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Assessment on estimations of currency basket weights—With coefficient correction for common factor dominance

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Abstract

This paper proposes an approach to correcting parameter misrepresentation under the dominance of a common factor, a customarily overlooked phenomenon. Meanwhile, it provides a general solution to a specific regression bias, namely coefficient correction for common factor dominance in econometrics, which is commonly encountered in the research on currency interactions and co-movements and beyond. The RMB basket weights are then scrutinized exhaustively, going through all stages of the evolving RMB regime and reforms. Correct and sensible currency basket weights are derived accordingly. It has been found that only the introduction of the central parity regime in 2015 has changed the RMB exchange rate patterns notably. The RMB market behavior and patterns virtually did not change during the prior reforms that had widened the band of daily fluctuation in the RMB exchange rate against the US dollar from 0.3% through to 2%, given the band's unique link to the US dollar.

KEYWORDS

exchange rate, RMB, RMB regime

1 | INTRODUCTION

The distribution of currency weights in a currency basket indicates the degree of flexibility of the currency on the foreign exchange market. Comprehending the flexibility of currencies is pertinent, particularly against a backdrop that many currencies adopt soft pegs of varied degrees of flexibility, mostly to the US dollar and to a lesser extent, the euro, alongside floating currencies. Moreover, the de jure arrangements as described by the countries and the de facto arrangements can differ, as documented by International Monetary Fund (IMF) in various issues of the *Annual Report on Exchange Arrangements and Exchange Restrictions* (IMF, 2018a). This is reinforced by Reinhart (2000) who observes that countries say they allow their exchange rate to float mostly do not. Therefore, currency basket weights need to be estimated, objectively. De facto arrangements could be reflected by the currency basket weights to a certain extent, whereas de facto arrangements do matter. For example, that the lack of exchange rate depreciation in the fixed exchange rate regime is accompanied by a stronger fall in exports than non-fixed exchange rate regimes is one of the three adverse findings for fixed exchange rate arrangements in Zeev (2019). It is also documented in Reinhart (2000) that the low relative exchange rate variability leads to very

high reserve volatility. Levy-Yeyati and Sturzenegger (2003) study the relationship between exchange rate regimes and economic growth. Their findings strongly suggest that exchange rate regimes indeed matter in terms of real economic performance for nonindustrial countries. Fixed exchange rate regimes are found to be connected with slower growth rates and higher output volatility.

The issue examined in this paper stems specifically from the custom of currency baskets for foreign exchange rate management and exchange rate regimes. The paper probes into a customarily overlooked phenomenon when two or more independent variables are linearly correlated. It is different from multi-collinearity—the independent variables do not even have to be highly correlated. Rather, the correlation and the resulting regression coefficient consist of two components that can be partitioned, under the influence of a kind of prevailing custom, theory or institution. It arises from the circumstance when two or more independent variables share a common factor. The common factor is embedded in one of them that dominates over the rest. The effect on the dependent variable of the common factor would partly shifted from the common factor instigator to the bearers wrongly, with other distortions potentially.

On occasions, monetary authorities adopting various pegs—conventional pegged arrangement, pegged exchange rate within horizontal bands, stabilized arrangement, crawling peg and crawl-like arrangement—would like their exchange rate to be formed, or be perceived to be formed, with the reference to a basket of currencies, instead of one currency that is usually the US dollar, only. The US dollar mostly accounts for the largest share in the currency basket, sometimes larger than the sum of shares of the rest. So the US dollar is a dominant currency in the basket. When certain other currencies in the basket are closely linked to the US dollar, a common factor comes into existence where the US dollar plays a role of dominant common factor.

Thus the purpose of the paper is twofold: correcting a particular estimation bias in econometrics on the one hand, which can evoke inquiries that involve the same issue in other fields; and ultimately deriving correct, sensible estimates for the weights of constituent currencies in a currency basket on the other. This constitutes two major contributions to the literature. By identifying the definite cause to the distortion that is accordingly removed, the paper helps improve our knowledge and understanding in currency basket construct. Meanwhile, it provides a general solution to a specific regression bias, namely coefficient correction for common factor dominance in econometrics. Empirical investigations are carried out mostly for the RMB currency basket in this paper. However, the solution provided, and the procedure developed, in this paper can be used for other currency baskets research as well.

The RMB is chosen since its exchange rate arrangements are of significant importance and relevance to the global economy. China has transpired as a leading emerging power over the last two decades. The country holds the second largest economy in the world and matches the Eurozone economy as a whole. The GDP figures for China, the Eurozone economy and the US in 2019 are 14,341 billion US dollar (99,087 billion yuan), 13,336 billion US dollar (11,913 billion euros) and 21,428 billion US dollar respectively (Organisation for Economic Co-operation and Development, 2020). PPP adjusted, China's GDP has overtaken that of the US since 2014. It is estimated that the PPP adjusted GDP for China increased from 16,725 billion US dollars in 2013 to 18,285 billion US dollars in 2014, while that for the US increased from 16,785 US dollars in 2013 to 17,522 US dollars in 2014; and China's PPP adjusted GDP remained higher than that of the US ever since (IFM, 2018b). China's international undertakings are enormous and momentous. Its international trade is phenomenal, accounting for 9.7% of the world total exports in 2019 (IMF, 2020). Meanwhile, China's overseas investment has been getting momentum, with its share of direct investment assets abroad in the world increasing from 1.5% in 2005 to around 4.0% in 2018–2019 (ibid). Effective from October 1, 2016, the RMB has been included in the SDR basket and assigned a weight of 10.92% behind the US dollar and euro while ahead of the Japanese yen and sterling (IMF Communications Department, 2016). This has effectively acknowledged the importance of the RMB to the global economy that the RMB is now the world's third largest currency. Thus, a better understanding of how the RMB works has become particularly relevant at a time when the RMB has been expected to play a greater role on the global stage to sustain real activities in the world.

The rest of the paper proceeds as follows. Research on exchange rate co-movements is reviewed in the next section. Then a review of RMB regime reforms is presented in Section 3, together with the corresponding prior research along the timeline of the reforms. Section 4 outlines the economic setting and demonstrates the implanted statistical problem, while Section 5 provides an econometric solution to the problem. A prelude prior to the main empirical analysis is presented in Section 6 for observing some facts and constraints in foreign exchange markets, which help understand currency co-movements and the extent to which currencies can un co-move. The main empirical work is carried out in Section 7 that implements empirical assessment and

presents case results and analysis. Finally, Section 8 summarizes the study.

2 | REVIEW OF EXCHANGE RATE CO-MOVEMENTS

The associations and interactions between exchange rates have been examined time and again, where the US dollar plays an anchor role usually but with its dominance diminishing slowly. One common approach is regression analysis for basket weight estimation and currency co-movements. Frankel and Xie (2010) and Frankel and Wei (2007) are typical of basket weight assessment where the US dollar is the dominant currency, keeping to their own approach proposed in 1994. Several studies have followed this line of inquiry, including Fang, Huang, and Niu (2012), Cui (2014), and Shimizu and Sato (2018). A few have investigated the extent to which selected currencies are linked in terms of co-movements. On the other hand, McCauley and Shu (2019) examine the co-movement of emerging market exchange rates with the euro, yen and RMB without weights notions. Similarly, Keddad (2019) investigates the co-movements of seven East Asian currencies with the euro, yen and RMB with a Markov switching model. Both of above studies focus on the RMB, though the euro and yen are included, playing an auxiliary role in the modelling.

There are two categories of research on currency basket weights involving the RMB—the weights of the constituent currencies in the RMB basket, and the weight of the RMB in other currencies' baskets. The RMB is the dependent variable in the former, and it is one of the independent or explanatory variables in the latter. Cui (2014) is in the former where the sample period is divided into three sub-periods of pre-crisis: January 1, 2007–June 30, 2008, during crisis: July 1, 2008–June 30, 2010 and post-crisis: July 1, 2010–March 30, 2013. Eleven currencies declared by People's Bank of China (PBOC) as the constituent currencies are included in the estimation of their weights in the RMB basket. His results, adopting the Frankel-Wei regression, indicate that the weight of the US dollar in the RMB currency basket is the highest in the second sub-period with a value of 0.901, suggesting that the RMB is pegged to the US dollar. The weight of the US dollar in the third sub-period is 0.802, the lowest, and the weight is 0.861 for the whole sample. Overall the Singaporean dollar possesses the next highest weight only second to the US dollar, while few coefficients are statistically significant. The Singaporean dollar adheres to a stabilized arrangement anchored at a group of composite currencies now and then, which explains that the weight of the Singaporean dollar is mostly attributed to its close link to the UD dollar. Using daily data from February 2005 to July 2011, Fang et al. (2012) have estimated the weights of the 11 PBOC declared constituent currencies in the RMB currency basket and the weights of the RMB in the de facto currency baskets of East Asian economies. They plot the median estimates along time together with the 95% probability interval to visualize the time-varying weights. The US dollar is found to be still dominant over other currencies, accounting for 85% of the value change in the RMB on average. The weights of major international currencies other than the US dollar in the basket, the euro, British pound, Japanese yen, Australian dollar and Canadian dollar have fluctuated around zero and been largely confined to a narrow band of ± 0.05. The weight of the Japanese yen is found to be significantly positive only in July 2005, and the weight of pound is once significant at the end of 2008, while the weight of the euro has never turned positive significantly. In contrast, the Malaysian ringgit, Singaporean dollar and Thai baht have been found to exhibit signicantly positive weights, exceeding or close to 0.1, on multiple occasions. The above results coincide with Frankel and Wei (2007), albeit the latter cover a shorter and earlier period between July 22, 2005 and January 8, 2007.

It is unreasonable and unrealistic that the Malaysian ringgit, Singaporean dollar and Thai baht influence the movement of the RMB more than the Japanese yen and euro. Such misrepresentation arises from common factor dominance, which the present study deals with. The Singaporean dollar operates a stabilized arrangement anchored at a group of composite currencies now and then, and the Malaysian ringgit and Thai baht at the time adopted conventional fixed peg arrangements and managed floating with no pre-announced path for the exchange rate. The Singaporean dollar co-moves with the US dollar highly extensively, while changes in the exchange rates of the Malaysian ringgit and Thai baht correlated to the US dollar considerably at the time. Their weights in the RMB currency basket are largely or mostly attributed to the US dollar through their tight co-movements with the US dollar. Avoiding the multicollinearity trap, Shimizu and Sato (2018) include only three large free floating currencies of the US dollar, euro and Japanese yen in their study. They report that the RMB currency basket comprises the US dollar exclusively for the period from August 2008 to December 2016, the weights of the euro and Japanese yen being minimum and insignificant. The weights of the euro and Japanese yen are only significantly positive in the period between July 2005 and July 2008, whereas the weight of the euro is as large as 0.3787, compared with 1.1677 for the weight of the US dollar.

