

EFFECT OF RENMINBI INTERNATIONALIZATION POLICY MEASURES ON CURRENCY CO-MOVEMENTS

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Preliminary version

Abstract

China has made significant progress in encouraging RMB internationalization. This paper examines the factors influencing currency co-movement with the RMB. Because bilateral currency co-movements are unobservable, we use Kawai and Pontines' (2016) approach, a modified Frankel and Wei regression, to estimate them. The factor model regression shows that not only trade and financial linkages, but also RMB internationalization efforts by Chinese authorities explain variations in the RMB co-movements. In particular, authorizations of clearing banks and the direct FX market help to intensify currency co-movements.

Keywords: Exchange Rates; Currency Co-movements; Renminbi Internationalization

JEL classification: F31, F33, F38

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1. Introduction

Recent research (Tovar and Nor, 2018; Rogoff, 2021) has highlighted the Renminbi's growing importance as an international currency. Given China's large proportion of global trade, the use of the Renminbi will grow even more, and China will require greater exchange-rate flexibility in the future. The key evidence for Renminbi internationalization is the rising co-movement between the Renminbi and other currencies. The dynamic correlations between the Renminbi and the MSCI emerging market currency index are shown in Figure 1. After 2015, we can clearly observe that the correlation is trending rising. This paper digs deeper into the question of what drives the co-movement and what speeds up RMB internationalization.

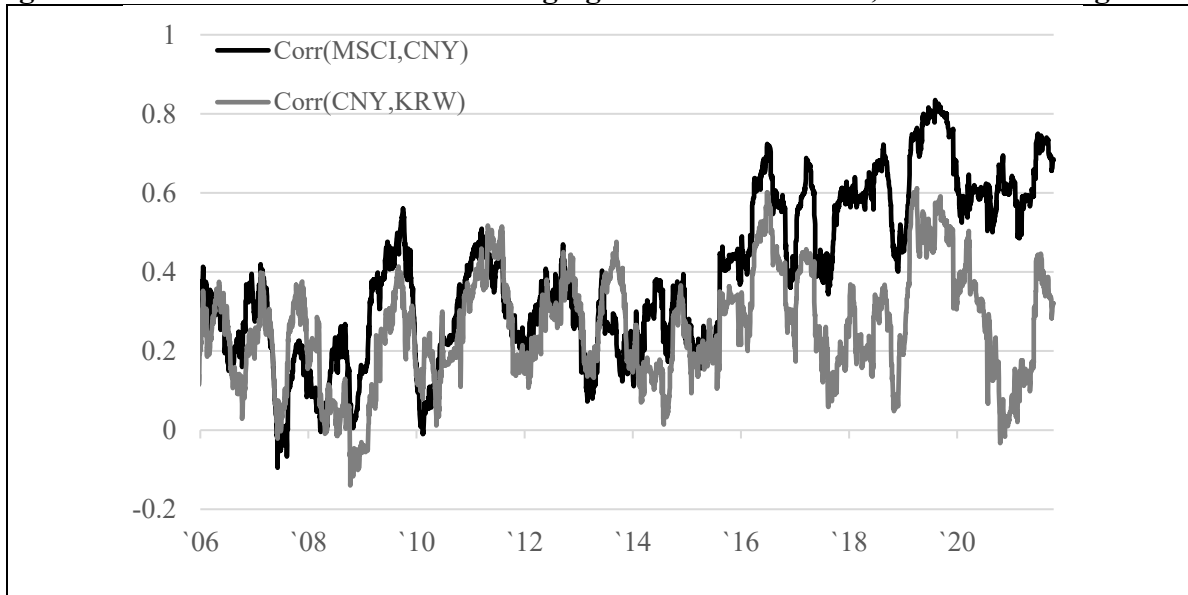
We use the method of Kawai and Pontines (2016), a modified version of Frankel and Wei (1994), in estimating the bilateral co-movement between the Renminbi and other currencies. As the co-movement measures are based on a one-year rolling window approach, they reflect dynamic changes in social, economic, and policy environments related to China and its partner countries. In general, currencies of major trading partners with China follow the movements of the Renminbi (such as Australia). That empirical evidence suggests that trade and other factors influence the co-movement. Therefore, this paper considers trade linkage, financial linkage, exchange-rate flexibility, and RMB internationalization policies of China.

The importance of institutional efforts has been newly investigated in this paper. For example, the People's Bank of China has made various institutional efforts to internationalize the Renminbi, such as signing bilateral currency swap agreements between RMB and local currency, authorizing RMB clearing banks in partner countries, and launching direct trade between RMB and local currency. We construct bilateral quantitative measures of SWAP agreements, RMB clearing banks, and direct trading systems between China and its partner country and examine whether the efforts have stimulated RMB internationalization and increased bilateral co-movements. This study is valid because it verifies the effectiveness of central bank policies that significantly impact currency internationalization.

Moreover, this paper interprets the results from the perspective of Korean won internationalization. China's share of Korea's economy is quite high (No. 1 in trade, China). In addition, Korea is China's third-largest trading partner after the United States and Japan (KOTRA

2021 article). Given the high degree of trade dependence between the two countries, the RMB internationalization factors are believed to affect the Korean Won internationalization. In the future, when regionalization centered on China further deepens and continues, the role of the Korean Won may increase. Through this study, we intend to provide implications for policy proposals for the Korean won internationalization.

Figure 1. Correlation of RMB and Emerging Market Currencies, 4-month Rolling Window



Source: Bloomberg.

The structure of this paper is as follows. The data and empirical approach for measuring currency co-movements are explained in section 2. The factor determinant models on the RMB weight are shown in section 3. The empirical results are presented in section 4, and the conclusions and implications are discussed in the last section.

2. The Currency Co-movements with the RMB

2.1. FX Data

We obtain daily exchange rates from Datastream from July 2005 to December 2020, when China maintains a floating exchange rate regime. China had been pegged its currency to the United States Dollar (USD) and changed to the managed exchange rate regime since July 2005. We carefully consider the period from July 2008 to June 2010 when China temporarily re-pegged its currency to the USD as the Global Financial Crisis (GFC) intensified.

Our results restrict the sample to 32 countries in consideration of data availability and exchange rate regimes.¹ We exclude countries that have fixed exchange regimes over the analysis period. We adopt the New Zealand Dollar (NZD) and the Swiss Franc (CHF) as numeraire currencies to capture the influence of the USD. The CHF was conventionally used for a numeraire currency in earlier studies à la Frankel and Wei (1994). Following the criticism² of Kawai and Pontines (2016), we use NZD as the main numeraire currency and the CHF for robustness check. After taking out the five major currencies (USD, EUR, JPY, GBP, RMB) and two anchor currencies (NZD, CHF), we estimate the influence of the RMB on 32 currencies.

2.2. Estimating the RMB weight

Since the operation of a formal or informal currency basket is unobservable, the currency weights can be inferred from the estimation models. The most conventional methodology, first developed by Frankel and Wei (1994) and pervasively used in literature, is to estimate the relative weights of major currencies (typically, USD, EUR, JPY, and GBP) in determining a country's exchange rate from the simple regression (Frankel-Wei regression). The estimated weights are interpreted as the formal or informal currency basket of the particular country.

The Frankel-Wei regression can have a multicollinearity problem if the RMB is included as an additional explanatory variable. Because the RMB variation is closely linked to the USD even in the period when the RMB is not pegged to the USD, the Frankel-Wei regression has difficulty

¹ Currencies with fixed exchange rate regimes. The list of countries we consider is available in 5-A1. In most analyses, Taiwan is excluded due to data limitations.

² “The Swiss Franc was pegged to the Euro between September 2011 and January 2015 and as such, estimation of the Frankel–Wei model for this period would go against the typical notion of a numeraire currency, that it should be free floating.”

disentangling between the weights of the RMB and the USD. Kawai and Pontines (2016) address this multicollinearity problem using two-step regression. Following Kawai and Pontines (2016) procedure and Chapter 4 of this report, the baseline models are estimated for 32 currencies in the sample against the major international currencies and the RMB.

