How do the Renminbi and other East Asian currencies co-move?

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How do the Renminbi and other East Asian currencies co-move? New evidence from non-linear analysis[☆]

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Abstract

This paper investigates the degree and the nature of exchange rate co-movements between the Renminbi and a set of seven East Asian currencies by estimating Markov switching models with regime-dependent correlations and time-varying transition probabilities. These models have several advantages. First, exchange rate co-movements can vary across different depreciation and appreciation regimes. Second, the Renminbi can act as a transition variable that provides information regarding how the exchange rates evolve over time. After controlling for global effects and exchange market pressures, the results yield robust evidence of the Renminbi's rising role in East Asia as a significant factor in currency fluctuations. A key result is that regional currencies tend to overreact when the Renminbi depreciates and underreact when it appreciates, suggesting that East Asian economies are not willing to allow their currencies to substantially appreciate against the Chinese currency. Finally, trade transactions and competition as well as financial flows demonstrate significant explanatory power regarding currency movements against the Renminbi – particularly during episodes of smaller exchange rate fluctuations.

Keywords: , Exchange Rates, East Asia, Renminbi Impact, Markov Switching Models, Asymmetric Co-movements, Time-Varying Transition Probabilities
JEL: F31, F41, F42,

1. Introduction

Over the last three decades, China has witnessed a spectacular period of rapid expansion and has become a key driver of world economic growth. In the aftermath of the 2007-08 financial crisis, China has continued to offer economic development opportunities to the rest of the world. More recently, China's economic slowdown has generated powerful spillovers on world markets. Its growing influence has placed China at the center of global economic issues, such as the resolution of global imbalances and the reform of the International Monetary System (IMS) (Dooley et al. , 2014; Bénassy-Quéré et al. , 2013; Mazier et al. , 2008). In the wake of the 2007-08 financial crisis, the configuration of the IMS was strongly criticized for having exacerbated global excess liquidity, asymmetric capital flows in favor of developed countries, and then-current global account imbalances (Gourinchas and Rey , 2007; Dooley et al. , 2003). China's

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economic rise, coupled with the negative externalities produced by fluctuations in the US Dollar (USD), has raised the prospect of a multi-polar monetary system in which the Chinese Renminbi (RMB) and the Euro would play increasingly more important roles (Fratzscher and Mehl , 2014; Yeh , 2012; Eichengreen , 2011; Wu et al. , 2010; Dobson and Masson , 2009). This development is viewed favorably by many countries that have called for a more stable and diversified IMS and less vulnerability to external fluctuations as a result.

Although many aspects of the RMB's potential with respect to becoming a global currency remain questionable, it is clear that the RMB will inevitably play an important role in East Asia.[1] Eichengreen and Lombardi (2015) stress that the RMB has special advantages in East Asia as a result of increasing regional trade integration. For instance, the RMB already acts as an important vehicle for trade settlements in Asia, where it has become the most active currency for payments between China and Hong Kong.[2] Furthermore, the development of the Asian trade network has been accompanied in recent years by greater competition on both regional and international markets. In light of this development, some studies have emphasized that China's increasing capacity to export during the 1990s has crowded out some lesser developed countries (see, e.g., Eichengreen et al. , 2007). However, the rapid development of China's manufacturing sector in recent years has occurred largely at the expense of its high-wage neighbors, as its production lines are becoming highly capital- and technology-intensive (Caporale et al. , 2015; Athukorala , 2009).

Trade relationships in East Asia are multifaceted, which implies that exchange rate fluctuations can generate regional spillovers through many channels and highlights important concerns regarding export competitiveness for countries engaged in regional and international trade. One established strand of the literature has studied the relationship between intra-regional trade and exchange rate volatility and has produced evidence pointing to the significant negative effects of intra-Asia exchange rate volatility on exports (Tang , 2014; Chit et al. , 2010). Likewise, Mattoo et al. (2012) address a different side of this issue and show that China's real appreciation significantly boosts Asian exports in third markets.

A new strand of the literature has focused on the RMB's co-movements with other regional currencies since China's exchange rate policy reforms in July 2005 (see, e.g., Shu et al. , 2015; Kawai and Pontines , 2015; Fratzscher and Mehl , 2014; Chow , 2014; Keddad , 2013; Henning , 2012; Ma and McCauley , 2011; Shu et al. , 2007). Overall, these studies concur with the notion that the incentives to track the RMB's fluctuations more closely have increased as a result of deeper trade and financial integration between China and its neighbors. For instance, Subramanian et al. (2012) find that co-movements between many East Asian currencies and the RMB are stronger than they are with the USD and argue that a stable exchange rate with the RMB might promote trade integration and maintain export competitiveness within the region. Several papers stress the growing role of the RMB as a potential regional anchor, although the Great and European debt crises have seriously dampened the case for regional monetary cooperation (see, e.g., Chinn , 2015; Ryan , 2015; Park and Song , 2011; Park , 2010).

Although the relationship between the RMB and other currencies in East Asia has strengthened over the last decade, the exact nature of their co-movements must yet be further investigated. Co-movements can emerge through many channels. For instance, when the RMB appreciates against the USD, it makes East Asian exports more competitive than

[1] Compared with the currencies of the other large economies on the global stage, the RMB's influence remains limited. However, Chinese authorities have recently taken a variety of measures to promote the RMB as a global currency, including developing the RMB in cross-border trade settlements, issuing RMB-denominated bonds, constructing currency swap agreements with foreign central banks and promoting the RMB as a reserve currency. See, among others, Ryan (2015), Yeh (2012) and Wu et al. (2010) on RMB internationalization matters.

[2] See https://www.swift.com/insights/press-releases/rmb-ranks-1-in-asia-pacific-for-payments-with-greater-china

Chinese exports (all other things equal), which would generate inflationary pressures as a result of a rising aggregate demand. Under inflation targeting regimes, central banks in East Asia in this set of circumstances would thus be more inclined to let their currency appreciate against the USD to reach price stability. Consequently, these circumstances should enhance currency co-movements during episodes of appreciation.[3] Conversely, it might be argued that the relevant authorities may be reluctant to let their currencies appreciate too much against the RMB to protect their domestic firms' exporting power in a highly competitive environment. If the competitive view prevails, then we should expect to observe greater co-movements during episodes of depreciation. Pontines and Siregar (2012) provide some elements of an answer in this regard by showing that the exchange rate policies of many East Asian countries are characterized by asymmetric behavior that features a significant degree of aversion to appreciation of the domestic currency against the RMB.

This paper focuses on the period spanning from July 2005 to May 2016 and seeks to provide additional empirical evidence regarding the nature of exchange rate co-movements between the RMB and seven East Asian currencies: the Indonesia Rupiah, the Malaysian Ringgit, the Singapore Dollar, the Thai Baht, the Philippine Peso, the Taiwanese Dollar and the Korean Won. As explained above, the need to further investigate how the RMB and regional currencies co-move is rooted in the fact that co-movements should depend on the state of exchange rates. This paper is among the first to address this issue for East Asian countries. This study attempts to answer the main following questions with great precision: Do exchange rate co-movements differ significantly between periods of depreciation and appreciation? Are exchange rate co-movements determined by market forces or market interventions? Does the RMB drive the transitional dynamics of other East Asian currencies? What are the economic factors that might explain the incentives for East Asian economies to maintain a stable relationship with the RMB? These issues have not yet been investigated in the previous literature because most studies in this field resort to linear measures that cannot capture non-linear co-movements.[4] This contribution sought to remedy these limits by relying on the Markov switching (MS) class of models (Hamilton , 1989; Filardo , 1994; Kim et al. , 2008). MS models have several advantages. First, the regimes of appreciation and deprecation are endogenously detected by the data, avoiding the need to choose exogenous break dates. Second, the MS model allows the computation of regime-dependent correlations – correlations that can differ between depreciation and appreciation episodes. Third, the transition probabilities between regimes can depend on variables that help predict turning points for exchange rates, which suggests that the RMB can act as an indicator that is informative regarding how East Asian currencies evolve over time without resorting to a sub-sample analysis. Fourth, the parametric structure of the MS model allows the states of exchange rate flexibility to be inferred, leading to a better assessment of the economic factors that might explain the episodes of limited flexibility against the RMB. Fifthly, the regime-switching model allows to capture asymmetric foreign exchange interventions of monetary authorities, and thus allowing to control for whether depreciations and appreciations result from market forces or market interventions.

The main results are as follows. First, there is evidence of the MS model's ability to capture asymmetric exchange

[3] Another argument relies on the fact that the collective realignment of East Asian currencies is necessary to resolve global imbalances. According to Ito (2008), East Asian countries (including China) would be more willing to allow their currencies to appreciate if their neighbors' currencies were also appreciating at an accelerated rate. The episodes of the RMB's gradual appreciation from July 2005 to the summer of 2008 and then during the period following June 2010 may have been characterized by greater exchange rate co-movements in East Asia. To wit, Ma and McCauley (2011) show that East Asian countries have a shared policy of gradual appreciation during 2006-2008, leading to greater intra-regional exchange rate stability.

[4] Among others, asymmetric exchange rate co-movements have already been studied between the Deutschmark and the Yen through models featuring conditional dependence structures (Patton , 2006), and between Australia, Canada, New Zealand, Sweden and United Kingdom, with asymmetric dynamic conditional correlation models (Li , 2011).

rate fluctuations for all countries (including China) in a convenient manner, as the MS model can clearly identify two distinct regimes of appreciation and depreciation. Second, exchange rate co-movements appear to be asymmetric since the sign, the significance and the magnitude of correlation coefficients differ widely across regimes. More precisely, many of the East Asian currencies tend to overreact when the RMB depreciates and underreact when it appreciates. Third, co-movements with the Renminbi during episodes of depreciation are in some cases associated with higher degree of foreign exchange interventions. Fourth, the RMB has become a key regional currency in East Asia as it significantly drives the regime transition probabilities of East Asian currencies. In particular, the Malaysian Ringgit and the Singapore Dollar are highly sensitive to the RMB's depreciation. Finally, bilateral trade and Foreign Indirect Investment (FDI)flows with China as well as trade competition are found to have significant explanatory power regarding the incentive to track the RMB more closely.

Next, some recent results on the regional influence of the RMB are first reviewed. Then, the different stages of the proposed methodology are explained in detail. Subsequently, I present the estimations and a discussion of the results, which is followed by concluding remarks.

2. Literature review

In the aftermath of the 1997-98 Asian financial crisis, there is evidence that many East Asian countries have returned to a soft USD pegging because of an inherent "fear of floating"; this exchange rate policy has forced monetary authorities to intervene heavily in the foreign exchange market at times to avoid the disruptive effects of sudden and large deprecations (McKinnon and Schnabl , 2004a; McKinnon and Schnabl , 2004b; Calvo and Reinhart , 2002). Subsequently, it has been argued that the central banks of many emerging countries intervene to limit currency appreciation rather than deprecation (see, e.g, Levy-Yeyati et al. , 2013). This asymmetric behavior of exchange rates is rational when considering that the relative competitiveness of domestic firms is an essential component of export-led growth that currently prevails in many emerging countries in East Asia. Rajan (2012) and Pontines and Rajan (2011) provide such evidence by estimating the intervention reaction function and policy preferences of central banks in East Asia. Similarly, Coudert et al. (2013) find that many emerging countries, particularly in East Asia, are more likely to loosen their peg when the USD is appreciating, resulting in greater real exchange rate co-movements with the USD during times of depreciation. Given China's growing role in the region in terms of trade and finance, Pontines and Siregar (2012) extend further by claiming that such asymmetric exchange rate policies are mainly aimed at limiting exchange rate appreciation against the RMB.

With the introduction of greater RMB flexibility since July 2005 and the gradual progress toward the RMB's internationalization, the roles have been partially redistributed within the region. Overall, previous studies generally find that the RMB exerts a significant and growing influence at the regional level, but some scholars extend further and posit that an effective RMB bloc has emerged in East Asia (e.g., Subramanian et al. , 2012; Henning , 2012). Most of these studies rely on the method introduced by Frankel and Wei (1994) (FW), or some modified version of the FW method augmented by regional or global factors (Kawai and Pontines , 2015; Fratzscher and Mehl , 2014). The main purpose of the FW model is to estimate the relative weights of major currencies (such as the USD, Yen, Euro, RMB) in a country's implicit basket peg. All exchange rates are generally defined in terms of a numeraire currency (such as the Swiss Franc, Special Drawing Rights, Australian, Canadian or New Zealand Dollars) whose fluctuations are supposedly independent of those of the currencies included in the model. Because the RMB's variations are closely linked to the USD, the FW standard model cannot disentangle between the weights of the RMB and the USD. Previous studies have addressed this issue using a variety of methods, such as auxiliary regressions (Kawai and Pontines , 2015; Shu et al. , 2007) or structural vector autoregressive (SVAR) models (Chow , 2014; Keddad , 2013). Finally, other studies have simply overcome this simultaneity bias by using the USD as the numeraire currency and focusing mainly on the role of the RMB instead of on the composition of the basket peg (e.g., Shu et al. , 2015).

Shu et al. (2007) run an auxiliary regression for a set of nine Asian currencies between 1999 and 2007 to orthogonalize the changes in the RMB and the USD, and these authors use the residuals to represent the RMB in the FW model. Their findings show that the USD continues to dominate in the implicit currency basket tracked by Asian countries, although its weight has declined since 2005 following the RMB's exchange rate reform. According to these authors, this result is explained by the rising RMB's influence even when fluctuations that are independent of the USD have been limited. This finding is supported by Subramanian et al. (2012) who claim that the RMB has become the dominant reference currency in East Asia and that more currencies co-move with the RMB than with the USD, particularly after 2010. The same conclusion is reached by Henning (2012) who find an ascending trend for RMB weights at the expense of USD weights. Ma and McCauley (2011) conclude that the RMB seems to have been managed to appreciate gradually against a trade-weighted basket of currencies from mid-2006 to mid-2008, leading to greater intra-regional exchange rate stability. Kawai and Pontines (2015) propose an FW empirical model that yields more robust results and thus provide contradictory evidence regarding the existence of a RMB bloc in East Asia.

Referring to the German mark's dominant role in Europe prior to the introduction of the Euro, Fratzscher and Mehl (2014) find evidence supporting what they term the "China's dominance hypothesis." These authors use a regional factor (including the RMB) as an explanatory variable in the FW model, and they test whether its influence has changed since 2005. In the last stage, they propose an extended version of the FW model by including an indicator variable for Chinese statements on the exchange rate regime or reserves. These authors find robust evidence that the RMB has become a key regional driver of currency movements since the mid-2000s.

Exploiting the SVAR methodology and the associated computational tools, Chow (2014) shows that the USD continues to exert a significance regional influence prior to 2008 but that there is clear evidence supporting an increasing co-movement with the RMB after the global financial crisis. Using a slightly different approach, Keddad (2013) find that the RMB shocks explain an average of 19% of East Asian exchange rate fluctuations after 2006, which is significantly higher than the period preceding the RMB exchange rate reform.

