Has the RMB expanded the Efficient Frontier of the SDR?*

Sheng Liu [i]

College of Economics and Finance, Hanyang University

Choon-won Park [ii]

Associate Professor, College of Economics and Finance, Hanyang University

Abstract

In November 2015, the IMF decided to include the Chinese yuan, which is also called Renminbi (RMB), in the SDR basket currency, and it was implemented from 1 October 2016. The purpose of this study is to analyze whether the SDR denominated bond has become more profitable by adding the RMB into the SDR currency basket. Interest rate and foreign exchange rate data of major currencies such as USD, EUR, GBP, JPY, CNY were used, and the Sharpe ratio comparison and spanning test show that inclusion of the RMB expands the efficient frontier of the SDR. This result is due to the high interest rate of RMB-denominated bonds and the higher foreign exchange gains from the RMB. As China still maintains comparatively high interest rates, the effect of SDR's efficient frontier expansion by including RMB is likely to continue for some time

Keywords: The SDR, efficient frontier, Sharpe ratio, spanning test

JEL Classification: F3, F4

* This work was supported by the research fund of Hanyang University(HY-2018)

i) First Author. Address: 222 Wangsimni-ro, Seongdong-gu, Seoul, 04763, South Korea. E-mail: liusheng89@hanyang.ac.kr

ii) Corresponding Author. Address: 222 Wangsimni-ro, Seongdong-gu, Seoul, 04763, South Korea. E-mail: chwonpark@hanyang.ac.kr

First received, February 08, 2021; Revision received, July 07, 2021; Accepted, July 17, 2021.

1 Introduction

In November 2015, the IMF decided to include the Chinese yuan, which is also called Renminbi (RMB), in the SDR basket currency. Accordingly, the Chinese yuan has become to play a role in determining the value of the SDR in addition to the US dollar, euro, pound sterling and yen. The Chinese government is highly encouraged in that the yuan has taken the first step to become one of major currencies. The IMF also wishes the use of SDR to be expanded through the inclusion of the yuan in the SDR basket. At present, SDR is only used in the public sector as a supplementary means of foreign exchange reserves, and the IMF hopes that it could be used even in private sector. Many countries including the G20 as well as the IMF seem to have consensus on the necessity of role expansion of the SDR, dealing with the related issues as major topics of international conferences. Specifically, we can expect the situation that SDR-denominated bonds are issued, commercialized, and treated as investment instruments. However, in order for a new financial instrument to be recognized as an investment target, it should have the properties to attract the investors' interest. In other words, it can attract investors' attention only when it can provide a stable and higher return than existing products.

The purpose of this study is to analyze whether the SDR denominated bond has become more profitable by adding the yuan into the SDR currency basket, under the assumption that the SDR bond is commercially and widely traded in the international financial market.

This study tried two analytical methods. First, we evaluated whether the inclusion of the yuan improves the profitability of SDR bonds by comparing Sharpe ratio, which estimates a risk adjusted return. Second, we examined whether the yuan extends the SDR bond's efficient frontier through spanning test.

The composition of the paper is as follows. Chapter 2 explains the SDR and internationalization of the RMB. Chapter 3 is a literature review. Chapters 4 and 5 introduce the analytical methods and analysis results, respectively, and conclusions are made in Chapter 6.

2. The SDR and Internationalization of the RMB

2.1 The SDR

The SDR (Special Drawing Rights) is an international reserve asset, created by the IMF in 1969 to supplement its member countries' official reserves. 204.1 billion SDRs (equivalent to about $285 billion) had been created and allocated to members till now. SDRs can be exchanged for freely usable currencies. The value of the SDR is based on a basket of five major currencies — the U.S. dollar, euro, the Chinese yuan, the Japanese yen, and pound sterling — as of October 1, 2016.

Even though SDR is currently a supplementary means of official international reserves, but it has once been issued and circulated in private markets. Since SDR was first introduced in 1969, SDR denominated products began to be traded in the private sector in 1975 and continued to expand until 1981. According to IMF, commercial transactions were relatively active in the private sector, such as 5–7 billion SDR outstanding of deposits, 560 million SDR of bonds issued, and 910 million SDR of syndicated loans at the end of 1981. Since then, however, the SDR market has shrunk sharply due to the appreciation of basket currencies, the lack of continuous market development, and the lack of liquidity.