The first-step regression

To discard the dependent component of the RMB from the influence of major currencies, including the USD, we consider the following auxiliary regression:

$$\Delta \log \left(\frac{RMB}{NZD} \right) = \varphi_0 + \varphi_1 \Delta \log \left(\frac{USD}{NZD} \right) + \varphi_2 \Delta \log \left(\frac{EURO}{NZD} \right) + \varphi_3 \Delta \log \left(\frac{JPY}{NZD} \right) + \varphi_4 \Delta \log \left(\frac{GBP}{NZD} \right) + \omega \quad (1)$$

where the exchange rates of currencies are denominated against the NZD. The residual ω in Equation (1) is interpreted as the RMB movements after controlling the major international currencies in China's currency basket. Kawai and Pontines (2016) chose the NZD as the numeraire currency as the CHF, the most commonly used for numeraire, was pegged to the EUR from September 2011 to January 2015.

We consider several variations of the baseline model as robustness checks: (1) to consider CHF as the numeraire; (2) to estimate Equation (1) quarter-by-quarter to match the second-step regression; (3) to add an explanatory variable, VIX, to capture global risk appetite.

The second-step regression

From the estimated residual $\hat{\omega}$ in Equation (1), the influences of the major international currencies and the RMB are estimated from the regression:

$$\Delta \log \left(\frac{x}{NZD} \right) = \gamma_0 + \gamma_1 \Delta \log \left(\frac{USD}{NZD} \right) + \gamma_2 \Delta \log \left(\frac{EUR}{NZD} \right) + \gamma_3 \Delta \log \left(\frac{JPY}{NZD} \right) + \gamma_4 \Delta \log \left(\frac{GBP}{NZD} \right) + \gamma_5 \hat{\omega} + v \quad (2)$$

$$\hat{\omega} = \Delta \log \left(\frac{RMB}{NZD} \right) - \left[\hat{\varphi}_0 + \hat{\varphi}_1 \Delta \log \left(\frac{USD}{NZD} \right) + \hat{\varphi}_2 \Delta \log \left(\frac{EUR}{NZD} \right) + \hat{\varphi}_3 \Delta \log \left(\frac{JPY}{NZD} \right) + \hat{\varphi}_4 \Delta \log \left(\frac{GBP}{NZD} \right) \right]$$

where $\gamma_1, \gamma_2, \gamma_3, \gamma_4$ are the weights of the USD, EUR, JPY, and GBP on currency x , respectively, and γ_5 is the weight of the RMB on currency x as $\hat{\omega}$ is a proxy variable for the actual RMB movements. Kawai and Pontines (2016) restrict that the coefficients of the explanatory variables

sum up to one, $\gamma_1 + \gamma_2 + \gamma_3 + \gamma_4 + \gamma_5 = 1$. In practice, we estimate the implied RMB coefficient γ_5 by subtracting $\hat{\omega}$ from dependent and explanatory variables in Equation (2) as follows:

$$\begin{aligned} \Delta \log \left(\frac{x}{NZD} \right) - \hat{\omega} = & \gamma_0 + \gamma_1 \left[\Delta \log \left(\frac{USD}{NZD} \right) - \hat{\omega} \right] + \gamma_2 \left[\Delta \log \left(\frac{EUR}{NZD} \right) - \hat{\omega} \right] \\ & + \gamma_3 \left[\Delta \log \left(\frac{JPY}{NZD} \right) - \hat{\omega} \right] + \gamma_4 \left[\Delta \log \left(\frac{GBP}{NZD} \right) - \hat{\omega} \right] + v \end{aligned} \quad (3)$$

Estimation of Equation (3) yields the implied RMB coefficient as $\gamma_5 = 1 - \gamma_1 - \gamma_2 - \gamma_3 - \gamma_4$. With daily exchange rates data, the regression is estimated with a one-year rolling window. Then, we collect the last day of every quarter estimates to construct the quarter panel of the RMB weights for 32 currencies, which is the key variable in our empirical analysis.

3. Factor Determinants on the RMB Weights

3.1. Models

To explain the variation in the RMB weights, we regress the estimated RMB coefficient in Equation (3) on various China's linkage measures and internal factors that could potentially influence the neighboring countries.

We run the following panel regression of the RMB weights on the determinant variables:

$$\gamma_{i,t} = \alpha + \beta Linkage_{i,t} + \theta Policy_{i,t} + \sum_{k=1} d_k Z_{i,t}^k + \mu_{i,t} \quad (4)$$

where $\gamma_{i,t}$ is the RMB weights of country i 's currency basket at time t . $Linkage_{i,t}$ is linkages measures between China and country i at time t . $Policy_{i,t}$ captures domestic and international policy measures of Chinese governments that can intentionally or unintentionally enhance the RMB internationalization. $Z_{i,t}^k$ is a vector of control variables. The following subsection provides details of explanatory variables.

The country panel data may induce heteroscedasticity and autocorrelation into the residuals (Lewis and Linzer, 2005). Thus, we employ the panel regression approach with Driscoll and Kraay (1998)'s nonparametric covariance matrix estimator. Driscoll and Kraay (1998) estimator produces heteroscedasticity consistent standard errors that are adjusted for country-pair-level heteroscedasticity and autocorrelation.

3.2. Factor Data

We consider potential factors to understand the variation in the RMB weights. Park and An (2020) empirically find that closer bilateral trade and financial market linkages with China result in stronger currency co-movement with the RMB. In addition to such linkage measures, we newly investigate the importance of institutional efforts of China to internationalize the RMB. Table 1 summarizes the feasible determinants.

Trade Linkage

The bilateral trade linkage between country i and China can be measured as follows:

$$TRADE_{i,t} = \frac{EXPORT_{i,China,t} + IMPORT_{i,China,t}}{\sum_j EXPORT_{i,j,t} + \sum_j IMPORT_{i,j,t}} \quad (5)$$

Thus, $TRADE_{i,t}$ is the sum of exports and imports of the country i with China to its total exports and imports. We obtain the monthly bilateral trade data from the IMF Direction of Trade (DOT) and aggregate it quarterly and annually.

As trade linkage captures several economic fundamentals that determine exchange rates, higher trade linkage to China anticipates stronger currency co-movement with the RMB. Trade linkage measures geographic characteristics such as size, distance, and cultural similarity under the gravity models in international trade literature and causes the business cycle synchronization with an increased intra-industry trade (Shin and Sohn, 2006; Inklaar et al., 2008; Duval et al., 2016).

Financial Market Linkage

A country's cross-border capital flows induce excess demand and supply of its currency. Thus, an increase in financial transactions with China, such as foreign direct investment, portfolio investment, and bank loans, may strongly relate to the co-movement of the domestic currency with the RMB.

The bilateral financial market linkages between country i and China can be measured by cross-border asset and liability positions. IMF reports bilateral foreign direct investment and portfolio investment positions on CDIS (Coordinated Direct Investment Survey) and CPIS (Coordinated Portfolio Investment Survey), respectively. Park and An (2020) test Chinese weights on foreign direct investment and portfolio investment can affect the RMB weight on exchange rates and find that portfolio investment holding is a significant variable regardless of the model specifications.

In this regard, we focus on portfolio investment. Unlike Park and An (2020), we separate portfolio investment into asset ($ASSETS_{i,t}$) and liability ($LIABILITIES_{i,t}$) sides. $ASSETS_{i,t}$ is the outward portfolio investment holdings of country i toward China, defined as the Chinese equities and debts held by the country i 's resident, and $LIABILITIES_{i,t}$ is the inward portfolio investment holdings of country i to China, defined as the country i 's securities held by Chinese residents. Both variables are normalized to GDP. We obtain the bilateral security holdings data from IMF CPIS, which can be acquired annually until 2013 and biannually after 2013. For $LIABILITIES_{i,t}$, the Chinese government released data after 2015. The bilateral portfolio investments with China as a proportion of GDP are shown in Figure A3 in the Appendix. The bilateral portfolio investment shares differ each country, but they tend to rise over time.