With the development of its offshore markets, there is an additional channel through which the RMB's influence can spread within the region. As the external use of the offshore RMB increases, central banks will push to monitor its fluctuations with greater attention. Rooted in this perspective, Shu et al. (2015) use a modified version of the FW regression model to control for Chinese exchange policies, and find that both the onshore and offshore RMB affect the movements of East Asian currencies.

These papers, however, are based on linear models and therefore neglect the fact that exchange rate policy (particularly in East Asia) depends on many factors, such as currency exposure, trade competition or inflationary pressures that could justify lower tolerance to either exchange rate depreciations or appreciations. In light of the recent empirical literature addressing the choice of exchange rate regimes, Pontines and Siregar (2012) are among the first to assess empirically the asymmetric nature of East Asian exchange rate regimes. These authors estimate a univariate MS model and show that the fixed transition probability of remaining in the appreciation regime is lower than the fixed transition probability of remaining in the depreciation regime. It implies that the the probability to observe the East Asian currencies appreciate against the RMB is lower than the probability to depreciate. Consequently, they conclude that the exchange rate behavior of East Asian currencies is characterized by a fear of appreciation against the RMB. This paper goes several steps further by exploring first the asymmetric nature of exchange rate co-movements with the RMB. Second, the Fixed Transition Probabilities assumption considered by Pontines and Siregar (2012) is relaxed in favor of Time-Varying Transition Probabilities, assuming that the influence of the RMB is time-varying and depends on the state of the exchange rate. Third, the economic determinants of exchange rate fluctuations against the RMB are carefully examined.

3. Data and empirical methodology

I use monthly data over the period spanning from July 2005 to May 2016 in a sample of the following eight currency exchange rates against the US dollar (the nominal rate of the domestic currency per USD): the Indonesia Rupiah (IDR), the Malaysian Ringgit (MYR), the Singapore Dollar (SGD), the Thai Baht (THB), the Philippine Peso (PHP), the Taiwanese Dollar (TWD), the Korean Won (KRW) and the RMB. The data are collected from International Financial Statistics (IFS) published by the International Monetary Fund (IMF).

The investigation is conducted in three steps. First, a MS model with regime-dependent correlations is estimated to shed new light on the asymmetric co-movements between the RMB and the other regional currencies. To this end, I estimate the following MS model:

$$\begin{aligned}
\Delta e_t^{EA/USD} &= \mu_1 + \sum_{m=1}^{M} \phi_1^m \Delta e_{t-m}^{EA/USD} + \beta_1^1 \Delta e_t^{RMB/USD} + \beta^2 \Delta e_t^{EUR/USD} + \beta^3 \Delta e_t^{JPY/USD} + \sigma \varepsilon_t \quad \text{in regime 1,} \\
&= \mu_2 + \sum_{m=1}^{M} \phi_2^m \Delta e_{t-m}^{EA/USD} + \beta_2^1 \Delta e_t^{RMB/USD} + \beta^2 \Delta e_t^{EUR/USD} + \beta^3 \Delta e_t^{JPY/USD} + \sigma \varepsilon_t \quad \text{in regime 2.}
\end{aligned} \tag{1}$$

where Δe_t^{EA} represents the (log) returns of a given East Asian exchange rate and Δe_t^{RMB}, Δe_t^{EUR} and Δe_t^{JPY} represent the (log) returns of the Chinese, Euro and Japanese exchange rates. I use the USD as the numeraire because it remains the main reserve and intervention currency within the region, while the East Asian currencies, in particular the RMB, remain fairly managed against a currency basket in which the USD maintains an important weight (see, e.g., Kawai and Pontines , 2015). Therefore, the USD is the natural base currency to depict the practice of the East Asian exchange rate policies and thus clearly identify the exchange rate Markov-regimes over the sample. This choice appears particularly justified in this case, where the main purpose is to describe how the recent developments in the Chinese exchange rate policy have affected the other regional currencies. Finally, the CHF or any other numeraire would have the inconvenient to make more difficult the statistical inference of regime probabilities since its movements are considered as fully independent from those of the other currencies. [5] This parametric form is quite similar to the standard FW model or to extended

[5] The USD has been used recently as a numeraire by Shu et al. (2015).

versions of the FW model proposed in the literature, but it differs in terms of one main characteristic. Indeed, the model in Eq.(1) allows the exchange rates to evolve across different regimes (in this instance, two) characterized by their own dynamics. The endogenous variable Δe_t^{EA} is assumed to visit the two states of a hidden variable $s_t \in \{1, 2\}$ that follows a first-order Markov chain. However, the states are unobservable such that the inference of s_t takes the form of a probability, given observations on Δe_t^{EA}. The regime-generating process is an ergodic two-regime Markov chain with the following transition probabilities:

$$P_{ij} = \mathbb{P}(s_t = i | s_{t-1} = j), \sum_{i=1}^{2} P_{ij} = 1, \text{ for all } i, j \in \{1, 2\} \tag{2}$$

This framework refers to Hamilton (1989)'s seminal Fixed Transition Probability MS (FTP-MS) model in which transition probabilities between each regime are constant over time. This assumption will be relaxed later.

This non-linear specification is entirely appropriate for capturing continued episodes of exchange rates appreciation and depreciation because it is based on the assumption of a regime-dependent mean μ_{s_t} whose value depends on the state of the exchange rate. Suppose that in the first regime μ_1 is positive, which indicates a depreciation regime in which the exchange rate fluctuates positively, on average. Obviously, the second regime should correspond to the appreciation regime with a negative μ_2 (i.e., negative variations). The model also incorporates auto-regressive lags to account for different dynamics in each regime.[6]

The greatest advantage here is that the model allows the capture of regime-dependent correlation through the coefficients $\beta_{s_t}^{RMB}$. These correlations can be of opposite signs, different magnitudes and also statistically significant in one regime and insignificant in the other. The Euro and the Yen are also included to control for their respective influences.[7]

The same exercise is repeated using a synthetic Asian Monetary Unit (AMU) in the left-hand side of Eq.(1). The goal is twofold. First, it allows an assessment of whether there is a regional factor that is responsive to RMB fluctuations. Second, the AMU can serve as a benchmark for comparing the estimates on a regional basis. The currencies included in the AMU are those in the original sample (excluding the RMB) and are equally weighted in the basket.[8]

Second, the FTP hypothesis is relaxed by assuming that transition probabilities between regimes depend on a "transition" variable. In other words, the RMB that played the role of an explanatory variable in Eq.(1) is now considered as a leading indicator that is potentially informative with regard to detecting the turning points of the East Asian exchange rates. The most closely related models refer to Filardo (1994) and Kim et al. (2008) that assume Time-Varying Transition Probability (TVTP-MS thereafter) features in MS models. The aim here is to move beyond the correlation analysis by evaluating whether the RMB provides relevant information regarding the probabilities that the East Asian currencies remain in, or switch from, a given regime. To this end, the transition matrix is now defined as follows

[6] The optimal number of lags is chosen using the general-to-specific criteria (10%) and considering a maximum of four lags.

[7] For purposes of simplicity and parsimony, the correlation coefficients are restricted to be common across regimes. The study of the exhaustive non-linear FW weights represents a promising avenue of research that exceeds the scope of this paper.

[8] Another possibility would be to use weights calculated as the arithmetic average of the respective countries' share in GDP (measured at purchasing power parity) and intra-regional trade. The choice of an equally weighted Asian currency basket prevents a given currency to be over- or under-weighted in the basket, which might lead to biased assessments. The results with countries' respective shares of GDP and intra-regional trade in the AMU are included in a previous version of this paper, and remain available upon request.

$$P_{ijt} = mathbbP(s_t = i|s_{t-1} = j, Z_t) = \begin{pmatrix} P_{11}(Z_t) & 1 - P_{22}(Z_t) \\ 1 - P_{11}(Z_t) & P_{22}(Z_t) \end{pmatrix}, \quad (3)$$

where $1-P_{11t} = P_{21t}$ and $1-P_{22t} = P_{12t}$. In this framework, the transition probabilities P_{ijt} are driven by a set of transition variables Z_t with a possible lag. This set includes not only the log variation of the RMB exchange rate against the USD at lag $k \in \{1, \cdots, 4\}$ but two common factors, i.e., the stance of US monetary policy and energy prices.

US monetary policy and energy prices are likely to affect exchange rates through many channels that might lead to misleading inferences regarding the RMB's real effects. Indeed, changes in US monetary policy induce important macroeconomic fluctuations, particularly exchange rates, through massive capital flows, carry trades, portfolio adjustments and terms of trade (see, e.g., Maćkowiak , 2007). Moreover, many energy commodities are traded in USD, which means that fluctuations in energy prices will supposedly generally affect the exchange rates of energy importers and exporters in East Asia (see, e.g, Basher et al. , 2012). As a proxy for US monetary policy, I choose the first difference of Krippner (2013)'s US Shadow Short Rate (ssr) to account for the stance of the US monetary policy beyond the zero lower bound. This choice follows the findings from recent papers that document the sizable effects of the unconventional US monetary policy on the exchange rates of emerging economies (see, e.g., Chen et al. , 2015). For energy prices, I use the log variations of the Energy Index (en) computed using World Bank Commodity Price Data.

The transition probabilities are assumed to be a function of these three factors. The following logistic specification is retained:

$$P_{11}(Z_t) = \frac{\exp(\alpha_1 + \lambda_1 \Delta s^{RMB}_{t-k} + \gamma_1 \Delta ssr_{t-1} + \omega_1 \Delta en_{t-1})}{1 + \exp(\alpha_1 + \lambda_1 \Delta s^{RMB}_{t-k} + \gamma_1 \Delta ssr_{t-1} + \omega_1 \Delta en_{t-1})}, \quad P_{22}(Z_t) = \frac{\exp(\alpha_2 + \lambda_2 \Delta s^{RMB}_{t-k} + \gamma_2 \Delta ssr_{t-1} + \omega_2 \Delta en_{t-1})}{1 + \exp(\alpha_2 + \lambda_2 \Delta s^{RMB}_{t-k} + \gamma_2 \Delta ssr_{t-1} + \omega_2 \Delta en_{t-1})}. \quad (4)$$

As a consequence, the two regimes are associated with opposite values of the transition variables. The TVTP-MS model assumes a notion of causality in the sense that variations in the RMB cause variations in the other currencies when the information in the former helps predict the latter. For purpose of illustration, assume that regimes 1 and 2 are the depreciation and appreciation regimes, respectively. A positive and significant coefficient λ_1 would indicate that the probability to see a given currency remaining in the depreciation regime is positively linked with the observed RMB variation k periods from earlier.[9] In other words, it indicates that when the RMB depreciates (appreciates), the probability to observe e^{EA}_t depreciate is higher (lower), which suggests that the former drives the latter. Additionally, a negative and significant coefficient λ_2 would indicate that a given currency is more likely to remain in the appreciation regime when the RMB has appreciated k periods before. The estimation procedure of TVTP-MS model is detailed in the Appendix (A).

Two TVTP-MS-based indicators are computed to enrich the analysis. The first is a smoothness indicator MP that measures the variation of P_{11_t} associated with a RMB depreciation of 1%.[10] The second indicator, ZM, provides the value of Δe^{RMB}_t for which the probability that Δe^{EA}_t remains in the depreciation regime is 0.5. For values of Δe^{RMB}_t above this threshold, it becomes more likely to observe Δe^{EA}_t in the depreciation regime.

[9]The lag is selected based on statistical significance at 10%.

[10]The reader may refer to Aloy et al. (2014) regarding the computation of regime-dependent indicators derived from TVTP-MS models.

Third, I explore the economic determinants that may explain the decision of East Asian countries to stabilize their currencies against the RMB. These economic factors are chosen to reflect the increasing trend in capital and current account transactions between East Asia and China. Following Kim et al. (2012), I take the first difference of the following variables: the Export Similarity Index (esi) between China and each of the other countries, Exports (X) and Imports(M) to and from China, Portfolio Investment outflows in China (pf) and FDI outflows ($fdix$) and inflows ($fdim$) to and from China.[11] This set of economic variables is included in the following model:

$$\begin{aligned}\Delta e_t^{EA/RMB} &= \beta_1^1 \Delta esi_t + \beta_1^2 \Delta X_t + \beta_1^3 \Delta M_t + \beta_1^4 \Delta pf_t + \beta_1^5 \Delta fdix_t + \beta_1^6 \Delta fdim_t + \sigma_1 \varepsilon_t \quad \text{in regime 1,} \\ &= \beta_2^1 \Delta esi_t + \beta_2^2 \Delta X_t + \beta_2^3 \Delta M_t + \beta_2^4 \Delta pf_t + \beta_2^5 \Delta fdix_t + \beta_2^6 \Delta fdim_t + \sigma_2 \varepsilon_t \quad \text{in regime 2.}\end{aligned} \tag{5}$$

where e_t^{EA} is the bilateral exchange rate between the RMB and a East Asian currency (expressed as the domestic currency price of the RMB). This parametric form has several notable features. First, the error variances are regime-dependent (i.e $\sigma_{s_t}\varepsilon_t$ with $s_t \in \{1, 2\}$), which indicates that the empirical model can discriminate between two separate regimes of high and low exchange rate fluctuations, respectively defined as regimes 1 and 2, where $\sigma_1\varepsilon_t > \sigma_2\varepsilon_t$. Accordingly, the second regime is assimilated to the regime in which the East Asian countries are expected to track more closely the RMB's fluctuations. Second, the influences of the economic factors are regime-dependent (β_{s_t}), thus fostering inferences regarding which economic factors explain the episodes of smaller exchange rate flexibility against the RMB.

4. Empirical results

4.1. Preliminary assessment

This section describes certain stylized facts in connection with the East Asian exchange rate dynamics based upon the estimates of the FTP-MS model without regime-dependent correlation. Estimation results are presented in Table 1, and Figures 1-9 plot the exchange rates and the regime probabilities. For each currency, the top graph corresponds to the USD exchange rate level, the second graph corresponds to the log-returns and the third graph corresponds to the filtered regime probabilities. When the filtered probability of state 1 is greater than 0.5, then the exchange rate is considered as in the depreciation regime. This corresponds to the red part of the plot lines.