The distinction between public sector SDR and private sector SDR is that the public sector SDR pays a fixed interest rate based on a weighted average of interest rates of basket currencies, while the value of private sector SDRs is determined by the SDR basket, the interest rate is determined by the market.

The IMF adjusts the kinds and weight of SDR basket currency every five years. The criteria are that the currency must be the 'freely usable currency' for international transactions, and the country issuing the currency should have large portion in theinternational trade and financial markets. The SDR currency basket was composed of 16 currencies in the early stages, but, due to the complexity of the value calculation, it was decreased into four currencies: the US dollar, the euro, the pound and the yen until September 30, 2016. Then, the yuan was added to the SDR basket currency from 1 October 2016. As for the inclusion of the yuan, some pointed out the situation of the Chinese financial market, where free capital movements

and exchange rate fluctuations are rather limited. The IMF, however, interpreted that the 'free use of currency' does not necessarily mean a full conversion of capital accounts or a free floating foreign exchange rates.

Table 1 shows the weight of currencies in the SDR basket. Despite its latest inclusion to the basket, the yuan is the third most significant contributor surpassing the pound and the yen, reflecting China's trade size and its economic status in the world.

Table 1. SDR basket weights by currency

		Before change (%) (2011-2016.9.30)	After change (%) (2016.10.1-)
US dollar	(USD)	41.9	41.73
euro	(EUR)	37.4	30.93
pound sterling	(GBP)	11.3	8.09
yen	(JPY)	9.4	8.33
yuan	(CNY)	-	10.92

Source: International Monetary Fund

SDR bonds are synthetic bonds and have portfolio effects that diversify exchange rate and interest rate risks. Since the value of SDR is determined by the basket of several currencies, the impact of changes in a particular currency on SDRs can be minimized. In other words, because of the weighted average of the individual currencies, SDR bond yields have a lower volatility than individual currency denominated bond yields. As shown in Table 2, the exchange rate correlation among SDR basket currencies is very low or negative (-). This means that the impact of the exchange rate fluctuation of a single currency on the SDR value is mitigated or offset by those of other currencies. As a result, the SDR value becomes more stable. In addition, the correlation of interest rates among countries is also relatively low or negative (-). In this way, investors can expect a portfolio effect when investing in SDR bonds due to the low correlation in exchange rates and interest rates among currencies.

Table 2. Correlation Coefficients, 2016.10-2019.12(Weekly Changes)

	Exchange rates					Interest rates				
	USD	EUR	GBP	JPY	CNY	USD	EUR	GBP	JPY	CNY
USD	1.00					1.00				
EUR	-0.95	1.00				0.42	1.00			
GBP	-0.68	0.57	1.00			0.89	0.33	1.00		
JPY	0.47	-0.53	-0.64	1.00		0.36	0.47	0.25	1.00	
CNY	-0.49	0.27	0.44	-0.40	1.00	-0.37	-0.26	-0.56	0.22	1.00

Source: Author's calculation
Note: For exchange rates, correlations are against the SDR

On the other hand, the disadvantage of the SDR denominated bonds is that the weights of the currencies are fixed. In a deep and broad financial market, theoretically, the portfolio combination can be flexibly structured as the investor wishes, in which case it is hard to say that SDR-denominated bonds with fixed weights can perform better than those customized portfolio combinations. However, in practice, individual investors or small institutional investors, who have too many financial alternatives to take all of them as a portfolio target, may prefer a standardized synthetic bond such as SDR-denominated bonds.

2.2 RMB internationalization and its influence on the SDR

As we can see in the People's Bank of China's report on the internationalization of the yuan in 2017, Chinese government's efforts for inclusion of the yuan into the SDR can be considered in three ways: internationalization of the RMB, diversification of the international monetary system, and China's financial reform.