The covered interest arbitrage (DINT), the short-term interest rate difference between country i and China, is a proxy for incentives for international financial transactions. The higher short-term interest rate differences could induce higher financial transactions between two countries.

Policy Measures

We consider the policy facilities in China implemented for the RMB internationalization. Since 2016, when the RMB accounted for 1.08 percent of global official exchange reserves, it has progressively climbed, reaching 2.45 percent in 2021Q1, the fifth highest in the world following USD (59.54%), EUR (20.57%), Yen (5.89%), and GBP (4.70%).

This is due to a surge in cross-border trade, direct investment, and portfolio investment, as well as changes in China's RMB cross-border payment policies. China has steadily increased the infrastructure for cross-border RMB use, such as RMB clearing banks and the RMB cross-border interbank payment system, particularly in countries along the Belt and Roads. Furthermore,

bilateral currency swap agreements, RMB clearing arrangements, and the direct FX market appear to be important policy considerations in growing the RMB's prominence.

We construct vectors of dummy variables based on Chinese policy implementations. Table A2~A4 in the Appendix reports countries and years of bilateral currency swap agreement with China, authorizations of clearing banks, and the direct FX market.

Control Variables

As control variables, we look at other potential factors such China's financial risk, the flexibility of the exchange rate system in China and its counterpart economies, and trade openness.

Financial risk in China: The level of financial risk or uncertainty in China may impact the co-movement. Excessive credit in China is likely to raise financial risk, causing counterpart economies to react more sensitively to RMB volatility. We calculate the risk as a private credit to GDP ratio gap (CRISK) from the BIS. Figure A1 in the Appendix shows its trend with peaks in 2010Q1, 2015Q3, and 2020Q1.

The flexibility of the exchange rate system: The exchange rate's flexibility has an impact on possible co-movement on both sides. On the one hand, if the currencies co-move due to the government's involvement in the exchange markets. On the other hand, a more flexible exchange rate system can synchronize currencies due to the international investors in the exchange markets.

Ilzetzki et al. (2019) classify exchange rate regimes (1-14), ranging from no separate legal tender or currency union to freely floating exchange rate employing de facto exchange rates arrangements. We use their regime classification (REGIME). Table A5 in the Appendix reports detailed classification. In addition, we construct a dummy variable (BASKET) to control the period from July 2008 to June 2010 when China temporarily re-pegged its currency to the USD as the global financial crisis intensified.

Trade openness: Various factors can potentially alter the exchange rate with a high trade volume. Trade openness (TRADEOPEN) is measured by total exports and imports as a proportion of GDP.

Table 1. List of Explanatory Variables

Classification	Variable	Definition
<i>Trade Linkage</i>		
Bilateral trade	<i>TRADE_ict</i> (+)	Bilateral trade with China / total trade, % (bilateral) <i>Source:</i> IMF DOT
<i>International Policy of China</i>		
SWAP agreements	<i>SWAP_ict</i> (+)	Dummy: one if SWAP MOU has been signed (bilateral) <i>Source:</i> Authors' elaboration
Clearing banks	<i>CLEARING_ict</i> (+)	Dummy: one if clearing bank has been authorized (bilateral) <i>Source:</i> Authors' elaboration
Direct trading system	<i>DIRECTEX_ict</i> (+)	Dummy: one if direct trading system has been authorized (bilateral) <i>Source:</i> Authors' elaboration
RMB Internationalization measure (2016-2020)	<i>RGI_ct</i> (+)	Renminbi Globalization Index (RGI) <i>Source:</i> Standard Chartered Research
<i>Financial Market Linkage</i>		
Financial linkage (2015-2020)	<i>ASSETS_ict</i> (+)	Chinese securities (equity, debt) held by residents of country <i>i</i> / GDP, % (bilateral) <i>Source:</i> IMF CPIS
	<i>LIABILITIES_ict</i> (+)	Country <i>i</i> 's securities (equity, debt) held by Chinese residents / GDP, % (bilateral) <i>Source:</i> IMF CPIS
Covered interest arbitrage (2016-2019)	<i>DINT_ict</i> (+)	Short-term interest rate - T bill rate of China, %, annual (bilateral) <i>Source:</i> IMF IFS, OECD
<i>Control Variables</i>		
Excessive Credit in China	<i>CRISK_ct</i> (+)	Credit-to-GDP gaps (actual-trend) of China, % (China) <i>Source:</i> BIS
Exchange Rate Flexibility	<i>REGIME_ict</i> (+)	Exchange rate regime (fine classification 6~14) <i>Source:</i> Itzetki, Reinhart and Rogoff (2019)
	<i>BASKET_ct</i> (+)	Dummy: 1 if China adapts the basket exchange rate regime (China) <i>Source:</i> Authors' elaboration
Trade openness	<i>TRADEOPEN_ict</i> (+)	Total export and import / GDP of country <i>i</i> , % <i>Source:</i> World Bank

Note: Expected signs are in parenthesis.

