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Exchange Rate Co-movements and Corporate Foreign Exchange Exposures: A Study on RMB*

By **He Qing, Wang Wenqing and Yu Jishuang***

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Abstract

We estimate the time-varying co-movements of large set of bilateral exchange rates/the RMB and explore their relationship with the firm-level exchange rate exposure in China.
Empirical evidence reveals that firms' exposure to exchange rate fluctuations increases during periods of heightened co-movements in exchange rate. The co-movements of emerging market currencies have a weaker effect on exposure compared to the co-movements of developed market currencies. This effect becomes more pronounced after the launch of One Belt One Road initiative, RMB inclusion in SDR basket and in highly multinational firms, providing evidence that the RMB's internationalization (i.e., its anchoring effect) has generally helped to reduce Chinese firms' exposure to exchange rate fluctuations of emerging market currencies.

JEL Classification: G32, G39, G15
Keywords: exchange rate co-movements, exchange rate exposure, RMB internalization

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1. Introduction

Amid China's burgeoning economy, the international use of the RMB in global markets has risen significantly in recent years (Cheung et al, 2018; Cheung, 2021). As of end-2019, about 19.15% of China's trade was settled using the RMB. According to the Society for Worldwide Interbank Financial Telecommunication (SWIFT), the transactions share of the RMB in the global financial market has increased to 1.94%, ranking 6th in the world (SWITF, 2020). It is clear that the RMB is playing an increasing role as an anchor currency. A growing number of studies have found that the RMB has substantially driven the movements of regional and other emerging market currencies since its detachment from the USD in July 2005 (Caporale et al., 2018; Marconi, 2018)1. More recent evidence has found stronger RMB impacts by observing strikingly similar movements between the RMB and a set of emerging market economies after the outbreak of COVID-19. During the period of the RMB's appreciation against the USD, Asia's emerging market currencies have experienced similar movements (Wei et al., 2020). The RMB's increased flexibility and its driving role in emerging market currencies raise an important question which has yet to be understood: whether and how exchange rate co-movements against the RMB influence Chinese firms' exchange rate exposure.

Theoretically, it would be straightforward to have a positive relationship between currency co-movements against the RMB and Chinese firms' exchange rate exposure since foreign exchange rate risks are not fully diversified if the currency movements in an international portfolio are highly correlated (Goldberg and Heflin, 1995; Krapl, 2017, 2020). However, the driving force behind co-movements against the RMB can manifest in two distinct ways. Changes in bilateral exchange rates/the RMB are determined by both the value of the RMB and the value of respective currencies. From the perspective of Chinese firms, if the RMB drives the dynamics of other currencies, the movements of multiple exchange rates (or a currency portfolio) are determined by the RMB's value changes. Nevertheless, currency co-movements against the RMB can also emerge simply because the values of other currencies move in the same direction, for instance, if their values are predominantly influenced by changes in the USD.

To answer our research question, we examined the relationship between currency co-movements against the RMB and corporate exchange rate exposures in China. In the foreign exchange market, the return and volatility of different currencies will be affected by various shocks, resulting in the similarity of returns and fluctuations of different currencies. The currency literature has referred this similarity as exchange rate co-movement (Chiang et al., 2007; Billio et al., 2017; Krapl, 2020). From the perspective of Chinese firms, exchange rate co-movement is reflected in the return similarity of various currencies against RMB (McCauley and Shu, 2019). Drawing from prior studies (Billio et al., 2017; Krapl, 2020), we employ unconditional correlation coefficients of bilateral exchange rates to gauge co-movements. A higher positive correlation coefficient indicates a stronger degree of exchange rate co-movement between currencies2

Specifically, we estimated multiple currency co-movements for developed economies (DE) and emerging market economies (EME). There are significant differences between the co-movements of DE and EME currencies. The integration of emerging market economies with global markets varies, with some, such as South Africa, China, and India, only partially linked to

[1] Caporale et al. (2018) show that the RMB is increasingly replacing the USD as an anchor currency in emerging market economies.

[2] This simple correlation measures co-movements as well or better than more sophisticated measures (Billio et al., 2017)

global financial markets, resulting in low correlations with developed economies' assets (Bekaert et al., 2011; Donadelli and Paradiso, 2014; Billio et al., 2017). Conversely, certain emerging market economies, like Korea and Thailand, experience heightened vulnerabilities during DE countries' economic turbulence due to their high integration with international financial markets3. Of particular significance, an increasing number of EME currencies are incorporating the RMB into their currency baskets, indicating the RMB's progression towards anchor currency status (Keddad, 2019). The anchoring effect should increase EME currency co-movements as their values are closely tied to the value of the RMB. Moreover, the anchoring effect increases the benefits of using a particular anchor (e.g., the RMB) for international trade and asset settlements with countries using the same anchor (Eichengreen et al., 2007; Meissner and Oomes, 2009). Consequently, this mitigates Chinese firms' exchange rate exposure by offsetting foreign currency revenues with costs denominated in the same currency. As a result, the co-movements of EME currencies are anticipated to exert a weaker impact on exchange rate exposure compared to those of DE currencies.

Using a large sample of all Chinese public firms from 2005 to 2019, we empirically examined the effects of currency co-movements on firms' exposure to exchange rate fluctuations. We found that currency co-movements against the RMB are time-varying. Notably, as the RMB attains status as a regional currency and undergoes increased flexibility, we observe a reduction in co-movements of developed economies' currencies against the RMB, juxtaposed with a noteworthy escalation in co-movements of emerging market economies' currencies against the RMB.

Our evidence is consistent with the prediction that exchange rate co-movements heighten firms' exchange rate exposure, while the anchoring effect of the RMB weakens the relationship between exchange rate co-movements and exposure to emerging market economy (EME) currencies. In particular, we found that exposure increased with DE currencies and EME currencies' co-movements, with the impact being economically smaller for the latter group. Notably, the influence of EME currency co-movements on firms' exchange rate exposure diminished following the implementation of the Belt and Road Initiative (BRI) and among highly multinational firms.

Similar results were obtained across multiple measures of exchange rate co-movements and exposure as well as with a variety of specifications. Furthermore, we find that these results remain unaffected even after controlling for other conventional determinants of exchange rate exposure, and incorporating fixed effects to account for industry, year, and firm-specific factors.

Finally, we provide further evidence on how the RMB's internationalization and movements affect our results. We found that the impact of exchange rate co-movement on exposure to EME currencies was more pronounced prior to the RMB's inclusion in the Special Drawing Right (SDR) and during periods characterized by RMB depreciation and heightened volatility. These results reinforce our previous findings that the RMB's internationalization (i.e., its anchoring effect) has generally helped to reduce the impact of exchange rate co-movements on Chinese firms' exchange rate exposure.

Our research is related to the growing body of economic and policy research on the RMB's internationalization. Existing research has predominantly focused on several key inquiries,

[3] Highly Integration of emerging market economies and the risk aversion of international investors are important reasons for EME vulnerability to the global financial crisis (Calvo et al., 2006; Reinhart and Rogoff, 2009; Aizenman et al. 2016). We thank the suggestions of an anonymous referee.

including the RMB's impact on the dynamics of emerging market economy (EME) currencies (Kawai and Pontines, 2016; Keddad, 2019), its role as a safe haven currency (Fatum et al., 2017; McCauley and Shu, 2019), and its effects on the international monetary system (He et al., 2016; Batten and Szilagyi, 2016; Marconi, 2018). In this context, our study advances this field of research by demonstrating that the RMB's internationalization can significantly influence the time-varying diversifiability of Chinese firms' exposure to exchange rate fluctuations involving EME currencies.

Our study also adds to the existing literature on exchange rate exposure, as it represents the first academic endeavor to directly examine the association between firms' exchange rate exposure level and exchange rate co-movements relative to the RMB. Recent empirical evidence indicates the significant relevance of undiversifiable currency risk arising from currency co-movements for numerous US firms (Krapl, 2020). Our findings suggest that this may be attributed to the prevalent inability of many firms to effectively hedge foreign revenue with costs denominated in the same currency. Consequently, future research should consider incorporating the invoicing currency utilized in international transactions to accurately estimate a firm's exposure to exchange rate fluctuations.

Our study underscores the significance of currency risk exposure and emphasizes the importance for firms to be vigilant about potential currency mismatches between their revenues and costs. The interplay of currency co-movements may result in fluctuations in a firm's exposure to exchange rate risk, thereby posing challenges to its risk management strategies. Furthermore, our research yields evidence supporting the added advantages of currency internationalization. Specifically, a higher level of currency internationalization, particularly the use of domestic currency in cross-border transactions, can serve to alleviate the undiversifiable risk arising from such co-movements.

The paper is structured as follows: Section 2 provides an overview of the institutional background relevant to our study and formulates our main hypotheses; Section 3 outlines the data and methodology employed in our analysis; Section 4 presents the empirical findings; Section 5 conducts various robustness checks to validate the results; and Section 6 offers concluding remarks to summarize the key insights of the paper.

2. Institutional background and hypothesis development

2.1 Institutional background

Prior to July 2005, China adhered to a fixed exchange rate system, pegging the RMB to the value of the USD. During the period from 1994 to 2005, the RMB's exchange rate remained relatively stable at approximately 8.28. In an effort to reduce the influence of the USD on the formulation of RMB exchange rate policies, the People's Bank of China (PBOC) announced on 21st July 2005 its adoption of a managed floating exchange rate regime with reference to a basket of currencies. The composition of this basket comprised currencies of countries with significant trade, external debt, and foreign direct investment exposure to China (Zhou, 2005). Under this new regime, the daily trading price of the USD/RMB exchange rate was allowed to fluctuate within a 0.3% band around the central parity. Subsequently, on 18th May 2007, the trading bandwidth of the RMB against the USD was extended to 0.5%.

However, during the 2008 global financial crisis, the market-oriented reform was interrupted, leading to the RMB being de facto pegged to the USD at a rate of 6.83. The reform resumed on 19th June 2010 when the PBOC expressed its intention to further advance the reform of the RMB exchange rate regime and enhance the RMB's exchange rate flexibility. The central

objective was for the RMB exchange rate to be more reflective of market supply and demand with reference to a basket of currencies. Consequently, the trading bandwidth was further expanded to 1% on 14th April 2012 and 2% on 17th March 2014.