The second category of research examines the influence of the RMB on currency co-movements—the weight of the RMB in other currencies' baskets. In this regard, McCauley and Shu (2019) examine the co-movement of emerging market exchange rates with the euro, yen and RMB for the period from January 1, 2014 to August 1, 2017. They divide the whole period into two sub-periods by August 11, 2015 when the central parity regime was introduced and implemented. Their results suggest that both Asian and non-Asian emerging markets currencies show a greater response to the RMB after August 2015. The RMB coefficient in the Asian currencies' regression model rises from 0.42 to 0.77, being significant in both sub-periods. The increase in the RMB coefficient for the non-Asian currencies is claimed to be even more notable—from statistical insignificance before the central parity regime to a highly significant at 0.97 after August 2015. Employing Markov switching models, Keddad (2019) investigates the degree and nature of exchange rate co-movements between the RMB and seven East Asian currencies over the period from July 2005 to May 2016 at monthly intervals. Evidence is found that clearly supports the notion that the RMB has driven currency movements in East Asia over the last decade.

The problem of multi-collinearity in estimations of the Frankel-Wei regression model for currency basket weights was also noticed in some of previous studies. It is addressed by Kawai and Pontines (2016) systematically. They have proposed and applied a two-step regression approach, summarizing and modifying several previous studies including Balasubramaniam, Patnaik, and Shah (2011) and Fratzscher and Mehl (2014). It works this way. Run the regression of exchange rate changes of the currency that is highly correlated with the US dollar on the US dollar in the first step, storing the residual. Use the first step regression residual as a regressor instead of the exchange rate changes of that currency in the second step regression. There is a hidden trap however, as shown in the Appendix. That approach can correct the coefficient of the US dollar to a certain extent by adding back a fraction of the coefficient of the currency that is highly correlated to the US dollar. The coefficient of the US dollar is thus increased. However, the coefficient of the residual in the second step regression remains the same as the coefficient of the currency it replaces. This causes two problems. The effect of the US dollar is doubly counted to a large extent with this approach, and the effect of the currency that is highly correlated to the US dollar is not corrected at all. The present paper moves forward the contemporary research on interwoven economic connexions and interactions while globalization intensifies. It recognizes and takes on the contemporary custom of the currency market where a common factor exists with the US dollar playing a role of dominant common factor. The US dollar is the common factor instigator, while other currencies sharing the common factor are the bearers of the common factor. The common factor effect is thereby partitioned unambiguously between the common factor instigator and the bearers in the paper via a kind of structural regression.

3 | REVIEW OF RMB REGIME REFORMS

A series of measures to reform the RMB exchange rate arrangements or regime began on July 21, 2005, marked by "*Announcement on Improvement on RMB Exchange Rate Regime*" issued by PBOC (2005). The RMB exchange rate regime in the document was literally the RMB exchange rate configuration mechanism. The RMB exchange rate was fixed to the US dollar prior to that date. The band of daily fluctuation in the RMB exchange rate vis-à-vis the US dollar was set at 0.3%. The band of daily fluctuation in the RMB exchange rate against the US dollar was widened to 0.5% from May 21, 2007, announced PBOC on May 18, 2007 (PBOC, 2007), which was exceeded previously already, albeit occasionally. There was virtually little fluctuation in the RMB exchange rate against the US dollar from July 2008 until June 2010 during the global financial crisis and its aftermath, to reserve financial stability and safeguard the economy from external shocks. Thereafter PBOC announced on April 14, 2012 that the band of daily fluctuation was widened again to 1% from April 16, 2012 (PBOC, 2012), with the global recovery on the horizon. Subsequently it was announced on March 15, 2014 that the band of daily fluctuation in the RMB exchange rate against the US dollar was to be broadened to 2% from March 17, 2014. A new measure, the central parity regime of "closing rate and rate change against a basket of currencies" was introduced and implemented on August 11, 2015 that improved the quotation mechanism of central parity between the RMB against the US dollar (POBC 2016). The mechanism emphasized that the daily central parity quotes of the RMB-dollar exchange rate should refer to the closing rate on the previous day to reflect the changes of market supply and demand. The central parity regime of the RMB against the US dollar of "closing rate and rate change against a basket of currencies" has been shaped and improved since its implementation (PBOC, 2017).

On December 11, 2015, China Foreign Exchange Trade System (CFETS) launched the CFETS RMB

Index, mainly referring to the CFETS currency basket, including RMB yuan versus foreign currency pair listed on CFETS. Thirteen currencies have been included in the CFETS RMB Index first published on December 11, 2015 on its website, with the weight of the US dollar being 26.40% and that of the euro being 21.39% (CFETS, 2015). Additional 11 currencies were added to the index from January 1, 2017. The sum of the weights for newly included currencies was 21.09%, while the weights of the US dollar and the euro dropped to 22.40 and 16.34% thereby (CFETS, 2016a). The CFETS methodology for compiling the index states: "The sample currency weight is calculated by international trade weight with adjustments of re-export trade factors. The sample currency value refers to the daily CNY Central Parity Rate and CNY reference rate (e.g., THB). The baseline date is 31 Dec 2014. The baseline index value is 100 points. The index is calculated by the geometric mean method" (CFETS, 2016b). "If necessary, CFETS will adjust the currency basket to Bank for International Settlements (BIS) Currency Basket RMB Index and SDR Currency Basket RMB Index according to official BIS Currency Basket and SDR Currency Basket" (ibid). The CFETS RMB Index is a kind of trade weighted effective exchange rate, similar to the BIS RMB Index. Yet, its introduction has changed the habit of viewing the strength/weakness of the RMB in sole relation to the US dollar on the one hand. For example, the RMB slightly but steadily appreciated against the US dollar since July 2005 until the eve of the last financial crisis; meanwhile, the RMB depreciated massively against the euro and most floating currencies. Only the former occurrence was observed and reported while the latter episode gone largely disregarded. On the other hand, the CFETS RMB Index gives an impression that the RMB exchange rates vis-à-vis respective foreign currencies in trading are determined with reference to the CFETS currency basket. Still, an index is an index that may be good at measuring the overall strength of a currency. Even if a currency is pegged to the US dollar alone, it can still have a BIS effective exchange rate index that is not fixed but varying over time, which was also the case for the RMB between 1996 and 2005.

It would be worthwhile reviewing the evolution of RMB regime reforms and the related studies while the reforms have progressed. Goldstein and Lardy (2006) have inspected the RMB exchange rate movement in the first 4 months since the start of RMB regime reform in July 2005. They remark "as of mid-December 2005, ... there is little evidence of pegging to a basket; rather, the RMB continues to track the US dollar closely." Looking into several pertinent macroeconomic variables, McKinnon (2006) assesses whether the Japan experience would be repeated by the RMB in the so called "China's exchange rate trap." Adopting the event study methodology, Liu and Pauwels (2012) investigate whether external political pressure for faster RMB appreciation affects both the daily returns and the conditional volatility of the RMB central parity rate. They conclude that the pace of the RMB appreciation is mostly based on domestic policy concerns. They document some evidence that the Sino-US meetings also make the NDF more volatile. Bacchetta, Benhima, and Kalantzis (2014) reflect on an alternative perspective to China's exchange rate policy. Their paper analyzes the optimal exchange rate policy by modelling the central bank as a Ramsey planner. The paper shows that the optimal exchange rate path is close to the one that would result in an economy with full capital mobility and no central bank intervention. Using a pre-central parity regime dataset between January 1, 2000 and September 30, 2013, Kawai and Pontines (2016) demonstrate that the RMB has taken on some importance in the implicit currency baskets of several regional economies in recent years, but not to the extent of supplanting the role of the US dollar as the major anchor currency in the region. Whereas Ryan (2015) claims that the global economy is already close to operating with three exchange rate anchors: the US dollar, the euro and, increasingly, the RMB. The continuing reforms of the RMB regime, especially the introduction of the central parity regime of "closing rate + rate changes in basket currencies" in August 2015, indicate different RMB effects may arise and develop. In this context, Cheung, Hui, and Tsang (2018) study the RMB central parity regime following the August 2015 reform. The effect of the CFETS RMB Index in determining the central parity is only revealed after controlling for multiplicative offshore RMB volatility effects.

4 | THE ECONOMIC SETTING AND THE IMPLANTED STATISTICAL PROBLEM

For simplicity, we keep the number of currencies minimum. The foreign exchange system includes the currency under investigation ¥ that contains the following currencies in its currency basket: the US dollar $; an aggregate of m freely floating currencies Ω; an aggregate of n currencies that are notably linked to $, symbolized by Θ and excluding ¥; and the numeraire currency ₣. The exchange rate, when expressed as $E_{₣/\$}$, indicates the

units of ₣ per \$, which applies to Ω, Θ and ¥ in the same way. As with the methodology of the BIS, the value of the currency in concern is calculated as the geometric weighted average of the bilateral exchange rates in the basket. The ¥ currency basket is therefore expressed as follows:

$$E^{1¥}_{₣/¥,t} = E^{w_{\$}\$}_{₣/\$,t} \cdot E^{w_{\Omega}\Omega}_{₣/\Omega,t} \cdot E^{w_{\Theta}\Theta}_{₣/\Theta,t}, \tag{1}$$

where $w_{\$}$ is the weight of \$, w_{Ω} is the weight of Ω and w_{Θ} is the weight of Θ in the basket. The weights are standardized and are the percentages of one unit of ₣; the standardized weights sum to one. The value of $E^{1¥}_{₣/¥}$ on the left hand side is the units of ₣ that one unit of ¥ can convert to/from, which the value of the right hand side matches up. Taking logarithmic operations yields a linear relationship:

$$e_{₣/¥,t}¥ = e_{₣/\$,t} w_{\$}\$ + e_{₣/\Omega,t} w_{\Omega}\Omega + e_{₣/\Theta,t} w_{\Theta}\Theta, \tag{2}$$

where the exchange rates in lower cases are their corresponding exchange rates in logarithms. Changes in exchange rates are then unit free measures in percentages as follows:

$$\Delta e_{₣/¥,t} = \Delta e_{₣/\$,t} w_{\$} + \Delta e_{₣/\Omega,t} w_{\Omega} + \Delta e_{₣/\Theta,t} w_{\Theta}, \tag{3}$$

which will be the same when ₣ is positioned in the denominator:

$$\Delta e_{¥/₣,t} = \Delta e_{\$/₣,t} w_{\$} + \Delta e_{\Omega/₣,t} w_{\Omega} + \Delta e_{\Theta/₣,t} w_{\Theta}. \tag{4}$$

