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RMB Internationalization and Currency Co-movement of Belt and Road Initiative Countries: Evolution and Impact Analysis

Jieting Cai

East China University of Science and Technology, Shanghai, China

Abstract: ***Since the launch of the pilot program for RMB settlement in cross-border trade in 2009, the process of RMB internationalization has advanced steadily, achieving significant milestones in cross-border trade and investment settlement, the development of offshore RMB markets, and currency swap agreements. Between 2013 and 2023, the exchange rate co-movement between the RMB and the currencies of Belt and Road Initiative (BRI) countries gradually increased, and the RMB's position in the global currency market has continued to rise. To examine the degree of linkage between the RMB and the currencies of BRI countries, as well as the evolution of its monetary influence, this paper first selected 91 representative currencies from BRI countries, estimates the exchange rate linkage between the RMB and other currencies, and applies the PMFG algorithm to construct an exchange rate co-movement network for analysis. Furthermore, the paper explores changes in the RMB's influence during the progression of the BRI and compares its influence with that of the U.S. dollar and the euro in the region.***

Keywords: RMB Internationalization, Exchange Rate Co-movement, PMFG, Monetary Influence**.**

1. Introduction

The launch of the pilot program for RMB settlement in cross-border trade in 2009 marked the official beginning of China's RMB internationalization policy. Subsequently, the process of RMB internationalization advanced rapidly, achieving significant milestones in cross-border trade and investment settlement, the development of offshore RMB markets, and currency swap agreements. However, following the "August 11" exchange rate reform in 2015, the internationalization process slowed due to multiple factors, including RMB depreciation against the U.S. dollar, a narrowing China-U.S. interest rate differential, strengthened capital outflow controls, and the exposure of domestic financial risks. These factors heightened market expectations of RMB depreciation.

Nevertheless, driven by the Belt and Road Initiative (BRI), RMB internationalization entered a new phase of rapid development. Since the introduction of the BRI in 2013, China's bilateral economic and trade relationships with participating countries have grown increasingly close, resulting in significant improvements in trade and capital flows. From 2013 to October 2023, the total import and export volume between China and BRI partner countries exceeded USD 21 trillion. Meanwhile, with the growth in cross-border trade and investment, the scale and scope of RMB usage have expanded rapidly, with its roles in reserve, transaction, and pricing functions steadily increasing. As of the end of August 2024, the People's Bank of China had signed bilateral local currency swap agreements with the central banks or monetary authorities of 42 countries and regions, 29 of which remain active, with a total swap value exceeding RMB 4.1 trillion.

As the RMB's status in the global currency market continues to rise, its co-movement with Asian currencies has become increasingly evident. Studies indicate that the RMB and the currencies of Belt and Road Initiative (BRI) partner countries exhibit a strong overall trend of convergence, which has intensified in recent years. Building on this observation, this paper aims to examine the degree of linkage between the RMB and the currencies of BRI countries, as well as the evolution of the RMB's monetary influence. The research methodology is divided into two steps: first, estimating the linkage between the RMB and the currencies of BRI countries and constructing an exchange rate co-movement network; second, exploring changes in the RMB's influence during the progression of the BRI, analyzing its influence compared to the U.S. dollar and the euro in the region, to clarify the RMB's position and development prospects among BRI countries.

This study holds both practical significance and academic value. First, by selecting representative currencies from BRI countries as research objects, this paper expands the sample to include currencies from countries across diverse regions, such as Southeast Asia, South Asia, Central Asia, West Asia, Central and Eastern Europe, Africa, Oceania, and the Americas. Second, the paper applies the PMFG (Planar Maximally Filtered Graph) algorithm to analyze exchange rate co-movement within the "BRI currency circle," presenting an innovative methodology. Finally, the study examines the interlinkages between currencies of BRI countries and conducts a comparative analysis of the RMB's influence relative to the U.S. dollar and the euro in the region. This provides a foundational basis for further research into the RMB's development trajectory and its evolving role in the global currency landscape.

2. Related Works

As China's economic strength grows, the international influence of the RMB has gradually become a key research topic for scholars at home and abroad. Existing literature generally conducts research from three aspects: the definition of RMB internationalization, the degree of RMB internationalization, and the factors affecting RMB internationalization.