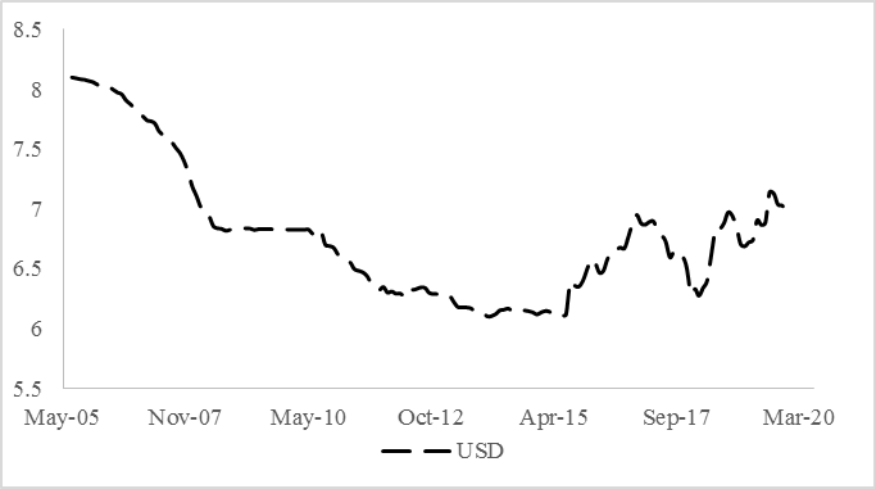
To enhance the influence of market forces in shaping the RMB exchange rate, the People's Bank of China (PBOC) took additional measures. On 11th August 2015, the PBOC announced its commitment to 'improve quotation of the central parity of RMB against the US dollar,' and instructed that market makers' daily reports of central parity to the China Foreign Exchange Trade System (CFETS) should reference the closing rate of the inter-bank foreign exchange market from the previous day[4].

The overhaul of the central parity quotation system marked a significant stride taken by China in its transition towards greater RMB exchange rate flexibility (Cheung et al., 2018). As depicted in Figure 1, the RMB exchange rate experienced a reversal in its downward trajectory in August 2015, the first instance since 2010. Subsequently, it resumed a downward trend in August 2017 before witnessing a renewed upswing in July 2018. The heightened fluctuation in the RMB-USD exchange rate indicates that market forces have played a discernible role in determining the RMB's value.

Furthermore, driven by China's increased prominence in the global economy, underscored by initiatives such as the Belt and Road Initiative (BRI) and the RMB's inclusion in Special Drawing Rights (SDR) baskets, the RMB has witnessed a substantial rise in its global standing. Trading in RMB has surged considerably over the past decade, growing more than sevenfold as a share of the global financial markets, from 0.25% in 2012 to 1.94% in 2019. By the end of 2019, approximately 19.15% of China's trade transactions were settled in RMB. Notably, China's RMB has surpassed the euro, securing the position of the second most widely used currency in international trade finance (SWIFT, 2020).

In summary, the enhanced exchange rate flexibility of the RMB has correspondingly intensified the co-movements of other emerging market economy (EME) currencies in relation to the RMB. Put differently, the RMB's influence on other currencies has been bolstered as the currency adopts a more flexible stance towards a range of multilateral currencies.

Figure 1 The bilateral USD-RMB exchange rate



[4] Available at http://www.pbc.gov.cn/en/3688110/3688181/a13b2cb0/index89.html.

2.2 Literature review and hypothesis development

It is well accepted that foreign exchange rate risks are significantly priced in the global financial market and are important determinants of expected equity returns (Reeb et al., 1998; Carrieri et al., 2006; Krapl, 2015). This is mainly attributed to the non-diversifiable nature of foreign exchange rate risk, which exerts adverse effects on the performance of international portfolios (Eun and Resnick, 1988; Goldberg and Heflin, 1995; Dolde et al., 2012). In line with this, numerous empirical studies have consistently identified a significant negative association between the diversifiability of foreign exchange rate risks and systematic risks (Goldberg and Heflin, 1995; Krapl, 2020).

The non-diversifiability of exchange rate risks arises from the high correlation among the movements of multivariate exchanges (Eun and Resnick, 1988; Allayannis et al., 2001; Krapl, 2020). From the perspective of Chinese firms, their exchange rate exposures predominantly hinge on the correlation between foreign exchange rates vis-à-vis the RMB. If these firms are exposed to multiple foreign exchange rates exhibiting strong and positive correlations, the resulting exchange rate co-movements become substantial, leading to a lack of diversification in exchange rate exposures.

The movement of foreign currency exchange rates against the RMB depends on both the value of the RMB and the value of respective foreign currencies. Consequently, currency co-movements arise in two scenarios: firstly, when the values of multiple currencies are driven by the value of the RMB, and secondly, when there exist common factors influencing the values of multiple currencies. The latter aspect has been extensively addressed in the currency co-movements literature (Benediktsdottir and Scotti, 2009; Li, 2011; Loaiza-Maya et al., 2015; Caporale et al., 2018), whereas the former has received relatively less attention.

Significantly, the RMB's increasing prominence as an anchor currency has exerted a growing influence on other emerging market economy (EME) currencies (Kawai and Pontines, 2016; Caporale et al., 2018). EME currencies tend to closely co-move with the RMB when significant changes occur in the RMB's value, as the RMB drives the movements of these currencies. However, a more globally integrated RMB strengthens its anchoring effect and enables the offsetting of foreign currency revenues with costs in the same currency, particularly for EME currencies, resulting in a substantial reduction in exposure[5].

The currency risks associated with emerging market economies (EME) have assumed growing significance, given their pivotal role in China's international trade and finance. Should Chinese firms possess the capability to conduct transactions with EME countries using the same currency (referred to as the anchoring effect), the non-diversifiable exchange rate risks arising from the co-movement of EME currencies are expected to have a diminished impact on firms' exchange rate exposure. Drawing from the aforementioned analysis, we have formulated the following hypothesis:

$\boldsymbol{H_1}$: Corporate exchange rate exposures are positively correlated with exchange rate co-movements. The co-movement of EME currencies has a smaller impact on firms' exchange rate exposure than the co-movement of DE currencies.

The next question pertains to whether the launch of the BRI has changed exchange rate co-movements and their impacts on Chinese firms' exchange rate exposure. The BRI, an

[5] Bodnar and Marston (2002) demonstrate the offsetting effects of foreign currency revenues and costs being in the same currency.

international economic cooperation initiative proposed by China, seeks to strengthen trade and financial collaborations with partner countries through the development of the land-based Silk Road Economic Belt and the 21st Century Maritime Silk Road[6]. This initiative has fostered international cooperation, promoted China's overseas direct investments, and amplified the significance of China's trade with its partner nations. Consequently, the RMB's influence on regional currencies has intensified, forging closer ties between the RMB and these currencies.

Several studies have identified a rise in the utilization of the RMB for cross-border transactions under the BRI (Ito, 2017). Furthermore, to uphold their price stability and international competitiveness, several emerging market economies (EMEs) have explicitly or implicitly incorporated RMB weights in their basket currencies (Lien et al., 2014; Marconi, 2018).

The implementation of the Belt and Road Initiative (BRI) is expected to augment the anchoring effect of the RMB and potentially strengthen its association with emerging market economy (EME) currencies. Additionally, the BRI is facilitating cross-border transactions for Chinese firms utilizing the RMB, consequently mitigating their exposure to currency risks. As a result, we hypothesize that the non-diversifiable exchange rate risks arising from the co-movement of EME currencies will have a reduced impact on firms' exposure under the BRI. Thus, we put forth the following hypothesis:

$\boldsymbol{H_2}$: The co-movements of EME currencies exhibit a smaller impact on firms' exchange rate exposure after the launch of the BRI.

It is important to note that exchange rate risks not only affect multinational companies (MNCs) directly engaged in international operations, but also domestic firms that do not engage in international trade or international financial transactions (Bergbrant et al., 2014; Francis et al., 2017). Domestic firms can be affected indirectly due to competition in the markets in which they operate (Hutson and Laing, 2014)[7] and by resource allocation from domestic firms to globally engaged firms (Goldberg, 1993).

In contrast, multinational companies (MNCs) face both direct and indirect exposures to exchange rate risks, but they also have various avenues for risk reduction, such as currency diversification, offsetting currency revenue with costs in the same currency, and enhanced flexibility in managing foreign exchange risks (Pantzalis et al., 2001; Hutson and Liang, 2014; He et al., 2021). Numerous studies have indicated a negative relationship between multinationality and exchange rate exposure. For instance, Pantzalis et al. (2001) examined a sample of 220 US-based MNCs and found that exposure decreases with the number of countries in which the firm has subsidiaries. Similarly, Williamson (2001) demonstrated that within the auto industry, a firm's exposure decreases with the extent of its foreign operations. More recently, Huston and Laing (2014) observed a significant inverse relationship between firms' exchange rate exposures and the level of their multinationality.

These discussions have two significant implications. Firstly, domestic firms are susceptible to indirect exposure. Thus, we anticipate a positive relationship between the exchange rate exposure of domestic firms and exchange rate co-movements. Secondly, the impact of exchange rate co-

[6] The Silk Road Economic Belt Initiative and the 21st Century Maritime Silk Road Initiative were put forward by President Xi Jinping in September and October 2013, respectively. On March 28, 2015, the National Development and Reform Commission (NDRC), China's Foreign Ministry, and China's Ministry of Commerce jointly issued the Vision and Actions on Jointly Building the Silk Road Economic Belt and the 21st Century Maritime Silk Road.

[7] The indirect exposure arises because domestic firms have business relationships with exporters or importers; also, they are competitors of firms that are significantly exposed to exchange rate fluctuations (Francis et al., 2017).

movements on the exposure of multinational companies (MNCs) is expected to be economically smaller compared to the impact on domestic firms. MNCs have the advantage of employing alternative strategies to mitigate exchange rate risks, which is not readily available to domestic firms. Notably, Chinese MNCs can effectively reduce their exposure by extensively utilizing the RMB in international transactions, thereby offsetting foreign revenue with costs. As the RMB plays an increasingly pronounced role in emerging market economies (EME), the impact of EME currency co-movements on MNCs' exposure is anticipated to be smaller than the impact of developed economy (DE) currency co-movements. In light of these expectations, we propose a third hypothesis:

$\boldsymbol{H_3}$**:** Exchange rate co-movements have larger impacts on the exposure of domestic firms than on the exposure of MNCs. The exposure of MNCs should be less sensitive to the co-movements of EME currencies than those of DE currencies.

3. Data and methodology

Our sample consisted of firms listed on the two major stock exchanges in China (i.e., Shanghai Stock Exchange and Shenzhen Stock Exchange). Following the literature (He et al., 2021, Liu et al., 2021; Shi et al., 2023), we excluded financial companies[8] and companies with missing financial statements and used two currency pools, namely developed economies (DE) and emerging market economies (EME) in our analysis[9].