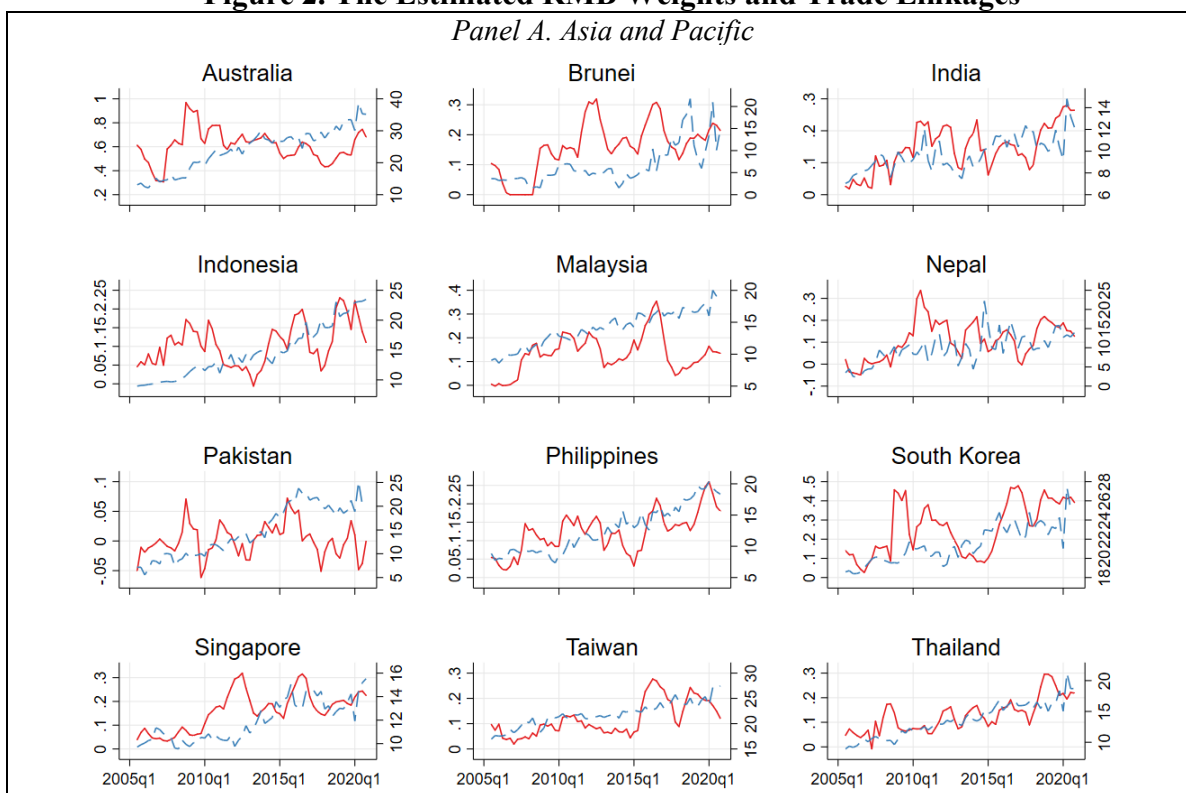
4. Empirical Results

4.1. The RMB Weights

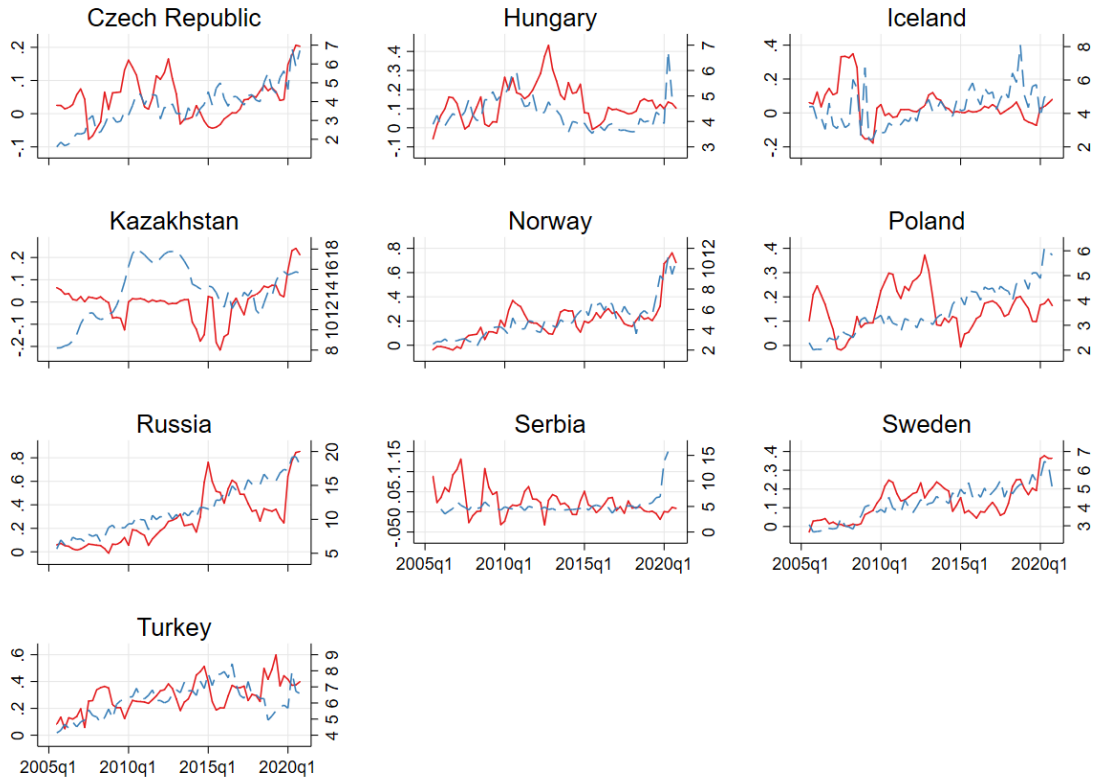
We begin by discussing the RMB weights estimation results for the 31 countries in our data set. The dynamic estimation findings of the RMB weights and bilateral trade linkages with China are shown in Figure 2. Even though the co-movement dynamics with the RMB differ among sample countries, most countries exhibit a general increasing tendency on both estimated RMB weight and bilateral trade linkage.

Asia-Pacific countries, in particular, have relatively higher RMB weights than other regions. We can observe a trend of synchronization between the RMB and the currencies of Asia-Pacific economies with strong trading ties to China, the so-called RMB block (Ito, 2017). Australia and Korea have estimated the highest RMB weights in Asia and Pacific region, which are consistent with the previous Chapter's findings. Co-movement tendencies can also be found outside of the Asia-Pacific region. This finding implies that a variety of factors influences the synchronization with the RMB in addition to trade linkages.

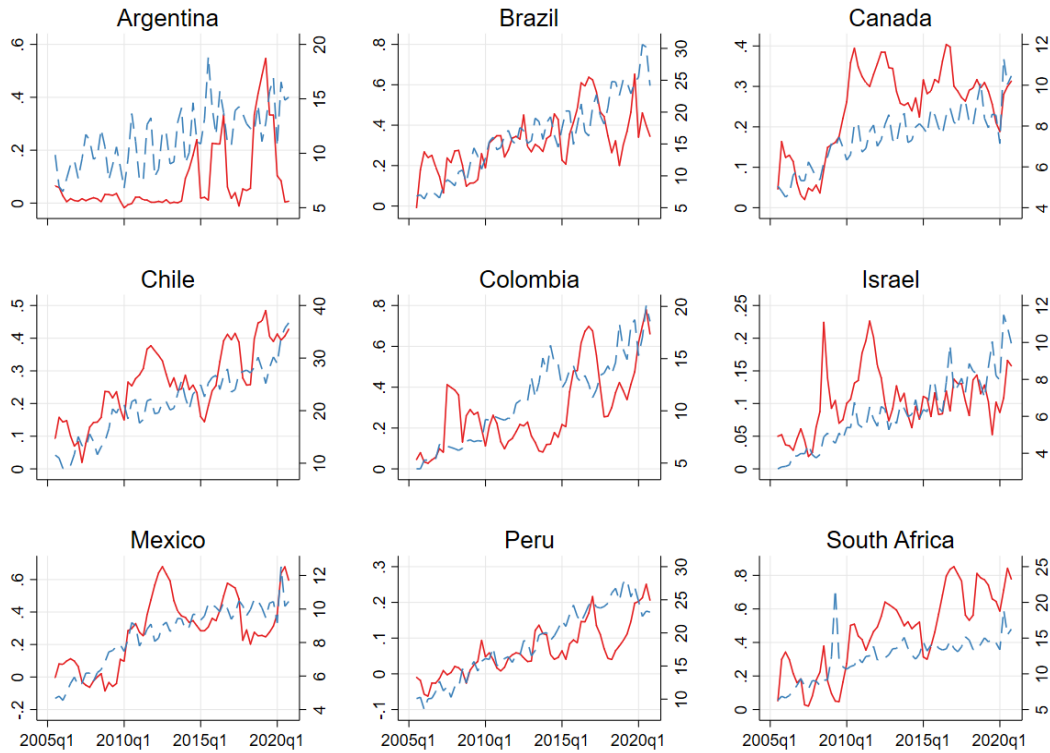
Figure 2. The Estimated RMB Weights and Trade Linkages



Panel B. Europe and Central Asia



Panel C. Other Countries



— Comovement with CNY (right) - - - Trade linkage (left, %)

4.2. Estimation Results on the determinants of the RMB Weights

4.2.1. Trade Linkages

Table 2 reports the estimation results of panel regression models in Equation (4) where the dependent variable is the estimated RMB weight. The trade linkage coefficients in all models are positive and statistically significant, implying that the higher the proportion of trade with China (TRADE), the higher the RMB synchronization.

The shift in the share of trade with China and the exchange rate co-movement followed a similar pattern, as shown in the figure 2. Using the Driscoll-Kraay standard error, this finding is also validated in the regression model. Moreover, the results are also consistent with controlling the country fixed effect in column (5). However, there was no statistically significant correlation between each country's trade openness and the RMB weight.

We employ China's credit-to-GDP gap as a control variable. The credit-to-GDP gap is often regarded as an early warning indicator for macroprudential policy (Borio and Lowe, 2002). The credit-to-GDP gap of China, which captures the level of risk in the Chinese financial market, widened dramatically after the GFC and into 2015, as shown in Figure A1. In all models, the coefficients for excessive credits (CRISK) in China are significant and positive, implying that more excessive credits in China are associated with stronger currency synchronization with the RMB.