2.1 Definition of Currency Internationalization and RMB Internationalization

An international currency is one that is widely used outside its country of issuance (Chinn and Frankel, 2005; Chey, 2012). Kannan (2008) defined an international currency as one used for "international transactions." Cohen (1971) was the first to define international currency from the perspective of its functions. He argued that an international currency not only performs monetary functions domestically but also extends these functions abroad. When private sectors and official institutions in the issuing country expand the use of a currency beyond its borders for specific purposes and when it is widely accepted by users, the currency becomes international.

Hartmann (1998) further developed Cohen's (1971) definition by elaborating on the various functions of an international currency from the perspectives of official and private use. A detailed explanation of these functions is provided in Table 1.

Table 1: Concepts of Currency Internationalization Based on Functions

Monetary Function	Official Use	Private Use
Medium of Exchange	Foreign exchange intervention	Trade and financial settlement
Unit of Account	Currency "anchor"	Trade and financial pricing
Store of Value	International reserves	Currency substitution

At present, most of the internationalization of RMB takes international currency as the starting point, observes the level of currency internationalization from the perspective of international currency functions, and then extends it to RMB internationalization. Li Daokui and Liu Linlin (2008), Gao Haihong and Yu Yongding (2010), Yu Xuewei (2017), Song Ke (2022), etc. also use the relevant definition of currency internationalization to study the level of RMB internationalization.

2.2 The Measurement Method of Currency Internationalization Degree

One of the more mainstream research methods is to construct a comprehensive currency internationalization index based on specific indicators reflecting the different functions of internationalized currencies. Peng Hongfeng (2017) constructed a currency internationalization aggregate index based on the three major functions of international currencies using principal component analysis, and used it to measure the degree of internationalization of eight major currencies. Zhang Chong (2022) combined the research of many scholars and used the invisible anchor model to obtain the currency anchor index representing the value scale function, and constructed a more complete measurement system. Scholars such as WorldBank (2011), Tung et al. (2012), Zhao Ran (2012), International Monetary Institute of Renmin University of China (2012), and Tu Yonghong et al. (2013) all selected indicators from different angles to consider the three major functions of currency and construct currency internationalization index.

The anchor currency status is also one of the bases for measuring the degree of currency internationalization. The most commonly used measurement method in the literature is to study the exchange rate linkage effect. Most of this literature uses GARCH-type methods to characterize the dynamic characteristics of exchange rate fluctuation transmission (Jian Zhihong and Zheng Xiaoxu, 2016; Yin Libo and Wu You, 2017; Cai Tongjuan and Lin Runhong, 2018; Liang et al., 2019). However, most of the above literature uses binary correlation analysis methods to measure the linkage characteristics between currencies. This method may ignore the overall correlation of currencies, and then there will be a phenomenon of local correlation but overall irrelevance, and it also ignores the asymmetric impact between currencies. At present, some literature also uses the method of constructing an exchange rate linkage network to study the degree of currency internationalization. The main construction method is to construct a network based on exchange rate correlation (Yu Bo and Guan Chao, 2020).

2.3 Factors Affecting Currency Internationalization

Based on the qualitative and quantitative research results of domestic and foreign scholars, it is found that among the current factors affecting currency internationalization, economic scale, financial market development, currency stability, currency network externalities and trade scale are the most critical factors (Chen Yulu, 2005; Fang Zhuo, 2006; Chinn and Frankel, 2010; Frankel, 2012; Zhuang Yongting, 2012; Huang et al., 2014;; Eichengreen et al., 2016; Lin Lefen and Wang Shaonan, 2016; Peng Hongfeng and Tan Xiaoyu, 2017; Wu Shuyu and Li Daokui, 2018; Cui, 2022). Some scholars also explore the factors affecting currency internationalization from the perspective of capital flows. Park (2010) pointed out that the prerequisite for the RMB to become an international currency is that the RMB must be freely convertible in global economic exchanges, that is, the Chinese financial market must be fully opened, and the fixed exchange rate system in the foreign exchange market should be abolished and a floating exchange rate system should be adopted. Su Yuhai et al. (2018) found that exchange rate stability can not only alleviate the impact of short-term capital flows, but also help promote the internationalization of the RMB.