We calculated the monthly bilateral exchange rates against the RMB for currencies in DEs and EMEs by using exchange rates against the USD in the International Financial Statistics (IFS) database published by the International Monetary Fund (IMF). The estimation window for our analysis spanned from August 2005 to December 2019.

3.1 Estimating exchange rate co-movements

To assess currency co-movements, we adopted the approach of utilizing unconditional correlation coefficients of bilateral exchange rates, as previously employed in the literature (Billio et al., 2017; Krapl, 2020). Correlation coefficients provide an intuitive measure for capturing currency co-movements, and the currency literature has recommended their use, which has shown consistency with other sophisticated methods (Chiang et al., 2007; Billio et al., 2017).

Using a 4-year rolling period window, we estimated the bilateral Pearson correlation coefficients (*UCC*) for DE and EME currency portfolios[10]. The mean values of *UCC* were used

[8] Accounting standards and supervision requirements for the financial industry differ substantially from those in other industries. Both operational and financial indicators are not comparable between financial and non-financial firms.

[9] For the currencies in DE, 19 developed countries and regions with sufficient data regarding the exchange rate against the RMB were selected: the United States, Canada, Australia, New Zealand, Japan, Norway, the United Kingdom, Sweden, Denmark, and the euro zone (Ireland, Austria, Belgium, Germany, France, Finland, the Netherlands, Portugal, Spain, and Italy). For EME, 54 countries and regions were selected: Albania, Afghanistan, the United Arab Emirates, Oman, Azerbaijan, Egypt, Pakistan, Bahrain, Belarus, Bulgaria, Bosnia and Herzegovina, Poland, Bhutan, Russia, Philippines, Georgia, Kazakhstan, Kyrgyzstan, Cambodia, the Czech Republic, Qatar, Kuwait, Croatia, Laos, Lebanon, Romania, Maldives, Malaysia, Macedonia, Mongolia, Bangladesh, Myanmar, Moldova, Nepal, Serbia, Saudi Arabia, Sri Lanka, Tajikistan, Thailand, Turkey, Brunei, Ukraine, Singapore, Hungary, Armenia, Yemen, Iraq, Iran, India, Indonesia, Jordan, Vietnam, Korea, and Chinese Taiwan.

[10] *UCC* for each month is estimated using a 4-year window, from 48 months prior to the current month. We also use a 5-year rolling window, and obtain similar results. And a broad combination of DEs and EMEs is presented in the robustness check.

as measures of currency co-movements for each currency portfolio. Higher mean *UCC* values indicate reduced diversifiability of a firm's exposure to a currency portfolio.

$$comove = mean(UCC) \quad (1)$$

Note that the existing literature encompasses various co-movement measures (Goetzmann and Kumar, 2008; Pukthuanthong and Roll, 2009; Lustig et al., 2011; Billio et al., 2017). To ensure the robustness of our findings, we employed several additional co-movement measures and conducted thorough analyses in Section 5.1.

3.2. Estimating corporate foreign exchange exposures

Following the literature (Jorion, 1990; He and Ng, 1998; Bartram et al., 2010), we estimated a linear two-factor model to measure individual firms' foreign exchange exposure:

$$LRf_{i,t} = \alpha_i + \mu_i LRm_t + \gamma_i LRc_t + \epsilon_{i,t} \quad (2)$$

where $LRf_{i,t}$ is the log monthly stock returns of firm i at time t; LRm_t is the log monthly returns of the value-weighted market index for all listed firms from both the Shanghai and the Shenzhen stock exchanges; and LRc_t is the log monthly returns of the currency index. The coefficient γ_i is a proxy for the firm's exchange rate exposure, measuring the sensitivity of the firm's value to exchange rate fluctuations. The exposure estimates largely rely on trade-weighted currency indices, such as the US Fed's MCI, OITP, and BROAD indices (Krapl, 2020). To investigate the impacts of co-movements of DE and EME currencies on exposure, we utilized two exchange rate indices in our analysis. These exchange rate indices are trade-weighted averages of log changes in the bilateral exchange rates between the RMB and (i) currencies in DE; (ii) the currencies in EME. Equation (2) was estimated using 4-year rolling window regression.

3.3. Research design

To test the hypotheses put forth in this study, we employed regression analysis, following the approach adopted in Krapl (2020) and He et al. (2021). Specifically, we conducted regression of the absolute FX exposure ($|\gamma_{i,t}|$) on the co-movements of bilateral exchange rates ($comove$). The panel fixed effects model is as follows:

$$|\gamma_{i,t}| = \delta_0 + \delta_i + \theta_t + \eta_{i,t} + \beta comove_t + \rho Control + \epsilon_{i,t} \quad (3)$$

where $|\gamma_{i,t}|$ is the absolute value of the FX exposure of firm i at month t; δ_0 is the intercept term; δ_i and θ_t are firm and year fixed effects, respectively; $\eta_{i,t}$ represents an industry dummy; $comove_t$ is the measure of the co-movements of bilateral exchange rates.

$Control$ includes a variety of firm-level exchange rate determinants used in prior studies. Firm size is considered, as smaller firms tend to exhibit higher susceptibility to exchange rate fluctuations compared to larger firms (Hutson and Laing, 2014; He et al., 2021). We controlled for firm size using the total assets as a measure (*size*). Moreover, firms' foreign sales could influence their exposure to exchange rate fluctuations. On one hand, firms with international sales tend to be more sensitive to changes in exchange rates (Jorion, 1990; Nance et al., 1993; Bartram, 2004). Conversely, international sales are linked to currency diversification and the adoption of hedging strategies (Wei and Starks, 2013; Hutson and Laing, 2014). To capture foreign sales, we employed the proportion of international sales to total sales as a proxy (*fsales*).

Indeed, highly indebted firms often face underinvestment issues (Nance et al., 1993; Froot et al., 1993). As a result, firms with high leverage are more inclined to engage in hedging activities,

which can result in reduced exposure to foreign exchange rate fluctuations (He and Ng, 1998). However, contrasting findings have been observed in some studies, indicating a positive relationship between leverage and firms' exchange rate exposure, suggesting that highly leveraged firms may not hedge their foreign exchange risks (Wei and Starks, 2013). To account for this, we incorporated the ratio of debt to assets as a metric for leverage (*leverage*) in our analysis.

Certainly, profitable firms and those with sufficient liquidity possess the ability to mitigate foreign exchange rate volatility by reducing the expected cost of financial shocks. Consequently, these firms may have less motivation to engage in hedging activities, leaving them exposed to more significant foreign exchange rate risks (Froot et al., 1993; He and Ng, 1998; Bartram, 2004; Krapl, 2020). To account for this aspect, we adopted the quick ratio as a proxy for firms' liquidity (*quickratio*) and utilized the operating margin as a metric for firms' profitability (*profit*) in our analysis.

Indeed, hedging holds greater value for growth-oriented firms in alleviating the underinvestment predicament, consequently resulting in lower exposure levels (Froot et al., 1993; He and Ng, 1998; Wei and Starks, 2013). In line with the approach taken by Géczy et al. (1997), we adopted the book-to-market value of equity (BM) as a proxy to capture a firm's growth prospects (*bmratio*) in our analysis.

Finally, numerous empirical studies have established that industry characteristics exert notable influences on firms' exchange rate exposures (Allayannis and Ihrig, 2001; Bartram et al., 2010). In order to address this concern, we employed firm-level industry fixed effects, utilizing the industrial classifications issued by the China Securities Regulatory Commission (CSRC).

3.4 Summary statistics

Table 1 provides the means, standard deviations, and percentiles for the main variables. Monthly stock returns and annual accounting variables were drawn from the WIND and CSMAR datasets[11]. Panel A of Table 1 presents the log monthly stock returns (LRf) and log monthly returns of the RMB as measured by DE currencies (LRc_{de}) and EME currencies (LRc_{eme}), respectively, over our sample period. The Pearson correlation coefficients of DE currencies are reported in Appendix B.

Firm-level control variables were constructed at an annual frequency and merged with monthly exchange rate exposures and currency co-movements by the previous fiscal year. In other words, for firm i, its foreign exchange exposure and currency co-movements in month t in year k is matched with its firm-level control variables in year k-1. The final sample contains 2771 unique firms and 278,598 firm-month observations.

Panel B of Table 1 reports the descriptive statistics of financial indicators, including total

[11] In the field of financial data, the Wind Economic Database has built a first-class, large-scale financial engineering and financial data warehouse with financial securities data as the core database in China. The data content covers stocks, funds, bonds, foreign exchange, insurance, futures, financial derivatives, spot trading, macro-economy, financial news, and other fields. CSMAR, China's financial database, fully draws on the success of international well-known databases and has been carefully designed with respect to China's national conditions. This database is the largest and most accurate financial and economic database in China. It is composed of eight series of stocks, funds, bonds, financial derivatives, listed companies, economy, industry, high-frequency data, and personalized data services.

assets, the book-to-market ratio, the operating margin, quick ratio, the asset-liability ratio, and share of foreign sales. All financial indicators are winsorized at the 1st and 99th percentile.

Table 1 Summary statistics

This table provides the numbers, means, standard deviations, and percentiles for the main variables. Panel A of Table 1 presents the log monthly stock returns (LRf) and log monthly returns of the RMB as measured by DE currencies (LRc_{de}) and EME currencies (LRc_{eme}), respectively, over our sample period. Panel B reports the descriptive statistics of financial indicators. Variable definitions are presented in Appendix A.

Panel A Stock returns and currency portfolio returns

Variable	N	Mean	Std. Dev.	Percentiles		
				25th	50th	75th
LRc_{de}	173	0.12%	1.42%	-0.63%	0.12%	0.93%
LRc_{eme}	173	0.23%	1.52%	-0.63%	0.14%	1.02%
LRf	278598	-0.04%	15.42%	-7.26%	0.13%	8.04%

Panel B Descriptive statistics of financial indicators

Variable	N	Mean	Std. Dev.	25th	50th	75th
$size$	278598	0.109	0.253	0.016	0.035	0.084
$bmratio$	278598	0.628	0.256	0.426	0.634	0.839
$profit$	278598	0.260	0.171	0.139	0.223	0.347
$quickratio$	278598	1.343	1.439	0.566	0.911	1.491
$leverage$	278598	0.490	0.213	0.331	0.492	0.641
$fsales$	278598	0.079	0.173	0.000	0.000	0.057

Table 2 reports summary statistics for exchange rate exposure as well as exchange rate co-movements over the sample period. For the entire sample, the average firms' exposures in DE (γ_{de}) and in EME (γ_{eme}) are -0.176 and -0.183, respectively, indicating that Chinese firms are negatively affected by the appreciation of the RMB against DE and EME currencies. Overall, 13.66% (11.23%) of firms have significant exposures to DE (EME) currencies, consistent with the findings of He et al. (2021)[12]. The exposures to DE (EME) currencies are relatively negatively distributed, with 56.48% (55.49%) of exposures being negative.