Note the exchange rate between the ¥ and ₣ is the product of the exchange rate between the ¥ and \$ and that between \$ and ₣:

$$E_{¥/₣,t} = E_{¥/\$,t} \cdot E_{\$/₣,t}. \tag{5}$$

It becomes the sum of the two latter rates in logarithms:

$$e_{¥/₣,t} = e_{¥/\$,t} + e_{\$/₣,t}. \tag{6}$$

So are the changes:

$$\Delta e_{¥/₣,t} = \Delta e_{¥/\$,t} + \Delta e_{\$/₣,t}. \tag{7}$$

Other exchange rates can also be decomposed similarly. This provides a base for analysis that exposes a hidden problem and offers a corrective solution.

$$\begin{aligned}
Cov\left(\Delta e_{\Theta/₣,t}, \Delta e_{¥/₣,t}\right) &= Cov\left(\Delta e_{\Theta/₣,t}, \Delta e_{¥/\$,t} + \Delta e_{\$/₣,t}\right) \\
&= Cov\left(\Delta e_{\Theta/₣,t}, \Delta e_{¥/\$,t}\right) + Cov\left(\Delta e_{\Theta/₣,t}, \Delta e_{\$/₣,t}\right) \\
&= Cov\left(\Delta e_{\Theta/\$,t} + \Delta e_{\$/₣,t}, \Delta e_{¥/\$,t}\right) + Cov\left(\Delta e_{\Theta/₣,t}, \Delta e_{\$/₣,t}\right) \\
&= Cov\left(\Delta e_{\Theta/\$,t}, \Delta e_{¥/\$,t}\right) + Cov\left(\Delta e_{\$/₣,t}, \Delta e_{¥/\$,t}\right) \\
&\quad + Cov\left(\Delta e_{\Theta/₣,t}, \Delta e_{\$/₣,t}\right) \\
&= Cov\left(\Delta e_{\Theta/\$,t}, \Delta e_{¥/\$,t}\right) - Cov\left(\Delta e_{₣/\$,t}, \Delta e_{¥/\$,t}\right) \\
&\quad + Cov\left(\Delta e_{\Theta/₣,t}, \Delta e_{\$/₣,t}\right).
\end{aligned} \tag{8}$$

The last term on the right side is the common factor of \$ borne by Θ in the general market represented by ₣. It is sizeable, given that Θ is highly correlated with the common factor instigator \$, by which it is dominated over. Whereas the second term is the general market association of ¥ through \$. They must not be concealed in $Cov(\Delta e_{\Theta/₣,t}, \Delta e_{¥/₣,t})$, being mingled with other correlation elements.

5 | AN ECONOMETRIC SOLUTION

The above economic setting and its analysis reveal a structural common factor on the currency market where the US dollar is the common factor instigator that dominates over the common factor bearers. The common factor effect can be partitioned unambiguously between the instigator and the bearer, so there is the following proposition.

Proposition 1 There exist unambiguously partitionable common factor effects on the foreign exchange market where common factor dominance prevails and the US dollar, as common factor instigator, dominates over common factor bearers.

The partition of the common factor effect can be achieved through a kind of structural regression. The estimation equation is specified as follows:

$$\Delta e_{¥/₣,t} = \beta_0 + \beta_{\$} \Delta e_{\$/₣,t} + \beta_{\Omega} \Delta e_{\Omega/₣,t} + \beta_{\Theta} \Delta e_{\Theta/₣,t} + \varepsilon_t, \tag{9}$$

$\varepsilon_t \sim iid(0, \sigma^2)$, $t = 1, 2, \ldots T$.

A condensed matrix representation is:

$$\boldsymbol{y} = \boldsymbol{X\beta} + \boldsymbol{\varepsilon}, \tag{10}$$

with

$\boldsymbol{y} = \boldsymbol{\Delta e_{¥/₣}} = \boldsymbol{\Delta e_{¥/\$}} + \boldsymbol{\Delta e_{\$/₣}}$ (T × 1)

$\boldsymbol{X} = [\boldsymbol{1}\ \boldsymbol{\Delta e_{\$/₣}}\ \boldsymbol{\Delta e_{\Omega/₣}}\ \boldsymbol{\Delta e_{\Theta/₣}}]$ (T × K)

$\boldsymbol{\beta} = [\beta_0\ \ \beta_\$\ \ \beta_\Omega\ \ \beta_\Theta]'$ (K×1)

K = m + n + 2, is the number of regressors including the intercept. The estimated coefficients are derived as follows:

$$\boldsymbol{b} = (\boldsymbol{X}'\boldsymbol{X})^{-1}\boldsymbol{X}'\boldsymbol{y} = (\boldsymbol{X}'\boldsymbol{X})^{-1}\left[\boldsymbol{1}\ \boldsymbol{\Delta e}_{\$/₣}\ \boldsymbol{\Delta e}_{\Omega/₣}\ \boldsymbol{\Delta e}_{\boldsymbol{\Theta}/₣}\right]'\boldsymbol{\Delta e}_{¥/₣}$$

$$= (\boldsymbol{X}'\boldsymbol{X})^{-1}\begin{bmatrix} (\boldsymbol{J}_{\boldsymbol{1},\boldsymbol{T}})'\cdot\boldsymbol{\Delta e}_{¥/₣} \\ (\boldsymbol{\Delta e}_{\$/₣})'\cdot\boldsymbol{\Delta e}_{¥/₣} \\ (\boldsymbol{\Delta e}_{\Omega/₣})'\cdot\boldsymbol{\Delta e}_{¥/₣} \\ (\boldsymbol{\Delta e}_{\boldsymbol{\Theta}/₣})'\cdot\boldsymbol{\Delta e}_{¥/₣} \end{bmatrix}$$

$$= (\boldsymbol{X}'\boldsymbol{X})^{-1}\begin{bmatrix} (\boldsymbol{J}_{\boldsymbol{1},\boldsymbol{T}})'\cdot(\boldsymbol{\Delta e}_{¥/\$} + \boldsymbol{\Delta e}_{\$/₣}) \\ (\boldsymbol{\Delta e}_{\$/₣})'\cdot(\boldsymbol{\Delta e}_{¥/\$} + \boldsymbol{\Delta e}_{\$/₣}) \\ (\boldsymbol{\Delta e}_{\Omega/₣})'\cdot(\boldsymbol{\Delta e}_{¥/\$} + \boldsymbol{\Delta e}_{\$/₣}) \\ (\boldsymbol{\Delta e}_{\boldsymbol{\Theta}/₣})'\cdot(\boldsymbol{\Delta e}_{¥/\$} + \boldsymbol{\Delta e}_{\$/₣}) \end{bmatrix}$$

$$= (\boldsymbol{X}'\boldsymbol{X})^{-1}\begin{bmatrix} (\boldsymbol{J}_{\boldsymbol{1},\boldsymbol{T}})'\cdot(\boldsymbol{\Delta e}_{¥/\$} + \boldsymbol{\Delta e}_{\$/₣}) \\ (\boldsymbol{\Delta e}_{\$/₣})'\cdot(\boldsymbol{\Delta e}_{¥/\$} + \boldsymbol{\Delta e}_{\$/₣}) \\ (\boldsymbol{\Delta e}_{\Omega/₣})'\cdot(\boldsymbol{\Delta e}_{¥/\$} + \boldsymbol{\Delta e}_{\$/₣}) \\ (\boldsymbol{\Delta e}_{\boldsymbol{\Theta}/\$} + \boldsymbol{\Delta e}_{\$/₣})'\cdot(\boldsymbol{\Delta e}_{¥/\$} + \boldsymbol{\Delta e}_{\$/₣}) \end{bmatrix}$$

$$= \begin{bmatrix} b_0 \\ b_\$ \\ b_\Omega \\ b_{\Theta c} + b_{\Theta\$} \end{bmatrix}, \tag{11}$$

In the last row above:

$$b_{\Theta\$} = (\boldsymbol{X}'\boldsymbol{X})^{-1}\left[(\boldsymbol{\Delta e}_{\boldsymbol{\Theta}/₣})'\boldsymbol{\Delta e}_{\$/₣} + (\boldsymbol{\Delta e}_{\$/₣})'\boldsymbol{\Delta e}_{¥/\$}\right], \tag{12}$$

where the first term is the common factor of \$ borne by Θ in the general market represented by ₣, while the second is the general market association of ¥ through \$. The actual effect of Θ on ¥ is:

$$b_{\Theta c} = (\boldsymbol{X}'\boldsymbol{X})^{-1}(\boldsymbol{\Delta e}_{\boldsymbol{\Theta}/\$})'\boldsymbol{\Delta e}_{¥/\$}, \tag{13}$$