INSERT TABLE 1

At first glance, we note from Figures 1-9 the FTP-MS model's ability to capture asymmetric exchange rate fluctuations in a convenient manner, as the computed regime probabilities overlap periods of sustained depreciation and appreciation. For instance, we can easily see from regime probabilities that the currencies depreciated sharply in 2008 before appreciating again until 2012. Since then, many currencies seem to have depreciated gradually, a result confirmed by the movements in the AMU (Figure 9). As a robustness check, the asymmetric behavior of exchange rates is simply

[11] The data sources are the Coordinated Portfolio Investment Survey (CIPS), UN Comtrade, the IMF's $DOTS$ and the UNCTAD databases. The esi is developed using the STIC two digit sectoral level (64 commodities) and is computed as follows: $esi_{i,j} = \sum^k [min(X_{ki}, X_{kj})]$, where X_{ki} and X_{kj} are industry k's world export shares of country i and j. A higher esi indicates that the competition between two countries is stronger in the world market. The data related to the pf variable are not available for Taiwan, and the data related to $fdim$ are not available for Taiwan and Indonesia.

tested through a log-likelihood ratio (LR) test between the MS and linear specifications. The results presented in Table 1 confirm without exception the assumption that two distinct regimes of depreciation and appreciation characterize East Asian exchange rates. Likewise, the estimates of the regime-dependent means differ significantly by their signs and their magnitudes. With respect to each currency, the first and second regimes are characterized by positive and negative means, respectively. For regime 1, the mean value ranges from 0.495 (THB) to 3.404 (KRW), suggesting that the KRW shows average fluctuations of 3.404% (per month) during times of depreciation. More generally, positive fluctuations are of larger magnitude than negative fluctuations. However, the expected duration (ED) of the appreciation regime is generally longer than that of the depreciation regime (on average, 6.8 months compared with 4.2 months, respectively), whereas the FTP of remaining in the appreciation regime is highest (except for the THB).

INSERT FIGURES 1-9

These findings are consistent with the observed East Asian practice of exchange rate policy under floating exchange rate arrangements implemented following the 1997-98 crisis. The sustained and gradual appreciation observed since the early 2000s has been counterbalanced by short episodes of depreciation, indicating that in addition to greater exchange rate flexibility, the exchange rates have turned out to be highly managed to avoid the disrupting effects of a too rapid appreciation caused by capital inflows. Alternatively, the short episodes of large depreciation may also reflect a possible deterioration in global sentiment that might trigger massive capital outflows.

There are also two alternative regimes of appreciation and depreciation with regard to the RMB (Figure 5), with monthly averaged fluctuations of −0.402% and 0.199%, respectively. The evolution of China's exchange rate policy is fairly well described by the model. The first period of gradual appreciation began on July 21, 2005 (regime 2), until the summer of 2008, when China decided to peg the RMB to a quasi-fixed rate of 6.83 RMB/USD (regime 1). After the first semester of 2010, the RMB appreciated almost continuously until 2014, except for the period between May and July 2012 following China's decision to widen the RMB's trading band from 0.5% to 1%. Since that time, the RMB has depreciated gradually from 6.05 to 6.57 RMB/USD between January 2014 and 2016 (regime 1).

4.2. Regime-dependent correlations

We now turn to the analysis of regime-dependent correlations. The estimation results are presented in Table 2. It is remarkably clear that exchange rate co-movements are non-linear since the sign, the significance and the magnitude of the correlation coefficients $\beta_{s_t}^{RMB}$ differ widely across regimes. These results are confirmed by Wald tests as we can easily reject the null of $\beta_1^{RMB} = \beta_2^{RMB}$ (except for the KRW, THB and TWD). A second test is performed to confirm this asymmetric relationship. The log-likelihood of the unconstrained model (i.e., the model with a non-linear $\beta_{s_t}^{RMB}$ coefficient) is compared with that of the constraint model (i.e., the model with a linear β^{RMB} coefficient). The LR statistic revealed in Table 2 allows us to reject the constrained model for all currencies except the IDR, thus confirming the existence of a regime-dependent relationship between the RMB and the other regional currencies.

INSERT TABLE 2

For all currencies except the PHP and the IDR, I find positive and statistically significant correlations in the depreciation regime, and these correlations are the highest for the MYR (1.49), the SGD (0.882) and the KRW (1.099). For this set of currencies, the co-movements appear to be stronger during times of depreciation than appreciation when the correlations in the second regime are compared (i.e., $\beta_1^{RMB} > \beta_2^{RMB}$). Conversely, the latter never exceeds unity and ranges from 0.414 (SGD) to 0.999 (TWD), while the correlation coefficient is insignificant for the IDR. As a whole, it appears that co-movement is greater in the depreciation regime. As a robustness check, the same empirical exercise is repeated with the AMU as the dependent variable. Although the sensitivity of each currency may differ, the use of a regional benchmark has the advantage of looking at the collective responsiveness to RMB's fluctuations. The results corroborated the previous intuition, as the correlation coefficient is positive and significant in the first regime and insignificant in the second.

4.3. Controlling for the degree of exchange rate flexibility

At this stage, it is not possible to state whether the observed correlations result from a deliberate exchange rate policy or reflect market forces. Following Frankel and Xie (2010), the *de facto* flexibility parameter is introduced on the right-hand side of Eq. (1), which corresponds to the variation in the Exchange Market Pressure (EMP). For each East Asian currency, the change in the EMP is computed as follows:

$$\Delta EMP_t \equiv \Delta e_t^{EA/USD} + \Delta Res_t/Res_t$$

where Res represents the foreign exchange reserves extracted from the IFS IMF database. When introducing the ΔEMP_t variable in the conventional FW model, the associated coefficient (i.e δ) captures the *de facto* degree of exchange rate flexibility. If the coefficient parameter is close to one, then $\Delta Res_t/Res_t$ is close to zero, thus indicating that the currency floats because market interventions are limited. In this case, exchange rates are essentially determined by market forces rather than by market interventions. Conversely, if δ is not significantly different from zero (or close to zero), it implies that $\Delta e_t^{EA/USD}$ displays very little change, which is contrary to $\Delta Res_t/Res_t$. This result indicates that exchange rates are essentially determined by market interventions.

As noted by Frankel and Xie (2010), the coefficient δ is likely to lie between 0 and 1 for most currencies. However, as previously mentioned, market interventions are not a linear process and depend upon many factors that could justify a low or high tolerance to exchange rate depreciations. Here, I include the variable ΔEMP_t in the regime-switching regression in Eq. (1), which has the main advantage of separately capturing episodes of low and high levels of market interventions. Indeed, allowing the coefficient δ to switch across regimes implies now that the exchange rate non-linear dynamic is also conditioned by the degree of market interventions, which leads to two important improvements in terms of economic modeling. First, it allows us to check whether exchange rate depreciation and appreciation are subsequently determined by foreign exchange market interventions or market forces. For instance, if δ_1 is close to zero or insignificant, it means that interventions in the depreciation regime are important. This implies that the observed episodes of exchange rate depreciations result mainly from foreign exchange market interventions. Conversely, a δ_2 coefficient which is significant and close to unity implies that observed episodes of appreciation are the result of market forces. Second, we can deduce from this whether the observed co-movement with the RMB in each regime are primarily related to market forces of supply and demand or to foreign exchange interventions.

The estimation results are displayed in Table 3. The first and second states still correspond to the depreciation and appreciation regimes, respectively. The result of the LR test shows that the ΔEMP_t indicator is regime-dependent. Indeed, we can see that, as expected, the coefficient δ_{s_t} takes different values across the two regimes which reveals asymmetric foreign market interventions. The only exception is the KRW for which δ_{s_t} is close to one in both regimes, suggesting that the value of the KRW is mainly determined by market forces. Conversely, δ_{s_t} is close to zero in both regimes for the PHP, which indicates the opposite.

INSERT TABLE 3

For the IDR, MYR, and TWD, the coefficient δ_{s_t} is close to zero or not significantly different from zero in the depreciation regime only, which might be the sign of a fear of appreciation because these currencies are tightly managed in order to foster exchange rate depreciation. The story seems different for the THB because it is the only currency for which $\delta_1 > \delta_2$. One potential explanation is related to the increase in short-term capital inflows during 2003-2008, which caused the Thai baht to rise significantly against the USD. A similar trend is observed between 2009 and 2013, a period during which Thailand's central bank announced new measures to curb the THB's appreciation. The SGD is a particular case as I find a negative coefficient in the first regime, which implies that exchange rate depreciation is associated with a decrease in foreign exchange reserves. Regarding the influence of the RMB, the inclusion of the EMP indicator produces more clear-cut evidence of asymmetric co-movements. For all currencies except the IDR, the co-movement is stronger in the depreciation regime, with correlation coefficients most often that are higher than unity.

What can we conclude from these combined observations? First, the strong co-movement during times of depreciation between the RMB and the currency set consisting of the MYR, PHP and TWD is related with market interventions aiming at fostering exchange rate depreciation. Although it is hard to state with confidence that foreign exchange market interventions are mainly intended to stabilize the exchange rate against the RMB, this finding support this view as it is clear that they lead to greater exchange rate co-movements with the RMB. Accordingly, this result have potentially strong implications and represent a significant finding of this paper.

Second, the synchronous fluctuations in the appreciation regime might be interpreted as a reflection of market expectations for the IDR, KRW, MYR and TWD since the coefficient δ_2 is close to unity for these currencies. When the RMB appreciates, other countries are encouraged to let their currency appreciate to ensure that the exchange rate remains consistent with underlying fundamentals. Indeed, as discussed by Fratzscher and Mehl (2014), this might be interpreted as a sign that China, followed by its neighbors, would decouple from the US, thereby encouraging capital inflows in emerging Asia and exchange rate appreciation. Furthermore, monetary authorities would become less reluctant to let their currencies appreciate when faced with an appreciating RMB. The Malaysian example is illustrative: on July 21, 2005, Malaysia removed the MYR peg to the USD in favor of a managed float, almost immediately after China announced its reform of the RMB's exchange rate.

What are the implications of these findings? They suggest that many East Asian currencies tend to overreact when the RMB depreciates ($\beta_1^{RMB} > 1$) while the inverse is true when it appreciates ($\beta_2^{RMB} < 1$). When the Chinese authorities allow the RMB to appreciate very gradually, these East Asian countries may be more willing to tolerate the appreciation of their own currencies to contain inflationary pressures, which might explain why positive co-movements are found in the second regime. However, the fact that these correlations are lower than unity also suggests that they are not inclined to allow their currencies to appreciate too much against the RMB. This notion is confirmed by the findings of stronger correlations in regime 1. Indeed, when the RMB is pegged to the US dollar or depreciates against it, it results in an appreciation of the East Asian currencies against the RMB, which makes domestic exporters less competitive against Chinese firms. Consequently, the East Asian countries may be pressured to help depreciate their own currency against the USD to stabilize the RMB exchange rate. However, an appreciating RMB has no impact on East Asian competitiveness and reduces the incentive to track the RMB movements. These arguments are particularly relevant for the MYR, PHP and TWD for which the *EMP* index suggests asymmetric interventions in the foreign exchange markets. The cases of the THB and KRW are interesting as the correlated episodes of depreciation are associated with a high degree of exchange rate flexibility. This result has strong implications since it shows that the RMB depreciation can spill over across Asia. As an illustration, the Korean Won has fallen to 4-year low on August 2015, mainly caused by capital outflows driven by the RMB depreciation and market expectations about China's economic growth potential. The estimates constitute a clear argument in this direction.

4.4. The transitional dynamics of East Asian exchange rates

The FTP-MS model presented in Eq. (1) is informative regarding exchange rate co-movements. However, the fact that two currencies co-move does not automatically imply causality. I therefore extend one step further by conducting a complementary approach based on the TVTP-MS model's estimations. The goal of such an analysis is to ask whether the RMB already acts as a leading currency within East Asia. The estimation results are displayed in Table 4. To keep the analysis tractable, an interpretation of the results is based on the TVTP P_{11t} and P_{22t}, which are the probabilities to stay into each regime. The value and the sign of coefficients α_{s_t} and λ_{s_t} reveal how the RMB fluctuations drive the transition probabilities of the other currencies.

First, a LR test is performed to check whether the TVTP-MS specification outperforms the FTP-MS model. The results suggest that the additional transition variables significantly improve the log-likelihood. The control variables are found to be significant in at least one regime, with the expected sign in many cases. We note that estimates of *ssr* are found to be significant for IDR, KRW, MYR, PHP, TWD and the AMU, implying that tighter US monetary conditions lead to greater likelihood of observing a depreciation, which is consistent with the common view that US monetary policy spills over to emerging markets, notably through the exchange rate channel.[12] Furthermore, the estimates of *en* are significant for the IDR, KRW, PHP, TWD and AMU.

INSERT TABLE 4

Now, I examine the effects of the RMB's fluctuations. The coefficient λ_1 is positive and statistically significant at conventional levels for all currencies, indicating that when the RMB depreciates, the probability that a given currency depreciates is higher. Additionally, the coefficient λ_2 is negative in all cases, suggesting that an appreciation of the RMB implies that any East Asian currency is more likely to remain in the appreciation regime. We can conclude from this that when China allows its currency to depreciate or appreciate, the East Asian currencies are more likely to react in a similar manner, which can be illustrated by the shape of the estimated transition probability functions. Figures 10-11 display

[12] For robustness checks, I used also the Wu-Xia shadow short rate (Wu and Xia , 2015). The results, not presented here but available upon request, do not differ significantly from those of Krippner (2013)'s US Shadow Short Rate.

the respective TVTP P_{11t} and P_{22t} for each currency, which is based on the degree of RMB fluctuations. Visually, these probabilities seem to share the same features, but the regime-switching indicators MP and ZM highlight differences from one currency to another.

Recall that MP is a smoothness indicator measuring the impact of a RMB depreciation (appreciation) of 1% in the variation of P_{11t} (P_{22t}). The results with the AMU as a benchmark indicate that the variation of P_{11t} is approximately 1.128, implying that, on average, the probability that East Asian currencies stay in the first regime, following the RMB's positive variation at 1%, reaches its maximum value.[13] The impact of an appreciation is lower and increases the probability P_{22t} by only 0.06. In examining each currency separately, the PHP, SGD, THB and TWD seem to be more sensitive to positive than negative fluctuations of the RMB. Similarly, this set of currencies displays marginal variations higher than 0.5, suggesting that the probability of observing these currencies in the first regime is fairly high. Conversely, the IDR and MYR are less responsive to the RMB's depreciation but particularly sensitive to the RMB's appreciation. Finally, the KRW does not seem to be sensitive to either positive or negative fluctuations in the RMB.

INSERT FIGURES 10-11

From Figures 10-11, the ZM indicator gives the values of Δe_t^{RMB} (x-axis) for which the probability to remain in each regime is 0.5 (y-axis). For values above the threshold $ZM(11)$, it becomes more likely to observe a given currency in the depreciation regime (see Figure 10). Conversely, for values below the threshold $ZM(22)$, it becomes more likely to observe a given currency in the appreciation regime (see Figure 11). Notably, the lower (higher) the threshold is, the higher the currency's response is to the RMB depreciation (appreciation). For instance, we see that the SGD is more likely to depreciate when the RMB's variations exceed -0.061%, but this threshold is further lower for the AMU (-0.287%). However, the RMB need to depreciate at least 0.5% for the MYR reaches its turning point of 0.5. Overall, the threshold is lowest for the IDR, PHP, SGD and THB. Examining the threshold parameters in the second regime reveals that the MYR is the most sensitive to RMB appreciation. On average, however, the threshold associated with the AMU indicates that P_{22} remains fairly high regardless of the value of the RMB's variations, suggesting that the RMB does not predict the probability of remaining in the appreciation regime.

