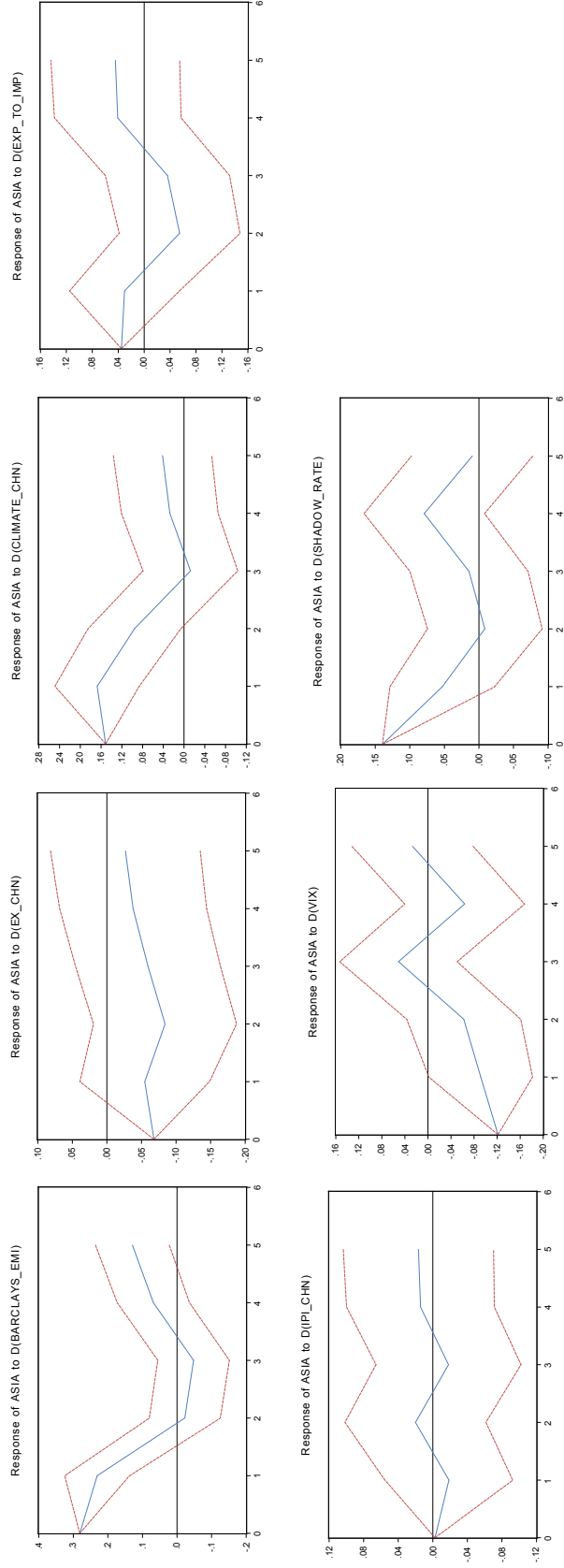
Our results also indicate that the VIX has a significant influence on the factor Asia. Indeed, an increase in risk entails an immediate decrease of the factor Asia, leading to a depreciation of Asian currencies. This result can be explained by the fact that, when the financial risk is important, investors fly to quality and, as a consequence, withdraw their short-run assets from emerging countries, which leads to a depreciation of Asian currencies. We also find that the U.S. Fed shadow rate positively influences the factor Asia. Indeed, an increase of the Fed Shadow rate leads to an immediate appreciation of Asian currencies. This result is in line with the prediction of the Uncovered Interest Parity (UIP). However, this effect only lasts one month.

Finally, it seems that the exports-to-imports ratio of China and the Industrial Production Index (IPI) of China have no significant impact on the regional factor Asia.

In a nutshell, our results highlight the influence of the macroeconomic variables of China on the factor Asia in the short run, even if the most influential driver is regional (the Barclays Asia EMI).

As a robustness check, we re-estimate the impulse-response functions relying on the Local Projection (LP) method developed by Jordá (2005, 2009). Figure 4 confirms the results from Figure 3.

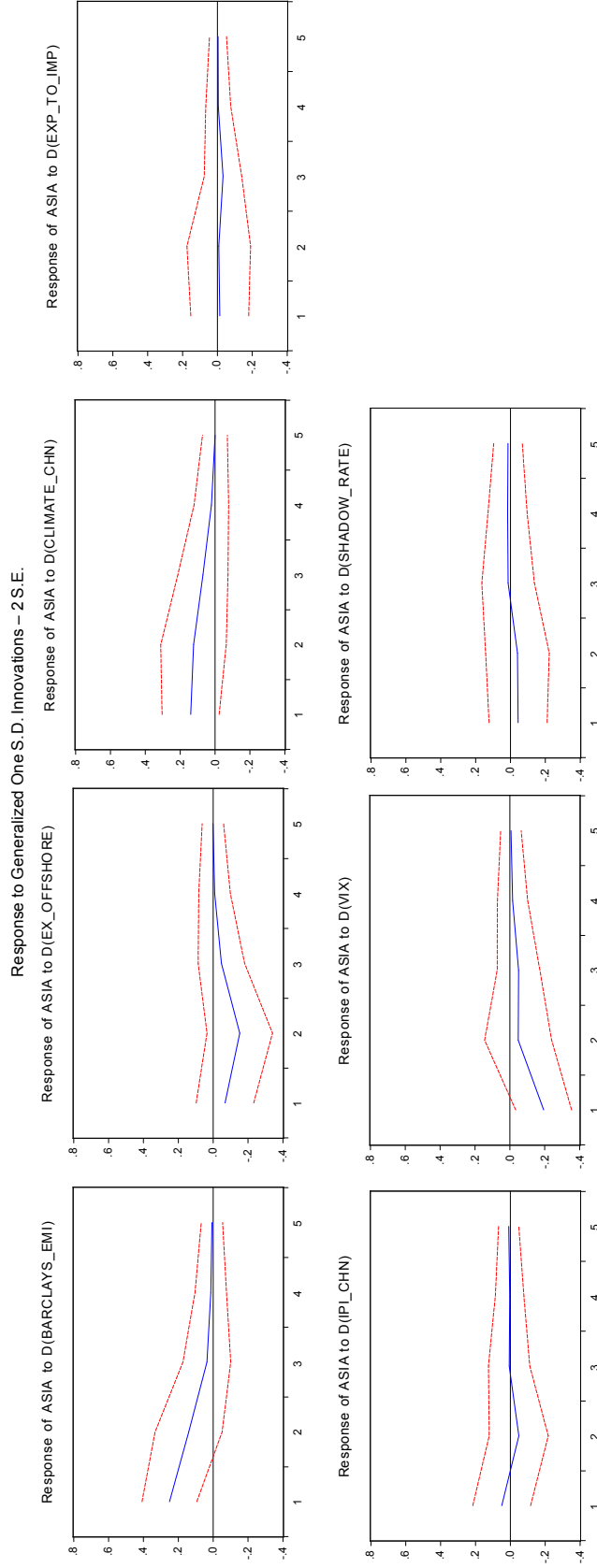
Figure 4: Determinants of the factor Asia using the Local Projection (LP) approach



Note: These graphs provide the response of the factor Asia (ASIA) to a generalized one standard deviation innovations in variation of bilateral onshore exchange rate of China ( $D(EX\_CHN)$ ), Barclays EMI ( $D(BARCLAYS\_EMI)$ ), macroeconomic climate in China ( $D(CLIMATE\_CHN)$ ), VIX ( $D(VIX)$ ), the Fed shadow interest rate ( $D(SHADOW\_RATE)$ ), IPI in China ( $D(IPL\_CHN)$ ) and exports-to-imports ratio of China ( $D(EXP\_TO\_IMP)$ ). Also included are two asymptotic standard error bands (100000 Monte Carlo replications).