It can be derived by a two-stage partition. First get $(\boldsymbol{\Delta e_{\Theta/₣}})'\boldsymbol{\Delta e_{¥/\$}}$ out from $(\boldsymbol{\Delta e_{\Theta/₣}})' \cdot (\boldsymbol{\Delta e_{¥/\$}} + \boldsymbol{\Delta e_{\$/₣}})$ and then regain $(\boldsymbol{\Delta e_{\Theta/\$}})'\boldsymbol{\Delta e_{¥/\$}}$ from $(\boldsymbol{\Delta e_{\Theta/\$}} + \boldsymbol{\Delta e_{\$/₣}})'\boldsymbol{\Delta e_{¥/\$}}$. The actual effect of Θ on ¥, corrected for bearing the common factor, is as follows:

$$b_{\Theta c} = \frac{(\boldsymbol{X}'\boldsymbol{X})^{-1}(\boldsymbol{\Delta e}_{\boldsymbol{\Theta}/₣})'\boldsymbol{\Delta e}_{¥/\$}}{(\boldsymbol{X}'\boldsymbol{X})^{-1}\left[(\boldsymbol{\Delta e}_{\boldsymbol{\Theta}/₣})'\boldsymbol{\Delta e}_{\$/₣} + (\boldsymbol{\Delta e}_{\boldsymbol{\Theta}/₣})'\boldsymbol{\Delta e}_{¥/\$}\right]} \cdot \frac{(\boldsymbol{X}'\boldsymbol{X})^{-1}(\boldsymbol{\Delta e}_{\boldsymbol{\Theta}/\$})'\boldsymbol{\Delta e}_{¥/\$}}{(\boldsymbol{X}'\boldsymbol{X})^{-1}(\boldsymbol{\Delta e}_{\boldsymbol{\Theta}/₣})'\boldsymbol{\Delta e}_{¥/\$}} \cdot b_\Theta$$

$$= \frac{(\boldsymbol{\Delta e}_{\boldsymbol{\Theta}/\$})'\boldsymbol{\Delta e}_{¥/\$}}{(\boldsymbol{\Delta e}_{\boldsymbol{\Theta}/₣})'\boldsymbol{\Delta e}_{\$/₣} + (\boldsymbol{\Delta e}_{\boldsymbol{\Theta}/₣})'\boldsymbol{\Delta e}_{¥/\$}} \cdot b_\Theta = \frac{(\boldsymbol{\Delta e}_{\boldsymbol{\Theta}/\$})'\boldsymbol{\Delta e}_{¥/\$}}{(\boldsymbol{\Delta e}_{\boldsymbol{\Theta}/₣})'\boldsymbol{\Delta e}_{¥/₣}} \cdot b_\Theta, \tag{14}$$

6 | PRELUDE

Prior to empirical assessment, let us observe some facts and constraints in foreign exchange markets. They help understand currency co-movements and the extent to which currencies can un co-move, revealing how much in co-movements can be explained by and associated with the correlation coefficient and regression coefficient. They help cognize realities in basket weights inferred from regression coefficients.

Remark 1 Correlations between pairs of freely floating exchange rate changes tend to be ±0.5.

Using \$, € and £ as currency symbols for example:

$$Var(\Delta e_{\$/£,t}) = Var(\Delta e_{\$/€,t} + \Delta e_{€/£,t})$$

$$= Var(\Delta e_{\$/€,t}) + Var(\Delta e_{€/£,t}) + 2Cov(\Delta e_{\$/€,t}, \Delta e_{€/£,t})$$

$$= Var(\Delta e_{\$/€,t}) + Var(\Delta e_{€/£,t}) - 2Cov(\Delta e_{\$/€,t}, \Delta e_{£/€,t}), \tag{15}$$

$$\therefore$$

$$Cov(\Delta e_{\$/€,t}, \Delta e_{£/€,t}) = \frac{Var(\Delta e_{\$/€,t}) + Var(\Delta e_{€/£,t}) - Var(\Delta e_{\$/£,t})}{2}, \tag{16}$$

$$Var(\Delta e_{\$/€,t}) = Var(\Delta e_{€/£,t}) = Var(\Delta e_{\$/£,t}) \Rightarrow Corr(\Delta e_{\$/€,t}, \Delta e_{£/€,t}) = 0.5, \tag{17}$$

$$Var(\Delta e_{\$/€,t}) \approx Var(\Delta e_{€/£,t}) \approx Var(\Delta e_{\$/£,t}) \Rightarrow Corr(\Delta e_{\$/€,t}, \Delta e_{£/€,t}) \approx 0.5, \tag{18}$$

That is, it would be illusory to assume that a freely floating currency could move at liberty against more than one other currency, by market forces or

TABLE 1 Standard deviations of changes in exchange rates between selected currencies

	EUR	JPY	GBP	CHF	AUD	CAD
USD	0.005927	0.006371	0.006179	0.006683	0.008241	0.006073
EUR		0.007476	0.005286	0.004801	0.006930	0.006041
JPY			0.008555	0.007228	0.010341	0.008988
GBP				0.006848	0.007238	0.006261
CHF					0.008512	0.007441
AUD						0.006223

Abbreviations: AUD, Australian dollar; CAD, Canadian dollar; CHF, Swiss franc; EUR, euro; GBP, British pound; JPY, Japanese yen; USD, US dollar.

TABLE 2 Correlation coefficients between changes in exchange rate pairs

	JPY/USD	GBP/USD	CHF/USD	AUD/USD	CAD/USD
EUR/USD	0.262523	0.619474	0.716183	0.563290	0.493327
JPY/USD		0.070964	0.387505	−0.041368	−0.042425
GBP/USD			0.435161	0.527311	0.477872
CHF/USD				0.364293	0.322654
AUD/USD					0.660135

Abbreviations: AUD, Australian dollar; CAD, Canadian dollar; CHF, Swiss franc; EUR, euro; GBP, British pound; JPY, Japanese yen; USD, US dollar.

monetary authorities. In a symmetric world where a large number of currencies contrive, correlations between pairs of exchange rate changes tend to be ± 0.5 on average.

Corollary 1 Let $\bar{Std}$ be average standard deviation of changes in exchange rates among a set of currencies $\Pi \supset \{x, y, ₣\}$. $Corr(\Delta e_{x/₣,t}, \Delta e_{y/₣,t}) > 0.5 \Leftrightarrow Std(\Delta e_{x/y,t}) < \bar{Std}$; $Corr(\Delta e_{x/₣,t}, \Delta e_{y/₣,t}) < 0.5 \Leftrightarrow Std(\Delta e_{x/y,t}) > \bar{Std}$.

Contrasts of figures in Tables 1 and 2[1] corroborate the statements of Corollary 1.

Remark 2 The US dollar differs from other freely floating currencies, being an exchange rate anchor to various currencies.

Currency "baskets" for the euro, Japanese yen, British pound and US dollar are reported in Tables 3–6. Daily exchange rates are used, with the Swiss franc being the numeraire currency starting from July 21, 2005 and ending on May 7, 2019.[2] The following should be noted. (i) The US dollar and euro, as the two largest currencies, detach from each other most, moving most freely between them. The coefficient of the US dollar in the euro "basket" is 0.0214 and that of the euro in the US dollar "basket" is 0.0259, as shown in Tables 3 and 6. The two coefficients are statistically insignificant, while the coefficients of other currencies in the two tables are mostly highly significant. (ii) The formidable influence of the US dollar can be acknowledged particularly in the case of the yen. The coefficient of the US dollar is as high as 0.7884 in the yen "basket" in Table 4, which can be interpreted as accounting for 78.82% of the yen "basket" in the currency basket literature. It is the second largest in the sterling "basket" after the euro, as Table 5 reveals. (iii) The significance of the euro is only second to the US dollar and far above the other currencies. Its coefficient in the sterling "basket" is the highest, with the statistic being 0.4615, as reported in Table 5. That is, the euro accounts for nearly half of the total basket weight for sterling. It is also a weighty figure of 0.1901 in the yen "basket" in Table 4. (iv) Overall, the pound is mostly associated with the euro to a large extent; and the yen is mostly associated with the US dollar to an even larger extent. Such associations are also reflected in the US dollar "basket" and the euro "basket." The coefficient of the yen is 0.3376 and that of the pound is 0.1701 in the former; and the coefficient of the pound is 0.2475 in the latter. For trade activities and geographic connections, the Canadian dollar possesses a large coefficient of 0.2684 in the US dollar "basket." Whereas the euro "basket" is rather dispersed. The US dollar acts as a dominant currency vis-à-vis the freely floating currencies too in some sense. (v) The coefficients,

TABLE 3 Euro vis-à-vis other currencies

	Coef	Std err	t-stat	*p*-value
Intercept	1.87^{E-05}	5.63^{E-05}	0.3318	.7401
USD/CHF	0.0214	0.0152	1.4104	.1585
JPY/CHF	0.0672***	0.0099	6.8155	.0000
GBP/CHF	0.2475***	0.0115	21.5108	.0000
AUD/CHF	0.1191***	0.0123	9.6949	.0000
NZD/CHF	0.0254**	0.0104	2.4449	.0145
CAD/CHF	0.0770***	0.0129	5.9924	.0000
RUB/CHF	0.0216***	0.0069	3.1471	.0017
KRW/CHF	0.0044	0.0086	0.5125	.6083

Note: * significant at 10% level, **significant at 5% level, *** significant at 1% level.
Abbreviations: AUD, Australian dollar; CAD, Canadian dollar; CHF, Swiss franc; EUR, euro; GBP, British pound; JPY, Japanese yen; KRW, Korean won; NZD, New Zealand dollar; RUB, Russian bubble; USD, US dollar.

TABLE 4 Japanese yen vis-à-vis other currencies

	Coef	Std err	t-stat	*p*-value
Intercept	3.66^{E-05}	9.47^{E-05}	0.3871	.6987
USD/CHF	0.7884***	0.0219	36.0822	.0000
EUR/CHF	0.1901***	0.0279	6.8155	.0000
GBP/CHF	−0.0636***	0.0205	−3.0954	.0020
AUD/CHF	−0.1476***	0.0208	−7.0996	.0000
NZD/CHF	0.0413**	0.0175	2.3590	.0184
CAD/CHF	−0.1083***	0.0217	−5.0016	.0000
RUB/CHF	−0.0210*	0.0116	−1.8198	.0689
KRW/CHF	−0.0465***	0.0144	−3.2314	.0012

Note: * significant at 10% level, **significant at 5% level, *** significant at 1% level.
Abbreviations: AUD, Australian dollar; CAD, Canadian dollar; CHF, Swiss franc; EUR, euro; GBP, British pound; JPY, Japanese yen; KRW, Korean won; NZD, New Zealand dollar; RUB, Russian bubble; USD, US dollar.