As a whole, these indicators show that co-movements between the RMB and other regional currencies are heavily asymmetric, confirming the preceding arguments that exchange rate management is characterized by a fear of appreciation against the RMB.

Figures 12-13 show how these transition probabilities evolve over time. For all currencies, the probability of depreciation coincides mainly with episodes where the RMB has weakened, including after 2012 and to some extent during the subprime crisis, suggesting that China's exchange rate policy has clearly shaped currency movements in East Asia during these recent years. The events of the summer of 2015 are illustrative: many Asian currencies depreciated sharply against the USD under the pressure of capital outflows caused by market anticipations of depreciation as a potential response to RMB devaluations. This influence of the RMB is less evident for the rest of the sample, which suppose in turn that factors other than the RMB (such as ssr or en) may have explained the positive currency variations observed before 2012. Finally,

[13]The value of transitional probabilities are bounded between 0 and 1, although these probabilities can theoretically take any value depending on the parameters of the transition function in Eq. (4)

the probability of remaining in the appreciation regime stays fairly high between 2006 and 2008 for the PHP, IDR, TWD and MYR but falls for all currencies after 2014.

INSERT FIGURES 12-13

4.5. Economic determinants behind the growing role of the RMB

In this section, I empirically assess the economic determinants that might explain the growing role of the RMB in East Asia. There are at least four reasons why East Asian countries would be inclined to track the RMB more closely. First, trade flows between China and its main regional partners have grown impressively, resulting in China overtaking Japan and the US as the largest trading partner within the region. This increasing role is mainly explained by the Chinese position in the Asian production network as a major trading hub for intra-regional and global trade but also by China's increasingly strong demand for consumer goods. Second, China's exports have shifted from labor-intensive manufactured goods to more capital- and technology-intensive production in recent years, bringing further export competition not only to low-income economies but also to newly industrialized economies. Third, and related to the preceding arguments, the influence of China's monetary policy shocks on East Asian firms, and then on East Asian stock markets, is likely to become more important as business cycle synchronization continues to intensify. In this view, Johansson (2012) and Koźluk and Mehrotra (2009) find that expansions in China's money supply positively affect several stock markets in Southeast Asia as well as real output. Fourth, regional financial integration is deepened as a result of the greater cooperation in regional economic surveillance, growing intraregional FDI and the development of local currency bond markets. As the financial ties tighten, exchange rate stability can be viewed as an implicit guarantee for regional investors seeking to promote their financial activities across the region by exporting short- and long-term capital flows.

INSERT TABLE 5

I estimate a MS model augmented with a set of economic indicators in which East Asian exchange rates against the RMB enter now as the dependent variables. Each regime is characterized by its proper variance of errors as described in Eq.(5). The first regime is defined as the regime in which the degree of flexibility against the RMB is high and the second as the regime in which this degree is low. Accordingly, the second regime can be assimilated to periods in which the East Asian countries weight the RMB more in their exchange rate policy. The esi is chosen to capture the increasing trade competition between China and its neighboring countries. The inclusion of exports (X) and imports (M) aim to consider the importance of trade flows between China and other countries. The portfolio (pf) and FDI ($fdix$, $fdim$) flows are included to account for capital account transactions.

The estimation results are displayed in Table 5 and regime probabilities are plotted in Figures 14-20. For each currency, the top graph corresponds to the RMB exchange rate in level, the second graph corresponds to the log-returns and the third graph corresponds to the filtered regime probabilities. When the filtered probability of state 1 is greater than 0.5, then the exchange rate is considered to be in the high flexibility regime, which corresponds to the green part of the plot lines.

INSERT FIGURES 14-20

With no exception, *esi* is significant in regime 2 and mostly insignificant in regime 1 (except for SGD and THB). Together, this leads to the conclusion that trade competition is a significant factor explaining why the East Asian countries decide to strengthen exchange rate stability vis-à-vis the RMB. Moreover, *X* turns out to be significant in regime 1 in all cases, while the other explanatory variables are always significant, expect for those associated with Indonesia. As a consequence, these results also provide evidence supporting the notion that as China's weight in terms of trade and capital transactions increases, the incentive for maintaining a stable exchange rate against the RMB is stronger.[14]

5. Concluding Remarks

In this paper, several empirical tools derived from non-linear models have been used to assess the size and nature of the co-movements between the RMB and a set of seven East Asian currencies plus an AMU. Estimates have been carried out over the July 2005-May 2016 period. In line with many recent studies, this paper has presented empirical evidence that stresses the influential role of the RMB in East Asia. First, it has been found that exchange rate fluctuations are characterized by asymmetric relationships with greater co-movements during times of RMB depreciation and when the RMB has been fixed to the USD. Furthermore, these co-movements are associated in some cases with higher degree of foreign exchange interventions by East Asian monetary authorities. This echoes recent findings that stress the aversion of many East Asian economies regarding their currencies' appreciation against the RMB (e.g., Pontines and Siregar , 2012; Pontines and Rajan , 2011). Second, there is clear evidence supporting the notion that the RMB has driven currency movements in East Asia over the last decade, and a clear illustration of this notion can be found in the recent episodes of 2012 and 2015, when the RMB weakened against the USD. Finally, the last stage of the empirical investigation demonstrated that deeper economic integration and trade competition with China might explain the need for East Asian countries to track variations in the RMB more closely.

In the medium-term, the RMB's role will depend on the pace of its internationalization (or regionalization). Exchange rate management will become increasingly dependent on China's exchange rate policy, as the use of the Chinese currency will spread within the region, such as in the recent example of the RMB's inclusion in the SDR basket, a decision welcomed by many East Asian policymakers. Such inclusion will promote the holding of RMB-denominated assets by private investors and East Asian central banks that are inclined to diversify the currency composition of their foreign reserves.

However, although the RMB may foster monetary stability within the region, it may be also be the source of important vulnerabilities. The recent movements in the RMB have shown the importance of the East Asian economies exposure to the RMB. During 2015, many East Asian currencies were seriously affected by the surge of capital outflows triggered to a large extent by RMB devaluation. These recent events have demonstrated the need to promote even deeper regional monetary cooperation, a project (however distant) that has been undermined in recent years by the lack of regional leadership.

The RMB is expected to become more flexible as China rebalances its economic growth, which presents several challenges for regional policymakers. One crucial issue in coming years will be the conjunction between the growing role of the RMB and the potential need for regional exchange rate coordination. Indeed, intra-regional exchange rate stability

[14] As a robustness check, the same empirical exercise has been replicated with exchange rate volatility (measured by the square of log-returns) as the dependent variable. The results, which are not presented here but are available upon request, match those reported in this section.

has been viewed for a long time as an important goal on the road to financial and trade integration. This stability might be achieved in the future by increasing the RMB's weight in the managed currency basket of East Asian economies. Such a shared policy would have several advantages, including increasing the stability of the nominal effective exchange rate at the regional level. Such a policy might also create favorable conditions for joint appreciation, including the RMB. Indeed, a deeper regional cooperation would foster currency realignment by rendering gradual appreciation less costly, which might in turn foster the transition of East Asian emerging economies into a more sustainable growth model. However, the foregoing assumes not only that China sets up favorable economic conditions for reducing its excessive dependency on exports and investment in the future but also that it implements macroeconomic policies aimed at maintaining price stability and ensuring the smooth development of its financial markets.

Appendix A

This appendix briefly details the estimation procedure for the general TVTP-MS model since the latter encompasses the basic specification. The maximum likelihood method is employed to provide estimates of the parameters[15].

The conditional likelihood function for the observed data is defined as

$$\begin{aligned} L(\Theta) &= \prod_{t=1}^{T} \sum_{i=1}^{2} \sum_{j=1}^{2} f(y_t | s_t = i, s_{t-1} = j, \Omega_t, \xi_{t-1}; \Theta) \times \mathbb{P}(s_t = i, s_{t-1} = j | \Omega_t, \xi_{t-1}; \Theta) \\ &= \sum_{t=1}^{T} \ln f(y_t | \Omega_t, \xi_{t-1}; \Theta). \end{aligned} \tag{6}$$

where $\xi_t = (y_t, y_{t-1}, \ldots, y_1)$ and $\Omega_t = (X'_t, X'_{t-1}, \ldots, X'_1, Z'_t, Z'_{t-1}, \ldots, Z'_1)$ denotes the vector containing observations through date t, and Θ_t the vector of model parameters. Considering the normality assumption, the regime-dependent densities are defined as

$$\begin{aligned} f(y_t | s_t = 1, s_{t-1} = j, \Omega_t, \xi_{t-1}; \Theta) &= \frac{\frac{1}{\sqrt{2\pi\sigma_1}} \exp\left(\frac{-\left(y_t - \mu_1 - \beta_1 X'_t - \sum_{m=1}^{p} \beta_{m,j}(y_{t-m} - \mu_j)\right)^2 \Phi(\alpha_j + \theta_j Z'_t)}{2\sigma_1^2} \right)}{\sigma_1 P_{1j,t}}, \\ f(y_t | s_t = 2, s_{t-1} = j, \Omega_t, \xi_{t-1}; \Theta) &= \frac{\frac{1}{\sqrt{2\pi\sigma_2}} \exp\left(\frac{-\left(y_t - \mu_2 - \beta_2 X'_t - \sum_{m=1}^{p} \beta_{m,j}(y_{t-m} - \mu_j)\right)^2 \Phi(-\alpha_j - \theta_j Z'_t)}{2\sigma_2^2} \right)}{\sigma_2 P_{2j,t}}. \end{aligned} \tag{7}$$

where Φ is the standard logistic cumulative distribution function. The model is estimated using a maximum likelihood estimator for mixtures of Gaussian distributions, which provides efficient and consistent estimates under the normality

[15]The BFGS algorithm is used to perform nonlinear optimization

assumption (see e.g. Kim et al. , 2008). Applying the Bayes' rule, the weighting probabilities are computed recursively:

$$
\begin{aligned}
\mathbb{P}(s_t = i, s_{t-1} = j|\Omega_t, \xi_{t-1}; \Theta) &= \mathbb{P}(s_t = i, s_{t-1} = j|z_t; \Theta)\mathbb{P}(s_{t-1} = j|\Omega_t, \xi_{t-1}; \Theta) \\
&= P_{ij}(z_t)\mathbb{P}(s_{t-1} = j|\Omega_t, \xi_{t-1}; \Theta), \\
\mathbb{P}(s_t = i|\Omega_{t+1}, \xi_t; \Theta) &= \frac{\sum_j f(y_t|s_t = i, s_{t-1} = j, \Omega_t, \xi_{t-1}; \Theta)\mathbb{P}(s_t = i, s_{t-1} = j|\Omega_t, \xi_{t-1}; \Theta)}{f(y_t|\Omega_t, \xi_{t-1}; \Theta)}.
\end{aligned}
\tag{8}
$$

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Table 1: Estimates of the FTP-MS models without exogenous variables

	CNY	IDR	KRW	MYR	PHP	SGD	THB	TWD	AMU
Regime 1:									
μ_1	0,199***	3,361***	3,404***	1,193**	1,179***	0,852***	0,495*	1,15***	0,545**
	(0,072)	(0,789)	(0,274)	(0,577)	(0,306)	(0,236)	(0,274)	(0,379)	(0,250)
ϕ_1^1		1,603***	1,483***	0,461		0,204**			0,097
		(0,120)	(0,140)	(0,287)		(0,087)			(0,122)
ϕ_2^1		0,244***	0,551***			0,156			
		(0,082)	(0,098)			(0,133)			
Regime 2:									
μ_2	-0,402***	-1,026***	-0,875*	-0,643**	-0,734***	-0,961***	-0,968***	-0,376*	-0,466*
	(0,047)	(0,395)	(0,514)	(0,300)	(0,196)	(0,190)	(0,350)	(0,221)	(0,245)
ϕ_1^2		-0,044	0,241**	0,251*		0,158			-0,448***
		(0,069)	(0,104)	(0,132)		(0,119)			(0,153)
ϕ_2^2		0,087	-0,043			-0,337***			
		(0,101)	(0,070)			(0,077)			
P_{11}	0,9	0,26	0,18	0,46	0,72	0,64	0,94	0,71	0,82
P_{22}	0,9	0,75	0,83	0,7	0,87	0,75	0,92	0,91	0,84
ED(1)	9,66	1,34	1,22	1,84	3,56	2,8	17,82	3,43	5,56
ED(2)	10,04	3,99	5,82	3,35	7,69	3,97	12,34	10,73	6,37
LL	-95,667	-248,518	-265,173	-227,769	-220,113	-190,638	-233,570	-204,224	-214,059
LR stat	20,174	91,266	31,106	25,782	18,673	25,275	14,807	16,154	21,385
p-value	[0,000]	[0,000]	[0,000]	[0,000]	[0,000]	[0,000]	[0,000]	[0,000]	[0,000]

Notes: This table shows the estimates of the FTP-MS models and presents some stylized facts regarding East Asian exchange rate dynamics. *,**,*** denote significance at 10, 5 and 1 %, respectively. Standard errors of parameters are reported in parentheses (.), while p-values are displayed in brackets [.]. The optimal number of lags is chosen using general-to-specific criteria (10%), considering a maximum of four lags. The LR test aims to determine whether the dynamics of exchange rates are non-linear. The test statistic is computed as follows: $LR = 2\times[L_{FTP-MS}(\Theta) - L_{Linear}(\Theta)]$ with Θ, the parameters of the model. The null hypothesis is that the FTP-MS model does not fit significantly better than the linear model. The probability P_{ij} represents the (fixed) probability of remaining in each regime and ED the duration of each regime.