China has made great efforts to internationalize RMB since 2008 to acquire the international status of its currency in line with the second biggest economy in the world. She took measures to expand the function of RMB in trade settlement, and gradually promoted policies related to the opening of the yuan bond market to foreigners (RQFII) and the development of offshore financial centers capable of issuing and circulating dim sum bonds. At the same time, the People's Bank of China has signed currency swap agreements with foreign central banks to providethe yuan liquidity. IMF expects that the inclusion of the RMB in the

SDR basket will further support the already increasing use and trading of the RMB internationally.[1]

As a result of the global financial crisis during 2008 ~ 2009, countries around the world have agreed that it is not desirable to depend heavily on the US dollar, whose value is determined by the political and economic circumstances of the United States. Consequently, the emerging market countries such as China, Russia and Brazil demanded the reform of the international monetary system and wider use of SDR as a transnational reserve. In this regard, Chinese government thinks that the inclusion of the yuan into the SDR will contribute to the diversification of the dollar-dominated international monetary system as well as the yuanserves as an international reserve asset.

In addition, China faces the challenge of fostering a more open and market-based financial system in order to acquire economic efficiency. In view of the fact that the requirement for SDR basket currency is a 'freely usable currency,' financial reform such as foreign exchange and capital liberalization and interest rate liberalization are likely to be steadily implemented to meet these requirements. In other words, through the inclusion of the RMB into the SDR basket, China can get the opportunity to accelerate its financial reform.

On the other hand, with yuan's inclusion in the SDR basket currency, the influence of the yuan fluctuation on the international financial market is increasing. First, the SDR is one of the components of central banks' foreign exchange reserves. The yuan will directly affect the profit and loss of the central banks because SDR value will change according to the yuan value. Furthermore, if the private SDR bond market is formed and activated in the future, the role of the yuan in the international financial market will become even larger. In fact, the People's Bank of China approved the World Bank's issuance of SDR-denominated bonds in the Chinese financial market in August 2016. As can be seen from this example, if the SDR bond market expands, the influence of the yuan will increase accordingly. In this regard, it would be meaningful to evaluate the asset selection behavior of international investors in the future by estimating the portfolio effect of SDR bonds including the RMB. This study examines

[1] "IMF Adds Chinese Renminbi to Special Drawing Rights Basket", IMF News, September 30, 2016, https://www.imf.org/en/News/Articles/2016/09/29/AM16-NA093016IMF-Adds-Chinese-Renminbi-to-Special-Drawing-Rights-Basket

whether the addition of the yuan to SDR basket extends the portfolio effect by focusing on the return and risk properties.

3 Literature Research

There are two broad categories of literatures that are relevant to this paper. One is the studies on the return and risk properties of the synthetic bonds composed of multiple currency baskets and the other is studies on the spanning test which examines whether a new asset expands the efficient frontier.

Studies on the return and risk characteristics of multi-currency basket denominated bonds, mainly deal with issues on ECU, AMU and SDR. Allen (1986) compared the Sharpe ratios of ECU and SDR, and Shimizu et al. (2004) estimated the portfolio effect when constructing AMU as a currency basket in nine Asian countries. Hoguet et al. (2011) calculated the portfolio effect of SDR-denominated bonds based on 6-month maturity.

On the other hand, mean-variance spanning test is widely used to examine whether new risk assets extend mean-variance frontier. This test was first proposed by Huberman and Kandel (1987). They used the LR test to examine whether the null hypothesis — the minimum-variance frontier of K reference assets equals that of assets in which new N assets are included — is supported. If the null hypothesis is supported, then K reference assets are said to span N + K assets which include new risk assets. They made an empirical analysis with monthly data of the New York stock market for 20 years since 1964, and found that the null hypothesis was not rejected. De Roon and Nijman (2001) made a comprehensive study on existing literatures which mainly focus on spanning test. They introduced a linear regression equation for testing the conditional model. De Roon and Nijman and Werker (2001) conducted a mean-variance spanning test to determine whether investing in emerging market countries had a diversification effect when US investors confronted the constraint of short sale restrictions and transaction costs. They made the Wald test on multiple regression model and the result showed that the diversification effect of including the emerging market assets with no restriction was clear, but the effect disappeared with the constraints mentioned before. Mamun and

Visaltanachoti (2005) made a spanning test on US government bonds (TIPS) and UK (ILG). They set up a linear regression model to investigate whether the new asset, i.e., TIPS extend the efficient frontier of the reference asset. They conducted the Wald test and concluded that the diversification effect of TIPS is clear.