Many scholars have also explored the influencing factors of RMB internationalization under the background of the Belt and Road Initiative. Han Yujun and Wang Li (2016) found that the construction of the Belt and Road Initiative can bring new development opportunities for the internationalization of the RMB, and put forward corresponding international cooperation suggestions; Jia Xiaoning (2016) believes that the Belt and Road Initiative will help to smooth my country's international trade transactions and drive economic growth in countries or regions along the route. Liu Ling (2019) took 28 countries along the Belt and Road Initiative as the research objects and found that factors such as foreign trade dependence, money supply and GDP have a significant impact on the internationalization of the RMB; Cheng Gui and Zhang Xiaoxia (2020) found through PSM-DID method empirical analysis that expanding foreign investment and reducing trade surplus under the Belt and Road Initiative can promote the internationalization of the RMB. Song Ke et al. (2022) empirically studied the impact of the "Belt and Road" initiative on the internationalization of the RMB and found that the "Belt and Road" initiative can significantly increase

the amount and number of cross-border RMB transactions in countries along the route and promote the internationalization of the RMB. Moreover, for the Maritime Silk Road countries, neighboring "Belt and Road" countries and countries with high capital account openness, the "Belt and Road" initiative has a more obvious role in promoting the internationalization of the RMB.

2.4 Research Review

At present, there are endless studies on currency internationalization, which mainly focus on the definition, conditions, influencing factors, and measurement methods of currency internationalization. However, there are few studies on RMB internationalization. Most of the literature extends the issue of currency internationalization to the issue of RMB internationalization. Since the current research focus in this field is more on the influencing factors of currency internationalization, a complete theoretical framework and analytical ideas have been formed. However, many scholars still stay on the previous research conclusions in selecting indicators of influencing factors of RMB internationalization, which lacks certain timeliness and scientificity. There are relatively few studies on the measurement of RMB internationalization. At the same time, the analytical indicators selected in the above analysis focus on local paths, thus ignoring the overall relationship and failing to comprehensively think about the construction of indicators of RMB internationalization. Although some literature adopts the method of complex network analysis, most of the current literature adopts the static method of constructing currency internationalization index or binary correlation analysis to comprehensively reflect the internationalization level of a certain currency. The method is relatively simple and there is still room for further improvement. This paper will use a complex network model to better capture the currency clustering and linkage in the exchange rate market, so as to more systematically analyze the regional influence of RMB.

3. Methodology

In the study of financial issues, complex network models were initially used to identify financial institutions of systemic importance. Later, some scholars realized that the currencies in the exchange rate market have similar linkages as the institutions in the financial system, and applied complex network models to the study of exchange rate linkage characteristics: assuming that the currencies in the exchange rate market are nodes, the edges between the nodes represent the correlation between exchange rate fluctuations, and the specific characteristics of each edge represent the magnitude of the exchange rate correlation between the corresponding currencies. Then, through the correlation coefficient matrix conversion, and using different network graph algorithms to construct the exchange rate linkage network. The research is generally divided into three steps: currency correlation measurement, exchange rate linkage network construction, and network structure feature analysis.

STEP1: Calculate correlation

Drawing on the practice of general literature (Ding Jianping et al., 2009), assuming that a country's currency $i(i = 1,2,\ldots,N)$. The rate of return in period T is:

$$R_{i,T} = ln(e_{i,T}) - ln(e_{i,T-1})$$

Among them, $e_{i,T}$ and $e_{i,T-1}$ represent the exchange rate of currency i at time T and time T-1 respectively. Based on this, we can calculate the correlation between the yields of two currencies i and j, expressed as the Pearson correlation coefficient (Liu Gang and Zhang Youze, 2018):

$$\rho_{i,j} = \frac{cov(R_i,R_j)}{\sqrt{VAR(R_i)\times VAR(R_j)}}$$

$\rho_{i,j}$ indicates the correlation information between currency i and currency j. The larger the value, the higher the correlation between the two corresponding currencies.

STEP2: Constructing exchange rate linkage network based on currency correlation

Based on the correlation, we can get the cross-correlation coefficient matrix C between N currencies, which consists of N×N elements. Convert the obtained correlation coefficient matrix C into the correlation distance matrix D: $d_{i,j} = 1 - |c_{i,j}|$, the higher the correlation between currencies, the smaller it is. Based on D, network construction can avoid the unreasonable situation that the correlation of negative correlation is higher than the correlation of uncorrelated ones. By converting the above N×N correlation distance matrix into the adjacency matrix of the network, and then using the adjacency matrix, we can construct a currency network model: each network node represents a currency, and the edge between each two nodes contains the correlation between the corresponding two currencies. The new network can be represented by G=(V,E,W), where V={1,2,…,N}, represents the point set of the network, E represents the edge set of the network, and W represents the weight set. This paper only examines the strength of the correlation between currencies, and does not consider the direction. The plane maximum filter graph method (PMFG) is used to construct an undirected network. These methods all construct the network by screening the most important edge information. This method helps to better capture the correlation information in the system, so as to further study the topological structure of the network.