Table 2: Estimates of regime-dependent correlations between the RMB and East Asian currencies

	IDR	KRW	MYR	PHP	SGD	THB	TWD	AMU
Regime 1:								
μ_1	4,279***	3,189***	1,533**	0,947*	0,668***	1,959***	0,688***	3,608***
	(0,308)	(0,503)	(0,638)	(0,550)	(0,142)	(0,215)	(0,225)	(0,554)
β_1^{RMB}	-2,855***	1,099**	1,49***	-1,139*	0,882***	0,367**	0,729***	0,881**
	(0,308)	(0,504)	(0,295)	(0,668)	(0,181)	(0,172)	(0,209)	(0,432)
ϕ_1^1	-1,411***	-1,344***	1,237***	-0,002	-0,235	-0,634***	-0,043	
	(0,162)	(0,361)	(0,207)	(0,391)	(0,195)	(0,201)	(0,155)	
ϕ_1^2	-1,352***							
	(0,196)							
Regime 2:								
μ_2	-0,432**	-0,165	-0,162	-0,332*	-0,493***	-0,463***	-0,593**	-0,227*
	(0,201)	(0,163)	(0,180)	(0,183)	(0,086)	(0,089)	(0,262)	(0,121)
β_2^{RMB}	-0,293	0,662*	0,543*	0,52**	0,414**	0,544**	0,999***	-0,311
	(0,410)	(0,381)	(0,279)	(0,239)	(0,173)	(0,277)	(0,256)	(0,222)
ϕ_2^1	0,014	-0,116	0,219*	0,323***	-0,294**	-0,185	-0,052	
	(0,090)	(0,089)	(0,116)	(0,101)	(0,137)	(0,113)	(0,256)	
ϕ_2^2	0,342***							
	(0,129)							
Common:								
β^{JPY}	-0,114*	-0,105	-0,084*	-0,075	0,025	-0,025	0,015	0,033
	(0,066)	(0,082)	(0,049)	(0,048)	(0,030)	(0,043)	(0,037)	(0,056)
β^{EUR}	0,265***	0,405***	0,347***	0,175***	0,327***	0,229***	0,211***	0,098
	(0,065)	(0,084)	(0,050)	(0,047)	(0,029)	(0,043)	(0,043)	(0,059)
σ	0,416***	0,594***	0,043	0,111	-0,432***	0,103	-0,28***	0,151*
	(0,095)	(0,087)	(0,091)	(0,074)	(0,079)	(0,099)	(0,088)	(0,079)
LL	-274,061	-263,812	-212,818	-205,908	-155,121	-224,646	-178,929	-196,207
LR Test								
LR stat	1,995	4,192	5,484	3,788	2,942	3,131	3,158	13,246
p-value	[0,158]	[0,041]	[0,019]	[0,052]	[0,086]	[0,077]	[0,076]	[0,000]
Wald test								
F stat	-	0,536	5,115	2,339	3,991	0,541	0,680	-
p-value	[-]	[0,465]	[0,02]	[0,021]	[0,048]	[0,59]	[0,411]	[-]

Notes: *,**,*** denote significance at 10, 5 and 1 %, respectively. Standard errors of parameters are reported in parentheses (.), while p-values are displayed in brackets [.]. Regime 1 and Regime 2 correspond to the depreciation and appreciation regimes, respectively. The optimal number of lags is chosen using the general-to-specific criteria (10%), considering a maximum of four lags. The parameters σ, β^{EUR} and β^{YEN} are common across regimes. The LR test aims to determine whether the influence of the Chinese RMB is regime-dependent. The test statistic is computed as follows: $LR = 2 \times [L_{MS}(\beta_{s_t}^{RMB}) - L_{MS}(\beta^{s_t RMB})]$. The null hypothesis is that the unconstrained model does not fit significantly better than the constrained model. The Wald test is used to check whether $\beta_1^{RMB} = \beta_2^{RMB}$ (when both coefficients are significantly different from zero). A rejection of the null hypothesis implies that the coefficients are not equal.

Table 3: Estimates of regime-dependent correlations between the RMB and the East Asian currencies: controlling for the non-linear degree of flexibility

	IDR	KRW	MYR	PHP	SGD	THB	TWD
Regime 1:							
μ_1	0,517*	1,746***	0,711***	1,32***	0,484*	2,418***	1,258***
	(0,268)	(0,392)	(0,214)	(0,354)	(0,258)	(0,671)	(0,358)
β_1^{RMB}	0,202	1,575***	1,227***	0,477***	1,508***	1,772**	1,963***
	(0,473)	(0,561)	(0,371)	(0,122)	(0,490)	(0,783)	(0,403)
δ_1^{EMP}	-0,128***	0,947***	-0,055	0,216**	-0,513***	0,949***	0,223
	(0,042)	(0,072)	(0,048)	(0,089)	(0,156)	(0,095)	(0,255)
ϕ_1^1	0,108	0,382*		-0,013	1,142***	1,361***	2,017***
	(0,210)	(0,205)		(0,206)	(0,171)	(0,423)	(0,465)
ϕ_1^2		1,229***		0,599***			
		(0,316)		(0,205)			
ϕ_1^3		2,572***		0,709***			
		(0,359)		(0,162)			
ϕ_1^4		-0,583***					
		(0,199)					
Regime 2:							
μ_2	-0,681**	-0,351**	-0,185	-0,545***	-0,428***	-0,437***	-0,331***
	(0,274)	(0,138)	(0,175)	(0,206)	(0,138)	(0,161)	(0,077)
β_2^{RMB}	1,512***	0,177	0,606**	0,301*	0,537***	0,458**	0,403***
	(0,303)	(0,198)	(0,269)	(0,158)	(0,197)	(0,195)	(0,117)
δ_2^{EMP}	0,974***	1,083***	0,985***	0,084**	0,263***	0,278***	0,722***
	(0,055)	(0,060)	(0,093)	(0,038)	(0,058)	(0,044)	(0,066)
ϕ_2^1	-0,39*	0,153*		0,634***	-0,07	0,391***	-0,006
	(0,202)	(0,090)		(0,116)	(0,102)	(0,091)	(0,085)
ϕ_2^2		-0,005		0,022			
		(0,067)		(0,118)			
ϕ_2^3		0,142**		-0,444***			
		(0,058)		(0,125)			
ϕ_2^4		-0,025					
		(0,065)					
Common:							
β^{JPY}	-0,129**	-0,065*	0,078*	0,101*	0,228***	0,053	0,134***
	(0,057)	(0,035)	(0,043)	(0,057)	(0,037)	(0,040)	(0,022)
β^{EUR}	0,216***	-0,057*	0,084*	-0,075***	0,002	0,235***	0,043*
	(0,070)	(0,030)	(0,045)	(0,019)	(0,041)	(0,042)	(0,024)
σ	0,174**	-0,197***	0,033	-0,423***	-0,227**	-0,043	-0,417***
	(0,086)	(0,073)	(0,075)	(0,134)	(0,101)	(0,071)	(0,071)
LL	-244,159	-185,299	-215,264	-193,454	-183,254	-204,669	-149,455
LR Stat	54,508	12,725	15,798	4,672	5,164	7,853	3,234
p-value	[0,000]	[0,000]	[0,000]	[0,031]	[0,023]	[0,005]	[0,072]

Notes: *,**,*** denote significance at 10, 5 and 1 %, respectively. Standard errors of parameters are reported in parentheses (.), while p-values are displayed in brackets [.]. Regime 1 and Regime 2 correspond to the depreciation and appreciation regimes, respectively. The optimal number of lags is chosen using the general-to-specific criteria (10%), considering a maximum of four lags. The parameters σ, β^{EUR} and β^{YEN} are common across regimes. The LR test aims to test whether the influence of the indicator ΔEMP_t is regime-dependent. The test statistic is computed as follows: $LR = 2\times[L_{MS}(\beta_{s_t}^{EMP}) - L_{MS}(\beta^{EMP})]$. The null hypothesis is that the unconstrained model does not fit significantly better than the constrained model.

Table 4: Estimates of the transition matrix parameters

	IDR	KRW	MYR	PHP	SGD	THB	TWD	AMU
α_1	4,48**	-9,597***	-5,199***	0,179	0,013	0,728	-0,449	1,438***
	(2,027)	(0,152)	(1,795)	(0,422)	(0,935)	(0,574)	(0,639)	(0,464)
γ_1^{ssr}	1,315**	6,361***	0,691	-0,112	0,193	-0,02	-0,103	0,604**
	(0,548)	(0,162)	(0,605)	(0,138)	(0,287)	(0,160)	(0,152)	(0,288)
ω_1^{en}	-1,113***	0,062***	-0,074	-0,105	0,091	-8,055	-0,345*	0,19
	(0,378)	(0,001)	(28,378)	(0,126)	(0,145)	(21,018)	(0,189)	(0,150)
λ_1^{RMB}	36,283***	7,218***	9,686**	2,954***	7,297*	2,27*	8,31***	5,019**
	(13,504)	(0,099)	(4,704)	(1,006)	(4,018)	(1,344)	(3,128)	(2,403)
α_2	-1,822	17,957***	-1,174	-1,026*	5,069*	3,357***	-1,604*	3,336***
	(1,692)	(0,355)	(2,088)	(0,573)	(2,563)	(0,886)	(0,914)	(0,762)
γ_2^{ssr}	-0,886*	0,588***	-1,835*	-0,517**	0,579	0,294	-0,327*	0,222**
	(0,489)	(0,002)	(0,981)	(0,214)	(0,419)	(0,185)	(0,190)	(0,109)
ω_1^{en}	-0,325	1,04***	3,023	-0,646**	0,962*	4,804	0,036	0,344***
	(0,248)	(0,006)	(26,791)	(0,254)	(0,559)	(17,322)	(0,109)	(0,122)
λ_2^{RMB}	-3,008***	-22,946***	-2,393	-1,55*	-2,647*	-5,552**	-2,202**	-1,692*
	(1,036)	(0,286)	(2,203)	(0,931)	(1,515)	(2,418)	(0,986)	(0,956)
k	1	1	1	3	4	2	2	2
LL	-263,234	-268,759	-234,811	-207,238	-194,932	-226,666	-173,483	-209,404
LR Stat	24,063	12,626	14,871	16,267	22,045	12,469	23,766	15,634
p-value	[0,001]	[0,049]	[0,021]	[0,012]	[0,001]	[0,052]	[0,001]	[0,016]
MP(11)	0,411	0,000	0,053	1,454	3,648	0,889	3,769	1,128
ZM(11)	-0,123	1,330	0,537	-0,061	-0,002	-0,321	0,054	-0,287
MP(22)	0,474	0,000	0,675	0,492	0,017	0,193	0,426	0,060
ZM(22)	-0,606	0,783	-0,491	-0,662	1,915	0,605	-0,728	1,972

Notes: This table presents the estimated transition matrix parameters of the TVTP-MS models. Here, the parameters of Eqs. (1) and (4) have been estimated simultaneously, but the RMB enters now as an explanatory variable in the transition matrix. The parameters of Eq. (1) are not reported to conserve space but are available on request. The LR test aims to test whether the TVTP-MS outperforms the FTP-MS. The LR test statistic is computed as follows: $LR = 2\times[LL_{TVTP-MS}(\Theta) - LL_{FTP-MS}(\Theta)]$ with Θ, the parameters of the model. The null hypothesis is that the TVTP-MS model does not fit significantly better than the FTP-MS model. *,**,*** denote significance at 10, 5 and 1 %, respectively. Standard errors of parameters are reported in parentheses (.), while p-values are displayed in brackets [.].

Table 5: Estimates of economic determinants

	IDR	MYR	PHP	SGD	TWD	THB	KRW
Regime-switching variances:							
Regime 1							
σ_1	0,041***	0,014***	0,015***	0,013***	0,012***	0,015***	0,027***
	(0,002)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Regime 2							
σ_2	0,013***	0,002***	0,002***	0,001***	0,004***	0,002***	0,001***
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
Regime-dependent factors:							
Regime 1							
esi	-6,7	0,133	-0,398	0,325*	0,958	1,089***	0,938
	(6,848)	(0,402)	(0,417)	(0,188)	(0,696)	(0,271)	(0,713)
X	-0,047	-0,002	-0,002	-0,007	0,013	-0,018*	-0,043**
	(0,044)	(0,007)	(0,008)	(0,007)	(0,008)	(0,009)	(0,018)
M	0,053	0,004	0,035***	0,007	-0,008	0,019**	0,076***
	(0,046)	(0,008)	(0,009)	(0,007)	(0,008)	(0,007)	(0,016)
pf		-0,011	0,007	-0,007		0,014	-0,013
		(0,016)	(0,027)	(0,078)		(0,014)	(0,011)
$fdix$	0,781*	-0,103*	-0,394***	0,074	0,021	0,01	-0,427*
	(0,447)	(0,057)	(0,092)	(0,083)	(0,076)	(0,012)	(0,242)
$fdim$	-0,035	-0,014	-0,01	-0,021		0,001	0,017
	(0,122)	(0,028)	(0,013)	(0,016)		(0,009)	(0,017)
Regime 2							
esi	1,901**	0,232***	-0,771***	0,628***	-1,717**	-6,415***	1,283***
	(0,842)	(0,012)	(0,142)	(0,005)	(0,680)	(0,043)	(0,008)
X	-0,006	-0,03***	-0,005**	0,005***	-0,041***	-0,114***	-0,065***
	(0,005)	(0,0002)	(0,002)	(0,0003)	(0,005)	(0,001)	(0,0001)
M	0,019***	0,019***	0,017***	0,02***	0,06***	-0,006***	0,044***
	(0,005)	(0,0002)	(0,004)	(0,0002)	(0,008)	(0,0005)	(0,0001)
pf		-0,005***	0,251***	0,124***		0,033***	-0,029***
		(0,0004)	(0,011)	(0,002)		(0,0004)	(0,001)
$fdix$	0,055	0,048***	-0,157***	0,049***	-0,175***	0,002***	1,004***
	(0,047)	(0,004)	(0,036)	(0,002)	(0,049)	(0,0005)	(0,001)
$fdim$	(0,036)	(-0,041***)	(-0,04***)	(-0,031***)		(-0,117***)	(0,057***)
	0,033	0,001	0,004	0,0004		0,001	0,0001
LL	283,373	280,672	281,262	354,416	362,729	331,496	263,653

Notes: This table shows the influence of economic factors on RMB exchange rates. Here, each regime is characterized by its proper variance. The estimates esi, X, M, pf, $fdix$ and $fdim$ correspond to correlations associated with the export similarity index between China and the other East Asian countries, exports to China, imports from China, portfolio investment outflows to China, FDI outflows to China and FDI inflows from China, respectively. *,**,*** denote significance at 10, 5 and 1 %, respectively.