We also examine how the flexibility of exchange rate regimes affects the degree of currency co-movement. Columns (2) and (3) track China's and corresponding countries' exchange rate regimes. To quantify the flexibility of exchange rates in corresponding countries, we employ Ilzetki et al. (2019) de facto exchange rate arrangements (REGIME). China returned to a regulated floating system following the GFC, gradually increasing the daily fluctuation band from 0.5 percent to 2.0 percent. The People's Bank of China (PBC) announced a transition to the de facto currency basket system in August 2015, allowing for greater exchange rate flexibility and a departure from the dollar-only linked system. We use a dummy variable (BASKET) to compare currency co-movements before and after this transition.

The coefficients of REGIME are strongly positive, indicating that a country with more exchange rate flexibility has stronger currency co-movements with the RMB. BASKET also shows

a significantly positive coefficient, which implies more synchronized movements between the RMB and other currencies after the transition to the basket system in China. Even after controlling for those variables, the trade linkage effect is still substantial.

Table 2. Trade Linkages

Models	(1)	(2)	(3)	(4)	(5)
Variables (expected signs)	<i>Trade and China Risk</i>	<i>Exchange Rate Regimes</i>	<i>Basket Regime</i>	<i>Trade Openness</i>	<i>Country FE</i>
<i>TRADE_ict</i> (+)	0.883*** (0.069)	0.746*** (0.084)	0.621*** (0.065)	0.586*** (0.067)	0.545*** (0.193)
<i>CRISK_ct</i> (+)	0.188** (0.073)	0.223*** (0.079)	0.181*** (0.063)	0.178*** (0.063)	0.186*** (0.060)
<i>REGIME_it</i> (+)		0.041*** (0.003)	0.042*** (0.003)	0.042*** (0.003)	0.013*** (0.004)
<i>BASKET_ct</i> (+)			0.062*** (0.017)	0.062*** (0.017)	0.060*** (0.019)
<i>TRADEOPEN_it</i> (+)				-0.113*** (0.025)	0.082 (0.056)
Observations	1,976	1,867	1,867	1,867	1,867
Adjusted R ²	0.142	0.377	0.401	0.407	0.662
# of countries	32	31	31	31	31

Note: Driscoll-Kraay standard errors in parenthesis. For better presentation of coefficients, variables with % units have been replaced to ratios and constant is omitted.

4.2.2. China's International Policies

Table 3 reports the effects of Chinese international policies on the RMB synchronization. As shown in all models, the estimation results of trade linkage and control variables are consistent with the results in the previous subsection. We utilize the same explanatory variables as the previous results and add dummy variables representing Chinese government institutional efforts such as bilateral currency swaps, clearing bank authorization, and direct FX market. To address the endogeneity problem, we additionally incorporate the Renminbi internationalization index, which has the capacity to alter both the dependent and explanatory variables.

Despite the finding that the coefficient of the bilateral currency swap dummy variable is negative and statistically significant as in column (1), both authorizations of clearing bank and the direct FX market are estimated to be positive and statistically significant (Columns (2) and (3)). In other words, clearing bank authorizations and direct FX market authorizations have been

implemented based on actual demand as part of China's RMB internationalization policy. These results can be interpreted as improving synchronization with the RMB through currency transactions.

The statistical significance and signs of most variables in columns (1)-(4) do not change following additional analysis after 2015Q3, which includes the RMB internationalization index (RGI) to control for endogeneity in column (5). We tested various internationalization indexes in addition to RGI, as shown in Figure A2, and the logarithm of RMB reserves. They also show comparable results. Aside from authorizations of clearing institutions and direct FX market, accumulating RMB as reserves or internationalization through various policy and market implementations helps boost the RMB synchronization.

Table 3. Chinese International Policies

Models	(1)	(2)	(3)	(4)	(5)
Variables (expected signs)	<i>Swap</i>	<i>Clearing Banks</i>	<i>Direct FX</i>	<i>Swap, Clearing Banks, Direct FX</i>	<i>2016-2020</i>
<i>TRADE_ict</i> (+)	0.637*** (0.069)	0.511*** (0.083)	0.553*** (0.072)	0.619*** (0.079)	0.379*** (0.126)
<i>SWAP_ict</i> (+)	-0.026** (0.011)			-0.071*** (0.014)	-0.125*** (0.016)
<i>CLEARING_ict</i> (+)		0.055*** (0.019)		0.052*** (0.017)	0.128*** (0.023)
<i>DIRECTEX_ict</i> (+)			0.109*** (0.016)	0.120*** (0.017)	0.136*** (0.025)
<i>RGI_ct</i> (+)					0.153** (0.064)
<i>CRISK_ct</i> (+)	0.200*** (0.065)	0.170** (0.066)	0.178*** (0.058)	0.229*** (0.062)	0.112 (0.076)
<i>REGIME_it</i> (+)	0.042*** (0.003)	0.040*** (0.003)	0.040*** (0.003)	0.039*** (0.003)	0.039*** (0.004)
<i>BASKET_ct</i> (+)	0.069*** (0.017)	0.048** (0.018)	0.029* (0.015)	0.029* (0.016)	
<i>TRADEOPEN_it</i> (+)	-0.093*** (0.031)	-0.151*** (0.040)	-0.128*** (0.026)	-0.110*** (0.037)	-0.386*** (0.045)
Observations	1,867	1,867	1,867	1,867	578
Adjusted R ²	0.41	0.414	0.444	0.463	0.555
# of countries	31	31	31	31	29

Note: Driscoll-Kraay standard errors in parenthesis. For better presentation of coefficients, variables with % units have been replaced to ratios and constant is omitted.

4.2.3. Financial Market Linkages

The estimation results of the influence of financial market linkages on the RMB synchronization are shown in Table 4. The empirical results in this subsection only cover the period from 2016 to 2019 due to data availability. The estimation results of trade linkage and Chinese policy implementation dummies are consistent except for the model includes country fixed effects. When the country-fixed effects were added, the number of explanatory variables increased too much based on the cross-sectional data of 21 countries with a short period, 2016-2019. Instead, we confirm the robustness by adding time-fixed effects.

The financial market linkage with China is examined by dividing it into assets and liabilities. Assets are Chinese financial assets held by counterparty countries' residents, and liabilities are external assets of counterparty countries owned by Chinese residents. Both ASSETS and LIABILITIES are positive and statistically significant to RMB weights, as seen in columns (1) through (3). DINT is a covered interest rate parity condition, the interest rate differential between China and counterparty countries. DINT is estimated to be positive and statistically significant in relation to RMB weights, which could indicate that a greater interest rate differential between the two countries can encourage more financial activities and, consequently, more synchronization of exchange rates.

Table 4. Financial Market Linkages

Models	(1)	(2)	(3)	(4)	(5)
Variables (expected signs)	<i>Assets and Liabilities</i>	<i>Clearing Banks, Direct EX</i>	<i>RGI</i>	<i>Country FE</i>	<i>Time FE</i>
<i>TRADE_ict</i> (+)	0.647*** (0.122)	0.575*** (0.128)	0.614*** (0.117)	-1.135*** (0.313)	0.655*** (0.126)
<i>ASSETS_ict</i> (+)	2.994*** (0.447)	2.168*** (0.653)	2.029*** (0.645)	0.546 (0.816)	1.950** (0.671)
<i>LIABILITIES_ict</i> (+)	0.467*** (0.012)	0.210*** (0.054)	0.196*** (0.055)	-0.275* (0.140)	0.192*** (0.054)
<i>DINT_ict</i> (+)	0.033*** (0.003)	0.030*** (0.003)	0.029*** (0.003)	0.024*** (0.002)	0.028*** (0.003)
<i>CLEARING_ict</i> (+)		0.082*** (0.015)	0.076*** (0.015)	0.076* (0.037)	0.071*** (0.016)
<i>DIRECTEX_ict</i> (+)		0.087** (0.031)	0.097*** (0.029)	0.014 (0.021)	0.100*** (0.029)
<i>RGI_ct</i> (+)			0.062 (0.044)	-0.010 (0.074)	
Observations	258	258	258	258	258
Adjusted R ²	0.494	0.588	0.591	0.873	0.619
# of countries	21	21	21	21	21

Note: Driscoll-Kraay standard errors in parenthesis. For better presentation of coefficients, variables with % units have been replaced to ratios and constant is omitted.