In this study, we follow Shimizu et al. (2005) for the calculation of Sharpe ratio, and Mamun and Visaltanachoti (2005) for the spanning test.

4 Methodology

The main purpose of this paper is to confirm whether investors could get the portfolio effect as the yuan is newly included into SDR basket currency. For this purpose, we selected investors of 10 countries which have the largest amount of SDR allocation except the countries whose currencies are included in the SDR basket, and examined the portfolio effect estimated by their own currencies. Selected 10 countries are Australia, Brazil, Canada, India, Korea, Mexico, Russia, Saudi Arabia, South Africa, and Switzerland.

Table 3. SDR Allocation to Selected Countries(in SDRs)

Country	Cumulative SDR Allocation (As of September 9, 2009)
Australia	3,083,171,021
Brazil	2,887,077,827
Canada	5,988,080,401
India	3,978,258,337
Korea	2,404,445,224
Mexico	2,851,195,262
Russia	5,671,802,571
Saudi Arabia	6,682,495,468
South Africa	1,785,415,141
Switzerland	3,288,037,190

4.1 Sharpe ratio comparison

Investors have concerns not only on the expected return but also on the risk of the investment. In general, the risk adjusted return is measured by the Sharpe ratio. The Sharpe ratio measures the performance of an investment (e.g., a security or portfolio) compared to a risk-free asset, after adjusting for its risk. It is defined as the difference between the returns of the investment and the risk-free return, divided by the standard deviation of the investment (i.e., its volatility). It represents the additional amount of return that an investor receives per unit of increase in risk.

This study compares the Sharpe ratios of SDR bonds as well as those of bonds denominated in US dollar, euro, pounds sterling, yen and yuan.

The return of each bond was calculated by the method in Shimizu and Ogawa (2004). When investors invest in foreign currency denominated bonds, they can get foreign exchange gains or losses in addition to the interest income. Therefore, considering the foreign exchange gain, the total return of bonds is calculated as follows.

$$(1 + r_t) \times \left(\frac{E_{t+1}}{E_t}\right) - 1 = \frac{E_{t+1} - E_t}{E_t} + r_t \times \left(\frac{E_{t+1}}{E_t}\right) \quad (1)$$

Total Return = Foreign Exchange Rate Gain + Interest Rate

where E_t is the exchange rate for the foreign currency converted into the local currency.

Return of SDR denominated bond including changes in exchange rates is expressed as follows.

$$\sum W_i \left[(1 + r_{t,i}) \times \frac{E_{t+1,i}}{E_{t,i}}\right] - 1 \quad (2)$$

Here, W_i, the weight of each currency applied to SDR bonds is shown in Table 1.

4.2 Spanning test

The concept of spanning test can be summarized as follows. Assume that

there are K benchmark assets and N new test assets. We can say that the K assets "span" the K + N assets when the efficient frontier of the K benchmark assets and that of the K + N assets are the same. If the spanning test results reject the hypothesis that the K + N assets are spanned by the K assets, we conclude that the N new assets can be additional strategic assets.

Let R_{1t} be the vector of returns of the K benchmark assets and R_{2t} be the vector of returns of the N test assets. If R_t is the vector of returns of the K + N risky asset at time t, its mean and variance-covariance can be specified as follows:

$$R_t = \begin{bmatrix} R_{1t} \\ R_{2t} \end{bmatrix}$$

$$E[R_t] = \mu = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix}$$

$$Var[R_t] = V = \begin{bmatrix} V_{11} & V_{12} \\ V_{21} & V_{22} \end{bmatrix} \tag{3}$$

Mamun and Visaltanachoti (2005) set up the following regression equation to examine if the test assets can be spanned by the benchmark assets.

$$R_{2t} = \alpha + \beta R_{1t} + \epsilon_t \tag{4}$$

According to Huberman and Kandel (1987), the necessary and sufficient condition for spanning is satisfied when the following restrictions on the coefficients in equation (4) are met:

$$H_0: \alpha_N = 0_N, \ \ \delta_N = 0_N \tag{5}$$

where $\delta_N = \beta_{N\times K} 1_K - 1_N$. Therefore, the spanning test is a joint test of the hypothesis that the constant α is equal to 0 and the hypothesis that the sum of slope coefficients (the sum of the elements of β) is equal to 1. The null hypothesis indicates that the benchmark assets span the yield space of the combination of the benchmark assets and the test assets. Rejection of the null hypothesis implies that one can move the mean-variance efficient frontier significantly upwards by adding the test assets to the benchmark

assets.