Table 2 Estimated FX exposure and Exchange rate co-movements

This table reports summary statistics for exchange rate exposure as well as exchange rate co-movements of DE and EME respectively. γ_{de} (γ_{eme}) is the firms' exposures in DE (EME) currencies. % sig shows the proportion of the FX exposure that is significant at the 10% confidence level. The four rightmost columns of table report the percentage (%N) and significance level (%sig) of positive and negative FX exposures. Variable definitions are presented in Appendix A.

Variable	N	Mean	Std.	25th	75th	% sig.	Pos.		Neg.	

[12] Within China's underdeveloped financial system, however, hedging instruments are still limited. Furthermore, the corporate ownership structure in China differs from that of many developed countries, as corporate ownership in China is highly concentrated in a small group; more distinctly, the controlling rights of the largest shareholder are greater than the cash flow rights (He et al., 2021).

			Dev.				% N	% sig.	% N	% sig.
γ_{de}	278598	-0.176	1.488	-1.069	0.667	13.66%	43.52%	4.86%	56.48%	8.80%
γ_{eme}	278598	-0.183	1.476	-1.022	0.635	11.23%	44.51%	3.97%	55.49%	7.26%
$comove_{de}$	173	0.438	0.042	0.405	0.464					
$comove_{eme}$	173	0.233	0.042	0.197	0.256					

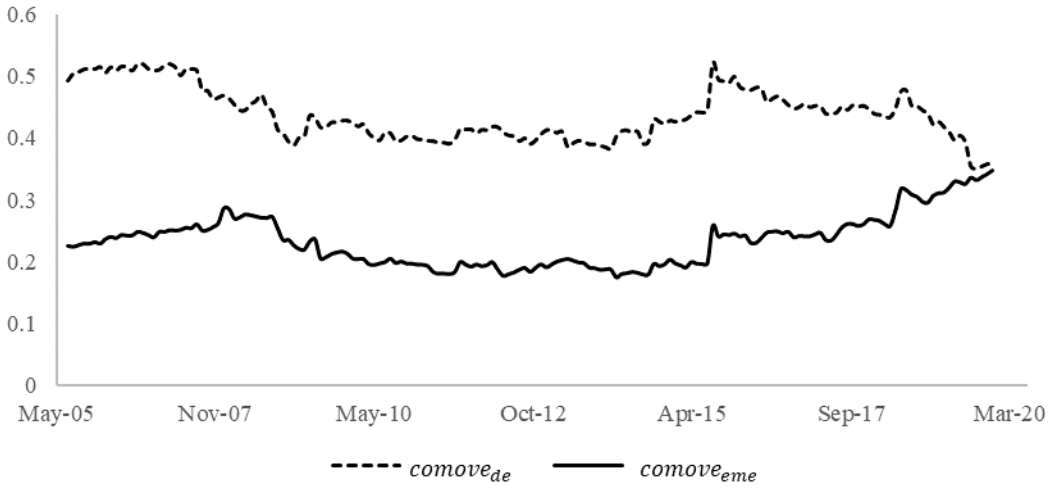
Figure 2 presents the time-varying averages of $comove_{de}$ and $comove_{eme}$ respectively. Following the end of the RMB being pegged to the USD in 2005, the co-movements of DE currencies and EME currencies against the RMB changed considerably and quickly. The breakup of the RMB's fixed exchange rate regime gave rise to the flexibility of the RMB against DE currencies and decreased the co-movement of DE currencies against the RMB. In contrast, there has been a significant rise of EME currency co-movements against the RMB, which is clearly commensurate with the emergence of the RMB as a regional currency.

During the 2008 global financial crisis, a reversal in these patterns occurred as the RMB was effectively pegged to the USD from 2008 to 2010. Consequently, there was a slight increase in DE currency co-movements, while there was a significant decrease in EME currency co-movements with the RMB. This highlights the crucial role of the RMB's flexibility in influencing EME currencies.

Following the resumption of the RMB's reform on June 19, 2010, the declining trend of EME currency co-movements was altered. Both DE and EME currency co-movements remained relatively stable between 2010 and 2015. However, notable changes occurred on August 11, 2015, when China implemented reforms to enhance the transparency of the RMB's exchange rate formation mechanism. As a result, there was a significant increase in EME currency co-movements and a decline in DE currency co-movements. These patterns are evidently linked to the increased flexibility of the RMB against DE currencies and its anchoring effect on EME currencies.

Figure 2 Time-varying co-movement of DE and EME exchange rates

This figure presents the time-varying averages of $comove_{de}$ and $comove_{eme}$ respectively. based on a 4-year rolling period window. We use mean values of bilateral Pearson correlation coefficients (*UCC*) for DE and EME currency comments, $comove_{de}$ and $comove_{eme}$.



4. Empirical Results

4.1. Main results

Table 3 reports two sets of regression results for exposure corresponding to each of the two exchange rate indices. The first set (Columns (1) – (3)) contains the regression results of DE currency exposure ($|\gamma_{de}|$) on DE currency co-movements ($comove_{de}$). The second set (Columns (4) – (6)) contains the regression results of EME currency exposure ($|\gamma_{eme}|$) on EME currency co-movements ($comove_{eme}$). The results of the currency co-movements' standalone estimates are statistically significant for both co-movements at the 1% confidence level (Columns (1) and (4)), indicating on average that firms are more likely to be exposed to exchange rate risks as a result of high currency co-movements. It is worth noting that the coefficient of $comove_{de}$ is much higher than that of $comove_{eme}$. On average, a one standard deviation increase in $comove_{de}$ is associated with a 0.041 increase in DE currency exposure ($|\gamma_{de}|$). In contrast, for $comove_{eme}$, there is a 0.026 increase in EME currency exposure ($|\gamma_{eme}|$). These results are consistent with our hypotheses. Overall, the non-diversifiability of exchange rate risks due to currency co-movements leads to high exposure. Different from DE currencies, EME currency co-movements is more likely to be influenced by the RMB's anchoring effect (He et al., 2023). As matching corporate foreign revenues with costs in the same currency reduce exchange rate exposure (Bodnar and Marston, 2002), the anchoring effect of RMB in EME currencies could mitigate Chinese firms' exposure arising from the non-diversifiability of EME currencies risks.

Similar results were obtained when we controlled for various firm characteristics. These results are reported in Columns (2) - (3), and (5) - (6) of Table 3. In all specifications, the magnitude of exposure coefficients is only slightly changed and all coefficients are statistically significant at the 1% confidence level.

Regarding the control variables, our findings show that both for DE and EME currencies, firm size has a significant negative relationship with exchange rate exposure, consistent with prior research (Hutson and Laing, 2014). Moreover, quick ratio, profits, and leverage have significantly positive coefficients. This aligns with existing literature, suggesting that firms with ample liquidity and profitability are less likely to hedge, leading to higher exposure to exchange rate movements (Froot et al., 1993; He and Ng, 1998). Additionally, growth firms and highly indebted firms exhibit higher exposure to exchange rate risks, indicating a tendency to avoid hedging, possibly due to the relatively higher hedging costs in China (He et al., 2021).

Furthermore, we observe a significantly negative association between foreign sales and exchange rate exposure, which can be attributed to the strong correlation between foreign revenues and foreign costs. The practice of offsetting revenues and costs is likely to reduce a firm's exposure to exchange rate fluctuations. Interestingly, firms with foreign sales exhibit lower exposure to EME currencies compared to DE currencies. This finding aligns with our expectations, as the growing anchoring effect of the RMB enables Chinese firms to settle their foreign trade with EME countries in the RMB, thereby reducing their exposure to EME currencies.

To summarize, our empirical findings consistently support a positive relationship between exposure magnitudes and exchange rate co-movements, using both DE and EME currencies.

However, the impact of co-movements on EME currencies is less pronounced compared to DE currencies. These results provide robust evidence in favor of H1, confirming that exchange rate co-movements have a significant influence on firms' exchange rate exposure, with a relatively smaller effect on EME currencies.

Table 3 FX exposure and co-movements of exchange rates

This table reports two sets of regression results for exposure corresponding to each of the two exchange rate indices. The first set (Columns (1) – (3)) contains the regression results of DE currency exposure ($|\gamma_{de}|$) on DE currency co-movements ($comove_{de}$). The second set (Columns (4) – (6)) contains the regression results of EME currency exposure ($|\gamma_{eme}|$) on EME currency co-movements ($comove_{eme}$). Different financial indicators are controlled across column (2) – (3) (column (5) – (6)). Firm, Industry and Year are firm-, industry- and year- level dummies respectively. Robust standard errors in parentheses, significance level: *** p<0.01, ** p<0.05, * p<0.1. Variable definitions are presented in Appendix A.

	(1)	(2)	(3)	(4)	(5)	(6)
Variable	$\|\gamma_{de}\|$	$\|\gamma_{de}\|$	$\|\gamma_{de}\|$	$\|\gamma_{eme}\|$	$\|\gamma_{eme}\|$	$\|\gamma_{eme}\|$
$comove_{de}$	0.978***	0.976***	0.976***			
	(0.089)	(0.089)	(0.089)			
$comove_{eme}$				0.610***	0.613***	0.614***
				(0.118)	(0.118)	(0.118)
$size$		-0.141***	-0.139***		-0.076***	-0.074***
		(0.016)	(0.016)		(0.016)	(0.016)
$bmratio$		-0.474***	-0.473***		-0.406***	-0.405***
		(0.012)	(0.012)		(0.012)	(0.012)
$profit$		0.039**	0.038**		0.219***	0.217***
		(0.019)	(0.019)		(0.019)	(0.019)
$quickratio$		0.015***	0.015***		0.013***	0.013***
		(0.002)	(0.002)		(0.002)	(0.002)
$leverage$		0.132***	0.131***		0.273***	0.272***
		(0.016)	(0.016)		(0.016)	(0.016)
$fsales$			-0.056***			-0.082***
			(0.018)			(0.017)
Constant	0.697***	0.916***	0.921***	0.950***	1.005***	1.011***
	(0.039)	(0.041)	(0.041)	(0.028)	(0.031)	(0.031)
Firm	yes	yes	yes	yes	yes	yes
Industry	yes	yes	yes	yes	yes	yes
Year	yes	yes	yes	yes	yes	yes
Observations	278,598	278,598	278,598	278,598	278,598	278,598
R-squared	0.374	0.379	0.379	0.379	0.383	0.383

4.2. Impact of the Belt and Road Initiative

The Belt and Road Initiative (BRI) holds paramount significance for China, as it endeavors to enhance economic policy coordination, trade, and investment facilitation between China and the countries and regions encompassing the BRI areas. This initiative has witnessed a growing

number of countries and international organizations participating in it by signing intergovernmental cooperation documents, predominantly in the form of memoranda of understanding, with China. The BRI serves as a pivotal strategy to foster connectivity, infrastructure development, and economic integration among participating nations, thereby fostering mutual development and cooperation on a global scale.