4.3. Robustness Checks

We conduct several variations of the baseline model to examine whether our empirical findings are robust. First of all, we use the CHF as the numeraire rather than the NZD. Prior to being pegged in the EUR, the CHF is most usually used as the numeraire in literature. Second, rather than using a one-year rolling window, we estimate the RMB weight quarter-by-quarter. The quarter-by-quarter window does not overlap observations in each quarter estimation. The estimation results resolve the autocorrelation problem, although they may be inconsistent due to the limited sample size in estimation. To address the autocorrelation problem in the baseline model, we apply Driscoll-Kraay standard errors. Third, rather than quarterly frequency, we examine at annual frequency. Overall, the main findings are very robust with the variations.

Columns (1)-(3) in Table 5 report the estimation results with anchor currency CHF. Each column confirms the roles of trade linkage, RMB internationalization policies, and financial market linkages. Except for the direct FX market, coefficients of main variables show the statistical

significance and expected signs. Columns (4)-(6) in Table 5 also show consistent results compared to the main findings even with RMB weights estimated with a quarter-by-quarter window. Columns (7) and (8) in Table 5 report the results with annual frequency. Due to a lack of time-series data, financial linkages are not examined.

Table 5. Robustness Checks

Models	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Robustness Tests	<i>Anchor</i>	<i>Currency</i>	<i>Swiss Franc</i>	<i>Rolling Window: 1 quarter</i>			<i>Annual Frequency</i>	
Variables (expected signs)	<i>Trade</i>	<i>RMB Policies</i>	<i>Finance</i>	<i>Trade</i>	<i>RMB Policies</i>	<i>Finance</i>	<i>Trade</i>	<i>RMB Policies</i>
<i>TRADE_ict</i> (+)	0.493*** (0.150)	0.419** (0.165)	0.346*** (0.097)	0.499*** (0.062)	0.534*** (0.076)	0.687*** (0.166)	0.603*** (0.099)	0.648*** (0.122)
<i>SWAP_ict</i> (+)		0.005 (0.020)			-0.073*** (0.013)			-0.080*** (0.015)
<i>CLEARING_ict</i> (+)		0.055** (0.022)	0.072** (0.026)		0.057*** (0.019)	0.068** (0.023)		0.064*** (0.020)
<i>DIRECTEX_ict</i> (+)		-0.030 (0.028)	-0.103** (0.038)		0.104*** (0.018)	0.093** (0.031)		0.119*** (0.020)
<i>RGI_ct</i> (+)			0.282** (0.114)			0.143* (0.066)		
<i>ASSETS_ict</i> (+)			1.268*** (0.391)			1.627** (0.663)		
<i>LIABILITIES_ict</i> (+)			-0.040 (0.040)			0.178** (0.066)		
<i>DINT_ict</i> (+)			0.002 (0.009)			0.024*** (0.003)		
<i>CRISK_ct</i> (+)	0.055 (0.113)	0.043 (0.121)		0.190*** (0.067)	0.242*** (0.071)		0.158** (0.063)	0.219*** (0.052)
<i>REGIME_it</i> (+)	-0.012* (0.007)	-0.013** (0.006)		0.041*** (0.004)	0.039*** (0.004)		0.042*** (0.005)	0.039*** (0.004)
<i>BASKET_ct</i> (+)	0.110*** (0.033)	0.104*** (0.029)		0.065*** (0.018)	0.036* (0.019)		0.053** (0.020)	0.018 (0.017)
<i>TRADEOPEN_it</i> (+)	0.081** (0.036)	0.043 (0.043)		-0.104*** (0.027)	-0.101** (0.039)		-0.116*** (0.036)	-0.114* (0.060)
Observations	1,867	1,867	258	1,867	1,867	258	479	479
Adjusted R ²	0.135	0.141	0.264	0.297	0.335	0.391	0.401	0.463
# of countries	31	31	21	31	31	21	31	31

Note: Driscoll-Kraay standard errors in parenthesis. For better presentation of coefficients, variables with % units have been replaced to ratios and constant is omitted.

5. Conclusion

In this study, dynamic synchronization between RMB and 32 currencies was calculated by estimating the RMB weights in each currency. We constructed the country-panel data from July 2005 to December 2020, when the RMB began to transition to a floating exchange rate system. We empirically investigate factors influencing currency co-movements with RMB. Our findings are robust with different anchor currencies, different estimation methods, and different data frequencies.

The implications of the results are the following. First, bilateral trade and financial market linkages increase the synchronization between RMB and other currencies. It indicates that increased bilateral trade demand the use of RMB in the settlement. Second, the more flexible the exchange rate system of the other country or China induces, the stronger the synchronization. As a more flexible exchange rate system in China is expected, currencies will correlate to RMB more. Third, RMB internationalization policy measures have intensified their co-movements. In particular, this finding provides direct policy implications for designing policy tools for Korean won internationalization. In fostering the international use of Won, policy measures based on demand for Korean Won are needed.

However, caution is required in interpreting the results in this paper. The recent increase in the synchronization between the currencies of various countries and the RMB indicates that RMB internationalization has progressed further. One might view that the rise in RMB use in trade and financial transactions hinders the Korean won settlement. However, this study does not purpose to examine the competitive relationship between the two currencies. Instead, this study intends to provide implications for the internationalization of the Korean won through the case of the RMB.

In addition, in the case of Korea, the level of capital liberalization is considerably higher than that of China, and exchange rate volatility is relatively high. It could be that this volatility can be a factor that slows the internationalization of the won. However, the volatility of RMB is different from that of the Korean Won, as it has been moving to a floating exchange rate only since August 2015. Future research could expand the study by analyzing the determinants of synchronicity with the euro or the dollar with free-floating regimes.

Exchange rate synchronicity means that the direction of currency value volatility is similar. For example, the synchronization with RMB can be seen as encompassing both directions rather

than only the appreciation and the appreciation. However, since the economic effects of appreciation and depreciation of currency values are different, this study needs a follow-up study that analyzes the RMB appreciation and depreciation period separately.

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Appendix

Table A1. List of Countries

Country	ISO	Income Group (WB)	Income Group (IMF)
<i>Asia & Pacific (13)</i>			
Australia	AUS	High	Advanced
Brunei	BRN	High	Emerging and developing
India	IND	Lower middle	Emerging and developing
Indonesia	IDN	Lower middle	Emerging and developing
Malaysia	MYS	Upper middle	Emerging and developing
Nepal	NPL	Lower middle	Emerging and developing
Pakistan	PAK	Lower middle	Emerging and developing
Philippines	PHL	Lower middle	Emerging and developing
Singapore	SGP	High	Advanced
South Korea	KOR	High	Advanced
Sri Lanka	LKA	Lower middle	Emerging and developing
Taiwan	TWN	High	Advanced
Thailand	THA	Upper middle	Emerging and developing
<i>Europe & Central Asia (10)</i>			
Czech Republic	CZE	High	Advanced
Hungary	HUN	High	Emerging and developing
Iceland	ISL	High	Advanced
Kazakhstan	KAZ	Upper middle	Emerging and developing
Norway	NOR	High	Advanced
Poland	POL	High	Emerging and developing
Russia	RUS	Upper middle	Emerging and developing
Serbia	SRB	Upper middle	Emerging and developing
Sweden	SWE	High	Advanced
Turkey	TUR	Upper middle	Emerging and developing
<i>North America, Latin America & Caribbean, Middle East & Africa (9)</i>			
Canada	CAN	High	Advanced
Argentina	ARG	Upper middle	Emerging and developing
Brazil	BRA	Upper middle	Emerging and developing
Chile	CHL	High	Emerging and developing
Colombia	COL	Upper middle	Emerging and developing
Mexico	MEX	Upper middle	Emerging and developing
Peru	PER	Upper middle	Emerging and developing
Israel	ISR	High	Advanced
South Africa	ZAF	Upper middle	Emerging and developing