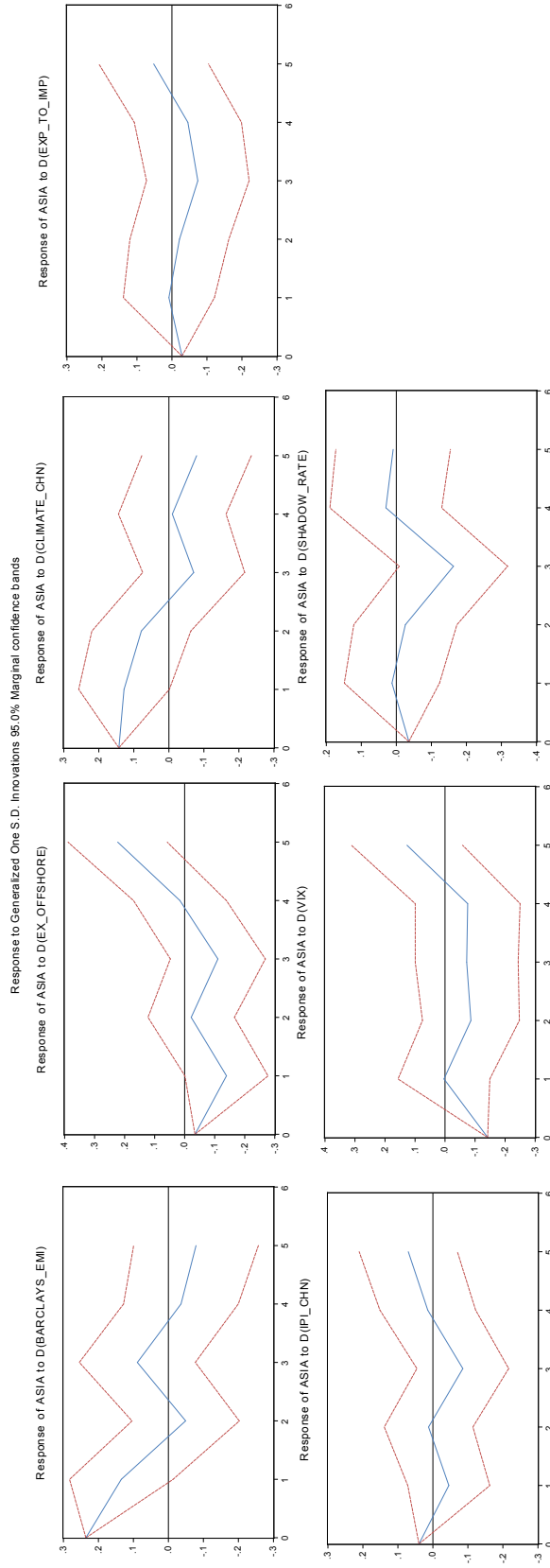
Figures 5 and 6 present the GIRFs from the estimation of the VAR model with the offshore Chinese exchange rate on the period from October 2010 to December 2015 and impulse-response functions from the LP method. Both figures confirm our previous results on the recent period. Indeed, in the short-run, the factor Asia seems to react positively to variations in the Barclays EMI Index and in the macroeconomic climate index in China, while it reacts negatively to a variation in the VIX. The offshore Chinese exchange rate seems to have a small negative impact on the factor Asia two months after the shock. Lastly, results show that, since 2010, the US shadow rate has appeared to no longer be significant when testing the impact of the Chinese offshore rate. It could mean that a more liberalized monetary environment in China protects the Asian zone against the spillover effects of the US monetary policy.

Figure 5: Determinants of the factor Asia using Generalized Impulse Response Functions (GIRF) and the offshore Chinese exchange rate



Note: Note: These graphs provide the response of the factor Asia (ASIA) to a generalized one standard deviation innovations in variation of bilateral offshore exchange rate of China ( $D(EX\_OFFSHORE)$ ), Barclays EMI ( $D(BARCLAYS\_EMI)$ ), macroeconomic climate in China ( $D(CLIMATE\_CHN)$ ), VIX ( $D(VIX)$ ), the Fed shadow interest rate ( $D(SHADOW\_RATE)$ ), IPI in China ( $D(IPI\_CHN)$ ) and exports-to-imports ratio of China ( $D(EXP\_TO\_IMP)$ ). Also included are two asymptotic standard error bands (100000 Monte Carlo replications).

Figure 6: Determinants of the factor Asia using the Local Projection (LP) approach and the offshore Chinese exchange rate



Note: These graphs provide the response of the factor Asia (ASIA) to a generalized one standard deviation innovations in variation of bilateral offshore exchange rate of China ( $D(EX\_OFFSHORE)$ ), Barclays EMI ( $D(BARCLAYS\_EMI)$ ), macroeconomic climate in China ( $D(CLIMATE\_CHN)$ ), VIX ( $D(VIX)$ ), the Fed shadow interest rate ( $D(SHADOW\_RATE)$ ), IPI in China ( $D(IPL\_CHN)$ ) and exports-to-imports ratio of China ( $D(EXP\_TO\_IMP)$ ). Also included are two asymptotic standard error bands (100000 Monte Carlo replications).



Note that, if we estimate impulse-response function including both the onshore and the offshore exchange rates, results are quite similar to Figure 3 and Figure 5 (see Figures A.2 and A.3 in Appendix).

It is important to note also that when we focus on real effective exchange rate as an explanatory variable (see Figures A.4 and A.5 in the Appendix), rather than on the nominal bilateral exchange rate of China, the results emphasize the key role of the Chinese currency on other Asian currencies in the short run, as the negative impact on the first period after the shock is significant.

#### 4.2.2 Long-run analysis

As depicted in Table A.3 in the Appendix, the regressors in our analysis are a mixture of  $I(0)$  and  $I(1)$  variables<sup>14</sup>. Furthermore, none of the variables under consideration in this analysis are integrated of an order superior to 1. As a consequence, we can implement the ARDL cointegration methodology developed by Pesaran et al. (2001) to estimate the long-run relationship between the regional factor Asia and its determinants. The Aikake criterion is used to select to optimal number of lags for the estimation of the ARDL model. Note that standard errors are corrected for heteroskedasticity using the Newey-West transformation. Note also that in all ARDL models, we include a dummy variable that takes the value one from August 2015 to December 2015 and zero otherwise to control for the reform of central parity formation mechanism that occurred in August 2015. This reform has opened the way to other reforms (Liang et al. (2019)) and to a more flexible exchange rate management.

Table 3 presents the long-run results (i.e., the cointegrating vector), and the diagnostic tests used to test the accuracy of the estimation.

Column (1) focuses on the nominal bilateral onshore exchange rate of China (EX.CHN), while column (2) provides results for the bilateral offshore exchange rate of China as an explanatory variable (EX.OFFSHORE) and column (3) displays results for the real effective exchange rate of China as explanatory variable (REER.CHN).

First, we can remark that the null hypothesis of no cointegration between the regional factor Asia and the retained determinants cannot be rejected at the 1% level for either model under scrutiny. Second, the diagnostic tests for both models confirm the accuracy of the estimation.

Finally, the results presented in Table 3 are quite relevant. They highlight three key drivers of the regional factor Asia in the long-run: the VIX, the climate index in China and the RMB exchange rate (bilateral onshore, offshore, or real effective). We find that, in the long-run, an increase of the VIX index level, suggesting a structural financial risk, entails a depreciation of Asian currencies. This goes in the same direction it does in the short-run. VIX is therefore one of the main determinants of the regional factor Asia. Furthermore, the economic situation in China, reflected by the climate index, also has a long-run positive effect on Asian currencies, as in the short-run. Finally, the RMB

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<sup>14</sup>We retain only the variables that were significant in the short-run analysis. However, we also estimate an ARDL model with these variables, but they are not significant.

Table 3: Long-run estimation results (ARDL, Newey-West bandwidth)

|                             | Onshore bilateral ex-<br>change rate | Offshore bilateral ex-<br>change rate | Real effective exchange<br>rate |
|-----------------------------|--------------------------------------|---------------------------------------|---------------------------------|
| BARCLAYS_EMI                | 0.0231<br>(0.2121)                   | 2.8401**<br>(1.2436)                  | 0.1299<br>(0.2363)              |
| VIX                         | -0.6387***<br>(0.1963)               | -0.5319**<br>(0.2178)                 | -0.4835***<br>(0.1806)          |
| CLIMATE_CHN                 | 11.6902***<br>(3.9731)               | 38.8663***<br>(7.4999)                | 12.1967**<br>(5.4252)           |
| EX_CHN                      | 1.3191***<br>(0.4738)                |                                       |                                 |
| SHADOW_RATE                 | -0.0213<br>(0.0298)                  | -0.0921<br>(0.0942)                   | 0.0026<br>(0.0283)              |
| DUMMY                       | -0.2504<br>(0.1884)                  | -0.3869*<br>(0.2046)                  | -0.4524***<br>(0.1548)          |
| EX_OFFSHORE                 |                                      | 2.7777***<br>(0.9351)                 |                                 |
| REER_CHN                    |                                      |                                       | 2.1126**<br>(0.9776)            |
| Bound test                  |                                      |                                       |                                 |
| F-test                      | 15.299                               | 5.739                                 | 15.196                          |
| I(0) critical value (5%)    | 2.39                                 | 2.39                                  | 2.39                            |
| I(1) critical value (5%)    | 3.38                                 | 3.38                                  | 3.38                            |
| Diagnostic tests            |                                      |                                       |                                 |
| Jarque-Béra                 | 5.630*                               | 5.087*                                | 2.381                           |
| LM test for autocorrelation | 1.918                                | 0.212                                 | 0.192                           |
| ARCH-LM test                | 2.471                                | 0.266                                 | 1.901                           |
| Harvey test                 | 1.307                                | 1.166                                 | 1.029                           |

Note: Number in parentheses are standard errors.