Note that in our study, we recognized the significance of exploring the impact of the Belt and Road Initiative (BRI) launch and the staggered entry of countries into the BRI. To achieve this, we collected data on each memorandum of understanding (MoU) signed between BRI member countries and China. This information was obtained from the official website "Belt and Road Portal,"[13] under the guidance of the leading group for promoting the Belt and Road Initiative. The data included the date of MoU signing and the respective counterpart country. To ensure accuracy, we cross-checked this data with information from various official sources, such as China's Ministry of Commerce, Ministry of Foreign Affairs, embassies, and relevant government departments of other countries.

By the end of 2019, a total of 137 countries and 30 international organizations participating in the BRI had signed memoranda of understanding with China. We constructed measures of BRI variables, $Ibr_{de(eme)}$, which is the ratio of the number of economies signing memorandum of understandings with China on BRI cooperation over the number of DE (EME) at each month. We then replicated the analysis of equation (3) with the addition of the interaction terms of the BRI and the two co-movements measures ($Ibr \times comove$). All specifications include firm, industry and year fixed effects.

The results in Table 4 show that the coefficients of $Ibr_{de(eme)} \times comove_{de(eme)}$ are significantly positive (negative). The results indicate that the positive relationship between co-movements and exposure is stronger for DE currencies and weaker for EME currencies. These results are largely consistent with H2. By the end 2022, the number of countries that have joined BRI is 151, 97% of them are emerging market countries. The launch of the BRI has led to a significant increase in China's economic engagement with emerging market countries (Xu et al., 2022), underscoring the importance of managing EME currency risks for Chinese corporations. As a result, the RMB has assumed a more prominent role in trade invoicing, settlements, and cross-border financial transactions within EME countries. The anchoring effect of the RMB has substantially reduced Chinese firms' exposure by allowing the offsetting of foreign revenues and costs in the same currency.

Conversely, the RMB's role in cross-border transactions with developed economies, such as the US, is less pronounced. Nonetheless, the launch of the BRI may have reduced the diversifiability of Chinese firms' exposure to DE currencies. This could be attributed to the escalating trade conflicts between the US and China, leading to various economic and trade sanctions imposed by developed countries, especially the US, against China (Guo et al., 2023). These conflicts have amplified the challenges of managing DE currency risks. Following the launch of the BRI, DE currencies have exhibited increased co-movements against the RMB, contributing to reduced diversifiability of Chinese firms' exposure to DE currencies. Consequently, the impact of exchange rate co-movements on corporate exchange exposures to DE currencies has intensified.

[13] The data is available at https://www.yidaiyilu.gov.cn/.

Table 4 Impact of the Belt and Road Initiative

This table presents the regression results of the Impact of the Belt and Road Initiative (BRI). $Ibr_{de(eme)}$ is the ratio of the number of economies signing memorandum of understandings with China on BRI cooperation over the number of DE (EME) at each month. $Ibr \times comove$ represents the interaction of binary variable Ibr and exchange rate co-movement $comove$. Robust standard errors in parentheses, significance level: *** p<0.01, ** p<0.05, * p<0.1. Variable definitions are presented in Appendix A.

	(1)	(2)	(3)	(4)	(5)	(6)
Variable	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{eme}\rvert$	$\lvert\gamma_{eme}\rvert$	$\lvert\gamma_{eme}\rvert$
$comove_{de}$	-0.168	-0.169	-0.168			
	(0.107)	(0.107)	(0.107)			
$Ibr_{de} \times comove_{de}$	16.000***	15.978***	15.979***			
	(0.959)	(0.955)	(0.955)			
$comove_{eme}$				3.110***	3.105***	3.105***
				(0.185)	(0.185)	(0.185)
$Ibr_{eme} \times comove_{eme}$				-6.372***	-6.363***	-6.362***
				(0.292)	(0.291)	(0.291)
Ibr_{de}	-7.031***	-7.017***	-7.017***			
	(0.413)	(0.411)	(0.411)			
Ibr_{eme}				1.850***	1.850***	1.850***
				(0.083)	(0.083)	(0.083)
$size$		-0.140***	-0.138***		-0.076***	-0.073***
		(0.016)	(0.016)		(0.016)	(0.016)
$bmratio$		-0.474***	-0.473***		-0.406***	-0.405***
		(0.012)	(0.012)		(0.012)	(0.012)
$profit$		0.039**	0.038**		0.219***	0.217***
		(0.019)	(0.019)		(0.019)	(0.019)
$quickratio$		0.015***	0.015***		0.013***	0.013***
		(0.002)	(0.002)		(0.002)	(0.002)
$leverage$		0.132***	0.131***		0.272***	0.271***
		(0.016)	(0.016)		(0.016)	(0.016)
$fsales$			-0.056***			-0.081***
			(0.018)			(0.017)
Constant	1.214***	1.431***	1.436***	0.337***	0.393***	0.400***
	(0.047)	(0.049)	(0.049)	(0.039)	(0.042)	(0.042)
Firm	yes	yes	yes	yes	yes	yes
Industry	yes	yes	yes	yes	yes	yes
Year	yes	yes	yes	yes	yes	yes
Observations	278,598	278,598	278,598	278,598	278,598	278,598
R-squared	0.374	0.380	0.380	0.380	0.385	0.385

4.3 Multinational companies (MNCs)

Most studies measure a firm's multinationality using the extent of its international activities (Pantzalis et al., 2001; Williamson, 2001; Hutson and Laing, 2014). For instance, Pantzalis et al. (2001) define firms with at least one foreign subsidiary as MNCs. Williamson (2001) defines

firms as MNCs if the percentage of foreign sales to total sales is more than 11% and finds that exposure falls with foreign sales. To test H3, we first split the sample firms into those with foreign sales or subsidiaries and those without. The former group is globally engaged firms, while the latter group is purely domestic firms.

Columns (1) – (8) of Table 5 report that exchange rate co-movement increases exposure both for global firms and for purely domestic firms, with the impact being greater for the latter group. These results suggest that globally engaged firms exhibit a lower sensitivity to exchange rate co-movements compared to domestic firms.

Note that the aforementioned measures of multinationality do not account for the dispersion of a firm's international activities. Firms with operations in multiple countries have greater opportunities for operational hedging compared to those concentrated in a single foreign country (Allayannis et al., 2001; Hutson and Laing, 2014). To address this, we adopt an alternative measure of multinationality by considering the number of foreign subsidiaries a firm has, denoted as "subs," following the approach of Allayannis et al. (2001).

Columns (9) – (10) of Table 5 show that the coefficients of both $subs \times comove_{de}$ and $subs \times comove_{eme}$ are negative and statistically significant, with the impact being greater for the latter group. These findings suggest that exchange rate co-movements have a relatively smaller effect on Multinational Corporations' (MNCs) exposure, particularly regarding exposure to Emerging Market Economy (EME) currencies. These results strongly support H3, indicating that MNCs are adept at employing operational hedging and alternative strategies to mitigate the impact of exchange rate risks. Furthermore, the anchoring effect of the RMB plays a significant role in reducing MNCs' exposure to EME currencies.

Table 5 Multinational companies

This table presents the regression results of multinational and domestic firms. We split the sample firms into those with foreign sales or subsidiaries and those without. The former group is globally engaged firms, while the latter group is purely domestic firms. Column (1) – (2) and (3) – (4) report the results of firms with foreign sales and with foreign subsidiaries respectively. Column (5) – (6) and (7) – (8) report the results of firms without foreign sales and without foreign subsidiaries respectively.

Following Allayannis et al. (2001), we used the number of countries in which a firm has foreign subsidiaries, subs, as an alternative measure of multinationality. The results are reported in Column (9) - (10). $Controls$ represent the control variables we have used before, here we omit their results to save space. Robust standard errors in parentheses, significance level: *** p<0.01, ** p<0.05, * p<0.1. Variable definitions are presented in Appendix A.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Multinational firms				Domestic firms				Multinational firms	
	With foreign sales		With subsidiaries		Without foreign sales		Without subsidiaries		Number of subsidiaries	
Variable	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{eme}\rvert$	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{eme}\rvert$	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{eme}\rvert$	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{eme}\rvert$	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{eme}\rvert$
$comove_{de}$	0.405***		0.461***		1.688***		1.807***		1.017***	
	(0.118)		(0.113)		(0.133)		(0.143)		(0.091)	
$comove_{eme}$		0.509***		0.428***		0.749***		0.920***		0.801***
		(0.156)		(0.148)		(0.177)		(0.191)		(0.119)
									-0.054**	
									(0.025)	
										-0.239***
										(0.023)
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	152,239	152,239	170,048	170,048	126,359	126,359	108,550	108,550	278,598	278,598
R-squared	0.406	0.407	0.392	0.403	0.358	0.363	0.372	0.364	0.379	0.384

5. Robustness and additional evidence

5.1 Alternative specifications

Previous studies have suggested several measures of currency co-movements (Goetzmann and Kumar, 2008; Pukthuanthong and Roll, 2009; Billio et al., 2017). To test the robustness of our results, we employed two additional measures, namely, eigenvalues of correlation matrices and normalized portfolio variance. The first measure uses principal component analysis (PCA) for analyzing the common factors in driving exchange rate co-movements[14]. Specially, following Pukthuanthong and Roll (2009), we conducted PCA to draw the principal components (PCs) of currency portfolio returns[15] and then estimated the following multi-factor regression model using the first three PCs:

$$LRc_t = \beta_{c,0} + \beta_{c,1} f_{1,t} + \beta_{c,2} f_{2,t} + \beta_{c,3} f_{3,t} + e_t \quad (4)$$

where LRc_t are log changes of the bilateral exchange rate of the RMB to each country and $f_{1,t}$, $f_{2,t}$, and $f_{3,t}$ capture three principal components with the strongest explanatory power.