Table A2. Bilateral Currency Swap Agreements

Country	The first year signed on MOU	The latest SWAP RMB amount (Billion yuan)
Albania	2013	2
Arab Emirates	2015	35
Argentina	2009	70
Armenia	2015	1
Australia	2012	200
Belarus	2009	20
Canada	2014	200
Chile	2015	22
Egypt	2016	18
Eurozone	2013	350
Georgia	2015	0
Hong Kong	2009	400
Hungary	2013	20
Iceland	2010	3.5
Indonesia	2009	200
Japan	2018	200
Kazakhstan	2011	7
Macao	2019	30
Malaysia	2009	180
Mongolia	2011	15
Morocco	2016	10
New Zealand	2011	25
Nigeria	2018	15
Pakistan	2011	20
Qatar	2014	35
Russia	2014	150
Serbia	2016	1.5
Singapore	2010	300
South Africa	2015	30
South Korea	2009	360
Sri Lanka	2014	10
Suriname	2015	1
Switzerland	2014	150
Tajikistan	2015	3
Thailand	2011	70
Turkey	2012	12
Ukraine	2012	15
United Arab Emirates	2012	35
United Kingdom	2013	350
Uzbekistan	2011	700

Source: Authors' elaboration

Table 5-A3. Authorization of Clearing Banks

Year	#	Countries
2011	1	Hong Kong
2012	1	Taiwan
2013	1	Singapore
2014	8	Australia, Canada, France, Germany, Luxembourg, Qatar, South Korea, United Kingdom
2015	8	Argentina, Chile, Hungary, Malaysia, South Africa, Switzerland, Thailand, Zambia
2016	3	Russia, United Arab Emirates, United States
2018	1	Japan
2019	1	Philippines

Source: Authors' elaboration.

Table A4. Authorization of direct trading via the interbank foreign-exchange market, CFETS (the China Foreign Exchange Trade System)

Year	#	Countries
2010	2	Malaysia
2012	1	Japan
2013	1	Australia
2014	4	EU, Kazakhstan, New Zealand, United Kingdom
2015	1	Switzerland
2016	12	United Arab Emirate, Canada, Denmark, Hungary, Mexico, Norway, Poland, Saudi Arabia, South Africa, South Korea, Sweden, Turkey
2017	2	Cambodia

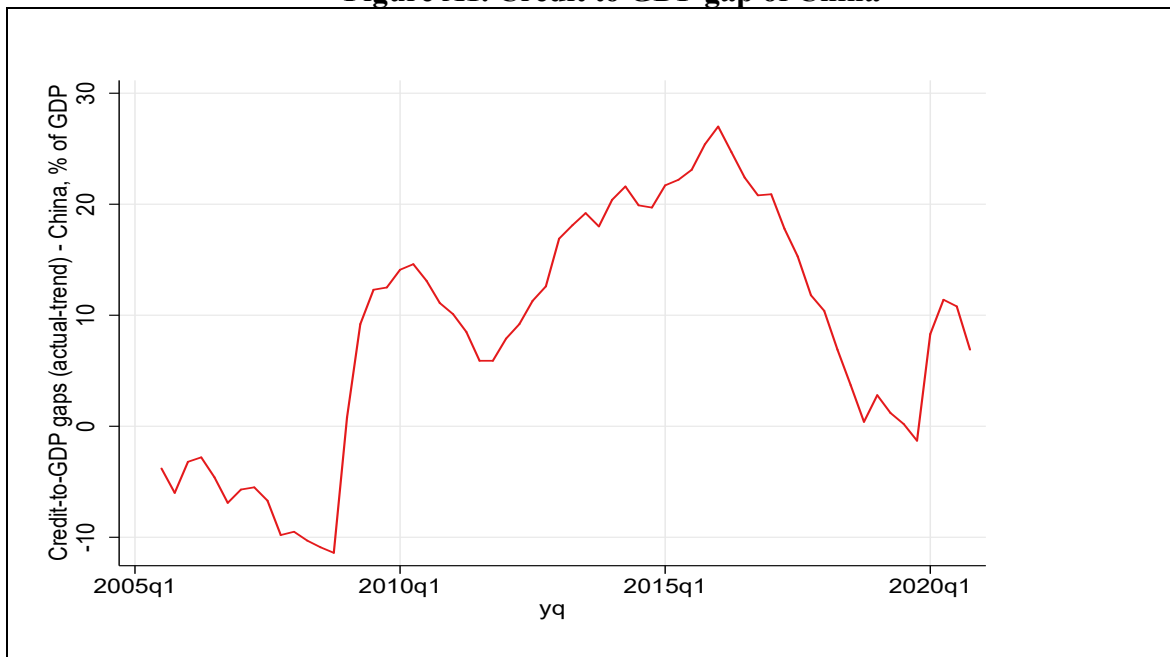
Source: Authors' elaboration.

Table A5. Exchange Rate Classification (in 2015)

Index	Definition	# of countries
6	Pre announced crawling band that is narrower than or equal to +/-2% or de facto horizontal band that is narrower than or equal to +/-2%	1
7	De facto crawling peg	3
8	De facto crawling band that is narrower than or equal to +/-2%	5
9	Pre announced crawling band that is wider than or equal to +/-2%	0
10	De facto crawling band that is narrower than or equal to +/-5%	2
11	Moving band that is narrower than or equal to +/-2% (i.e., allows for both appreciation and depreciation over time)	6
12	De facto moving band +/-5%/ Managed floating	10
13	Freely floating	1
14	Freely falling	3

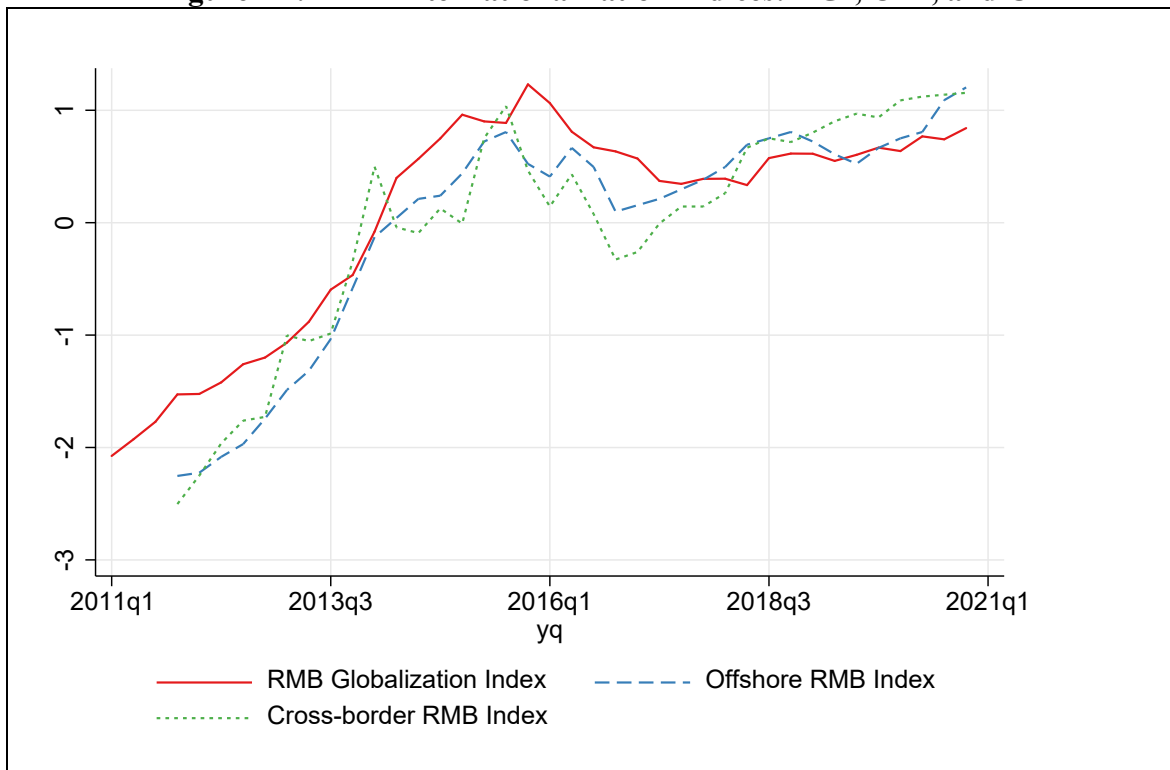
Source: Itzetki, Reinhart and Rogoff (2019)