TABLE 6 US dollar vis-à-vis other currencies

	Coef	Std err	t-stat	*p*-value
Intercept	-4.20^{E-05}	6.19^{E-05}	−0.6795	.4969
EUR/CHF	0.0259	0.0184	1.4104	.1585
JPY/CHF	0.3376***	0.0094	36.0822	.0000
GBP/CHF	0.1701***	0.0132	12.9365	.0000
AUD/CHF	−0.1068***	0.0136	−7.8638	.0000
NZD/CHF	0.0137	0.0115	1.1958	.2319
CAD/CHF	0.2684***	0.0135	19.8946	.0000
RUB/CHF	0.0710***	0.0075	9.5085	.0000
KRW/CHF	0.2112***	0.0087	24.1467	.0000

Note: * significant at 10% level, **significant at 5% level, *** significant at 1% level.
Abbreviations: AUD, Australian dollar; CAD, Canadian dollar; CHF, Swiss franc; EUR, euro; GBP, British pound; JPY, Japanese yen; KRW, Korean won; NZD, New Zealand dollar; RUB, Russian bubble; USD, US dollar.

TABLE 5 British pound vis-à-vis other currencies

	Coef	Std err	t-stat	*p*-value
Intercept	6.36^{E-05}	7.69^{E-05}	0.8273	.4081
USD/CHF	0.2619***	0.0202	12.9365	.0000
EUR/CHF	0.4615***	0.0215	21.5108	.0000
JPY/CHF	−0.0419***	0.0135	−3.0954	.0020
AUD/CHF	0.0846***	0.0169	4.9954	.0000
NZD/CHF	0.0595***	0.0142	4.1984	.0000
CAD/CHF	0.1226***	0.0175	6.9961	.0000
RUB/CHF	0.0054	0.0094	0.5709	.5681
KRW/CHF	0.0279**	0.0117	2.3900	.0169

Note: * significant at 10% level, **significant at 5% level, *** significant at 1% level.
Abbreviations: AUD, Australian dollar; CAD, Canadian dollar; CHF, Swiss franc; EUR, euro; GBP, British pound; JPY, Japanese yen; KRW, Korean won; NZD, New Zealand dollar; RUB, Russian bubble; USD, US dollar.

large or small, are mostly highly significant, indicating that these freely floating currencies interact between them robustly and diversely. This is in stark contrast to the currencies that are pegged or stabilized to varied degrees, in which only one or at most two regression coefficients of the freely floating currencies, usually the US dollar, are significant. It is necessary to acknowledge that the Korean won was classified as independent floating by IMF (2003) and floating rather than free floating in de facto classification of exchange rate arrangements and monetary policy frameworks, April 30, 2018 (IMF, 2018a). It is closely linked to the US dollar, through which it shares common elements with the yen, Canadian dollar and pound. It has gained a considerable coefficient of 0.2112 in the US dollar "basket," shifting the weights away from the yen, Canadian dollar and pound. This likewise bears the estimation problem addressed in this study, though to a minor extent.

7 | EMPIRICS AND ANALYSIS

Data sample for this study contains currencies of the US dollar, euro, Japanese yen, British pound, Australian dollar, New Zealand dollar, Swiss franc, Canadian dollar, Russian bubble, Hong Kong dollar, Singaporean dollar, Malaysian ringgit, Thai baht, and Korean won. The first 13 currencies have been included in the CFETS RMB Index first published on December 11, 2015 on its website (CFETS, 2015). Additional 11 currencies were added to the index from January 1, 2017, including the Korean won that is assigned a nominal weight of 0.1077 (CFETS, 2016a). The rest 10 currencies, with minor nominal and concrete weights, are excluded for warding off trivial, oscillating regression results. The same source, WM/Reuters, was used for exchange rate retrievals as much as possible, to keep the exchange rate data as much transaction based as possible, to reduce idiosyncratic and asynchronous errors introduced in data collection processes. For the same reason, the Swiss franc, instead of the SDR, is used as numeraire currency, as the latter involves various conglomeration and aggregation.

The sample period and its sub-periods in this study go along with the events in the RMB regime reform, which are hereby outlined briefly. People's Bank of China (PBOC) has been carrying on the reform of the RMB exchange rate regime over time. A series of measures to reform the RMB exchange rate arrangements or regime began in 2005, marked by "*Announcement on Improvement on RMB Exchange Rate Regime*" issued by PBOC on July 21, 2005. Prior to that date, the RMB was fixed to the US dollar. The band of daily fluctuation in the RMB exchange rate vis-à-vis the US dollar was set at 0.3%. The band of daily fluctuation in the RMB exchange rate against the US dollar was widened to 0.5% from May 21, 2007, announced PBOC on May 18, 2007 (PBOC, 2007), which was exceeded previously already, albeit occasionally. Then followed the global financial crisis, there was virtually little fluctuation in the RMB exchange rate against the US dollar from July 2008 until June 2010, to reserve financial stability and safeguard the economy from external shocks. With the global recovery on the horizon, PBOC announced on April 14, 2012 that the band of daily fluctuation was widened again to 1% from April 16, 2012 (PBOC, 2012), for the sake of meeting the development needs in the foreign exchange market and enhancing the elasticity in the bi-directional floating of the RMB exchange rate. Then it was announced on March 15, 2014 that the band of daily fluctuation in the RMB exchange rate against the US dollar was broadened to 2% from March 17, 2014 (POBC, 2014). A new measure, the central parity regime of "closing rate and rate change against a basket of currencies" was introduced and implemented on August 11, 2015 that improved the quotation mechanism of central parity between the RMB against the US dollar (POBC, 2016). The mechanism emphasized that the daily central parity quotes of the RMB-dollar exchange rate should refer to the closing rate on the previous day to reflect the changes of market supply and demand. The whole sample, at daily frequency, starts from July 21, 2005 when a series of measures to reform the RMB exchange rate regime began, and ends on May 7, 2019. The whole sample is divided into sub-periods according to the regime reform events, marked by 0.3% (July 21, 2005–May 18, 2007), 0.5%a (May 21, 2007–July 25, 2008), 0.5%b (June 18, 2010–April 13, 2012), 1% (April 16, 2012–March 14, 2014), 2% (March 17, 2014–August 10, 2015) for the percentage width of the band, and cp (August 11, 2015 -) for the central parity regime of "closing rate + rate changes in basket currencies" respectively.

Tables 7–12 reports the parameter estimates for the RMB vis-à-vis the freely floating currencies in the CFETS RMB Index in the six sub-periods to get a general sense how an RMB currency basket looks like, which involves the largest Ω currencies without being distorted by Θ currencies. The currencies are the US dollar, euro, Japanese yen, British pound, Australian dollar, New Zealand dollar, Canadian dollar, and Russian bubble, with the Swiss franc being the numeraire currency. Although there had been prior reforms that had widened the band of daily fluctuation in the RMB exchange rate against the US dollar from 0.3% through to 0.5, 1 and lately 2% on March 17, 2014, RMB patterns virtually did not change given the band's unique link to the US dollar. Therefore, the subsequent empirical research will be based on two sub-periods divided by August 11, 2015. The weight of the US dollar, as indicated by its coefficient, remains largely the same in the 0.3%, 0.5%a, 0.5%b, 1% and 2% band sub-periods with the figure being 0.9647, 0.9687, 0.9720, 0.9665, and 0.9581 respectively, reported in Tables 7–9. Only the introduction of the central parity regime of "closing rate + rate changes in basket currencies" has changed the patterns notably, and the "weight" of the US dollar has dropped to 0.8250 in the central parity regime, as Table 10 indicates. Only one additional currency possesses a significant coefficient at varied levels of significance in each of the five sub-periods; while there are two currencies with significant coefficients in the central parity regime sub-period. None of the coefficients of the rest currencies, significant or not, have exceeded 0.0800. These coefficient figures serve as estimate guidance for the main empirical study in the following—the patterns should not change much when the smaller currencies are added to the equations.

The problem in parameter estimation becomes noticeable when Θ currencies are included, as shown in

Tables 13 and 14. Tables 13 and 14 includes all the currencies in the CFETS RMB Index at its launch, plus the Korean won that was later added to the adjusted Index. So, in addition to the currencies in Tables 7–12, the Hong Kong dollar, Singaporean dollar, Malaysian ringgit, Thai baht and Korean won are brought to the "basket." Among them, the Hong Kong dollar adopts a currency board regime with the US dollar being its exchange rate anchor; the Singaporean dollar operates a stabilized arrangement anchored at a group of composite currencies; the Malaysian ringgit and Thai baht are now classified as floating but were conventional fixed peg arrangements and managed floating with no pre-announced path for the exchange rate earlier; the Korean

TABLE 7 RMB basket with freely floating currencies: band 0.3%

	(0.3%)			
	Coef	**Std err**	**t-stat**	***p*-value**
Intercept	−0.0001***	2.98E-05	−3.8754	.0001
USD/CHF	0.9647***	0.0160	60.16479	.0000
EUR/CHF	−0.0117	0.0228	−0.5115	.6093
JPY/CHF	0.0135*	0.0075	1.7932	.0736
GBP/CHF	0.0057	0.0111	0.5144	.6072
AUD/CHF	0.0098	0.0092	1.0668	.2866
NZD/CHF	−0.0054	0.0061	−0.8873	.3754
CAD/CHF	0.0042	0.0071	0.5854	.5586
RUB/CHF	0.0196	0.0219	0.8936	.3720

Note: * significant at 10% level, **significant at 5% level, *** significant at 1% level.
Abbreviations: AUD, Australian dollar; CAD, Canadian dollar; CHF, Swiss franc; EUR, euro; GBP, British pound; JPY, Japanese yen; KRW, Korean won; NZD, New Zealand dollar; RUB, Russian bubble; USD, US dollar.

TABLE 8 RMB basket with freely floating currencies: band 0.5%a

	(0.5%a)			
	Coef	**Std err**	**t-stat**	***p*-value**
Intercept	−0.0004***	6.73E-05	−5.5217	.0000
USD/CHF	0.9687***	0.0364	26.5882	.0000
EUR/CHF	−0.0518	0.0510	−1.0165	.3102
JPY/CHF	0.0028	0.0168	0.1663	.8680
GBP/CHF	−0.0014	0.0169	−0.0802	.9361
AUD/CHF	−0.0093	0.0148	−0.6252	.5323
NZD/CHF	0.0378***	0.0115	3.2986	.0011
CAD/CHF	−0.0146	0.0128	−1.1434	.2538
RUB/CHF	−0.0029	0.0681	−0.0429	.9658

Note: * significant at 10% level, **significant at 5% level, *** significant at 1% level.
Abbreviations: AUD, Australian dollar; CAD, Canadian dollar; CHF, Swiss franc; EUR, euro; GBP, British pound; JPY, Japanese yen; KRW, Korean won; NZD, New Zealand dollar; RUB, Russian bubble; USD, US dollar.