The higher the adjusted R-square of equation (4), the higher the level of exchange rate co-movements, as a limited set of common variables can explain most movements of exchange rates. We defined the co-movements as the median value of adjusted R-squares for DE and EME, respectively:

$$comove^{r2} = median(adjusted\_R^2) \quad (5)$$

Second, following the investment literature (Goetzmann and Kumar, 2008), we used portfolio variance to measure the co-movement, which is estimated as follows:

$$comove^{var} = \frac{var(LRc)}{weighted\_var(LRc_i)} \quad (6)$$

where $var(LRc)$ is the variance for the return of the currency portfolio and $weighted\_var(LRc_i)$ is the trade-weighted average of the bilateral exchange rate. The level of exchange rate co-movement increases with the value of $comove^{var}$, as portfolio variance is larger compared to individual exchange rate variance.

We should acknowledge that our analysis separately estimated the influence of co-movements in both DE and EME currencies on exposure, considering the increasing significance of the RMB in international transactions with EME countries. However, it may also be of interest to investigate the combined impacts of exchange rate co-movements in both DE and EME currencies on firms' exposure. To address this, we constructed a comprehensive trade-weighted index of bilateral exchange rates between the RMB and the currencies of all countries (referred to as comprehensive economies, CM). Subsequently, we estimated equation (3) using the CM currency co-movement in CM and exposure to CM currencies.

Panel A of Table 6 confirms that exchange rate co-movements remain statistically significant determinants of the foreign exchange rate exposure of Chinese firms, and this effect is larger for currencies in DE. In addition, the effect of co-movements on exchange rate exposure has become more (less) pronounced for DE (EME) currencies since the launch of the BRI, consistent with previous findings that the RMB's anchoring effect has been strengthening since the inception of the BRI. Interestingly, the interaction term $Ibr_{cm} \times comove_{cm}$ is significantly negative. A

[14] Lustig et al. (2011) show that the first and second principal components account for most variation of currency portfolio returns.

[15] The regression is based on a 4-year rolling window.

possible explanation is that the most of economies joining in the BRI are EME. Hence the RMB's anchoring effect mitigates overall firms' exchange rate risk exposure.

Additional support for our main findings was provided by examining the above alternative co-movement measures on the exposure of firms with and without foreign sales (i.e., global and domestic firms). The results, reported in Panel B of Table 6, are qualitatively similar to those reported in Table 5[16]. Interestingly, we found that CM currency co-movement increases the exposure of domestic firms, but has no significant impact on the exposure of global firms[17].

[16] We also separated the sample into firms with foreign subsidiaries and those without and obtained similar results. These results are not reported but are available upon request

[17] We conduct two additional robustness checks. First, we recalculated Spearman correlations between different currencies and used equation (1) in Section 3.1 to construct the co-movement of DE and EME currency portfolios. We re-estimated the equation (3) using the new co-movement indicators. Second, Szczygielski et al.(2020) point out that the return-factor model may be underspecified due to factor omission. We thus employ Fama-French three-factor model augmented with the exchange rate factor to re-estimate exchange rate exposure, and its relation with co-movement indictors. Our empirical results remain qualitative unchanged across both robustness checks. These results are not reported but are available upon request.

Table 6 Alternative measures

This table presents the regression results estimated using alternative measures of FX exposure and currency co-movement. Panel A report basic and BRI results using alternative measures. We adopt three different co-movement measures: Column (1) – (4) and column (5) – (8) report $comove^{r2}$ and $comove^{var}$ as the measure of exchange rate co-movement respectively, and column (9) – (10) report results estimating using comprehensive currencies (CM) of DE and EME. Ibr_{cm} equals the ratio of the number of economies signing memorandum of understandings on BRI cooperation over the number of sample countries at each month. Panel B report results of firms with and without foreign sales. Column (1) – (2), (5) – (6) and (9) report results of firms with foreign sales, and others report firms without foreign sales. $Controls$ represent the control variables we have used before, here we omit their results to save space. Robust standard errors in parentheses, significance level: *** p<0.01, ** p<0.05, * p<0.1. Variable definitions are presented in Appendix A.

Panel A Alternative measures: BRI effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	$comove^{r2} = median(adjusted\_R^2)$				$comove^{var} = \frac{var(LRc)}{weighted\_var(LRc_i)}$				Comprehensive currencies	
Variable	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{eme}\rvert$	$\lvert\gamma_{eme}\rvert$	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{eme}\rvert$	$\lvert\gamma_{eme}\rvert$	$\lvert\gamma_{cm}\rvert$	$\lvert\gamma_{cm}\rvert$
$comove_{de}$	0.953***	-0.541***			0.774***	0.165**				
	(0.104)	(0.118)			(0.068)	(0.075)				
		29.776***				16.771***				
		(1.399)				(0.960)				
$comove_{eme}$			0.444***	0.692***			0.204***	0.402***		
			(0.058)	(0.072)			(0.027)	(0.028)		
				-0.346**				-1.997***		
				(0.155)				(0.134)		
$comove_{cm}$									0.404***	2.134***
									(0.129)	(0.197)
										-7.454***
										(0.434)
Ibr_{de}		-22.832***		0.593***						
		(1.050)		(0.100)						
Ibr_{eme}						-7.512***		0.704***		
						(0.409)		(0.045)		
Ibr_{cm}										2.404***

										(0.130)
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	278,598	278,598	278,598	278,598	278,598	278,598	278,598	278,598	278,598	278,598
R-squared	0.379	0.380	0.383	0.384	0.379	0.380	0.383	0.384	0.382	0.383

Panel B Alternative measure: Foreign sales

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	$comove = median(adjusted\_R^2)$				$comove = \frac{var(LRc)}{weighted\_var(LRc_i)}$				Comprehensive currencies	
	With foreign sales		Without foreign sales		With foreign sales		Without foreign sales		With	Without
Variable	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{eme}\rvert$	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{eme}\rvert$	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{eme}\rvert$	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{eme}\rvert$	$\lvert\gamma_{cm}\rvert$	$\lvert\gamma_{cm}\rvert$
$comove_{de}$	0.675***		1.309***		0.356***		1.287***			
	(0.138)		(0.158)		(0.092)		(0.101)			
$comove_{eme}$		0.428***		0.459***		0.195***		0.217***		
		(0.078)		(0.086)		(0.037)		(0.040)		
$comove_{cm}$									0.009	0.896***
									(0.169)	(0.197)
Controls	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Firm	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	152,239	152,239	126,359	126,359	152,239	152,239	126,359	126,359	152,239	126,359
R-squared	0.406	0.407	0.358	0.363	0.406	0.407	0.358	0.363	0.411	0.359

5.2 Alternative model specifications

Two methodological issues need to be addressed. First, the coefficients estimated from the first stage may be influenced by a measurement error and hence may confound the results of the second stage. We addressed this issue by inversing the standard error from the first stage and using it as the weight for the second stage of the WLS regression (Allayannis and Ofek, 2001). Second, Dominguez and Tesar (2006) show that $|\gamma_i|$ changes the distribution of the original γ_i, hence deviating the resulting error term away from the normal distribution. To resolve this problem, we transform it into $\sqrt{|\gamma_i|}$ to re-estimate our main regression. Column (1) – (8) of Table 7 confirm that exchange rate co-movements remain statistically significant determinants of the foreign exchange rate exposure of Chinese public firms.

Companied could over-report international trade to evade capital controls for foreign exchange arbitrage (Liu et al., 2021), which actually influences its foreign exchange exposures. To address this concern, we include a measure of capital flow, $dcip$, deviations from covered interest rate parity between the RMB and the USD (Cheung et al., 2016). Following Cheung et al. (2016) and Liu et al. (2021), we define $dcip$ as $100 * \{\frac{r_{RMB} - r_{USD}}{1+r_{USD}} - \frac{F-S}{S}\}$, where $r_{RMB(USD)}$ is Chinese (USD London) interbank offered rate, F is the one-month RMB/USD non-deliverable forward rate, and S is the spot RMB/USD exchange rate. Results of including $dcip$ are reported in Column (9) – (10). Our primary results remain qualitatively unchanged.

A major empirical challenge is to identify the causal effect of exchange rate co-movements on individual firm's exchange rate exposure. Exchange rate co-movement is clearly not randomly assigned. Nor, however, is it a choice variable. It is also safe to dismiss the possibility of reverse causality because each firm's exchange rate exposure is far too small to influence currency co-movements. Hence, the main identification challenge is not self-selection or reverse causality, but the omission of important variables. We thus adopted Arellano and Bover (1995)'s dynamic panel Generalized Method of Moments (GMM) procedure to address potential endogeneity in which one or more of the explanatory variables are not strictly exogenous[18]. This technique utilizes appropriate lags of the changes in both dependent variables and regressors to address the potential endogeneity of all regressors, and it can account for time-invariant unobservable heterogeneity (i.e., time-invariant firm-specific characteristics). The results, reported in Column (11) – (12) of Table 7, are qualitatively similar to previous findings. The p-values for both Sargan and Hansen J-statistics in all regressions are larger than the conventional confidence level. Thus, there is no evidence to reject the validity of our instruments. We also reported first-order and second-order serial correlations using the Arellano-Bond tests. We can reject the first-order serial correlation, but we cannot reject the null of no second-order serial correlation.

[18] Since our key variables are measured as monthly frequency, we allow dependent variable to appear with 12 lags.

Table 7 Alternative model specifications

This table presents the regression results estimated using alternative model specifications. Column (1) – (4) report the results using WLS. We use the standard error of FX exposure as the weight: $|\gamma_{de}|/\sigma_{de}$, where γ_{de} is the FX exposure in DE estimated using a OLS model and σ_{de} is the standard error of FX exposure. Similar as EME. Column (5) – (8) report the result using the square root of absolute values of FX exposure as dependent variable. Column (9) – (10) report the result including a measure of capital flows, $dcip$, deviations from covered interest rate parity between the RMB and the USD. Column (11) – (12) report the results using Arellano and Bover (1995)'s dynamic panel Generalized Method of Moments (GMM). $Controls$ represent the control variables we have used before, here we omit their results to save space. Robust standard errors in parentheses, significance level: *** p<0.01, ** p<0.05, * p<0.1. Variable definitions are presented in Appendix A.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Weighted least square				Square root of absolute values of FX exposure				Capital control		GMM	
Variable	$\|\gamma_{de}\|$	$\|\gamma_{de}\|$	$\|\gamma_{eme}\|$	$\|\gamma_{eme}\|$	$\sqrt{\|\gamma_{de}\|}$	$\sqrt{\|\gamma_{de}\|}$	$\sqrt{\|\gamma_{eme}\|}$	$\sqrt{\|\gamma_{eme}\|}$	$\|\gamma_{de}\|$	$\|\gamma_{eme}\|$	$\|\gamma_{de}\|$	$\|\gamma_{eme}\|$
$comove_{de}$	1.667***	1.657***			0.480***	0.479***			0.857***		0.863***	
	(0.083)	(0.082)			(0.042)	(0.042)			(0.098)		(0.211)	
$comove_{eme}$			0.829***	0.843***			0.336***	0.338***		0.247**		0.657*
			(0.103)	(0.103)			(0.056)	(0.056)		(0.123)		(0.379)
$dcip$									-0.005***	-0.019***		
									(0.002)	(0.002)		
Controls	no	yes	no	yes	no	yes	no	yes	yes	yes	yes	yes
Firm	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Industry	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	278,598	278,598	278,598	278,598	278,598	278,598	278,598	278,598	278,598	278,598	214,975	214,975
R-squared	0.343	0.349	0.342	0.347	0.324	0.329	0.329	0.333	0.379	0.384		
p(AR1)											0	0
p(AR2)											0.600	0.976
Hansen											150.1	134.7
P(Hansen)											0.348	0.700

5.3 Additional evidence

In this subsection, we attempt to deepen our understanding of the relationship between exchange rate co-movements and exposure by examining whether the RMB's internationalization and movements weaken the above relationship.