Figure 1: Regime probabilities of the Philippine Peso

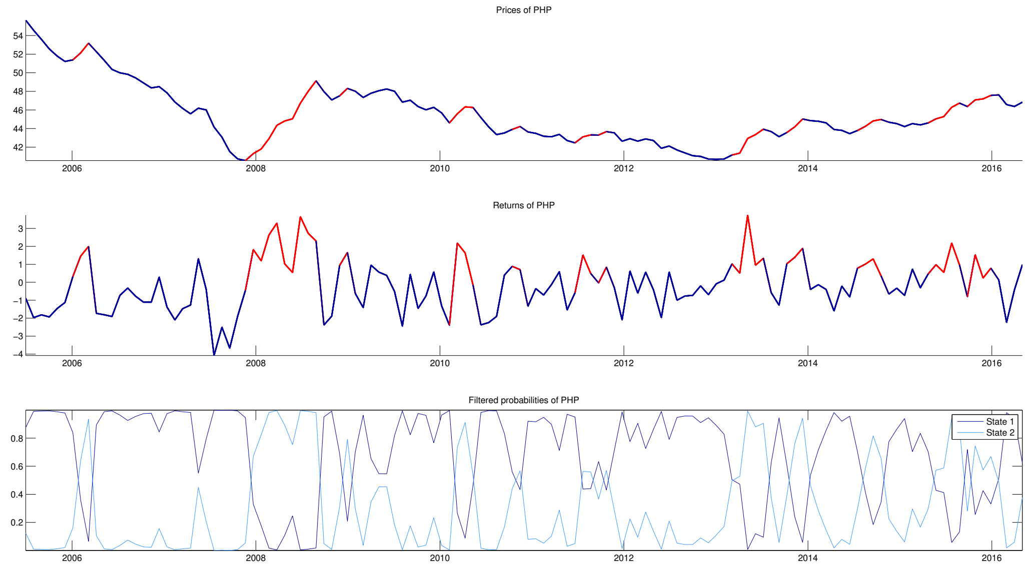


Figure 2: Regime probabilities of the Malaysian Ringgit

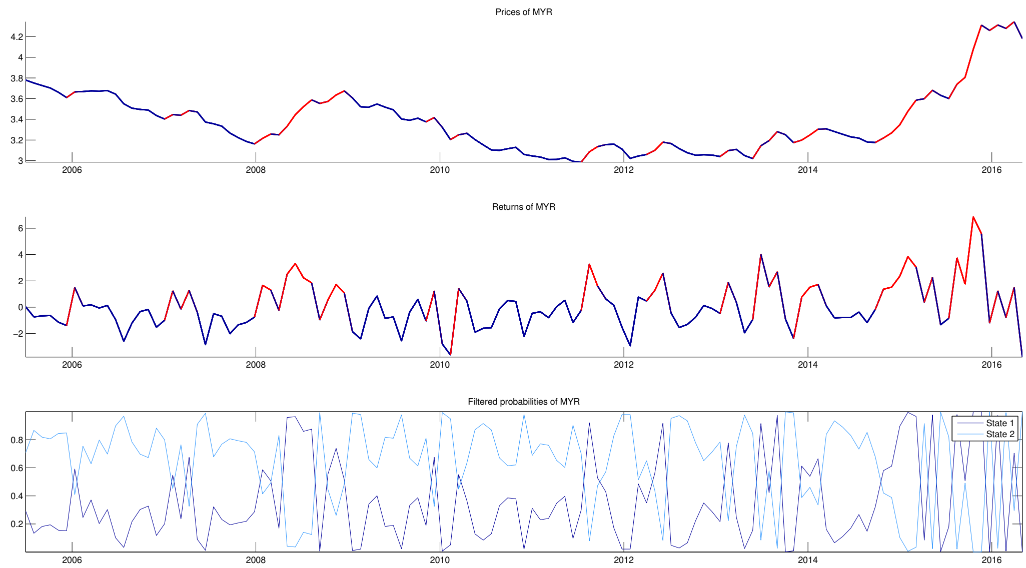


Figure 3: Regime probabilities of the Singapore Dollar

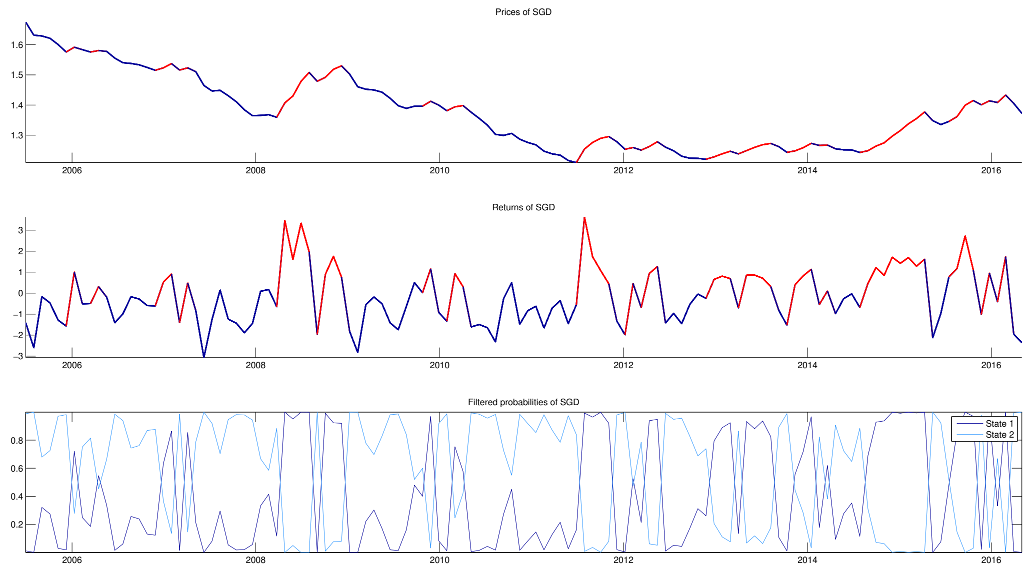


Figure 4: Regime probabilities of the Taiwanese Dollar

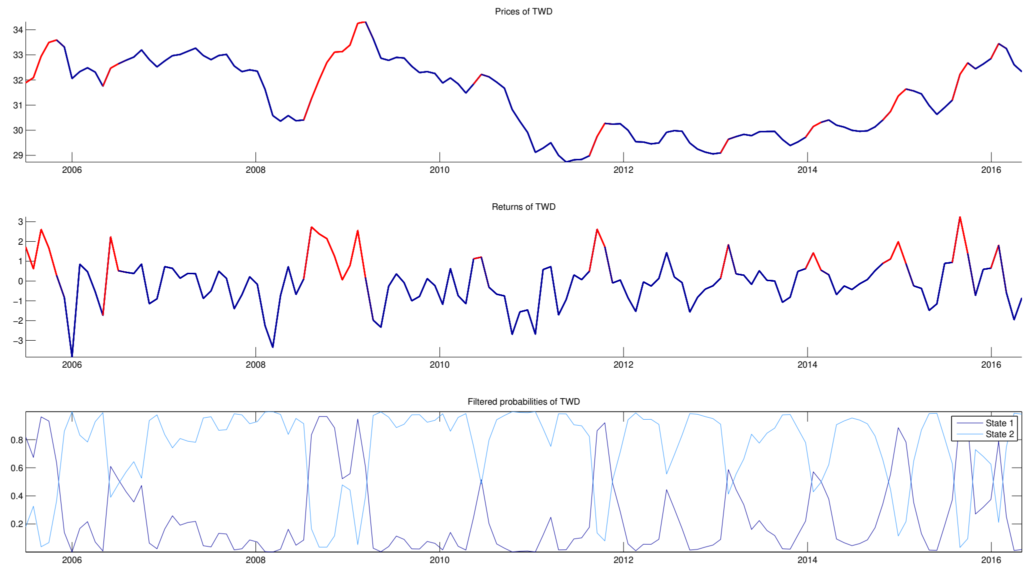


Figure 5: Regime probabilities of the Chinese Renminbi

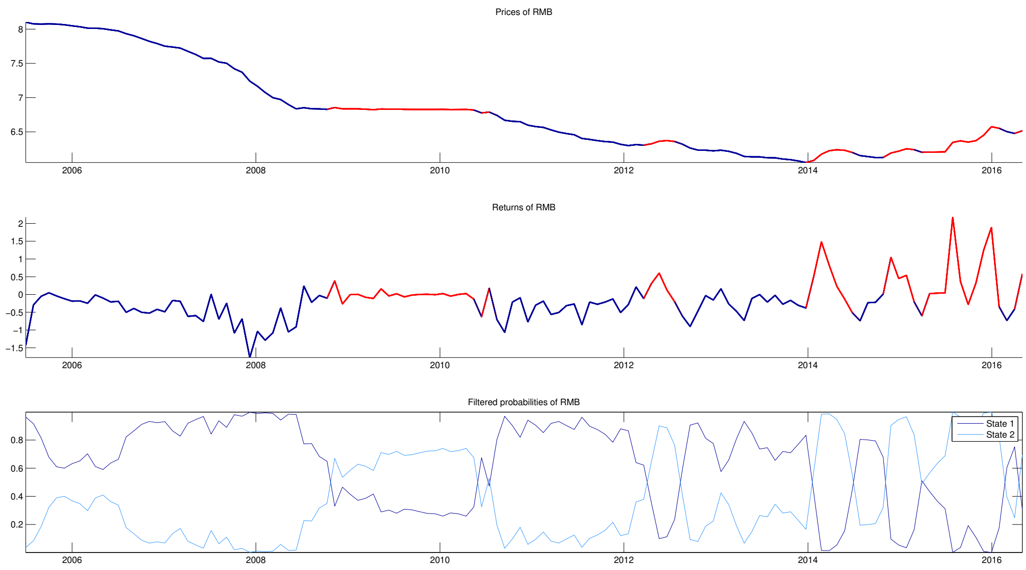


Figure 6: Regime probabilities of the Thai Bath

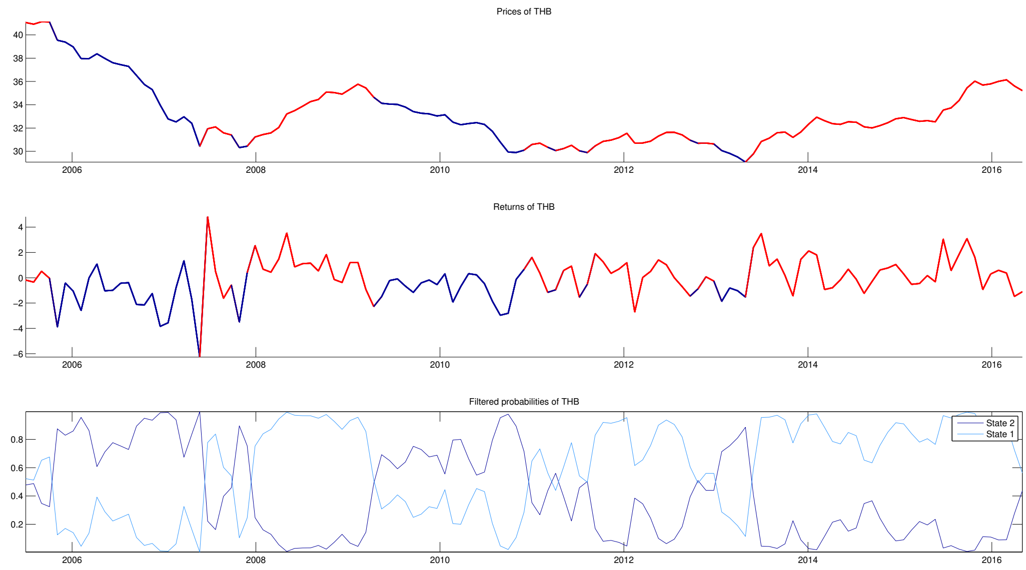


Figure 7: Regime probabilities of the Korean Won

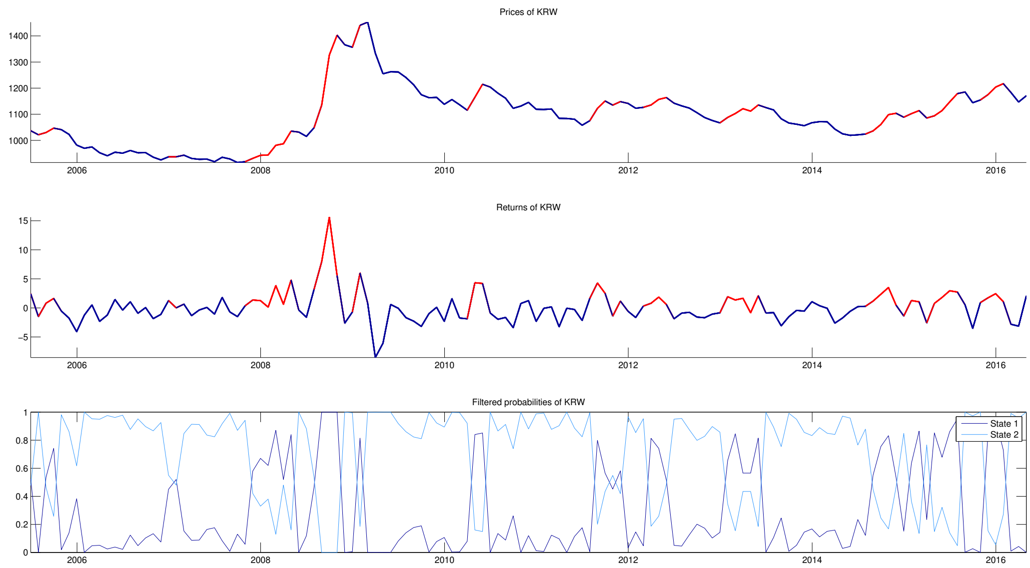


Figure 8: Regime probabilities of the Indonesian Rupiah

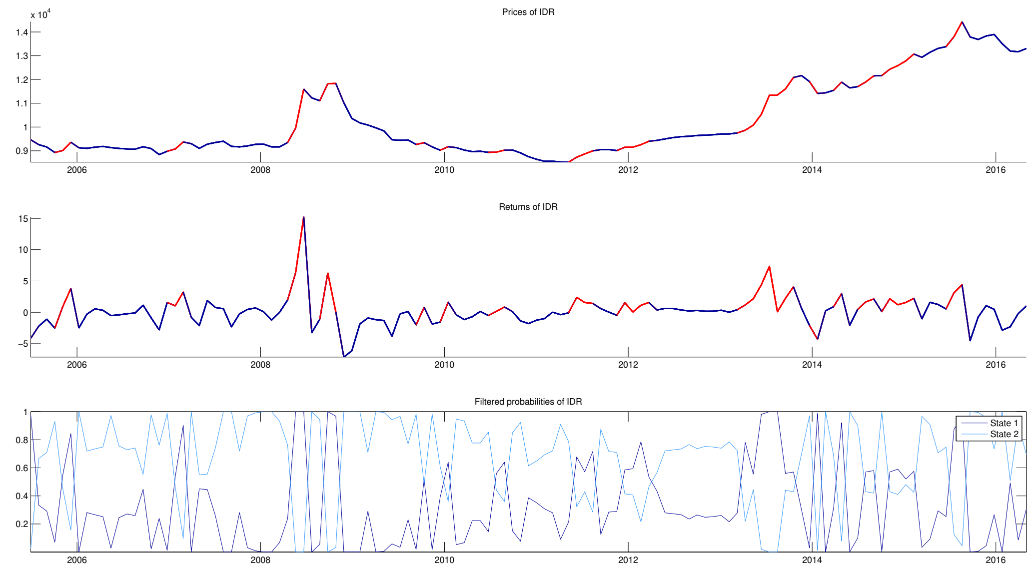


Figure 9: Regime probabilities of the AMU

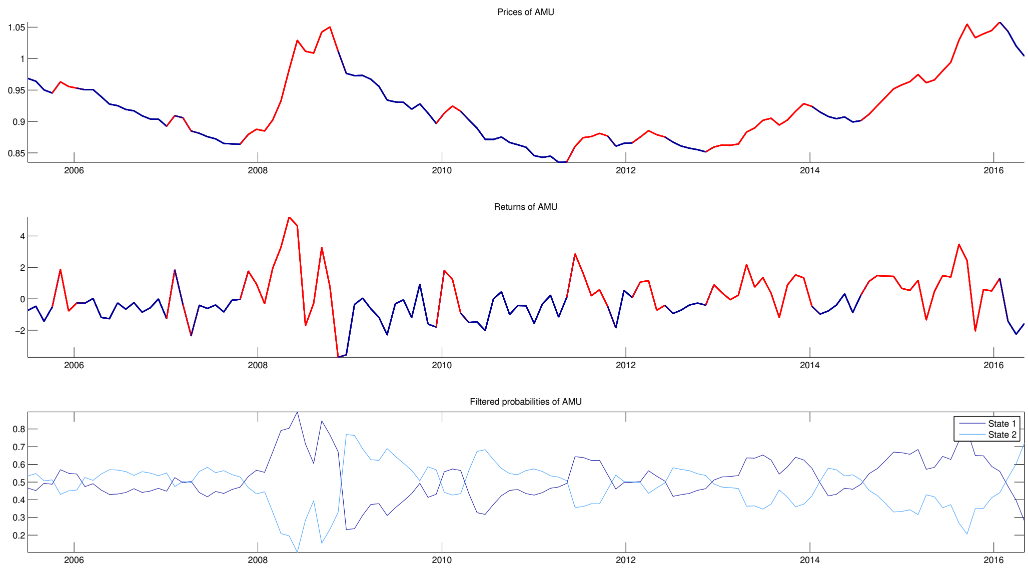
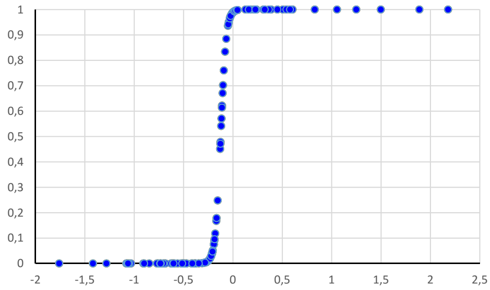
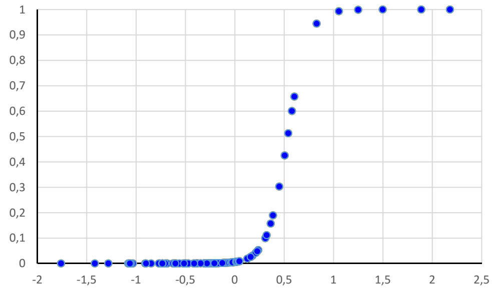


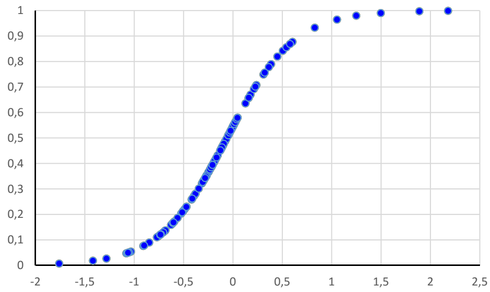
Figure 10: Probabilities to stay in the depreciation regime (P_{11t}) according to RMB's variations



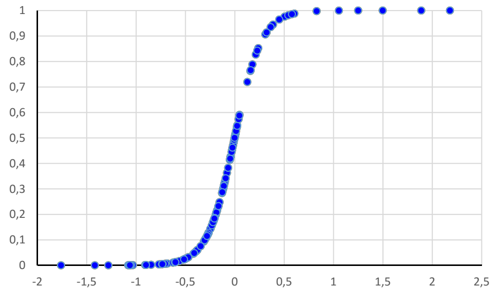
(a) Indonesian Rupiah



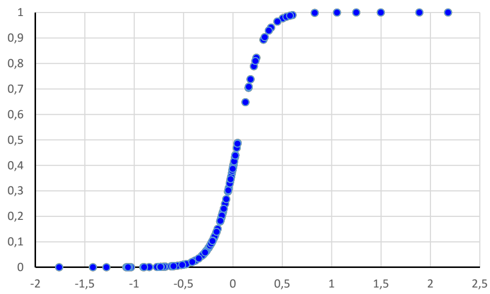
(b) Malaysian Ringgit



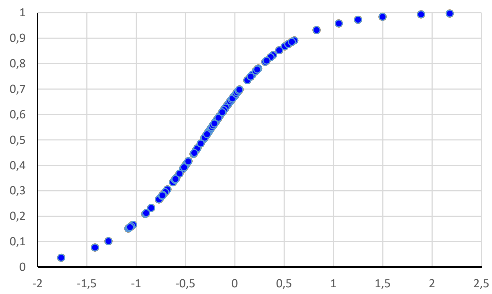
(c) Philippine Peso



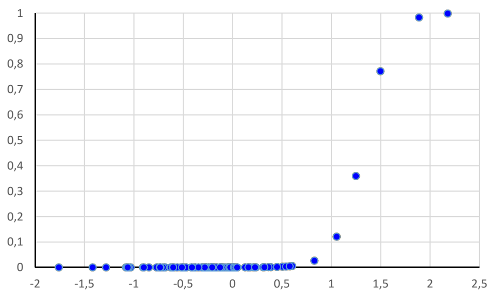
(d) Singapore Dollar



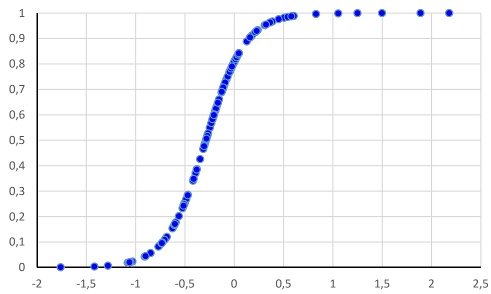