STEP3: Analysis of network structure characteristics

The structural characteristics analysis of complex networks generally includes degree distribution, average path length and other aspects. In the exchange rate linkage network we constructed, the degree ranking of each node currency is an important basis for measuring the status of each currency in a certain exchange rate market. The degree value is the number of connections between a node and other nodes. Each connecting line represents the degree of correlation between the node currencies at both ends of the line. Therefore, in the exchange rate network diagram, the degree value is equivalent to the price influence of a currency on other currencies in the entire exchange rate market. The larger the degree value, the stronger the dominance of the corresponding currency over other currencies and the higher the systemic importance. Based on the construction of the exchange rate linkage network, this paper will study the influence of the RMB in the

currency circle of countries along the "Belt and Road" by comparing and analyzing the degree values of the RMB currency nodes.

4. Data and Analysis

4.1 Data Source and Sample Selection

According to the "China Belt and Road Network", as of the end of August 2023, China has signed more than 200 cooperation documents on the joint construction of the "Belt and Road" with 152 countries and 32 international organizations. The cooperation countries have also expanded from the initial Asia and Europe to Africa, Latin America, the South Pacific and other regions. The data in this article comes from the monthly data of currency exchange rates against SDR in the International Financial Database (IFS) on the website of the International Monetary Fund (IMF), and the sample period is from January 2017 to July 2024. After eliminating the currencies with missing data from the 152 partners, 88 currencies were finally retained as research objects. In order to be able to compare and analyze the differences in the influence of the RMB, the euro and the US dollar in the currency circle of countries along the route, this article additionally adds the US dollar, the euro and the RMB as samples, a total of 91 currencies.

4.2 Analysis and Conclusion

Based on the monthly data of the exchange rates of the above 91 currencies against the SDR, the yield correlation coefficient matrix between the 91 currencies can be calculated. Based on this correlation coefficient matrix and using the PMFG rules, this paper constructs the exchange rate linkage network diagram shown in Figure 1. Each node in the diagram represents a currency, and each edge represents the correlation between the currencies at both ends.