The cointegrating vector has been estimated with an intercept, not reported in this Table.

\*\*\*, \*\*, \* denotes significance at the 1%, 5% and 10% level, respectively.

The model includes only one restricted intercept.

The normality assumption of residuals is tested using the Jarque-Béra test.

The serial correlation of residuals is tested using the Lagrange Multiplier test.

The homoskedasticity assumption is tested using both the ARCH-LM and the Harvey tests.

exchange rate also influences other Asian currencies in the long-run. However, the impact is found to be positive in the long-run, contrary to the short-run analysis. An increase in the level of the nominal exchange rate of China (appreciation) leads to an increase in the regional factor Asia and, thus, to an appreciation of other Asian currencies. We find the same positive impact with an increase in the level of the offshore exchange rate

of China over the recent period of 2010-2015. This conclusion can also be drawn from the analysis of the real effective exchange rate of China. In all cases, as the magnitude of estimated coefficients is relatively high (above 0.5), this could mean, as in McCauley and Shu (2018), that there was a *de facto* RMB zone in Asia in the long-run. Note that, as the two Chinese exchange rates (onshore and offshore) are strongly correlated (0.94), we do not include both variables in the same ARDL model. Lastly, the dummy variable has a negative impact on the factor Asia when testing the offshore rate and the real effective rate, meaning a depreciation of other Asian currencies. It could mean that the more flexible management of the onshore exchange rate creates some instability and outflows that impact and weaken other Asian currencies.

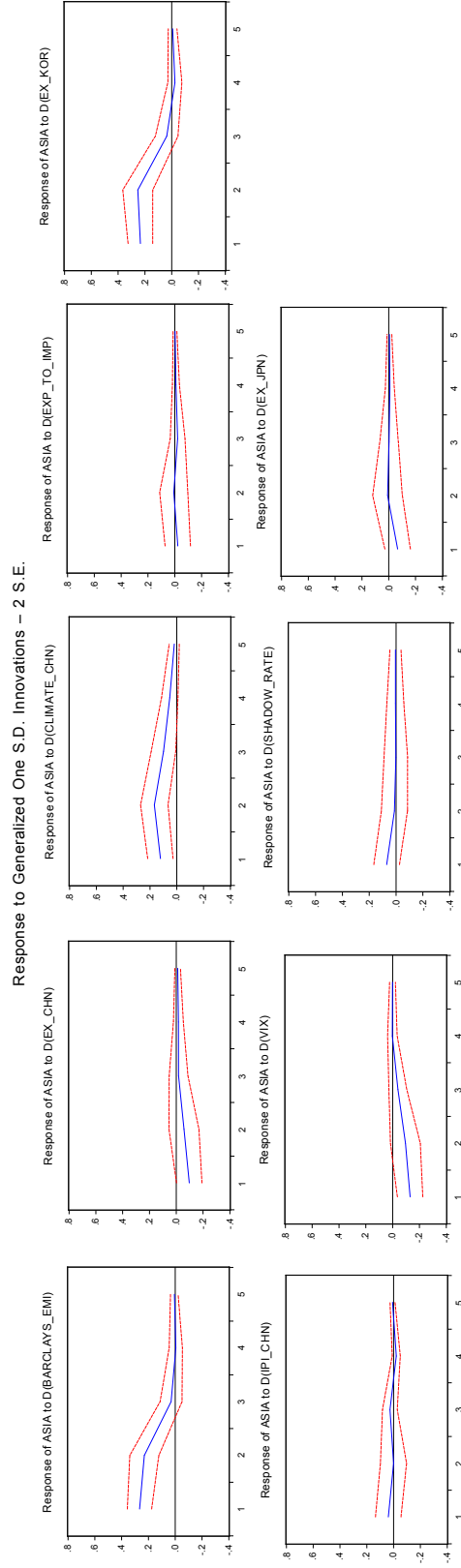
### 4.3 Robustness check

In the previous sections, we give evidence of the dominant role of the regional factor in explaining the co-movements of the Asian exchange rates. Moreover, we give support to the RMB exchange rate (onshore and offshore) as a driving force of the regional factor, especially in the long-run. In this section, we test the robustness of our results to the inclusion of two other major Asian currencies, i.e. the Japanese Yen (as in Shu et al. (2015)) and the Korean Won, in our different models used to evaluate the drivers of the regional factor Asia.

Figure 7 displays results of impulse-response functions estimation using a VAR model that includes the Japanese Yen, the Korean Won and the onshore Chinese exchange rate, while Figure 8 presents results for the offshore Chinese exchange rate.

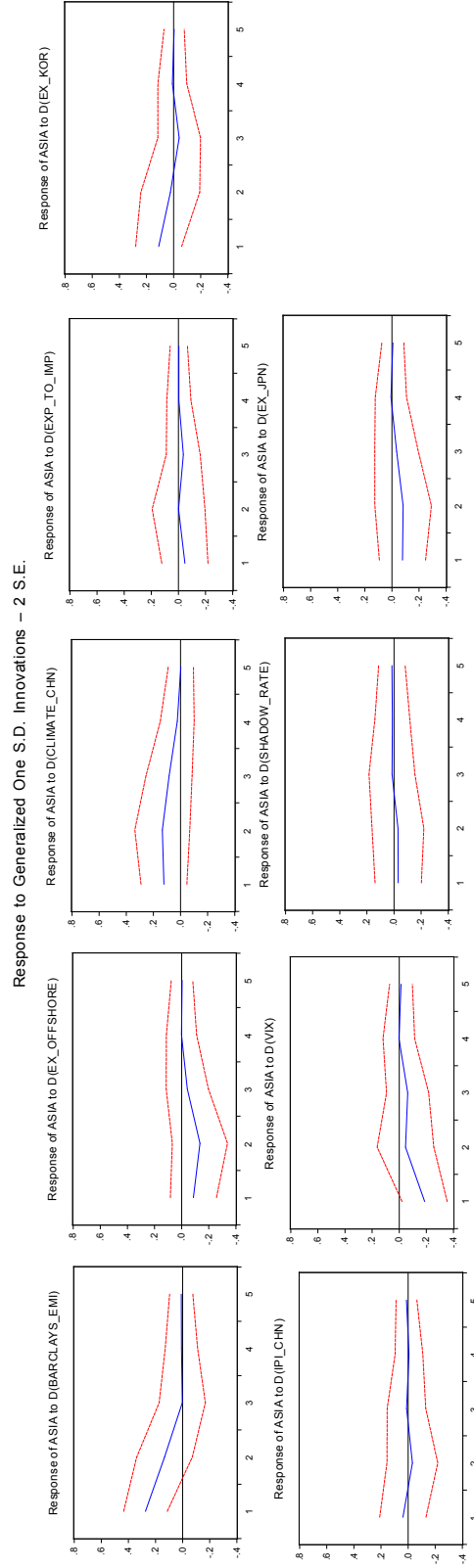
Results are very similar to those found in Figures 3 and 5. It confirms the key role lead by the VIX, the macroeconomic conditions in China and the Barclays EMI Index in influencing the factor Asia in the short-run. However, we do not find evidence of a significant impact of the Japanese Yen on the factor Asia (contrary to Shu et al. (2015) that used the Frankel and Wei equation). Nevertheless, our results point out the role of the Korean Won on the factor Asia in the short-run when focusing on the whole period (onshore rate). Indeed, a positive shock on the Korean Won entails an immediate increase in the factor Asia, that is an appreciation of the other Asian currencies. Finally, a small significant negative impact of the Chinese RMB (onshore) on the factor Asia in the short-run is found. Results relying on the LP method support these findings (see Figures A.6 and A.7 in Appendix).