TABLE 9 RMB basket with freely floating currencies: band 0.5%b

	(0.5%b)			
	Coef	**Std err**	**t-stat**	***p*-value**
Intercept	−0.0002***	5.41E-05	−2.9119	.0038
USD/CHF	0.9720***	0.0148	65.4981	.0000
EUR/CHF	0.0196	0.0132	1.4854	.1381
JPY/CHF	−0.0003	0.0101	−0.0308	.9755
GBP/CHF	0.0038	0.0135	0.2821	.7780
AUD/CHF	0.0324**	0.0141	2.2958	.0221
NZD/CHF	−0.0029	0.0099	−0.2942	.7688
CAD/CHF	−0.0162	0.0143	−1.1364	.2564
RUB/CHF	−0.0038	0.0134	−0.2809	.7789

Note: * significant at 10% level, **significant at 5% level, *** significant at 1% level.
Abbreviations: AUD, Australian dollar; CAD, Canadian dollar; CHF, Swiss franc; EUR, euro; GBP, British pound; JPY, Japanese yen; KRW, Korean won; NZD, New Zealand dollar; RUB, Russian bubble; USD, US dollar.

TABLE 10 RMB basket with freely floating currencies: band 1%

	(1%)			
	Coef	**Std err**	**t-stat**	***p*-value**
Intercept	−5.80E-05	3.55E-05	−1.6344	0.1028
USD/CHF	0.9665***	0.0115	83.8597	0.0000
EUR/CHF	0.0061	0.0206	0.2942	0.7687
JPY/CHF	−0.0054	0.0066	−0.8111	0.4177
GBP/CHF	0.0055	0.0110	0.5015	0.6163
AUD/CHF	0.0113	0.0099	1.1456	0.2525
NZD/CHF	−0.0046	0.0081	−0.5661	0.5716
CAD/CHF	0.0200*	0.0114	1.7543	0.0800
RUB/CHF	0.0094	0.0085	1.1019	0.2710

Note: * significant at 10% level, **significant at 5% level, *** significant at 1% level.
Abbreviations: AUD, Australian dollar; CAD, Canadian dollar; CHF, Swiss franc; EUR, euro; GBP, British pound; JPY, Japanese yen; KRW, Korean won; NZD, New Zealand dollar; RUB, Russian bubble; USD, US dollar.

TABLE 11 RMB basket with freely floating currencies: band 2%

	(2%)			
	Coef	**Std err**	**t-stat**	***p*-value**
Intercept	1.26^{E-05}	6.06^{E-05}	0.2083	.8351
USD/CHF	0.9581***	0.0173	55.2255	.0000
EUR/CHF	−0.0131	0.0142	−0.9189	.3588
JPY/CHF	0.0230	0.0155	1.4874	.1378
GBP/CHF	0.0239	0.0175	1.3624	.1739
AUD/CHF	0.0293**	0.0143	2.0505	.0410
NZD/CHF	−0.0160	0.0124	−1.2867	.1990
CAD/CHF	−0.0145	0.0179	−0.8091	.4190
RUB/CHF	0.0030	0.0033	0.9084	.3643

Note: * significant at 10% level, **significant at 5% level, *** significant at 1% level.
Abbreviations: AUD, Australian dollar; CAD, Canadian dollar; CHF, Swiss franc; EUR, euro; GBP, British pound; JPY, Japanese yen; KRW, Korean won; NZD, New Zealand dollar; RUB, Russian bubble; USD, US dollar.

TABLE 12 RMB basket with freely floating currencies: central parity

	(cp)			
	Coef	**Std err**	**t-stat**	***p*-value**
Intercept	7.67^{E-05}	6.94^{E-05}	1.1058	.2691
USD/CHF	0.8250***	0.0190	43.5220	.0000
EUR/CHF	0.0014	0.0276	0.0519	.9586
JPY/CHF	0.0061	0.0148	0.4138	.6791
GBP/CHF	0.0262*	0.0135	1.9388	.0528
AUD/CHF	0.0706***	0.0202	3.4980	.0005
NZD/CHF	−0.0028	0.0156	−0.1771	.8594
CAD/CHF	0.0097	0.0193	0.5036	.6147
RUB/CHF	0.0108	0.0090	1.1941	.2327

Note: * significant at 10% level, **significant at 5% level, *** significant at 1% level.
Abbreviations: AUD, Australian dollar; CAD, Canadian dollar; CHF, Swiss franc; EUR, euro; GBP, British pound; JPY, Japanese yen; KRW, Korean won; NZD, New Zealand dollar; RUB, Russian bubble; USD, US dollar.

won was classified as independent floating earlier but is floating rather than free floating currently (IMF, 2003, 2018a). They are all linked to the US dollar closely, with the Hong Kong dollar being the most and almost identical to the US dollar in patterns of movement. The whole period is divided by August 11, 2015, given that RMB patterns virtually did not change in the first five sub-periods based on band management, namely the bands sub-period, before August 11, 2015. Table 13 reports the results for the first sub-period or the bands sub-period, and Table 14 for the second sub-period or the central parity regime. The first four columns of Tables 13 and 14 report the regression statistics as usual. The last two columns of the tables report the excess weights removed and the corrected coefficients with the procedure developed in the present paper.

The outlooks of the basket configuration change strikingly when the currencies that are notably linked to the US dollar are included. The Hong Kong dollar, Singaporean dollar, Malaysian ringgit and Thai baht possess coefficients that are significant at 1% level in the first sub-period. The coefficient of the US dollar remains highly significant, though its "weight" falls considerably to 0.7283. Whereas the "weight" of the Hong Kong dollar is 0.1880, only second to the US dollar and considerably higher than any other currencies, the freely floating currencies in particular. The Malaysian ringgit becomes truly floating in the second sub-period of the central parity regime of "closing rate + rate changes in basket currencies", and its coefficient turned into insignificant. The coefficient of the Korean won turns out to be significant at 1% level in the second sub-period when it moved out from the independent floating club and joined the floating league, with a "weight" of 0.1156. The Hong Kong dollar has acquired an even larger "weight" of 0.2903, though the coefficient is significant at a modest 10% level. Strikingly, the Thai baht and Singaporean dollar also possess sizeable "weights" of 0.1815 and 0.0831, with the coefficients being significant at 1% level and 5% level respectively. In contrast, the "weight" of the US dollar has been reduced to 0.2986 and its coefficient is significant at a modest 10% level. Meanwhile, the Japanese yen, Australian dollar, New Zealand dollar, Russian rubble and British pound are pushed out from the "basket."

The part of the coefficient that is attributed to the common factor instigator but wrongly assigned to the respective basket currency is reported in column 5 of Tables 13 and 14. The corrected coefficients are reported in the last column, which capture the actual effect on the RMB of the basket currencies, corrected for bearing the common factor. The correction and adjustment are applied to all currencies indiscriminately. Nevertheless, the variation is minor for Ω currencies—the coefficient of the euro remains almost unchanged in the central parity regime in Table 14. For Θ currencies, as much as 0.2886 out of 0.2903 in the coefficient of the Hong Kong dollar is attributed to the common factor instigator, being wrongly shifted from the common factor instigator to the bearer, in the central parity regime reported in Table 14. To a less extent, the excess weight figure is 0.1579 out of

TABLE 13 RMB basket estimation: bands sub-period

	Coef	Std err	t-stat	*p*-value	Excess weight	Corrected Coef
Intercept	$-1.00^{E-04***}$	1.81^{E-05}	−5.5195	.0000		-1.00^{E-04}
USD/CHF	0.7283^{***}	0.0586	12.4287	.0000		0.9982
EUR/CHF	0.0008	0.0053	0.1517	.8794	0.0008	3.20^{E-05}
JPY/CHF	0.0033	0.0031	1.0603	.2891	0.0033	3.25^{E-05}
GBP/CHF	0.0048	0.0042	1.1557	.2479	0.0047	0.0001
AUD/CHF	0.0007	0.0038	0.1950	.8454	0.0007	2.96^{E-05}
NZD/CHF	−0.0018	0.0032	−0.5749	.5654	−0.0018	-5.90^{E-05}
CAD/CHF	-0.0087^{**}	0.0040	−2.1883	.0287	−0.0085	−0.0001
RUB/CHF	0.0009	0.0023	0.4013	.6882	0.0009	2.02^{E-05}
HKD/CHF	0.1880^{***}	0.0597	3.1492	.0017	0.1879	0.0001
SGD/CHF	0.0297^{***}	0.0088	3.3716	.0008	0.0291	0.0006
MYR/CHF	0.0428^{***}	0.0060	7.1221	.0000	0.0419	0.0009
THB/CHF	0.0134^{***}	0.0050	2.6793	.0074	0.0132	0.0002
KRW/CHF	−0.0024	0.0027	−0.8774	.3803	−0.0024	-4.50^{E-05}

Note: * significant at 10% level, ** significant at 5% level, *** significant at 1% level.
Abbreviations: AUD, Australian dollar; CAD, Canadian dollar; CHF, Swiss franc; EUR, euro; GBP, British pound; HKD, Hong Kong dollar; JPY, Japanese yen; KRW, Korean won; MYR, Malaysian ringgit; NZD, New Zealand dollar; RUB, Russian bubble; SGD, Singaporean dollar; THB, Thai baht; USD, US dollar.