The coefficients of the regression model are estimated by the OLS method, and the Wald coefficient restriction test is adopted to test the null hypothesis.

4.3 Data

The interest rate data for each bond is weekly yield of 3 month- maturity government bonds issued by US, Germany, UK, Japan and China. Foreign exchange rate data are selected currencies' weekly changes against five major currencies. We got the interest rate and foreign exchange rate data from Bloomberg, China Central Depository and Clearing Co. and Pacific exchange rate service, respectively. Data period in Table 4 is from October 2016, when the RMB began to be included in the SDR, to December 2019.

Table 4. Data Summary

	Average	Standard Dev.	Max.	Min.
Foreign Exchange Rate[2]				
KRW/USD	1,134.20	37.56	1,214.00	1,060.90
KRW/EUR	1,290.04	35.45	1,358.90	1,200.50
KRW/GBP	1,468.15	33.23	1,564.30	1,378.80
KRW/JPY	10.27	0.43	11.46	9.44
KRW/RMB	167.64	3.07	173.90	161.78
Interest Rate (Weekly, %)				
US	0.030127	0.012767	0.047308	0.005385
Germany	-0.011614	0.001230	-0.009151	-0.016526
UK	0.008631	0.005285	0.014856	-0.000577
Japan	-0.003833	0.001565	-0.001827	-0.008942
China	0.050883	0.009532	0.076371	0.037056

[2] Calculated assuming that Korean investor is the representative investor.

5 Analysis Results

5.1 Return, standard deviation and Sharpe ratio (2016.10-2019.12)

As mentioned before, the RMB has been included into the SDR currency since October 2016. In order to understand the investment effect after the RMB was included in the SDR, we calculated yields of the hypothetical SDR-denominated bond which does not include the RMB and compared it with those of the SDR-denominated bond which includes the RMB.

Table 5 shows the return, standard deviation, and Sharpe ratios that the selected 10 countries' investors could have received when investing in the SDR bonds and major currencies-denominated bonds. Columns (1) and (2) in the table compare the investment performance of SDR1 and SDR2. SDR1 is a bond that does not include the RMB, and is composed of the US dollar, the euro, the pound sterling and the Japanese yen, and SDR2 is the bond with the RMB added. The composition weights are shown in Table 1.[3]

First, the total return of SDR2 is 0.03999% whichincreases by 0.00215%-p compared to that of SDR1, and the standard deviation of SDR2 0.91567% is 0.00748%-p lower than that of SDR1. Naturally, owing to the higher return and lower standard deviation, the Sharpe ratio of SDR2 (0.04412) is higher than that of SDR1 (0.04065), and this means that SDR2 shows better investment performance than SDR1. In other words, SDR bonds get higher risk-adjusted return by including the RMB.

The fact that the SDR bond gets higher profitability due to the inclusion of the yuan suggests that the investment performance of the yuan bond is higher than other currencies. From the column (3) to (7) in Table 5, we can confirm that the weekly yield of RMB is 0.05331%, which is definitely higher than those of the JPY, EUR, however, very slightly lower than that of GBP, and somewhat lower than that of USD. Meanwhile, the standard deviation of the RMB of 0.98343% is the lowest among 5 major currencies. As a result, the Sharpe ratio of the RMB is fairly high compared to those of other currencies except the USD. In short, inclusion of the relatively stable and profitable RMB makes the SDR bond more attractive to investors.

[3] The composition weights of SDR1 are shown in the left side of Table 1, and those of SDR2 are shown in the right side.