Figure 7: Determinants of the factor Asia using Generalized Impulse Response Functions (GIRF) controlling for the Japanese Yen and the Korean Won



Note: These graphs provide the response of the factor Asia (ASIA) to a generalized one standard deviation innovations in variation of bilateral onshore exchange rate of China ( $D(EX\_CHN)$ ), Barclays EMI ( $D(BARCLAYS\_EMI)$ ), macroeconomic climate in China ( $D(CLIMATE\_CHN)$ ), VIX ( $D(VIX)$ ), the Fed shadow interest rate ( $D(SHADOW\_RATE)$ ), IPI in China ( $D(IPI\_CHN)$ ), exports-to-imports ratio of China ( $D(EXP\_TO\_IMP)$ ), bilateral exchange rate of the Japanese Yuan ( $D(EX\_JPN)$ ) and the bilateral exchange rate of the Korean Won ( $D(EX\_KOR)$ ). Also included are two asymptotic standard error bands (100000 Monte Carlo replications).

Figure 8: Determinants of the factor Asia using Generalized Impulse Response Functions (GIRF) and the offshore Chinese exchange rate, controlling for the Japanese Yen and the Korean Won



Note: These graphs provide the response of the factor Asia (ASIA) to a generalized one standard deviation innovations in variation of bilateral offshore exchange rate of China ( $D(\text{EX\_OFFSHORE})$ ), Barclays EMI ( $D(\text{BARCLAYS\_EMI})$ ), macroeconomic climate in China ( $D(\text{CLIMATE\_CHN})$ ), VIX ( $D(\text{VIX})$ ), the Fed shadow interest rate ( $D(\text{SHADOW\_RATE})$ ), IPI in China ( $D(\text{IPL\_CHN})$ ), exports-to-imports ratio of China ( $D(\text{EXP\_TO\_IMP})$ ), bilateral exchange rate of the Japanese Yuan ( $D(\text{EX\_JPN})$ ) and the bilateral exchange rate of the Korean Won ( $D(\text{EX\_KOR})$ ). Also included are two asymptotic standard error bands (100000 Monte Carlo replications).

Table 4 presents the long-run results obtained using ARDL models, controlling for the Japanese Yen and the Korean Won.

Table 4: Results of ARDL models controlling for Japanese Yen and Korean Won

|                             | Japanese Yen           |                       | Korean Won             |                         | Both                   |                        |
|-----------------------------|------------------------|-----------------------|------------------------|-------------------------|------------------------|------------------------|
|                             | Onshore                | Offshore              | Onshore                | Offshore                | Onshore                | Offshore               |
| Barclays EMI                | 0.1344<br>(0.2399)     | 3.1082**<br>(1.1902)  | 0.4286**<br>(0.1733)   | 3.8198***<br>(1.2551)   | 0.2683**<br>(0.1097)   | 12.0537**<br>(4.8694)  |
| VIX                         | -0.8474***<br>(0.2160) | -0.6061**<br>(0.2522) | -0.2648<br>(0.1712)    | -0.5760**<br>(0.2391)   | -0.2936***<br>(0.0594) | -0.5101<br>(0.4685)    |
| CLIMATE_CHN                 | 13.6893***<br>(4.6074) | 38.445***<br>(7.3046) | 7.5960**<br>(3.7660)   | 47.2590***<br>(14.0143) | 12.0545***<br>(1.3957) | 67.5240**<br>(30.7528) |
| EX_CHN                      | 1.3109**<br>(0.5708)   |                       | 0.8941**<br>(0.4457)   |                         | 1.5139**<br>(0.6781)   |                        |
| SHADOW_RATE                 | -0.0404<br>(0.0303)    | -0.1247<br>(0.1115)   | -0.0024<br>(0.0306)    | -0.2605*<br>(0.1324)    | -0.0039<br>(0.0377)    | -0.8336*<br>(0.4559)   |
| DUMMY                       | -0.1666<br>(0.2289)    | -0.3496<br>(0.2164)   | -0.5835***<br>(0.0830) | -0.5863***<br>(0.1422)  | -0.4747***<br>(0.1183) | -1.4860***<br>(0.4476) |
| EX_JPN                      | -0.0115<br>(0.5052)    | 0.4014<br>(0.5713)    |                        |                         | -0.4977<br>(0.3756)    | 3.1770<br>(2.0905)     |
| EX_KOR                      |                        |                       | 0.5495<br>(0.7651)     | -2.2764<br>(2.3369)     | 0.0895<br>(0.8540)     | -7.1385<br>(5.4260)    |
| EX_OFFSHORE                 |                        | 2.7901***<br>(0.9524) |                        | 6.1350**<br>(2.3147)    |                        | 15.5330**<br>(7.1880)  |
| Bound test                  |                        |                       |                        |                         |                        |                        |
| F-test                      | 18.305                 | 6.911                 | 24.442                 | 5.367                   | 19.668                 | 7.526                  |
| I(0) critical value         | 2.39                   | 2.39                  | 2.39                   | 2.39                    | 2.39                   | 2.39                   |
| I(1) critical value         | 3.38                   | 3.38                  | 3.38                   | 3.38                    | 3.38                   | 3.38                   |
| Diagnostic tests            |                        |                       |                        |                         |                        |                        |
| Jarque-Béra                 | 6,097**                | 5,115*                | 12,892***              | 0,344                   | 20,927***              | 0,394                  |
| LM test for autocorrelation | 0,44                   | 0.119                 | 0.001                  | 1.277                   | 0.969                  | 1.112                  |
| ARCH-LM test                | 1,622                  | 0.315                 | 1.857                  | 0.042                   | 1.708                  | 0.374                  |
| Harvey test                 | 2,327***               | 0.863                 | 1.393                  | 0.770                   | 1.242                  | 1.522                  |

Note: Number in parentheses are standard errors.

The cointegrating vector has been estimated with an intercept, not reported in this Table.

\*\*\*, \*\*, \* denotes significance at the 1%, 5% and 10% level, respectively.

The model includes only one restricted intercept.

The normality assumption of residuals is tested using the Jarque-Béra test.

The serial correlation of residuals is tested using the Lagrange Multiplier test.

The homoskedasticity assumption is tested using both the ARCH-LM and the Harvey tests.

Columns (1), (3) and (5) of Table 4 focus on the onshore bilateral exchange rate of China, while columns (2), (4) and (6) provides results for the offshore bilateral exchange rate of China. Furthermore, in columns (1) and (2), we control for the inclusion of the Japanese Yen only, in columns (3) and (4), we control for the inclusion of the Korean Won only and in columns (5) and (6), we control for both the Japanese Yen and the Korean Won. We find that our results are quite robust to the inclusion of other Asian currencies. Indeed, in all regressions, the coefficient associated to the Chinese currency (onshore or

offshore) is significant and positive at the 5 % level, while coefficients associated with the Japanese Yen and the Korean Won seem to be not significant, whatever the regressions. Furthermore, if we focus on the period from October 2010 to December 2015, we find that the coefficient associated with the offshore exchange rate is higher than the one estimated on the whole period for the onshore exchange rate. It, therefore, reveals that the Chinese RMB beats other major Asian currencies in driving the regional factor in Asia in the long-run and that this effect has been reinforced by the introduction of the offshore exchange rate in September 2010.

## 5. Conclusion

The objective of this article is to analyse the determinants of emerging markets' exchange rate movements. To shed light on this issue, we implement the dynamic latent factor model to investigate the determinants of 24 emerging countries' exchange rate movements and decompose the patterns into the contribution of a global factor, a regional factor and a country-specific factor. The results are quite interesting for Asia, notably in the long run, in four ways.