(e) Taiwanese Dollar



(f) Thai Bath

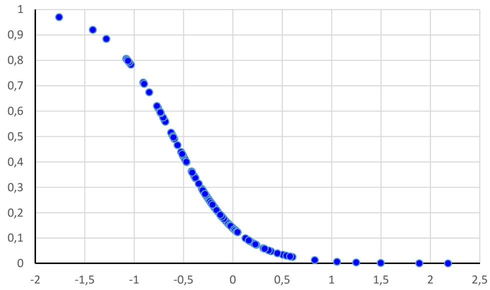


(g) Korean Won

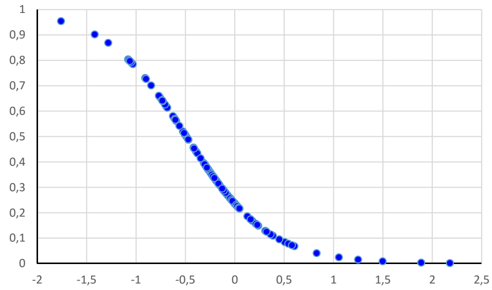


(h) Asian Monetary Unit

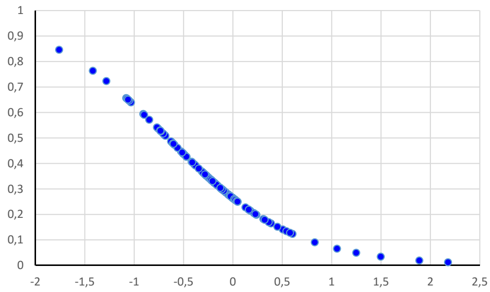
Figure 11: Probabilities to stay in the appreciation regime (P_{22t}) according to RMB's variations



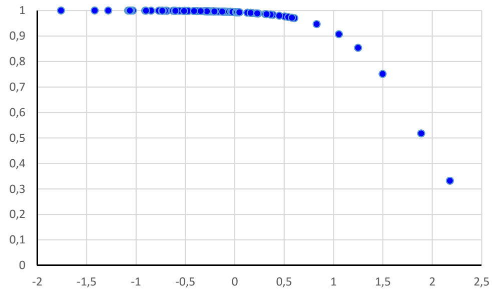
(a) Indonesian Rupiah



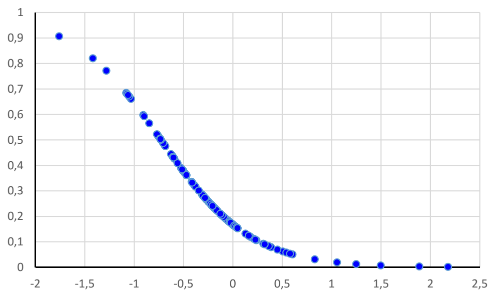
(b) Malaysian Ringgit



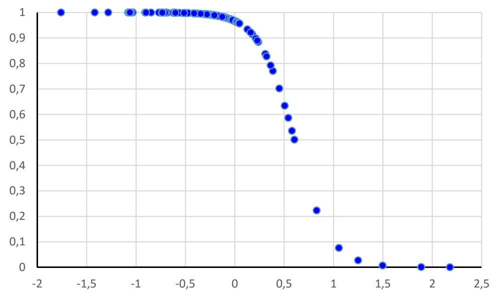
(c) Philippine Peso



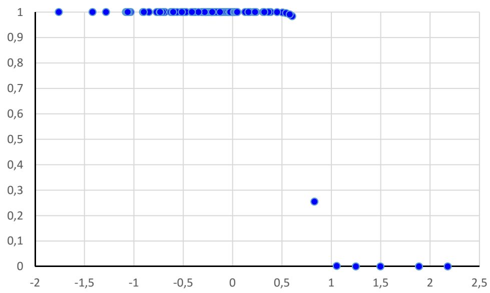
(d) Singapore Dollar



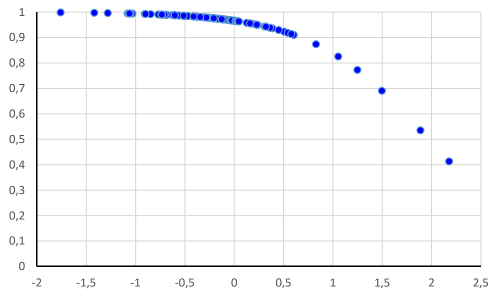
(e) Taiwanese Dollar



(f) Thai Bath

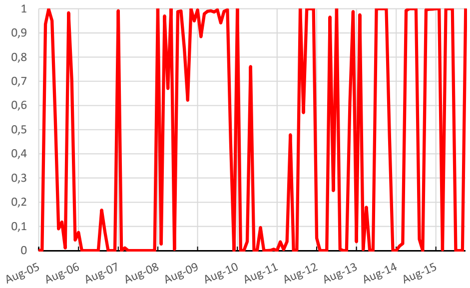


(g) Korean Won

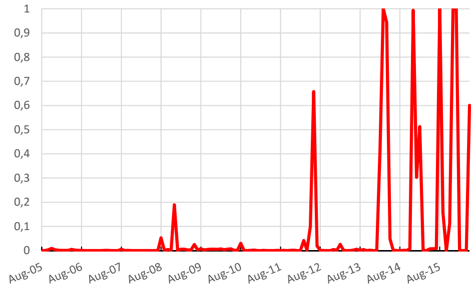


(h) Asian Monetary Unit

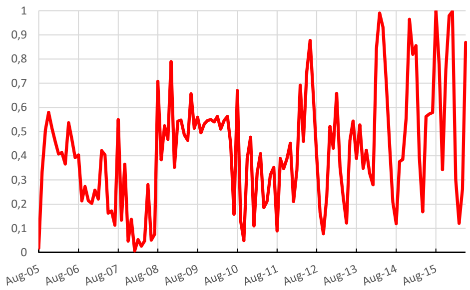
Figure 12: Time-varying transition probabilities (P_{11t})



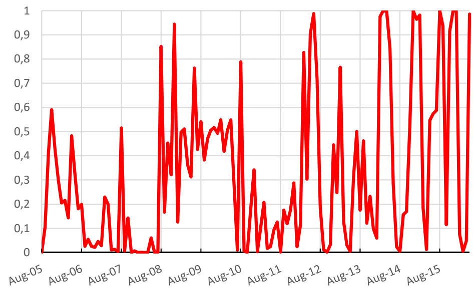
(a) Indonesian Rupiah



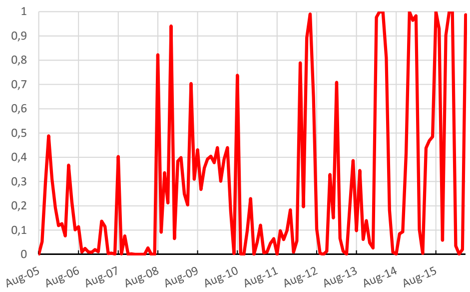
(b) Malaysian Ringgit



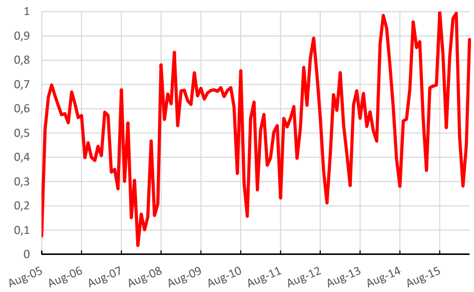
(c) Philippine Peso



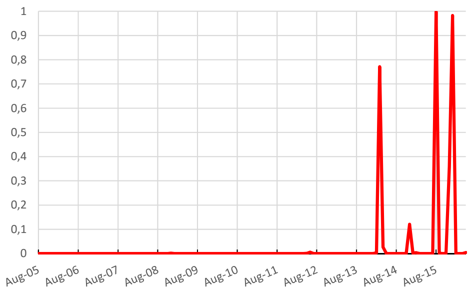
(d) Singapore Dollar



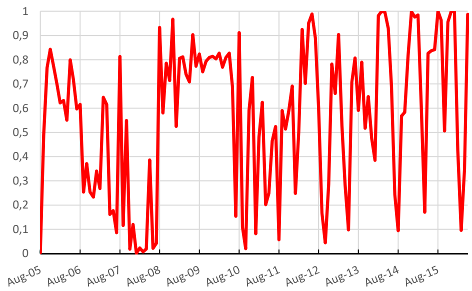
(e) Taiwanese Dollar



(f) Thai Bath

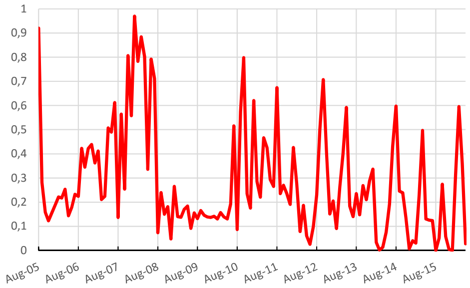


(g) Korean Won

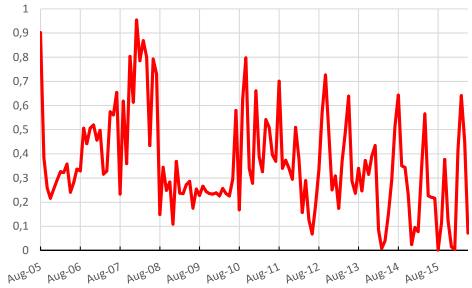


(h) Asian Monetary Unit

Figure 13: Time-varying transition probabilities (P_{22t})