Table 5. Return, standard deviation and Sharpe ratio, 2016.10-2019.12 (Weekly Average)

	SDR1 (1)	SDR2 (2)	By currency				
			USD (3)	EUR (4)	GBP (5)	JPY (6)	RMB (7)
Total Return (%)							
Average	0.03784	0.03999	0.06191	0.01623	0.05678	-0.00623	0.05331
Australia	0.06459	0.06681	0.08924	0.04250	0.08288	0.02069	0.08009
Brazil	0.15383	0.15590	0.17757	0.13267	0.17357	0.10848	0.16871
Canada	0.00613	0.00823	0.02988	-0.01523	0.02489	-0.03733	0.02157
India	0.05004	0.05210	0.07329	0.02906	0.06992	0.00599	0.06532
Korea	0.03507	0.03724	0.05915	0.01339	0.05385	-0.00864	0.05028
Mexico	0.00339	0.00563	0.02767	-0.01829	0.02222	-0.04125	0.01950
Russia	0.01206	0.01410	0.03565	-0.00915	0.03097	-0.03139	0.02702
Saudi Arabia	0.00777	0.00982	0.03028	-0.01255	0.02785	-0.03591	0.02336
South Africa	0.03674	0.03896	0.06296	0.01325	0.05328	-0.00661	0.05195
Switzerland	0.00876	0.01107	0.03337	-0.01340	0.02840	-0.03634	0.02534
Standard Deviation (%)							
Average	0.92315	0.91567	0.98461	1.01632	1.21401	1.17584	0.98343
Australia	0.72638	0.72650	0.89910	0.75243	0.96479	1.01799	0.78490
Brazil	1.40113	1.39177	1.43506	1.48204	1.62883	1.48017	1.38621
Canada	0.68052	0.66946	0.75277	0.80426	0.98044	1.02928	0.73655
India	0.66038	0.64001	0.66127	0.83687	1.07246	0.95788	0.69338
Korea	0.68195	0.67180	0.79667	0.76824	0.98170	1.00416	0.69907
Mexico	1.24586	1.24991	1.32770	1.29572	1.43509	1.37933	1.32797
Russia	1.23655	1.22454	1.26403	1.32169	1.43384	1.45480	1.22940
Saudi Arabia	0.39479	0.35709	0.11121	0.74262	0.95340	0.83702	0.51507
South Africa	1.71906	1.72117	1.88711	1.64562	1.73682	1.89214	1.72753
Switzerland	0.48494	0.50443	0.71120	0.51374	0.95270	0.70562	0.73424
Sharpe ratio (=TR/STDV)							
Average	0.04065	0.04412	0.08494	0.01233	0.04647	-0.00944	0.05657
Australia	0.08893	0.09196	0.09925	0.05648	0.08590	0.02032	0.10204
Brazil	0.10979	0.11202	0.12373	0.08952	0.10656	0.07329	0.12170
Canada	0.00901	0.01229	0.03970	-0.01893	0.02539	-0.03626	0.02928
India	0.07578	0.08141	0.11084	0.03473	0.06520	0.00625	0.09421
Korea	0.05142	0.05544	0.07425	0.01743	0.05486	-0.00861	0.07192
Mexico	0.00272	0.00451	0.02084	-0.01412	0.01549	-0.02991	0.01468
Russia	0.00976	0.01151	0.02820	-0.00692	0.02160	-0.02158	0.02198
Saudi Arabia	0.01967	0.02749	0.27230	-0.01690	0.02921	-0.04290	0.04535
South Africa	0.02137	0.02264	0.03336	0.00805	0.03067	-0.00349	0.03007
Switzerland	0.01807	0.02194	0.04692	-0.02608	0.02981	-0.05150	0.03451

We examined the cause of relatively higher returns and lower volatility of the RMB by analyzing the foreign exchange gain and the interest rate

factors.