First, we show that the exchange rate movements in Asia are mostly explained by the regional factor in the recent period of 2006-2015. The explicative power of this factor has increased by 703% and it is the dominant factor after 2005. After the 2010 launch of the offshore CNH rate, it remains the dominant factor, with an increasing influence with respect to the whole period of 2006-2015 and the period of 2006-2010. Second, using a VAR model, we show that this regional factor is explained by several variables in the short-run, notably Chinese ones. Among them, the Chinese macroeconomic climate index and the nominal onshore and real effective exchange rates are important determinants. Consequently, the results highlight the important and growing influence of the regional factor on Asian currencies' movements, and the important role of Chinese variables in the evolution of this regional factor. Third, the results of the ARDL model are more relevant and may allow us to conclude the existence of a RMB zone in Asia in the long-run. Whatever the Chinese exchange rate used (nominal exchange rate onshore, offshore rate or real effective exchange rate), there is a positive impact on the factor Asia; that is, an appreciation of Asian currencies. Four, including the Japanese Yen and the Korean Won, two other major currencies in Asia, does not change the results: it would appear that the Chinese currency beats other major Asian currencies in driving the regional factor in Asia, notably in the long run, and that this influence has been reinforced by the introduction of the offshore rate since 2010.

Finally, our article contributes to the literature on the growing influence of China on its neighbours, notably in a monetary way, and mainly after 2005 and 2010. It would be interesting to extend our article by analysing the existence of network effects that could support and accelerate the influence of China and of the RMB on its neighbours.

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## Appendix

Table A.1: List of studied countries by region

| Asian economies | Latin American economies | Eastern European economies |
|-----------------|--------------------------|----------------------------|
| India           | Argentina                | Czech Republic             |
| Indonesia       | Brazil                   | Estonia                    |
| Malaysia        | Bolivia                  | Hungary                    |
| Philippines     | Chile                    | Latvia                     |
| South Korea     | Colombia                 | Lithuania                  |
| Thailand        | Mexico                   | Poland                     |
| Vietnam         | Peru                     | Romania                    |
|                 | Venezuela                | Slovakia                   |
|                 |                          | Slovenia                   |

Table A.2: Variance decomposition for real effective exchange rates

|  | 2000-2015 |       |        | 2000-2005 |       |        | 2006-2015 |       |        |
|--|-----------|-------|--------|-----------|-------|--------|-----------|-------|--------|
|  | World     | Reg.  | Idios. | World     | Reg.  | Idios. | World     | Reg.  | Idios. |
| <i>Panel A. Asian economies</i>            |           |       |        |           |       |        |           |       |        |
| India                                      | 0,239     | 0,158 | 0,603  | 0,526     | 0,014 | 0,460  | 0,113     | 0,338 | 0,549  |
| Indonesia                                  | 0,028     | 0,025 | 0,948  | 0,059     | 0,218 | 0,724  | 0,138     | 0,043 | 0,819  |
| Korea                                      | 0,332     | 0,006 | 0,662  | 0,076     | 0,115 | 0,810  | 0,389     | 0,035 | 0,576  |
| Malaysia                                   | 0,223     | 0,063 | 0,714  | 0,446     | 0,067 | 0,487  | 0,142     | 0,143 | 0,714  |
| Philippines                                | 0,061     | 0,387 | 0,552  | 0,081     | 0,144 | 0,775  | 0,013     | 0,543 | 0,444  |
| Thailand                                   | 0,013     | 0,347 | 0,641  | 0,004     | 0,124 | 0,872  | 0,004     | 0,382 | 0,614  |
| <i>Panel B. Latin American economies</i>   |           |       |        |           |       |        |           |       |        |
| Argentina                                  | 0,011     | 0,100 | 0,890  | 0,004     | 0,131 | 0,864  | 0,066     | 0,278 | 0,655  |
| Brazil                                     | 0,221     | 0,326 | 0,453  | 0,046     | 0,430 | 0,524  | 0,265     | 0,419 | 0,316  |
| Chile                                      | 0,105     | 0,143 | 0,753  | 0,075     | 0,335 | 0,589  | 0,079     | 0,102 | 0,819  |
| Colombia                                   | 0,227     | 0,077 | 0,697  | 0,131     | 0,161 | 0,708  | 0,246     | 0,042 | 0,712  |
| Mexico                                     | 0,588     | 0,032 | 0,380  | 0,273     | 0,043 | 0,684  | 0,638     | 0,071 | 0,291  |
| Peru                                       | 0,011     | 0,103 | 0,885  | 0,234     | 0,080 | 0,686  | 0,004     | 0,087 | 0,909  |
| Venezuela                                  | 0,014     | 0,016 | 0,970  | 0,108     | 0,032 | 0,860  | 0,078     | 0,008 | 0,915  |
| <i>Panel C. Eastern European economies</i> |           |       |        |           |       |        |           |       |        |
| Poland                                     | 0,315     | 0,265 | 0,420  | 0,137     | 0,305 | 0,557  | 0,541     | 0,151 | 0,308  |
| Romania                                    | 0,093     | 0,049 | 0,859  | 0,276     | 0,021 | 0,704  | 0,117     | 0,109 | 0,775  |
| Hungary                                    | 0,145     | 0,389 | 0,465  | 0,016     | 0,181 | 0,803  | 0,347     | 0,287 | 0,366  |
| Czech Republic                             | 0,004     | 0,433 | 0,563  | 0,158     | 0,103 | 0,739  | 0,095     | 0,351 | 0,554  |
| Estonia                                    | 0,290     | 0,245 | 0,465  | 0,681     | 0,024 | 0,295  | 0,190     | 0,575 | 0,235  |
| Latvia                                     | 0,015     | 0,003 | 0,983  | 0,495     | 0,079 | 0,426  | 0,270     | 0,314 | 0,416  |
| Lithuania                                  | 0,039     | 0,007 | 0,954  | 0,140     | 0,112 | 0,747  | 0,369     | 0,382 | 0,249  |
| Slovakia                                   | 0,046     | 0,182 | 0,772  | 0,010     | 0,176 | 0,814  | 0,067     | 0,322 | 0,611  |
| Slovenia                                   | 0,251     | 0,206 | 0,543  | 0,395     | 0,011 | 0,594  | 0,182     | 0,542 | 0,276  |
| Asia                                       | 0,149     | 0,164 | 0,687  | 0,199     | 0,113 | 0,688  | 0,133     | 0,247 | 0,619  |
| Latin America                              | 0,168     | 0,114 | 0,718  | 0,124     | 0,173 | 0,702  | 0,197     | 0,144 | 0,660  |
| Eastern Europe                             | 0,133     | 0,198 | 0,669  | 0,257     | 0,112 | 0,631  | 0,242     | 0,337 | 0,421  |
| All  | 0,149     | 0,162 | 0,690  | 0,199     | 0,132 | 0,669  | 0,198     | 0,251 | 0,551  |