5.3.1 The effects of RMB inclusion in SDR

Effective October 1, 2016, the IMF added the Chinese RMB to the basket that composes SDR, an international reserve asset. The initial share of the RMB in the SDR basket was 10.9%, ranking the RMB third among five SDR basket currencies (USD, EUR, RMB, JPY, and GBP). On one hand, adding the RMB to SDR baskets benefits the SDR for both official and commercial reasons. A number of studies have shown that adding the RMB increases the attractiveness and broadens the usage of the SDR in international transactions (Mccauley and Shu, 2019; Wei et al., 2020)[19]. On the other hand, it is an important step in China's integration into the global financial system, reflecting China's significant progress in its reform toward becoming a liberalized and market-oriented financial market (IMF, 2015). The RMB's inclusion has significantly increased its acceptance among central bank holders of foreign exchange rate reserves. Before its addition to the SDR, the RMB accounted for less than 1% of the global foreign exchange reserves in 2015. The RMB's share of foreign exchange reserves rose to about 2% by the end of 2019. Some reasons for this are that international investors strengthened their confidence in holding RMB assets, as the RMB's exchange rate formation became more market-oriented after a series of reforms and due to the RMB's inclusion in the SDR. In addition, a number of EME countries have started to purchase Chinese government bonds as part of their reserve holdings. The RMB appears to have become one of the world's reserve currencies.

To the extent that our findings are associated with the RMB's role in cross-border transactions, the inclusion of the RMB in the SDR, which has had a substantial influence on the RMB's internationalization, could potentially weaken the relationship between EME currency co-movements and exposure. To examine the effects of the RMB's inclusion in the SDR on the impact of currency co-movements on exposure, we augmented equation (3) with the interaction term $Isdr \times comove$ (an SDR dummy), where $Isdr$ is defined as a one in the period after the RMB's inclusion (October 2016 and beyond) and a zero prior to its inclusion. If the RMB's inclusion is associated with a decrease in the impact of co-movement on exposure, the interaction term of one should be negative and statistically significant, whereas the interaction term of zero should be different. The standalone coefficient represents the pre-SDR estimates of co-movement effects, while the post-SDR effect is the sum of the coefficients for co-movement and the interaction terms.

The results are reported in Columns (1) – (2) of Panel A in Table 8. The positive relationships between co-movement and exposure are more pronounced following the RMB's inclusion in the SDR for DE currencies, whereas they are weaker for EME currencies. Consistent with our expectation, the RMB's inclusion in the SDR has strengthened the RMB's anchoring effect on EME, hence weakening the effect of co-movement on exposure.

5.3.2 Depreciation and appreciation

Although the RMB has exerted a growing influence on EME currencies, several researchers

[19] The Central Bank of Russia took the lead in saying that it would include the RMB in its official reserves.

have found that the influence of the RMB is asymmetrical and relies on the status of the RMB's exchange rate. More specifically, EME currencies tend to depreciate more when the RMB depreciates and to appreciate less when the RMB appreciates (Pontines and Siregar, 2012; Keddad, 2019).

The rationale for this is that the pace of the RMB's internationalization appears to be closely related to its value. For a number of years before mid-2015, the RMB had a "one-way" movement of appreciating against the USD. Investors sought to take advantage of the higher returns of the RMB and thus boosted the holdings of RMB assets in non-residents (Lowe, 2017). However, during the post-811 reform period, the RMB experienced a few months of depreciation against the USD, and investors turned to holding more foreign currency assets rather than converting them to the RMB. The use of the RMB as a vehicle for cross-border transactions slowed and even reversed in some respects.

China has become a large source of EME imports, creating heightened incentives for EME to let their currencies be anchored by the movements of the RMB and to increase the use of the RMB as a vehicle currency when the RMB appreciates. In addition, many EME "fear appreciation against the RMB," and instead allow their currencies to remain stable with relation to the RMB in order to maintain their firms' competition in exports (Levy-Yeyati et al, 2013; Keddad, 2019). As a result, it is expected that the RMB's appreciation should weaken the impacts of exchange rate co-movements on firms' exposure. In contrast, the depreciation of the RMB is likely to create a downward pressure of EME currencies due to the possibility that investors may expect a slowing down of regional economies (Keddad, 2019). This commonly leads to greater EME currency depreciation against the RMB during the RMB's depreciation episodes. We therefore expect that the RMB's depreciation should strengthen the impacts of exchange rate co-movements on firms' exposure.

To examine these implications, we split our sample into different periods of the RMB's appreciation and depreciation according to trade-weighted DE and EME currency indices. Specifically, LRc_{de} and LRc_{eme} are the log monthly returns of the trade-weighted RMB index. The RMB appreciates against DE (EME) currencies if LRc_{de} (LRc_{eme}) is positive or equal to zero, and the RMB depreciates if otherwise. The results in Columns (3) – (6) of Panel A of Table 8 show that exchange rate co-movements have a greater (smaller) impact on a firm's exposure to DE currencies (EME currencies) when the RMB appreciates against DE currencies (EME currencies). Consistent with our expectation, the impact of the RMB's anchoring effect on EME currencies increases with the RMB's appreciation.

5.3.3 Volatility of the RMB exchange rate

Clearly, the atypical volatility observed in the exchange rate of the RMB may diminish its effectiveness as a vehicle currency for cross-border transactions. Consequently, if the effects of exchange rate co-movements on exposure tend to diminish with the increased internalization of the RMB, we would anticipate a more noticeable impact during periods characterized by unusual RMB exchange rate volatility. To investigate the influence of RMB volatility on the association between co-movement and exposure, we conducted three supplementary tests.

First, we calculated rolling (annual) deviations of LRc_{de} and LRc_{eme} for the whole sample period and split the sample into normal and unusual exchange rate volatility periods. Specifically, we defined a dummy variable, $Ivol_{de}$ $(Ivol_{eme})$, which equals one if the volatility of

LRc_{de} (LRc_{eme}) is outside the interval of its mean plus or minus one standard deviation, and zero otherwise. We then augmented equation (1) with the interaction terms $Ivol_{de} \times comove_{de}$ ($Ivol_{eme} \times comove_{eme}$). If unusual exchange rate volatility is associated with a decline in the RMB's anchoring effect, the coefficient on the interaction term will be positive and statistically significant.

The results are reported in Columns (1) – (2) of Panel B of Table 8. We found that the effect of co-movement on exposure is magnified during the unusual volatility period more than it is during the normal period, consistent with the expectation that the RMB's anchoring effect on EME currencies decreases with the RMB's volatility.

Second, we used the Chicago Board Options Exchange (CBOE) volatility index (VIX), the measure of implied volatility of S&P 500 options, as our indicator of market uncertainty (Bekaert et al, 2013; Ouyang, 2019; Albrizio et al, 2020)[20]. We defined a dummy variable, $Ivix$, which equals one if the VIX index is above the median, and zero otherwise. We then included the interaction terms ($Ivix \times comove$) in the main regression. Despite the growing global importance and internationalization of the RMB, the RMB is still not a safe haven currency. For instance, Fatum et al. (2017) have found that the value of the RMB relative to the USD and the JPY decreases with market uncertainty, suggesting that the RMB is less safe than other major world currencies. If the RMB's anchoring effect decreases with the VIX index, the coefficient on the interaction term will be significant and positive. The results in Columns (3) – (4) of Panel B of Table 8 confirm the positive coefficients on the interaction terms. The evidence indicates that the positive impacts of exchange rate co-movements on exposure strengthen in periods of high market uncertainty.

Third, we focused on one year of data surrounding the 811 reform. This reform represents one of China's biggest steps in the transition process toward RMB exchange rate flexibility, but the RMB experienced a short period of high volatility during this time. The mean standard deviations of the RMB against DE and EME currencies between September 2015 and August 2016 are 1.414% and 1.226%, respectively, while the means after August 2016 are 1.356% and 1.179%. Accordingly, we constructed a dummy variable, $Ireform$, which equals one in the sample period between September 2015 and August 2016, and zero otherwise. The results in Columns (5) – (6) of Panel B of Table 8 show that the coefficients on the interaction terms $Ireform \times comove$ are positive and statistically significant. The evidence indicates that the elevated exchange rate volatility may undermine the RMB's anchoring effect. As a result, co-movement has a larger impact on firms' exposure in periods of high RMB exchange rate volatility.

5.3.4 Anchoring effects

In this section, we delve deeper into the influence of RMB anchoring effects on the association between exchange rate co-movements and exposure. Our primary focus is on understanding how currency co-movement positively affects corporate foreign exchange exposure, with a particular emphasis on the currency mismatch between corporate income and costs. The extent of RMB

[20] From Investopedia, https://www.investopedia.com/terms/v/vix.asp, a real-time market index that represents the market's expectation of 30-day forward-looking volatility.

internationalization, as reflected by the strength of the RMB anchoring effect, plays a crucial role in mitigating the currency mismatch faced by Chinese corporations, particularly in the case of EME currencies, where the RMB anchoring effect is more pronounced.

To offer additional empirical validation, we partitioned our sample of EME currencies into two distinct groups based on the findings of He et al. (2023)[21] regarding RMB anchoring effects. Currencies that exhibit significant anchoring with the RMB are categorized into the high anchoring group (HA), while those without such pronounced anchoring are placed in the low anchoring group (LA)[22]. Subsequently, we conducted separate re-estimations of equation (3) within each group. The outcomes of these analyses are presented in Panel C of Table 8.