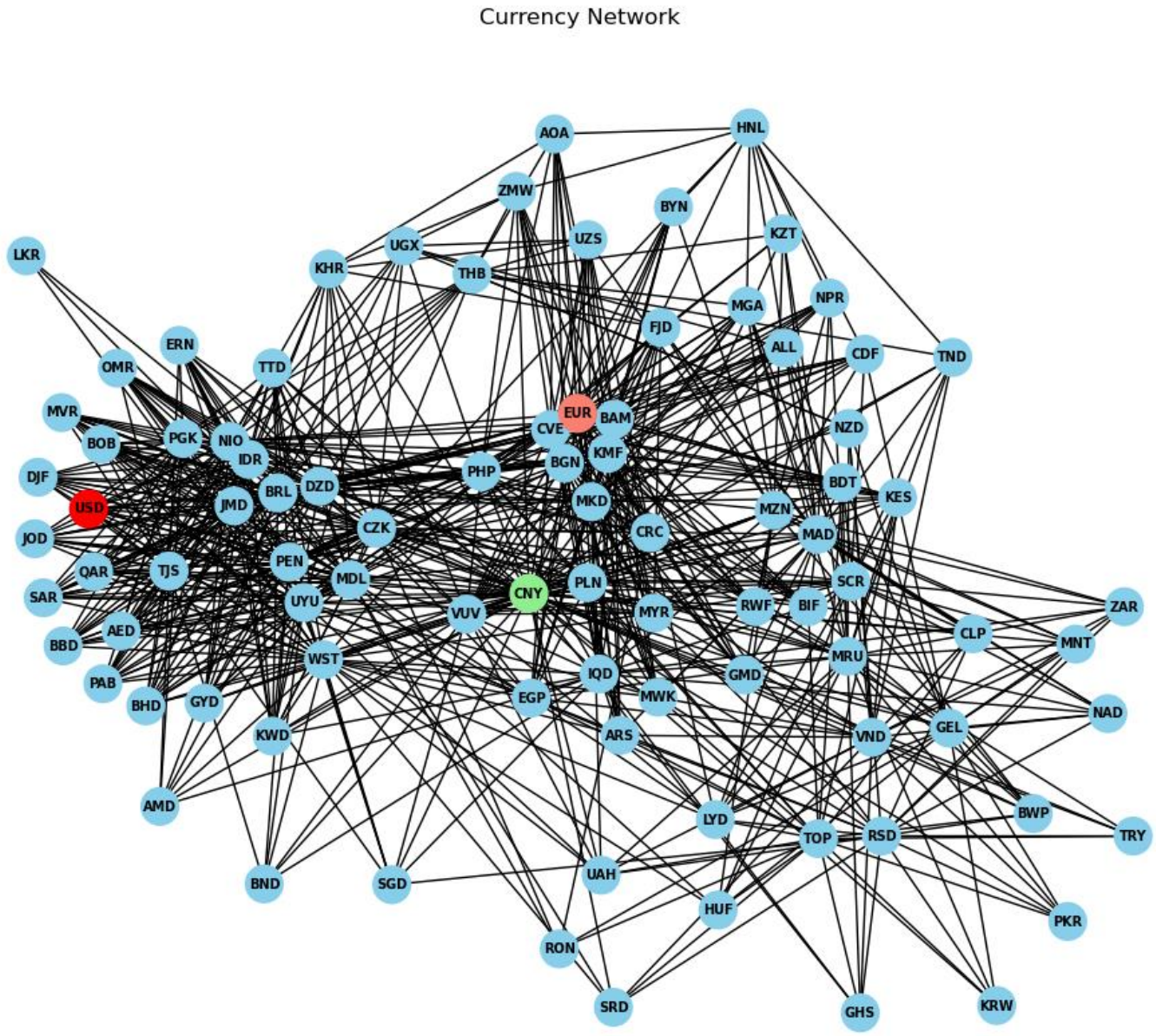

Figure 1: Currency exchange rate linkage network diagram

Next, we will study the influence ranking of RMB, Euro, USD and currencies of countries along the Belt and Road according to the degree distribution. As introduced in STEP3, each node i has its corresponding degree, that is, the number of connections with other nodes. The larger the degree of a node i, the higher the influence of its corresponding currency i on other currencies. Table 2 shows the currencies whose degree ranking is higher than RMB in the PMFG network diagram, including RMB, Euro, USD and 88 currencies of countries along the Belt and Road, from January 2017 to July 2024. The degree rankings of USD, EUR and RMB are 1, 4 and 10 respectively, which means that when we include RMB, Euro and USD in the Belt and Road currency circle and examine their influence together, USD has the strongest linkage with the region, followed by Euro and RMB.

Table 2: Ranking of currency influence

Rank	Curreny	Degree
1	USD	32
2	BGN	30
3	BBD	28
4	EUR	22
5	KWD, KHR, PAB	20
8	BHD	18
9	PHP	16
10	CNY, GYD, MYR	15

Existing studies generally show that a series of factors such as economic scale, trade scale, network effect, usage inertia, and the degree of development of financial markets will affect the degree of internationalization of a country's currency. The US dollar has an absolute leading position in the currency circle of countries along the "Belt and Road", which is inseparable from the absolute advantages of the US dollar in international settlement, transactions, reserves, etc. From the network diagram, we can see that the exchange rate linkage effect of the US dollar is widespread. And for a long time, the currency usage inertia of countries along the "Belt and Road" in international economic and trade activities has made it difficult for the absolute leadership of the US dollar to be broken in a short period of time.

Secondly, the euro also has a strong influence in the currency circle of countries along the route, but it is lower than the US dollar. On the one hand, this may be mainly due to the close trade between Western Europe and Central and Eastern Europe; on the other hand, it is restricted by its relatively few economic and trade exchanges with Asian countries. From the exchange rate linkage network diagram, we can also find that in addition to having a direct impact on the currencies of Central and Eastern Europe and some African countries, the exchange rate linkage of the euro with the currencies of the Asian region is relatively weak. And intra-eurozone trade has always occupied an important position in EU countries.