Table 6. Foreign Exchange Gain, 2016.10–2019.12(Weekly Average)

	USD	EUR	GBP	JPY	RMB
FX Gain (%)					
Average	0.03177	0.02784	0.04818	-0.00239	0.00239
Australia	0.05909	0.05411	0.07427	0.02453	0.02916
Brazil	0.14739	0.14429	0.16496	0.11232	0.11773
Canada	-0.00025	-0.00362	0.01629	-0.03349	-0.02934
India	0.04315	0.04067	0.06131	0.00983	0.01439
Korea	0.02901	0.02500	0.04525	-0.00480	-0.00064
Mexico	-0.00246	-0.00668	0.01362	-0.03741	-0.03140
Russia	0.00551	0.00246	0.02237	-0.02755	-0.02390
Saudi Arabia	0.00016	-0.00094	0.01925	-0.03207	-0.02755
South Africa	0.03281	0.02486	0.04467	-0.00277	0.00104
Switzerland	0.00325	-0.00179	0.01979	-0.03249	-0.02557
Standard Deviation (%)					
Average	0.98368	1.01640	1.21396	1.17576	0.98242
Australia	0.89788	0.75252	0.96462	1.01792	0.78443
Brazil	1.43403	1.48213	1.62873	1.48000	1.38517
Canada	0.75198	0.80433	0.98046	1.02931	0.73576
India	0.66023	0.83688	1.07233	0.95763	0.69192
Korea	0.79564	0.76819	0.98169	1.00404	0.69860
Mexico	1.32718	1.29599	1.43508	1.37937	1.32721
Russia	1.26280	1.32173	1.43379	1.45464	1.22777
Saudi Arabia	0.11046	0.74273	0.95362	0.83693	0.51263
South Africa	1.88565	1.64564	1.73656	1.89213	1.72733
Switzerland	0.71093	0.51388	0.95278	0.70564	0.73338
FX Gain/STDV					
Average	0.02960	0.02530	0.03899	-0.00590	-0.00290
Australia	0.06581	0.07191	0.07699	0.02410	0.03717
Brazil	0.10278	0.09735	0.10128	0.07589	0.08499
Canada	-0.00033	-0.00450	0.01661	-0.03253	-0.03987
India	0.06535	0.04860	0.05718	0.01027	0.02080
Korea	0.03647	0.03255	0.04609	-0.00478	-0.00091
Mexico	-0.00185	-0.00516	0.00949	-0.02712	-0.02366
Russia	0.00436	0.00186	0.01560	-0.01894	-0.01946
Saudi Arabia	0.00141	-0.00127	0.02018	-0.03832	-0.05375
South Africa	0.01740	0.01510	0.02572	-0.00146	0.00060
Switzerland	0.00457	-0.00349	0.02078	-0.04605	-0.03487

Table 6 shows the results regarding the foreign exchange gain factor. During the sample period from October 2016 to December 2019, the

average weekly foreign exchange gain of the RMB stays at 0.00239%, which ranks fourth among the five currencies, and is only higher than the Japanese yen of -0.00239%. Gain from the pound sterling (0.04818%) is the highest followed by the US dollar (0.03177%) and the euro (0.02784%).

The reason why the RMB shows so low foreign exchange gain is that Chinese government has been trying to make the yuanstaying weak to meet China's economic slowdown from 2016. Therefore, the RMB has been under depreciation pressure during this period. Most of international investors would have suffered from foreign exchange loss by investing in the RMB during this period. Only four countries including Brazil would have acquired slight foreign exchange gain by investing in the RMB.

The standard deviation of the RMB exchange rate is fairly stable at 0.98242, which is the lowest among the five currencies. This can be explained by the fact that the Chinese authorities use a managed floating exchange rate system to limit daily exchange rate fluctuations to less than 2%. Although the standard deviation of the RMB is relatively low, since the foreign exchange gain is significantly lower than other currencies, the exchange gain of the RMB divided by the standard deviation is very small at -0.00290, which is only higher than that of the yen (-0.00590) among the five currencies. In short, the RMB showed very weak performance in the foreign exchange gain factor.

In Table 7, the weekly average interest rate of the yuan-denominated bond is 0.05092%, which is the highest among five currencies. It even surpasses one and half of USD's interest yield which is the second highest among currencies. In addition, it is worth noting that both euro- and yen-bond rates are negative, and this is mainly due to the negative interest rate measures adopted by developed countries such as Japan during this period, by which they tried to stimulate banks to actively lend and thus to induce domestic inflationary pressures. Even though the standard deviation of the RMB is rather high in the five currencies, interest rate divided by standard deviation is 5.31264 which marks absolutely highest score among 5 currencies.