TABLE 14 RMB basket estimation: central parity

	Coef	Std err	t-stat	*p*-value	Excess weight	Corrected Coef
Intercept	9.84^{E-05}	6.29^{E-05}	1.5644	.1180		9.84^{E-05}
USD/CHF	0.2986^{*}	0.1678	1.7799	.0754		0.9030
EUR/CHF	0.0030	0.0258	0.1178	.9063	0.0003	0.0028
JPY/CHF	0.0022	0.0140	0.1552	.8767	0.0017	0.0005
GBP/CHF	0.0156	0.0123	1.2647	.2063	0.0103	0.0053
AUD/CHF	0.0128	0.0190	0.6761	.4991	0.0096	0.0033
NZD/CHF	−0.0166	0.0146	−1.1379	.2554	−0.0124	−0.0042
CAD/CHF	−0.0068	0.0176	−0.3853	.7001	−0.0056	−0.0012
RUB/CHF	−0.0128	0.0085	−1.5058	.1324	−0.0107	−0.0021
HKD/CHF	0.2903^{*}	0.1699	1.7092	.0877	0.2886	0.0018
SGD/CHF	0.0831^{**}	0.0368	2.2545	.0244	0.0673	0.0158
MYR/CHF	0.0139	0.0198	0.7013	.4833	0.0116	0.0023
THB/CHF	0.1815^{***}	0.0288	6.2931	.0000	0.1579	0.0236
KRW/CHF	0.1156^{***}	0.0150	7.7280	.0000	0.0859	0.0297

Note: * significant at 10% level, ** significant at 5% level, *** significant at 1% level.
Abbreviations: AUD, Australian dollar; CAD, Canadian dollar; CHF, Swiss franc; EUR, euro; GBP, British pound; HKD, Hong Kong dollar; JPY, Japanese yen; KRW, Korean won; MYR, Malaysian ringgit; NZD, New Zealand dollar; RUB, Russian bubble; SGD, Singaporean dollar; THB, Thai baht; USD, US dollar.

0.1815 for the Thai baht, 0.0859 out of 0.1156 for the Korean won and 0.0673 out of 0.0831 for the Singaporean dollar respectively. The corrected coefficient of the US dollar resumes a normal size of 0.9067, adding the excess weights in other currencies' coefficients back to the US dollar, the common factor instigator. The corrected coefficients bring into line with the figures in Table 12. The distortion is less considerable in the first sub-period except the Hong Kong dollar that possesses a highly significant coefficient of 0.1880. The distorting effect reduces

TABLE 15 RMB basket estimation, freely floating currencies + HKD: bands sub-period

	Coef	Std err	t-stat	*p*-value	Excess weight	Corrected Coef
Intercept	−0.0001***	1.85^{E-05}	−5.6043	.0000		−0.0001
USD/CHF	0.6770***	0.0598	11.3240	.0000		0.9979
EUR/CHF	0.0070	0.0053	1.3359	.1817	0.0067	0.0003
JPY/CHF	0.0053*	0.0031	1.6904	.0911	0.0053	5.18^{E-05}
GBP/CHF	0.0059	0.0043	1.3890	.1650	0.0058	0.0001
AUD/CHF	0.0092**	0.0038	2.4443	.0146	0.0088	0.0004
NZD/CHF	−0.0004	0.0032	−0.1368	.8912	−0.0004	-1.4^{E-05}
CAD/CHF	−0.0059	0.0040	−1.4565	.1454	−0.0058	-8.1^{E-05}
RUB/CHF	0.0043*	0.0023	1.8783	.0605	0.0042	9.57^{E-05}
HKD/CHF	0.2964***	0.0603	4.9146	.0000	0.2962	0.0002

Note: * significant at 10% level, ** significant at 5% level, *** significant at 1% level.
Abbreviations: AUD, Australian dollar; CAD, Canadian dollar; CHF, Swiss franc; EUR, euro; GBP, British pound; HKD, Hong Kong dollar; JPY, Japanese yen; KRW, Korean won; MYR, Malaysian ringgit; NZD, New Zealand dollar; RUB, Russian bubble; SGD, Singaporean dollar; THB, Thai baht; USD, US dollar.

TABLE 16 RMB basket estimation, freely floating currencies + HKD: central parity

	Coef	Std err	t-stat	*p*-value	Excess weight	Corrected Coef
Intercept	7.11^{E-05}	6.92^{E-05}	1.0279	.3042		7.11^{E-05}
USD/CHF	0.3431*	0.1837	1.8677	.0621		0.9127
EUR/CHF	0.0049	0.0275	0.1773	.8593	0.0004	0.0045
JPY/CHF	0.0065	0.0148	0.4411	.6592	0.0050	0.0016
GBP/CHF	0.0260*	0.0135	1.9249	.0545	0.0172	0.0088
AUD/CHF	0.0670***	0.0202	3.3209	.0009	0.0500	0.0170
NZD/CHF	−0.0043	0.0156	−0.2778	.7812	−0.0032	−0.0011
CAD/CHF	0.0076	0.0193	0.3945	.6933	0.0063	0.0013
RUB/CHF	0.0095	0.0090	1.0491	.2944	0.0079	0.0015
HKD/CHF	0.4891***	0.1854	2.6379	.0085	0.4862	0.0030

Note: * significant at 10% level, ** significant at 5% level, *** significant at 1% level.
Abbreviations: AUD, Australian dollar; CAD, Canadian dollar; CHF, Swiss franc; EUR, euro; GBP, British pound; HKD, Hong Kong dollar; JPY, Japanese yen; KRW, Korean won; MYR, Malaysian ringgit; NZD, New Zealand dollar; RUB, Russian bubble; SGD, Singaporean dollar; THB, Thai baht; USD, US dollar.

the "weight" of the US dollar to 0.7283, which is out of line with what the figures in Tables 7–11 suggest—around 0.9600–0.9700. The coefficients of the Singaporean dollar, Malaysian ringgit and Thai baht, though highly significant, are small. They are nevertheless distortions and excess weights wrongly shifted from the common factor instigator to the common factor bearers of Θ currencies. The coefficients of the freely floating currencies are very small in the first sub-period, which is reasonable given the nature of band management. The band is uniquely linked to the US dollar, leaving little room for other currencies except statistical and exchange noises. Much, if not all, of these very small coefficients are more statistical noises than economically maintainable links. Thus only the data in the second sub-period of the central parity regime of "closing rate + rate changes in basket currencies" provides a means to study the RMB basket construct and weights plausibly. A minor piece of evidence worthwhile mentioning is that the RMB has been steadily consistently appreciating during the 0.3%, 0.5%a and 0.5%b band sub-periods, that is, between July 21, 2005 and April 13, 2012, with a highly significant negative intercept in Tables 7–12. The appreciation, though steady and consistent, is tiny. The intercept becomes marginally significantly negative in the 1% band period and insignificantly positive in the 2% band period and the central parity regime from April 16, 2012 and May 7, 2019. When the band sub-periods are combined in Table 13, the intercept is negatively significant but tiny in the band sub-period from July 21, 2005 to August

10, 2015. The intercept is insignificantly positive and also tiny in the central parity regime period from August 11, 2015 onwards. The changes in the intercept indicate that the RMB is steadily consistently appreciating in earlier stages of the reform. In later stages of the reform, especially in the central parity regime, the RMB moves either way with to tendency to depreciate. This fact is consistent with Liu and Pauwels (2012) who study whether political pressure calling for faster RMB appreciation, while the RMB is experiencing steady minor appreciation during their data set period that ends on May 30, 2011. They find that US and non-US political pressure does not have a significant influence on Renminbi's daily returns. Beyond the band period, a different regime is emerging however when the RMB moves either way, deserting the approach of steady but tiny appreciation regardless of external political pressure.

Finally, the correction procedure is applied to a case where only one of Θ currencies that is linked to the US dollar most, the Hong Kong dollar, is included. The results are reported in Tables 15 and 16, with Table 15 for the bands sub-period and Table 16 for the central parity regime. It can be observed that the coefficient of the Hong Kong dollar has increased in both sub-periods against the corresponding figures in Tables 13 and 14. The coefficient has increased to the extent that it soaks up the coefficients of the Singaporean dollar, Malaysian ringgit and Thai baht in the bands sub-period, and the coefficients of the Singaporean dollar, Thai baht and Korean won in the central parity regime. The "weights" of the US dollar have also been reduced awfully to 0.6770 and 0.3431 in the two sub-periods respectively, though slightly higher than the corresponding figures in Tables 13 and 14. The corrected coefficients of the US dollar are 0.9979 and 0.9127 in the two sub-periods, very close to the corrected ones in Tables 13 and 14. Hence one of Θ currencies, the Hong Kong dollar alone, is sufficient to build up almost all the distortion and shifts in coefficients or "weights." This happens as expected, given the close connection of the other Θ currencies with the US dollar, through which they are correlated with the Hong Kong dollar considerably. These results corroborate the main findings presented in Tables 13 and 14 scrutinized and discussed in the previous three paragraphs.

That the "weight" of the US dollar is still as high as 90% and the other freely floating currencies have usually accounted for less than 1% each even in the second sub-period of the central parity regime should not come as a surprise. Regression analysis with the freely floating currencies only, which is immune from parameter misrepresentation, has told a comparable story. The "weight" of the US dollar is nearly 80% even in the currency basket of the Japanese yen, the third largest freely floating currency. In the sterling basket, the combined "weight" of the US dollar and euro is over 70%; the rest account for less than 10% each except the Canadian dollar that possesses a coefficient of 0.1226. Whereas in the euro basket, only the "weight" of the Australian dollar has exceeded 10% following the main component of the pound that has accounted for a quarter. There might be misperceptions about currency baskets that statistically estimated currency weights should match or reflect the weights in a currency index, such as the BIS effective exchange rate index or the IMF effective exchange rate index. The CFETS RMB Index is the same in construct with different currency weights, assembled in a similar way as the indexes assembled by other central banks and the European Central Bank that may differ from the BIS or IMF indexes. For example, the weights in CFETS RMB Index are US dollar: 0.2240, euro: 0.1634, Japanese yen: 0.1153, Hong Kong dollar: 0.0428, British pound: 0.0316, effective from January 1, 2017 (CFETS, 2016a). Whereas they are US dollar: 0.197, euro: 0.180, Japanese yen: 0.119, British pound: 0.030, Hong Kong dollar: 0.010 in the BIS RMB Index currently based on 2014–2016 trade. The weights in BIS RMB Index currently based on 2002–2004 trade are US dollar: 0.220, euro: 0.179, Japanese yen: 0.198, British pound: 0.031, Hong Kong dollar: 0.012 (BIS, 2019). So, the weight of the US dollar is slightly higher and that of the euro slightly lower than the corresponding weights in the BIS RMB Index, with the differences resulting from their respective trade estimates to some extent. The BIS RMB Index, like the BIS effective exchange rate indexes for almost all currencies, had long existed when the RMB was fixed to the US dollar exclusively. Foreign exchange market transaction based, or established currency basket weights have no logical associations with the weights used for calculating the effective exchange rate index for the same currency. However, the launch of the CFETS RMB Index did create some impression that the actual patterns in RMB transactions on the foreign exchange market should or could keep to the CFETS RMB Index. Meanwhile, the new measure of the central parity regime in the RMB reform and the accompanied press releases did suggest the development trends and evolving patterns in the RMB, with the loosening link to the US dollar and the augmenting association with other currencies largely represented by the euro.