Thirdly, although the RMB has a certain influence in the countries along the route, there is still a certain gap compared with the US dollar and the euro. At the same time, from the network diagram, we can see that the currencies directly affected by the RMB are: SGD, MYR, ZMW, PHP, etc. However, the linkage effect of the RMB mainly involves some countries in Asia and Africa, and the impact on Europe and America is relatively weak. There are obvious regional differences in the impact of the RMB in the countries along the route.

5. Conclusion and Suggestions

Based on the plane maximum filter graph method, this paper first constructs the exchange rate linkage network diagram including RMB, Euro, US dollar and 88 currencies of countries along the Belt and Road, studies the exchange rate linkage characteristics of this region, and then compares the influence of RMB, Euro and US dollar in this currency circle by ranking the constructed degree values. The following main conclusions are drawn: Compared with the US dollar and the euro, the influence of RMB is not enough, and the current level of RMB's "Belt and Road" is still low; the influence of RMB has obvious regional differences. RMB mainly affects neighboring countries, with the strongest in Central and West Asia, followed by Africa and Southeast Asia, and the weakest in South Asia and Central and Eastern Europe.

In response to the above conclusions, this paper puts forward the following policy recommendations:

First, promote the internationalization of RMB in different regions of the "Belt and Road" according to local conditions. For regions with relatively high recognition of RMB, such as Central Asia and West Asia, the use of RMB should be increased in bilateral trade settlements with relevant countries. For regions with relatively low regionalization of RMB, such as Central and Eastern Europe, precise economic and trade cooperation should be actively promoted. There are large differences in the economic development levels among the Central and Eastern European countries. The breadth and depth of my country's current economic and trade cooperation with Central and Eastern Europe are not enough. In the future, based on the fact that there are large differences in economic development among Central and Eastern European countries, we should increase cooperation between domestic industries (enterprises) and Central and Eastern European countries, strengthen bilateral trade exchanges, and gradually enhance the influence of the RMB in the Central and Eastern European region.

Second, the "double shock" of the COVID-19 pandemic and the Russia-Ukraine conflict has brought new challenges and opportunities to the internationalization of the RMB. The new challenges mainly include: first, the global industrial chain has become more fragmented, regionalized and localized after the COVID-19 pandemic; second, the United States and its allies have frozen Russia's foreign exchange reserves after the Russia-Ukraine conflict, which means that the U.S. Treasury bonds have defaulted on Russia, weakening the status of U.S. Treasury bonds as the world's most important safe asset; third, after the Russia-Ukraine conflict, the United States urged the SWIFT system to exclude most Russian financial institutions. In other words, the fragmentation of the global industrial chain and the "weaponization of the U.S. dollar" have posed new challenges to the internationalization of the RMB. Deepen monetary and financial cooperation between China and countries along the Belt and Road. Seize the opportunity of the Belt and Road, continue to improve my country's financial market system, further promote the reform of the RMB exchange rate formation mechanism, and on this basis deepen monetary and financial cooperation with relevant countries, such as issuing RMB bonds, signing more bilateral local currency swap agreements, and establishing more RMB

cross-border settlement pilots, and establish a stable mechanism between the RMB and local currencies, so that the RMB can truly "go out", thereby gradually forming an international currency competitive advantage in countries along the route.

Third, the People's Bank of China should expand the "new trinity" strategy to meet new challenges and seize new opportunities, mainly including: first, taking advantage of the trend of oil and gas resources in Russia, Iran and other countries shifting "from west to east" after the Russian-Ukrainian conflict, further expand the scale of RMB pricing and settlement of bulk commodity transactions; second, taking advantage of the global shortage of safe assets after the Russian-Ukrainian conflict, increase the efforts to provide high-quality RMB-denominated financial assets to foreign institutional investors in the domestic market and offshore market, such as national debt and provincial local debt; third, taking advantage of the trend of other major countries looking for SWIFT alternatives under the background of "weaponization of the US dollar", vigorously develop the RMB cross-border payment and settlement system (CIPS), and strive to achieve cooperation between the system and other major systems; fourth, vigorously consolidate the international currency status of RMB in the Asian industrial chain. For example, it is necessary to better combine the promotion of cross-border use of RMB with the enhancement of the chain leader role and central position of Chinese enterprises in RCEP and along the Belt and Road; fifth, strive to promote the cross-border use of digital RMB, and actively participate in international cooperation on digital currency bridges advocated by relevant countries and regions.

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