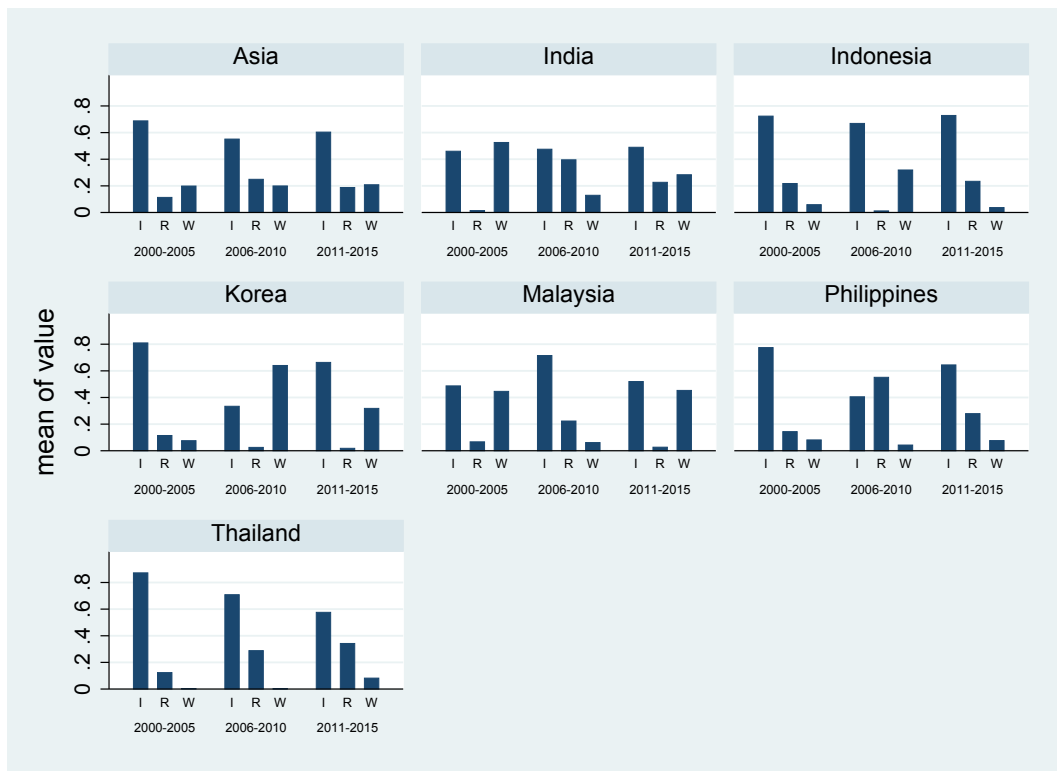
Table A.3: Results of unit root tests

|              | Level            |                          |               |                          |
|--------------|------------------|--------------------------|---------------|--------------------------|
|              | ADF              |                          | KPSS          |                          |
|              | With Constant    | With Constant<br>& Trend | With Constant | With Constant<br>& Trend |
| ASIA         | -9.6557***       | -9.4235***               | 0.0549        | 0.0510                   |
| BARCLAYS_EMI | -1.2333          | -1.9696                  | 1.6609***     | 0.1857**                 |
| CLIMATE_CHN  | -1.4080          | -2.3415                  | 0.5774**      | 0.2474***                |
| EX_CHN       | -1.8216          | -1.6772                  | 0.4185*       | 0.2452***                |
| IPI_CHN      | -2.4986          | -3.0125                  | 0.5991**      | 0.2831***                |
| VIX          | -3.9406***       | -4.0185***               | 0.2230        | 0.1428*                  |
| SHADOW_RATE  | -1.8616          | -1.2764                  | 1.1019***     | 0.1323*                  |
| EXP_TO_IMP   | -4.5791***       | -5.049***                | 0.5124***     | 0.1360*                  |
| REER_CHN     | -0.1507          | -1.5172                  | 1.1554***     | 0.3262***                |
| EX_OFFSHORE  | -1.4793          | -2.1088                  | 0.3519*       | 0.2032**                 |
| EX_JPN       | -1.826           | -2.0755                  | 0.6505**      | 0.1992**                 |
| EX_KOR       | -1.6136          | -1.8276                  | 1.3172***     | 0.1612**                 |
|              | First Difference |                          |               |                          |
|              | ADF              |                          | KPSS          |                          |
|              | With Constant    | With Constant<br>& Trend | With Constant | With Constant<br>& Trend |
| ASIA         | -12.4016***      | -12.3723***              | 0.1023        | 0.1004                   |
| BARCLAYS_EMI | -11.1792***      | -11.2123***              | 0.1053        | 0.0320                   |
| CLIMATE_CHN  | -6.3841***       | -6.5331***               | 0.0439        | 0.0268                   |
| EX_CHN       | -6.0541***       | -6.5331***               | 0.0978        | 0.0485                   |
| IPI_CHN      | -17.1174***      | -17.1061***              | 0.1215        | 0.0330                   |
| VIX          | -15.7701***      | -15.7287***              | 0.0658        | 0.0627                   |
| SHADOW_RATE  | -6.7968***       | -6.9262***               | 0.1502        | 0.1108                   |
| EXP_TO_IMP   | -14.0894***      | -14.068***               | 0.0988        | 0.0834                   |
| REER_CHN     | -9.4545***       | -9.5368***               | 0.1993        | 0.0529                   |
| EX_OFFSHORE  | -9.1157***       | -9.3133***               | 0.2123        | 0.0255                   |
| EX_JPN       | -13.6754***      | -13.6418***              | 0.0623        | 0.0574                   |
| EX_KOR       | -12.4622***      | -12.4683***              | 0.1130        | 0.0471                   |

Note: Lags are selected according to Schwartz information criteria (SIC).

\*, \*\*, \*\*\*: significant at the 10%, 5%, 1% level, respectively.

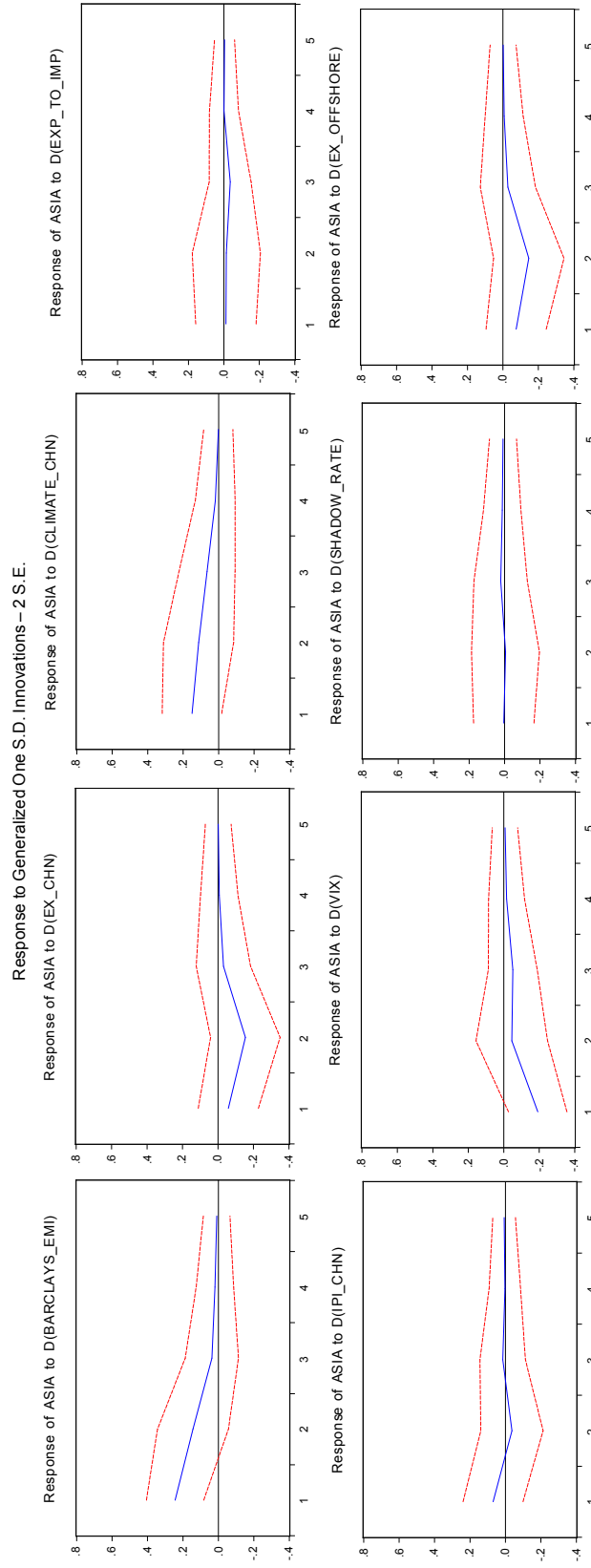
Figure A.1: Variance decompositions for country real effective exchange rate variations, 2000-2005, 2006-2010, 2011-2015 sub-samples, Asian economies



Note: I, R, W represents respectively the idiosyncratic factor, the regional factor and the world factor.