The coefficient on $comove_{ha}$ is significantly positive, while the coefficient on $comove_{la}$ is significantly negative. This outcome aligns with our anticipated hypothesis. In the high anchoring group, exchange rate co-movement is predominantly influenced by RMB movements, signifying that higher currency co-movement corresponds to a greater impact of the RMB and an extensive utilization of the RMB in cross-border transactions. Consequently, both corporate income and costs are settled in the same currency, leading to a reduced exposure of firms to exchange rate risks. On the other hand, in the low anchoring group, currency co-movement arises due to other currencies moving in the same direction, indicating that the exchange rate risk faced by firms is more challenging to diversify.

Table 8 Additional evidence

Column (1) – (2) of Panel A reports the results of the RMB's inclusion in the SDR on the impact of currency co-movements on exposure. $Isdr$ is a binary variable, that takes the value of 1 since October 2016, and 0 otherwise. Column (3) – (6) of Panel A report the results of exchange rate co-movements on firms' exposure in periods of the RMB's appreciation and depreciation. Panel B reports results of RMB volatility on the relationship between co-movement and exposure. Column (1) – (2) of Panel B report impacts of RMB volatility on the relationship between co-movement and exposure. $Ivol_{de}(Ivol_{eme})$ is a binary variable that takes the value of 1 when the volatility of $LRc_{de}(LRc_{eme})$ is outside its mean plus or minus one standard deviations interval, and zero otherwise. Column (3) – (4) report the impact of market uncertainty on the relationship between co-movement and exposure. $Ivix$ is a binary variable that takes the value of 1 when the VIX index exceeds its median value, and 0 otherwise. Column (5) – (6) report the impacts of 811 reform on the on the relationship between co-movement and exposure. $Ireform$ is a binary variable that takes the value of 1 between September 2015 and August 2016, and zero otherwise. Panel C reports results of the relationship between co-movement and exposure in high anchoring group and low anchoring group. When a currency significantly anchors the RMB, it is classified into the high anchoring group (HA). Otherwise, it belongs to the low anchoring group (LA). $comove_{ha(la)}$ is exchange rate co-movement of currencies in high (low) anchoring group. γ_{ha} (γ_{la}) is the firms' exposures in HA (LA) currencies. $Controls$ represent the control

[21] He et al. (2023) estimates the anchoring effects of RMB on other developing economies from 2006 to 2020, and find that the RMB has become influential anchor currency in developing countries.

[22] The high anchoring group consists of 21 economies: Albania, Belarus, Bulgaria, Poland, Russia, Philippines, Georgia, Kazakhstan, Kyrgyzstan, the Czech Republic, Malaysia, Macedonia, Bangladesh, Nepal, Thailand, Turkey, Brunei, Singapore, India, Indonesia and Korea. The low anchoring group consists of 33 economies: Afghanistan, the United Arab Emirates, Oman, Azerbaijan, Egypt, Pakistan, Bosnia and Herzegovina, Bhutan, Cambodia, Qatar, Kuwait, Croatia, Laos, Lebanon, Romania, Maldives, Mongolia, Myanmar, Moldova, Serbia, Saudi Arabia, Sri Lanka, Tajikistan, Ukraine, Hungary, Armenia, Yemen, Iraq, Jordan, Vietnam, and Chinese Taiwan.

variables we have used before, here we omit their results to save space. Robust standard errors in parentheses, significance level: *** p<0.01, ** p<0.05, * p<0.1. Variable definitions are presented in Appendix A.

Panel A RMB inclusion into SDR, appreciation and depreciation

	(1)	(2)	(3)	(4)	(5)	(6)
	Inclusion into SDR		Appreciation		Depreciation	
Variable	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{eme}\rvert$	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{eme}\rvert$	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{eme}\rvert$
$comove_{de}$	0.085		1.408***		0.556***	
	(0.112)		(0.123)		(0.143)	
$comove_{eme}$		3.168***		0.333*		1.427***
		(0.154)		(0.172)		(0.208)
$Isdr \times comove_{de}$	2.445***					
	(0.188)					
$Isdr \times comove_{eme}$		-5.696***				
		(0.237)				
$Isdr$	-1.091***	1.440***				
	(0.087)	(0.059)				
Controls	yes	yes	yes	yes	yes	yes
Firm	yes	yes	yes	yes	yes	yes
Industry	yes	yes	yes	yes	yes	yes
Year	yes	yes	yes	yes	yes	yes
Observations	278,598	278,598	150,866	150,574	127,695	127,996
R-squared	0.380	0.385	0.380	0.370	0.392	0.419

Panel B Volatility of the RMB exchange rate

	(1)	(2)	(3)	(4)	(5)	(6)
	RMB volatility		VIX volatility index		811 reform period	
Variable	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{eme}\rvert$	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{eme}\rvert$	$\lvert\gamma_{de}\rvert$	$\lvert\gamma_{eme}\rvert$
$comove_{de}$	-0.275***		0.865***		0.624***	
	(0.103)		(0.102)		(0.097)	
$comove_{eme}$		0.503***		0.515***		0.110
		(0.123)		(0.120)		(0.124)
$Ivol_{de} \times comove_{de}$	2.062***					
	(0.146)					
$Ivol_{eme} \times comove_{eme}$		1.440***				
		(0.301)				
$Ivol_{de}$	-0.931***					
	(0.061)					
$Ivol_{eme}$		-0.314***				
		(0.070)				
$Ivix \times comove_{de}$			0.255***			
			(0.088)			
$Ivix \times comove_{eme}$				0.254***		
				(0.074)		
$Ivix$			-0.085**	-0.054***		
			(0.038)	(0.018)		

$Ireform \times comove_{de}$					3.847***	
					(0.479)	
$Ireform \times comove_{eme}$						4.276***
						(0.903)
$Ireform$					-1.806***	-0.945***
					(0.230)	(0.219)
Controls	yes	yes	yes	yes	yes	yes
Firm	yes	yes	yes	yes	yes	yes
Industry	yes	yes	yes	yes	yes	yes
Year	yes	yes	yes	yes	yes	yes
Observations	278,598	278,598	278,598	278,598	278,598	278,598
R-squared	0.380	0.385	0.379	0.383	0.379	0.384

Panel C Anchoring effect

	(1)	(2)	(3)	(4)
	High anchoring group		Low anchoring group	
Variable	$\lvert\gamma_{ha}\rvert$	$\lvert\gamma_{ha}\rvert$	$\lvert\gamma_{la}\rvert$	$\lvert\gamma_{la}\rvert$
$comove_{ha}$	-2.021***	-2.021***		
	(0.087)	(0.086)		
$comove_{la}$			0.266***	0.264***
			(0.075)	(0.074)
Controls	no	yes	no	yes
Firm	yes	yes	yes	yes
Industry	yes	yes	yes	yes
Year	yes	yes	yes	yes
Observations	278,598	278,598	278,598	278,598
R-squared	0.385	0.389	0.344	0.347

6. Conclusion

This paper explores the relationship between exchange rate co-movements and firm-level exchange rate exposure in China, and it investigates how the RMB's internationalization affects this relationship. Our findings reveal a positive association between exchange rate co-movements and firms' exchange rate exposure. Notably, the impact of EME currency co-movements on exposure is smaller in comparison to DE currency co-movements. Furthermore, the impact of EME currency co-movements on firms' exchange rate exposure appears to be diminished after the introduction of the BRI, particularly for highly multinational firms.

Our supplementary analyses have yielded robust evidence supporting the proposition that the effects of exchange rate co-movements on Chinese firms' exposure diminish with the extent of the RMB's internationalization. Notably, the correlation between currency co-movements for a portfolio comprising EME currencies and exposure has exhibited a weakened positive association following the RMB's inclusion in the SDR, during periods of RMB appreciation, and when the RMB maintains stability. These findings further highlight the importance of the RMB's internationalization in shaping firms' exchange rate exposure dynamics.

The empirical findings of our study carry significant policy implications, shedding light on the advantages of currency internationalization for non-financial companies in their home countries.

Regardless of a firm's underlying fundamentals, its exchange rate exposure can fluctuate due to currency co-movements, presenting a risk management challenge. However, the adoption of the home currency for international transactions, or currency internationalization, seems to mitigate the temporal variations in undiversified risks arising from co-movements. This suggests that currency internationalization can reduce non-diversified risks for firms operating in the global market.

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Appendix A

Table A.1 Variable definitions and data sources

Note: this table presents the abbreviation, definition and source of variables we have used.

Variable	Definition	Source
Exchange rate exposure and currency co-movement		
LRc	Log monthly return of trade-weighted currency index.	FX data from IMF IFS Trade data from CSMAR
LRf	Log monthly return of stocks	CSMAR
LRm	Log monthly return of value-weighted market index	
γ	The coefficient of LRc using OLS, as the proxy for the firm's exchange rate exposure	Estimated
$comove$	The mean value of unconditional correlation coefficients for log monthly return of bilateral exchange rate, as the proxy for currency co-movement	
$comove^{r2}$	The median value of adjusted R-squares using three-factor regression model, as the proxy for currency co-movement	
$comove^{var}$	The ratio of the variance for log monthly return of currency portfolio over the trade-weighted average variance for log monthly return of bilateral exchange rate, as the proxy for currency co-movement	
Controls		
$size$	Total assets (100 billion RMB)	CSMAR
$bmratio$	The ratio of the book value of equity over the market value of equity	
$profit$	The ratio of the operating revenue minus operating cost over the operating revenue	
$quickratio$	The ratio of the quick assets over the current liabilities	
$leverage$	The ratio of the total liabilities over the total assets	
$fsales$	The ratio of the overseas business income over the operating revenue	
$subs$	The average number of foreign countries that a firm's subsidiaries lie in during each year of 2004 - 2019	

Appendix B

Table B.1 The correlation coefficients of currencies in DE

Note: this table presents the Pearson correlation coefficients of log monthly return of bilateral exchange rate between RMB and currencies in DE from September 2001 to December 2019. Austria represents log monthly return of bilateral exchange rate between RMB and Australian dollar, others are similar.

country	1	2	3	4	5	6	7	8	9	10
1 Australia	1.000									
2 Denmark	0.649	1.000								
3 Canada	0.681	0.496	1.000							
4 United States	0.034	0.081	0.130	1.000						
5 Norway	0.662	0.760	0.573	-0.005	1.000					
6 Japan	0.106	0.219	0.082	0.245	0.128	1.000				
7 Sweden	0.691	0.850	0.580	0.029	0.820	0.168	1.000			
8 New Zealand	0.809	0.620	0.550	0.027	0.556	0.074	0.641	1.000		
9 United Kingdom	0.531	0.631	0.443	0.093	0.586	0.052	0.619	0.501	1.000	
10 Euro Area	0.656	0.995	0.511	0.082	0.782	0.216	0.862	0.621	0.641	1.000