Figure A1. Credit to GDP gap of China



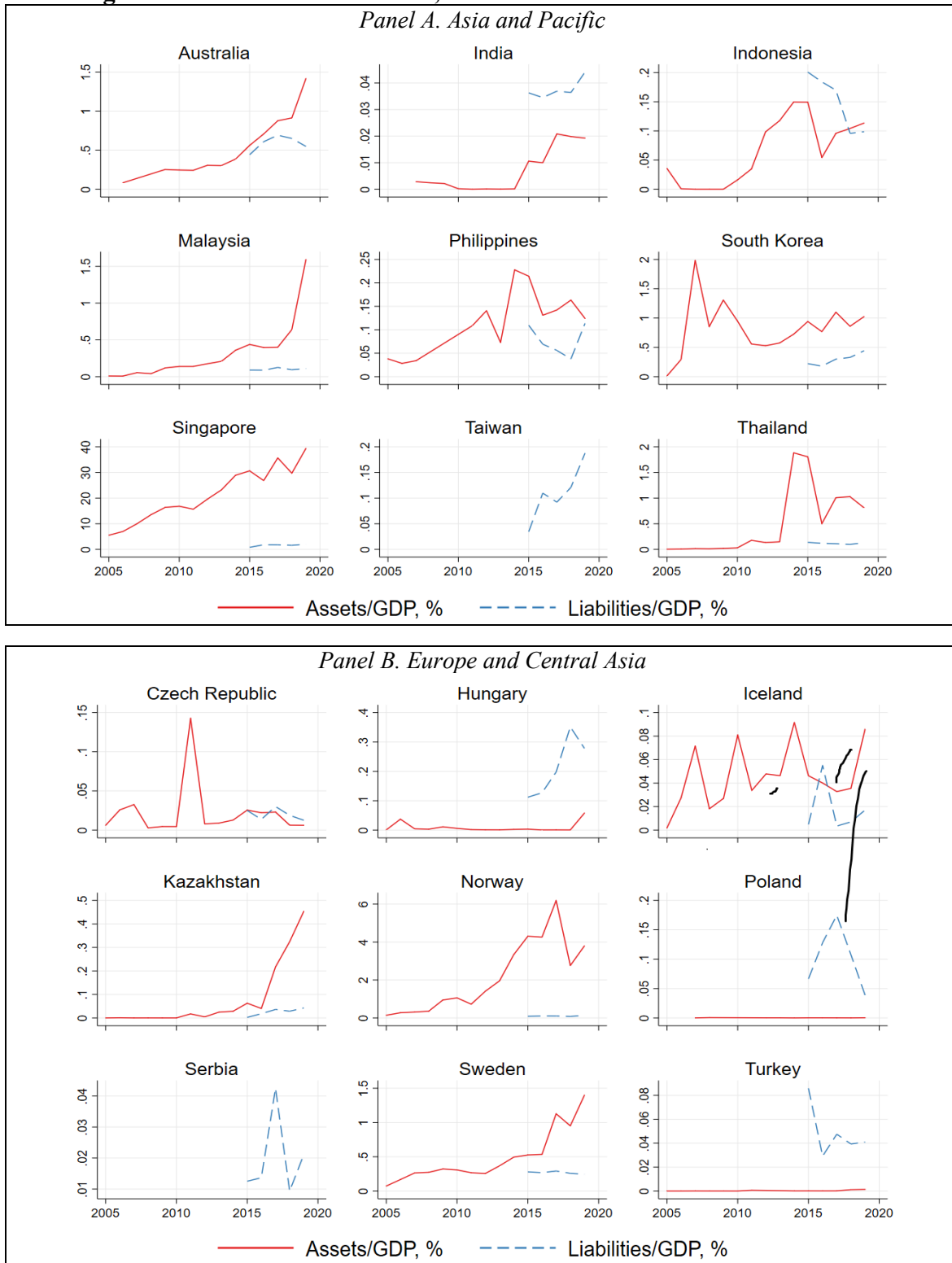
Source: BIS.

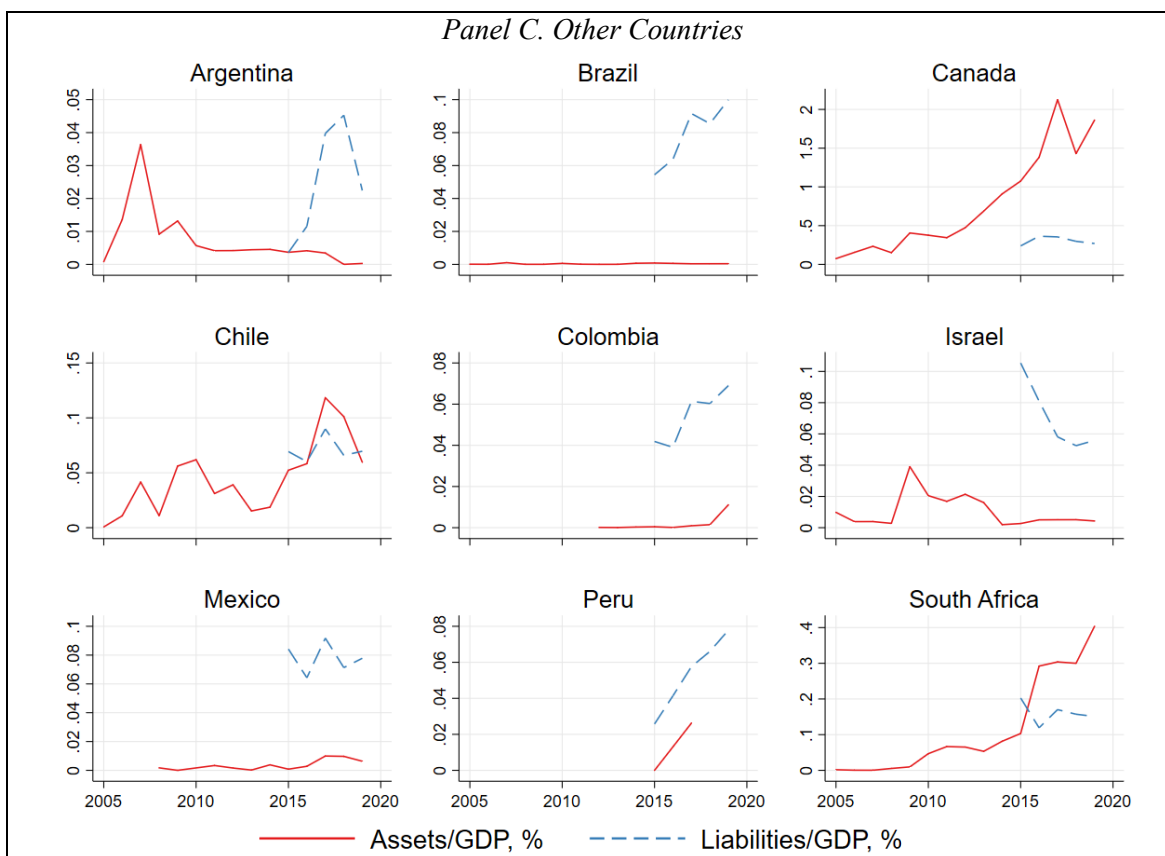
Figure A2. RMB Internationalization Indices: RGI, ORI, and CRI



Source: Standard Chartered; People's Bank of China.

Figure A3. Portfolio Investment, Bilateral Assets and Liabilities with China





Source: IMF CPIS.