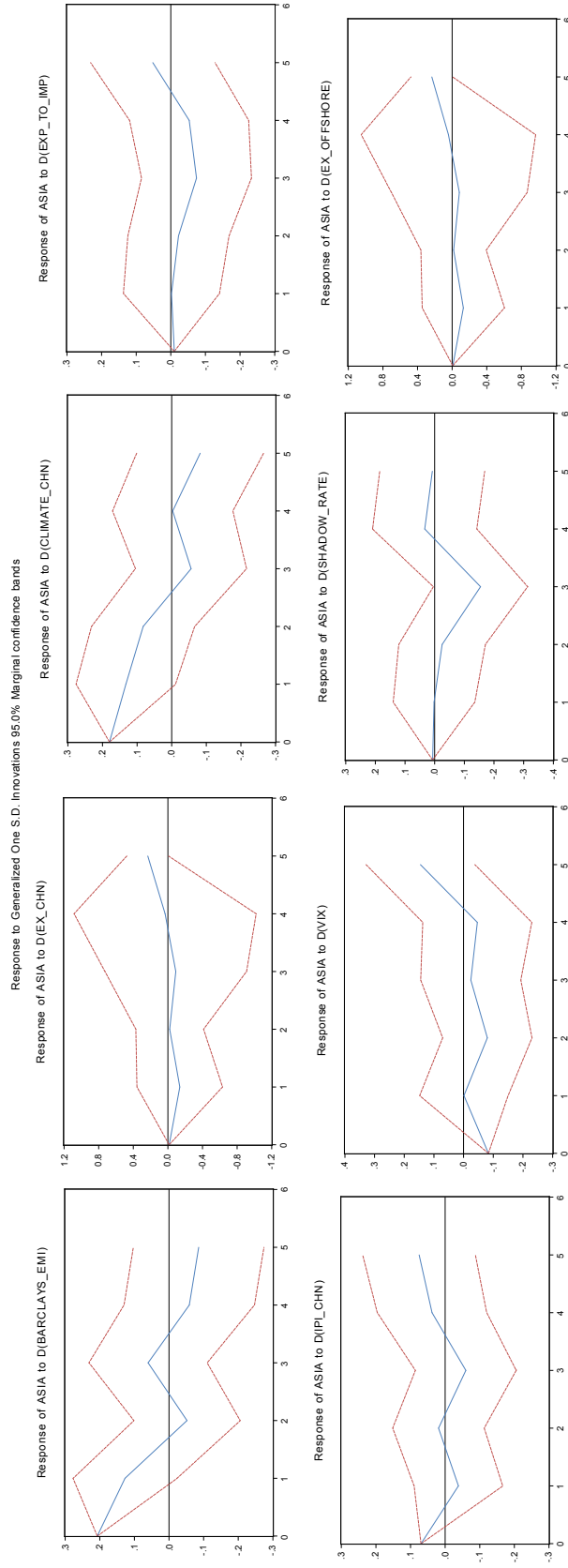


Figure A.2: Determinants of the factor Asia: Generalized Impulse Response Functions (GIRF) including both onshore and offshore Chinese exchange rates



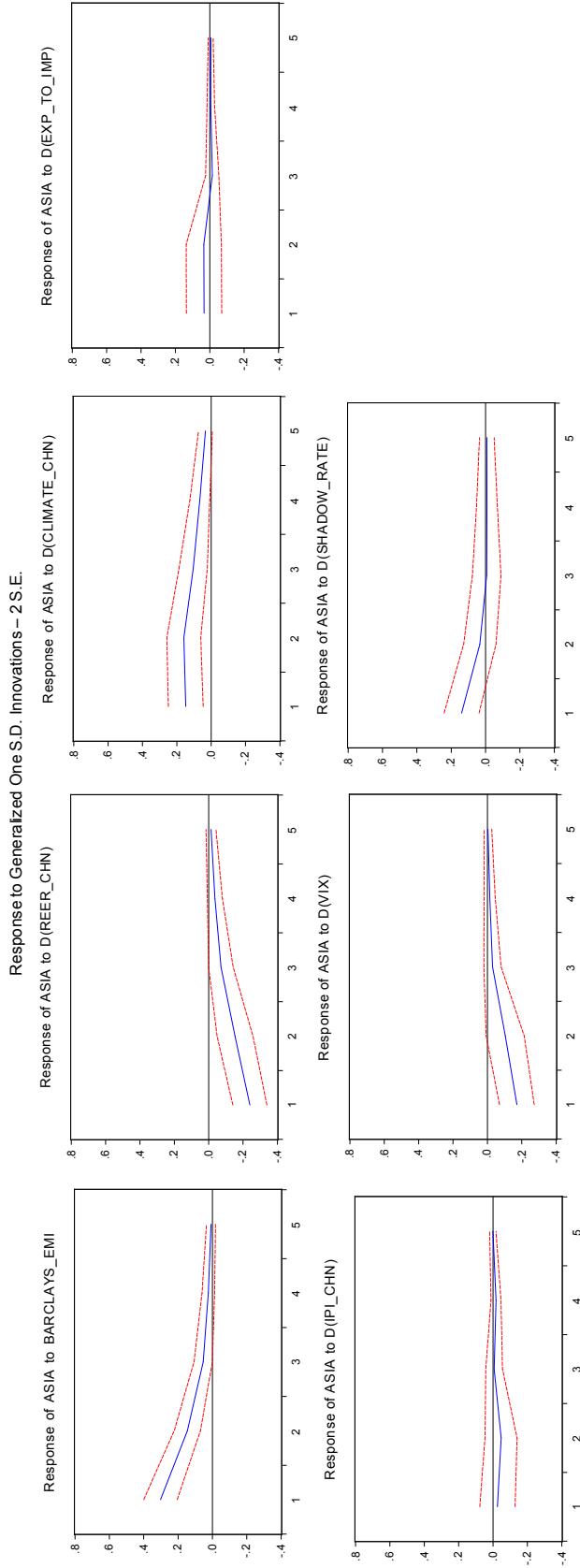
Note: These graphs provide the response of the factor Asia (ASIA) to a generalized one standard deviation innovations in variation of bilateral offshore exchange rate of China ( $D(EX\_OFFSHORE)$ ), Barclays EMI ( $D(BARCLAYS\_EMI)$ ), macroeconomic climate in China ( $D(CLIMATE\_CHN)$ ), VIX ( $D(VIX)$ ), the Fed shadow interest rate ( $D(SHADOW\_RATE)$ ), IPI in China ( $D(IPL\_CHN)$ ), exports-to-imports ratio of China ( $D(EXP\_TO\_IMP)$ ) and the bilateral onshore exchange rate of China ( $D(EX\_CHN)$ ). Also included are two asymptotic standard error bands (100000 Monte Carlo replications).

Figure A.3: Determinants of the factor Asia using the Local Projection (LP) approach including both onshore and offshore Chinese exchange rates



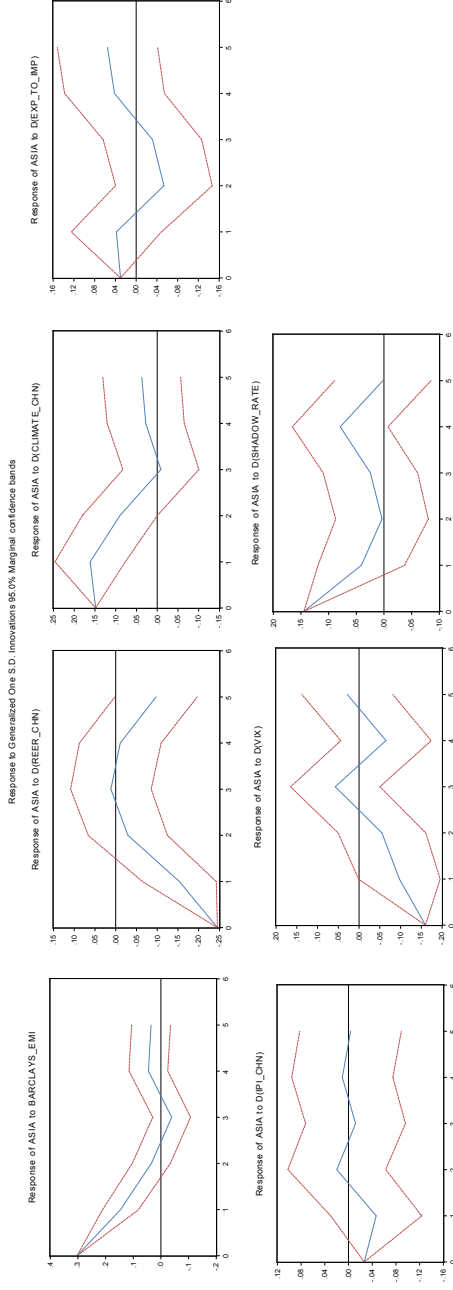
Note: These graphs provide the response of the factor Asia (ASIA) to a generalized one standard deviation innovations in variation of bilateral offshore exchange rate of China ( $D(EX\_OFFSHORE)$ ), Barclays EMI ( $D(BARCLAYS\_EMI)$ ), macroeconomic climate in China ( $D(CLIMATE\_CHN)$ ), VIX ( $D(VIX)$ ), the Fed shadow interest rate ( $D(SHADOW\_RATE)$ ), IPI in China ( $D(IPL\_CHN)$ ), exports-to-imports ratio of China ( $D(EXP\_TO\_IMP)$ ) and the bilateral onshore exchange rate of China ( $D(EX\_CHN)$ ). Also included are two asymptotic standard error bands (100000 Monte Carlo replications).