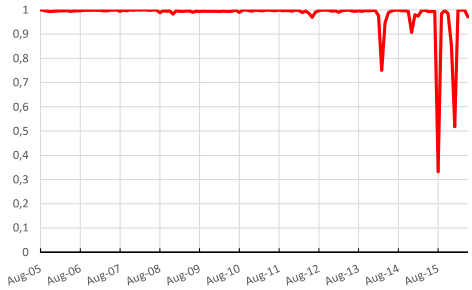


(a) Indonesian Rupiah

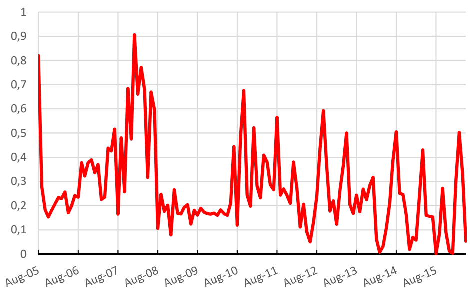


(b) Malaysian Ringgit

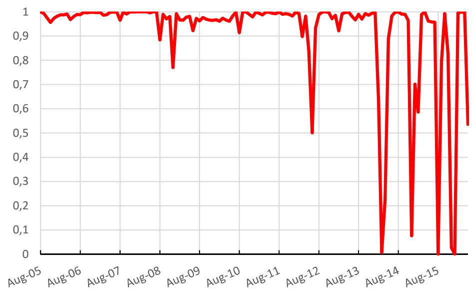
(c) Philippine Peso



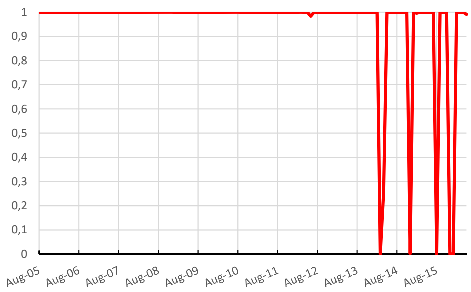
(d) Singapore Dollar



(e) Taiwanese Dollar



(f) Thai Bath



(g) Korean Won

(h) Asian Monetary Unit

Figure 14: Regime probabilities of the Malaysian Ringgit

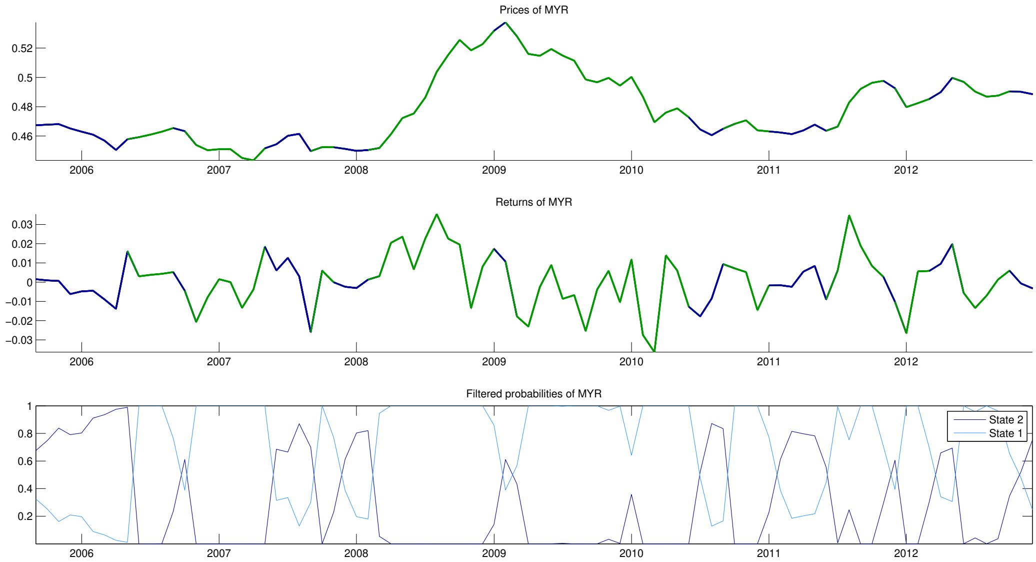


Figure 15: Regime probabilities of the Indonesian Rupiah

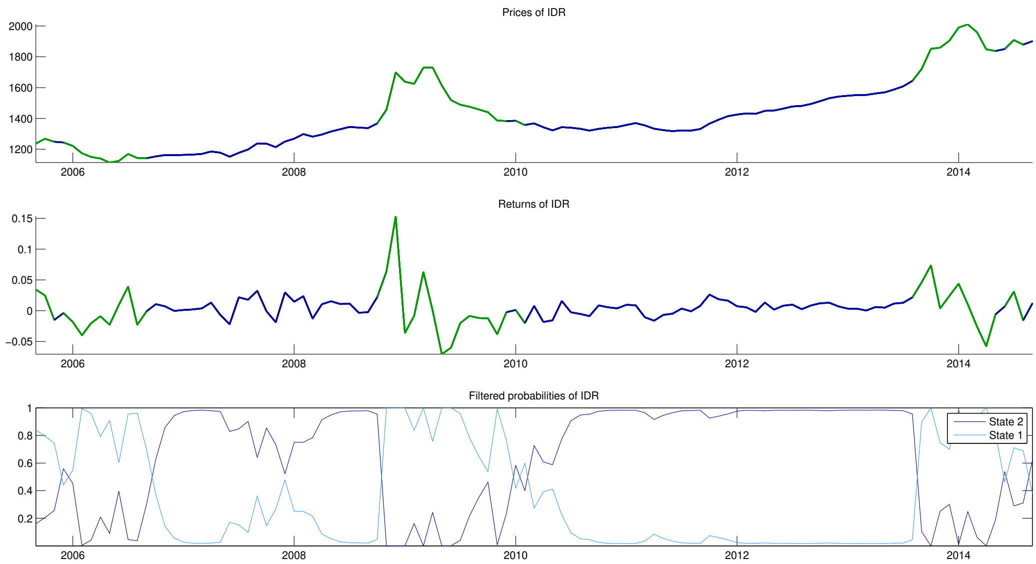


Figure 16: Regime probabilities of the Korean Won

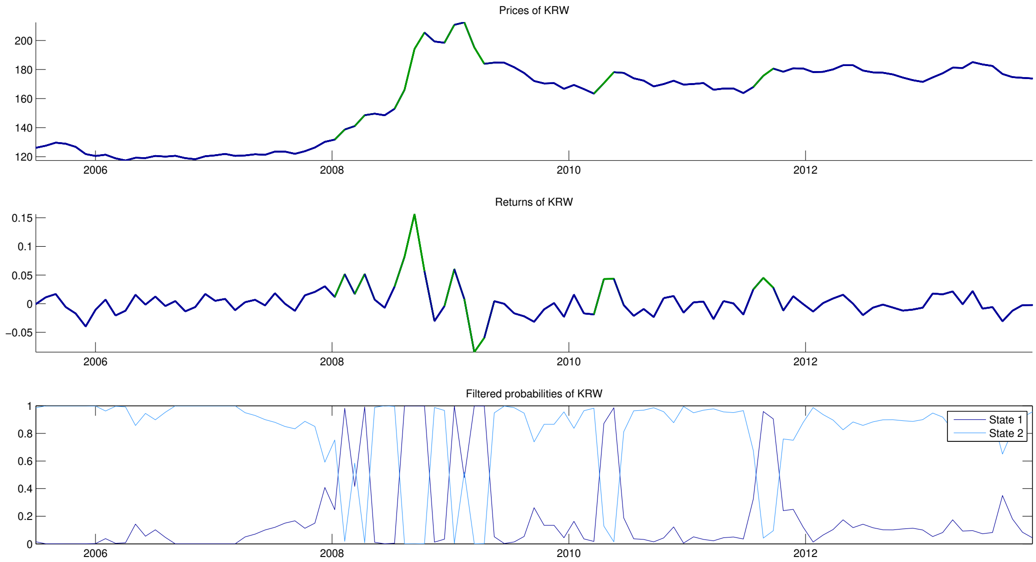


Figure 17: Regime probabilities of the Singapore Dollar

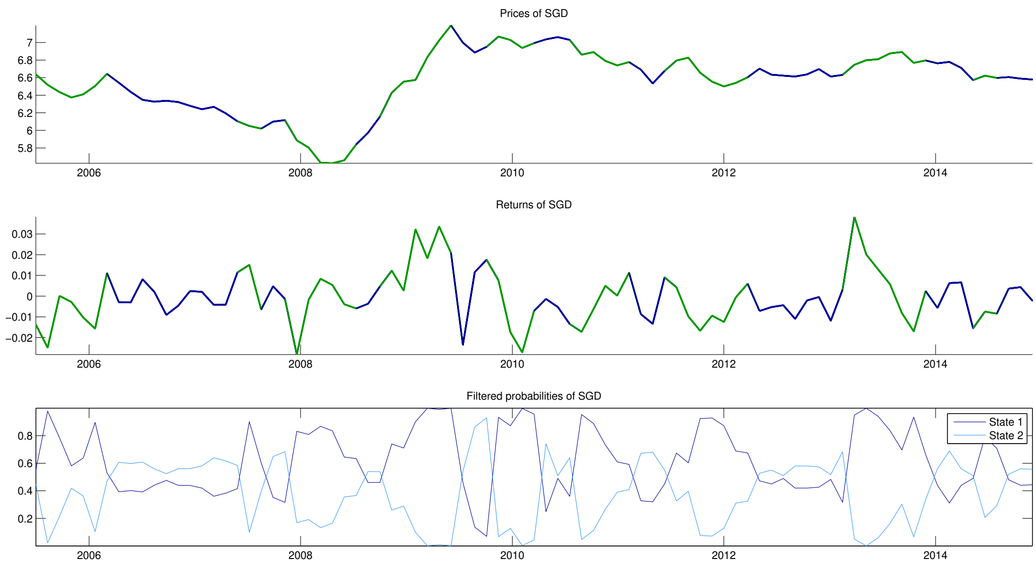


Figure 18: Regime probabilities of the Philippine Peso

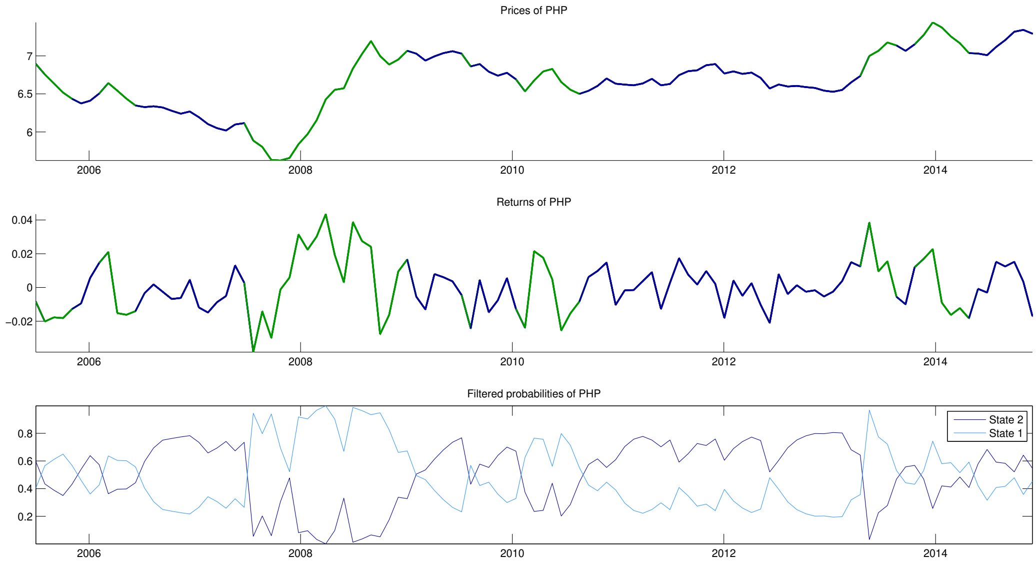


Figure 19: Regime probabilities of the New Taiwanese Dollar

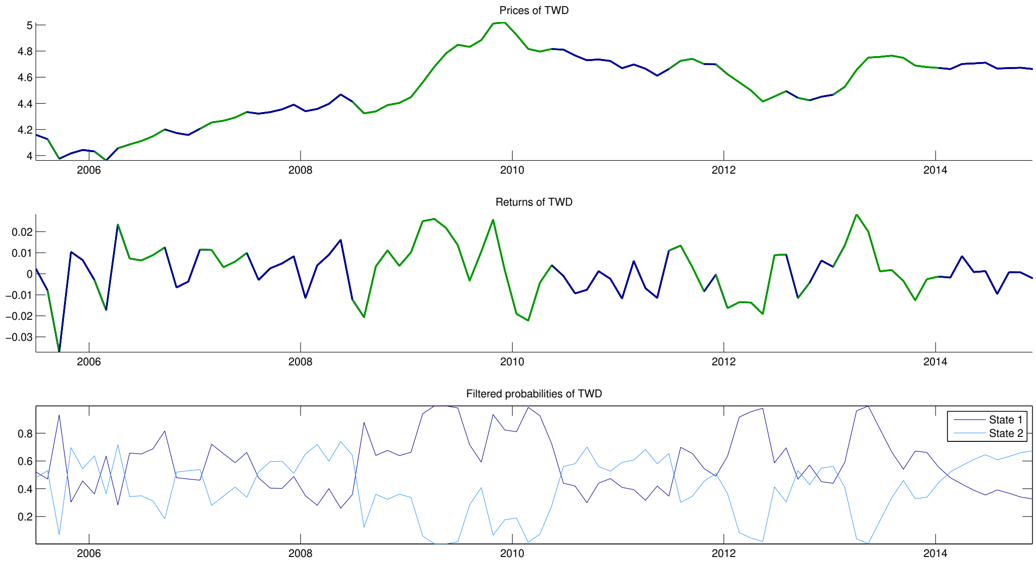


Figure 20: Regime probabilities of the Thai Bath