8 | SUMMARY

The present paper has scrutinized the RMB currency basket weights exhaustively, going through all stages of the evolving RMB regime and reforms. The RMB currency basket weights are assessed sensibly and weight estimates are achieved objectively, applying an approach developed

in this paper to correcting parameter misrepresentation under the dominance of a common factor. The estimation bias problem of common factor dominance is regularly encountered but overlooked in the research on currency interactions and co-movements. The contemporary custom of the currency market is observed in the economic setting of the paper, calling for realistic and sensible currency weight estimations. It has been revealed that there exists a structural common factor in the currency market where the US dollar is the common factor instigator that dominates over the common factor bearers in currency basket construct. Estimating two sets of regression, without and with the common factor bearers being included as regressors together with the freely floating currencies, reveals the severe bias problem in parameter estimation. By identifying the definite cause to the distortion that is accordingly removed, the common factor effect is thereby partitioned unambiguously between the common factor instigator and the bearers in the paper structurally analytically. The paper thus helps improve our knowledge and understanding in currency basket construct.

It has been found that only the introduction of the central parity regime of "closing rate + rate changes in basket currencies" in 2015 has changed the RMB patterns notably. Although there had been prior reforms that had widened the band of daily fluctuation in the RMB exchange rate against the US dollar from 0.3% through to 0.5, 1 and 2%, RMB patterns virtually did not change given the band's unique link to the US dollar. The weight of the US dollar in the currency is estimated to have dropped considerably to 90% in the central parity regime period, which should be hailed given the prolonged prior impasse. That the "weight" of the US dollar is still as high as 90% in the central parity regime should not come as a surprise. Regression analysis for freely floating currencies has told a comparable story. The "weight" of the US dollar is nearly 80% even in the currency basket of the Japanese yen, the third largest freely floating currency. In the sterling basket, the combined "weight" of the US dollar and euro is over 70%. The new measure of the central parity regime in the RMB reform and the accompanied press releases did suggest the development trends and evolving patterns in the RMB with the loosening link to the US dollar.

It is thus inferred that a decade's RMB regime reforms between 2005 and 2015 had achieved little, if any, in reforming the RMB regime. The market behavior and characteristics of the RMB exchange rate had remained fundamentally unchanged in the decade. The reform measures themselves had demonstrated a lack of imagination in designing, configuring and implementing a viable RMB regime, which is not prone to unnecessary criticism. They had achieved no enhanced elasticity in the exchange rate that could hardly be determined on the basis of market supply and demand as claimed, given the combined constraints imposed by the market, statistical relationship and regime design itself. In comparison, the central parity regime of "closing rate + rate changes in basket currencies" is innovative and bold in bringing about noticeable changes in the market behavior and characteristics of the RMB exchange rate that is determined based on market supply and demand to a certain extent.

It is realistic and reasonable that the "weight" of the US dollar is still as high as 90% in the central parity regime. The weight estimate has been reinforced by regression analysis with the freely floating currencies only, which is immune from parameter misrepresentation. Furthermore, currency basket weight estimations for the freely floating currencies help remove unrealistic and unreasonable expectations on currency weights. The "weight" of the US dollar is nearly 80% even in the currency basket of the Japanese yen, the third largest freely floating currency. The "weight" of the US dollar in the RMB basket was 99.8% in the band management period should not come as a surprise and should not be considered too high. Indeed, the "weight" of the US dollar should be 100% in the band management period, given that the band is uniquely linked to the US dollar. The little room, if any, left was filled by statistical noises. There was only the US dollar in the basket and dust in the gap and corner, with no other currencies being brought in.

On the other front of investigation, the paper provides a general solution to a specific regression bias, namely coefficient correction for common factor dominance in econometrics. The paper has probed into a regression coefficient bias problem that is different from the problems caused by multi-collinearity. Under the economic analytical setting of the paper, the correlation and the resulting regression coefficient can be partitioned, when two or more independent variables share a common factor. The common factor is embedded in one of them that dominates over the rest. This phenomenon is common in, but not unique to, currency co-movements and/or currency basket weight studies. Thus the approach and correction procedure can be potentially exploited and applied in other fields.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from Thomson Reuters Eikon. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the authors with the permission of Thomson Reuters.

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ENDNOTES

[1] Data sample detailed in the next section.

[2] Data sample detailed in the next section.

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APPENDIX

The Singaporean dollar that is closely linked to the US dollar is used in the case. The regression with the Singaporean dollar being one of the regressors is:

$$\Delta e_{¥/₣,t} = \beta_0 + \beta_{\$}\Delta e_{\$/₣,t} + \beta_{\Omega}\Delta e_{\Omega/₣,t} + \beta_{S\$}\Delta e_{S\$/₣,t} + \varepsilon_t. \quad \text{(A1)}$$

In the two-step approach, the first step is running regression of the Singaporean dollar on the US dollar:

$$\Delta e_{S\$/₣,t} = \alpha_0 + \alpha_{\$}\Delta e_{\$/₣,t} + \nu_t. \quad \text{(A2)}$$

The residual is:

$$\nu_t = \Delta e_{S\$/₣,t} - \alpha_0 - \alpha_{\$}\Delta e_{\$/₣,t}. \quad \text{(A3)}$$

The second step regression with the residual in the place of the Singaporean dollar is:

$$\Delta e_{¥/₣,t} = \beta'_0 + \beta'_{\$}\Delta e_{\$/₣,t} + \beta'_{\Omega}\Delta e_{\Omega/₣,t} + \beta'_{S\$}\nu_t + \varepsilon'_t$$

$$= \beta'_0 + \beta'_{\$}\Delta e_{\$/₣,t} + \beta'_{\Omega}\Delta e_{\Omega/₣,t} + \beta'_{S\$}\left[\Delta e_{S\$/₣,t} - \alpha_0 - \alpha_{\$}\Delta e_{\$/₣,t}\right] + \varepsilon'_t$$

$$= \beta'_0 + \beta'_{36}\Delta e_{36/₣,t} + \beta'_{\Omega}\Delta e_{\Omega/₣,t} + \beta'_{S\ 36}\Delta e_{S\ 36/₣,t} - \beta'_{S\ 36}\alpha_0 - \beta'_{S\ 36}\alpha_{36}\Delta e_{36/₣,t} + \varepsilon'_t$$

$$= \beta_0 + \beta_{S\$}\alpha_0 + \left(\beta_{\$} + \beta_{S\$}\alpha_{\$}\right)\Delta e_{\$/₣,t} + \beta_{\Omega}\Delta e_{\Omega/₣,t} + \beta_{S\$}\nu_t + \varepsilon_t. \quad \text{(A4)}$$

Therefore, the intercept changes by $\beta'_{S\$}\alpha_0$, the coefficient of the US dollar changes by $\beta'_{S\$}\alpha_{\$}$, the coefficient of the first step regression residual is the same as the coefficient of the Singaporean dollar, the coefficients of the rest currencies remain the same.

The RMB is regressed on the US dollar, euro, yen, pound, Australian dollar, New Zealand dollar, Canadian dollar, Russian rubble and Singaporean dollar, using daily exchange rates from August 11, 2015 to May 7, 2019, that is, the central parity regime period. The results are reported in Table A1. The left side is the results from running Equation (A1). The right side is the results from running Equation (A4) where the Singaporean dollar is replaced by the residual of Equation (A2), where the intercept and the coefficient are obtained as $\alpha_0 = -0.2.8894^{\text{E-5}}$ and $\alpha_{\$} = 0.6403$.

$\therefore$

$$\beta_0 + \beta_{S\$}\alpha_0 = 8.20^{\text{E}-05} - 0.2479 \times 0.2.8894^{\text{E}-5} = 6.78^{\text{E}-05},$$

$$\beta_{\$} + \beta_{S\$}\alpha_{\$} = 0.7384 + 0.2497 \times 0.6403 = 0.8983.$$

The rest coefficients remain unchanged. Figures in Table A1 confirm these. The sum of the "weights" is 1.1115, well in excess of one.

TABLE A1 Residual approach estimation

	(SGD/CHF)				(SGD/CHF residual)			
	Coef	**Std err**	**t-stat**	***p*-value**	**Coef**	**Std err**	**t-stat**	***p*-value**
Intercept	$8.20^{\text{E-05}}$	$6.78^{\text{E-05}}$	1.2099	0.2266	$7.48^{\text{E-05}}$	$6.78^{\text{E-05}}$	1.1035	0.2701
USD/CHF	0.7384	0.0223	33.0702	0.0000	0.8983	0.0213	42.1458	0.0000
EUR/CHF	−0.0333	0.0274	−1.2152	0.2246	−0.0333	0.0274	−1.2152	0.2246
JPY/CHF	−0.0163	0.0148	−1.0990	0.2720	−0.0163	0.0148	−1.0990	0.2720
GBP/CHF	0.0168	0.0133	1.2608	0.2077	0.0168	0.0133	1.2608	0.2077
AUD/CHF	0.0341	0.0204	1.6707	0.0951	0.0341	0.0204	1.6707	0.0951
NZD/CHF	−0.0284	0.0157	−1.8101	0.0706	−0.0284	0.0157	−1.8101	0.0706
CAD/CHF	−0.0046	0.0190	−0.2446	0.8068	−0.0046	0.0190	−0.2446	0.8068
RUB/CHF	−0.0047	0.0091	−0.5219	0.6019	−0.0047	0.0091	−0.5219	0.6019
SGD/CHF	0.2497	0.0360	6.9354	0.0000				
SGD/CHF residual					0.2497	0.0360	6.9354	0.0000

Note: * significant at 10% level, ** significant at 5% level, *** significant at 1% level.
Abbreviations: AUD, Australian dollar; CAD, Canadian dollar; CHF, Swiss franc; EUR, euro; GBP, British pound; HKD, Hong Kong dollar; JPY, Japanese yen; KRW, Korean won; MYR, Malaysian ringgit; NZD, New Zealand dollar; RUB, Russian bubble; SGD, Singaporean dollar; THB, Thai baht; USD, US dollar.