Figure A.4: Determinants of the factor Asia: Generalized Impulse Response Functions (GIRF)



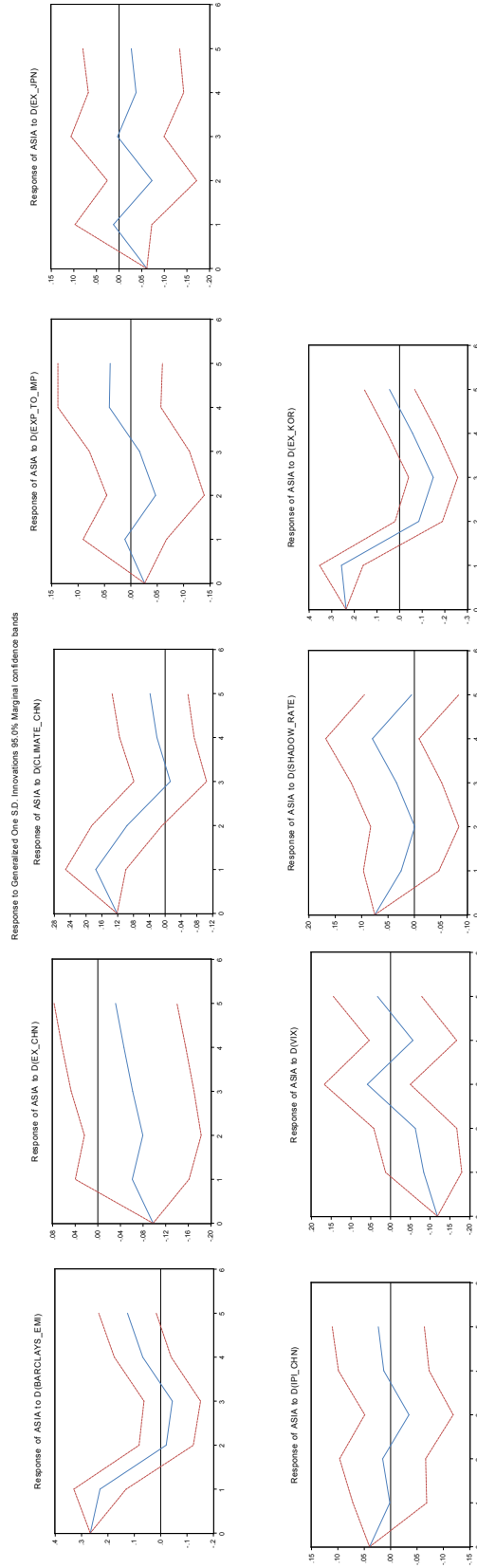
Note: These graphs provide the response of the factor Asia (ASIA) to a generalized one standard deviation innovations in variation of real effective exchange rate of China ( $D(RRER\_CHN)$ ), Barclays EMI ( $D(BARCLAYS\_EMI)$ ), macroeconomic climate in China ( $D(CLIMATE\_CHN)$ ), VIX ( $D(VIX)$ ), the Fed shadow interest rate ( $D(SHADOW\_RATE)$ ), IPI in China ( $D(IPI\_CHN)$ ) and exports-to-imports ratio of China ( $D(EXP\_TO\_IMP)$ ). Also included are two asymptotic standard error bands (100000 Monte Carlo replications).

Figure A.5: Determinants of the factor Asia using the Local Projection (LP) approach and the real effective exchange rate of China



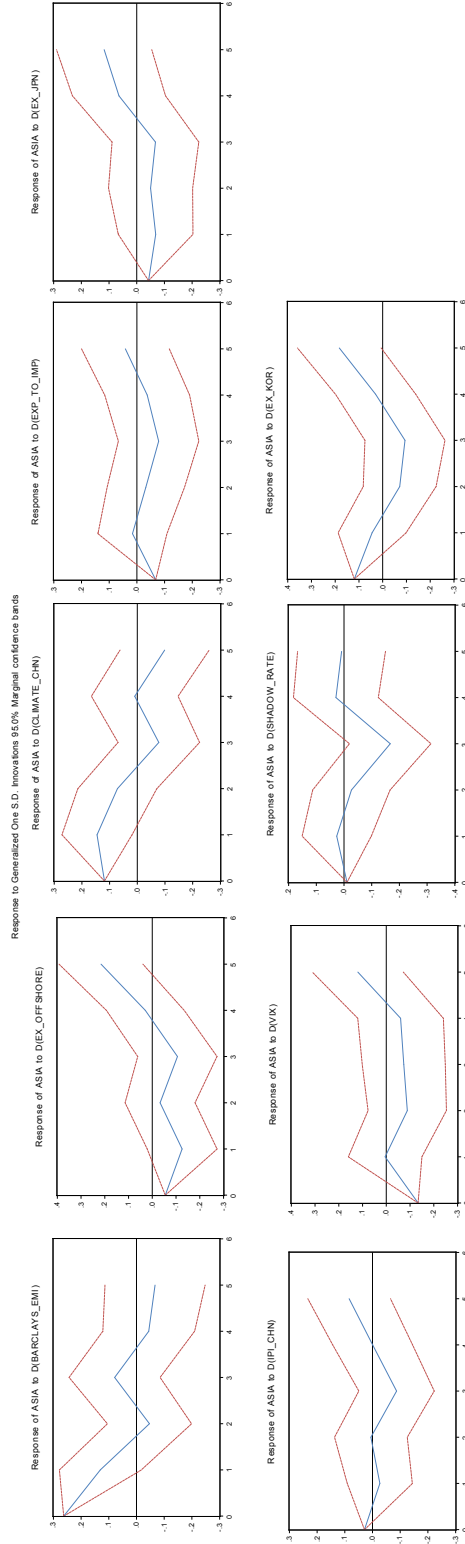
Note: These graphs provide the response of the factor Asia (ASIA) to a generalized one standard deviation innovations in variation of real effective exchange rate of China ( $D(REAL\_CHN)$ ), Barclays EMI ( $D(BARCLAYS\_EMI)$ ), macroeconomic climate in China ( $D(CLIMATE\_CHN)$ ), VIX ( $D(VIX)$ ), the Fed shadow interest rate ( $D(SHADOW\_RATE)$ ), IPI in China ( $D(IPI\_CHN)$ ) and exports-to-imports ratio of China ( $D(EXP\_TO\_IMP)$ ). Also included are two asymptotic standard error bands (10000 Monte Carlo replications).

Figure A.6: Determinants of the factor Asia using the Local Projection (LP) approach, controlling for the Japanese Yen and the Korean Won



Note: These graphs provide the response of the factor Asia (ASIA) to a generalized one standard deviation innovations in variation of bilateral onshore exchange rate of China ( $D(EX.CHN)$ ), Barclays EMI ( $D(BARCLAYS.EMI)$ ), macroeconomic climate in China ( $D(CLIMATE.CHN)$ ), VIX ( $D(VIX)$ ), the Fed shadow interest rate ( $D(SHADOW.RATE)$ ), IPI in China ( $D(IPL.CHN)$ ), exports-to-imports ratio of China ( $D(EXP.TO.IMP)$ ), Japanese Yen ( $D(EX.JPN)$ ) and Korean Won ( $D(EX.KOR)$ ). Also included are two asymptotic standard error bands (10000 Monte Carlo replications).

Figure A.7: Determinants of the factor Asia using the Local Projection (LP) approach and the offshore Chinese exchange rate, controlling for the Japanese Yen and the Korean Won



Note: These graphs provide the response of the factor Asia (ASIA) to a generalized one standard deviation innovations in variation of bilateral offshore exchange rate of China ( $D(EX\_OFFSHORE)$ ), Barclays EMI ( $D(BARCLAYS\_EMI)$ ), macroeconomic climate in China ( $D(CLIMATE\_CHN)$ ), VIX ( $D(VIX)$ ), the Fed shadow interest rate ( $D(SHADOW\_RATE)$ ), IPI in China ( $D(IPL\_CHN)$ ), exports-to-imports ratio of China ( $D(EXP\_TO\_IMP)$ ), Japanese Yen ( $D(EX\_JPN)$ ) and Korean Won ( $D(EX\_KOR)$ ). Also included are two asymptotic standard error bands (100000 Monte Carlo replications).