On the whole, although the RMB does not have an advantage in foreign exchange factor, itfairly outperforms other currencies due to its much higher interest rate.

Table 7. Interest rate, 2016.10-2019.12(Weekly Average)

		USD	EUR	GBP	JPY	RMB
Interest Rate (%)						
Average		0.03014	-0.01161	0.00861	-0.00384	0.05092
	Australia	0.03015	-0.01161	0.00861	-0.00384	0.05093
	Brazil	0.03018	-0.01162	0.00861	-0.00384	0.05098
	Canada	0.03013	-0.01161	0.00860	-0.00384	0.05090
	India	0.03014	-0.01161	0.00861	-0.00384	0.05093
	Korea	0.03014	-0.01161	0.00860	-0.00384	0.05092
	Mexico	0.03013	-0.01161	0.00860	-0.00384	0.05090
	Russia	0.03014	-0.01161	0.00860	-0.00384	0.05092
	Saudi Arabia	0.03013	-0.01161	0.00860	-0.00384	0.05091
	South Africa	0.03015	-0.01161	0.00861	-0.00384	0.05090
	Switzerland	0.03013	-0.01161	0.00860	-0.00384	0.05091
Standard Deviation (%)						
Average		0.01283	0.00123	0.00529	0.00156	0.00958
	Australia	0.01284	0.00123	0.00529	0.00156	0.00956
	Brazil	0.01284	0.00123	0.00529	0.00155	0.00962
	Canada	0.01282	0.00123	0.00529	0.00156	0.00957
	India	0.01281	0.00123	0.00529	0.00156	0.00960
	Korea	0.01284	0.00122	0.00529	0.00156	0.00957
	Mexico	0.01282	0.00126	0.00529	0.00156	0.00960
	Russia	0.01282	0.00122	0.00528	0.00155	0.00964
	Saudi Arabia	0.01280	0.00124	0.00529	0.00156	0.00962
	South Africa	0.01286	0.00122	0.00529	0.00156	0.00950
	Switzerland	0.01281	0.00124	0.00529	0.00156	0.00957
IR/STDV						
Average		2.35001	-9.42456	1.62713	-2.46420	5.31264
	Australia	2.34903	-9.40867	1.62691	-2.46414	5.32772
	Brazil	2.35045	-9.44309	1.62788	-2.47664	5.29923
	Canada	2.35034	-9.42559	1.62761	-2.45915	5.32006
	India	2.35230	-9.45807	1.62678	-2.46862	5.30440
	Korea	2.34827	-9.48774	1.62654	-2.46345	5.32314
	Mexico	2.35066	-9.21587	1.62718	-2.45487	5.30384
	Russia	2.35032	-9.49389	1.62808	-2.47346	5.28081
	Saudi Arabia	2.35269	-9.38955	1.62724	-2.46107	5.29356
	South Africa	2.34447	-9.53482	1.62564	-2.46142	5.35688
	Switzerland	2.35154	-9.38830	1.62745	-2.45917	5.31674

5.2 Spanning test

In this paper, we examine whether the inclusion of the RMB has expanded the efficient frontier of SDR by conducting the spanning test as mentioned earlier. Benchmark asset is the hypothetical SDR1, which is

composed of only four currenciessuch as the USD, the euro, the pound sterling and the yen with SDR basket weights which were applied during 2011 – Sep. 30, 2016. The test asset is SDR2 in which the RMB is added to the four major currencies with SDR basket weights which were applied after Oct. 1, 2016. The null hypothesis is that the "test asset is spanned by the benchmark assets",and it means that the return of the test asset can be achieved by linear combination of existing benchmark assets. In the case that this null hypothesis is rejected, the test asset will outperform any combination of existing assets and thus have the effect of expanding the efficient frontier of the existing assets. Namely, in our case, inclusion of the RMB has expanded the efficient frontier of the SDR if the null hypothesis is rejected.

In Table 8, seven among ten cases reject the null hypothesis with 10% of significance. They are Brazil, Canada, India, Korea, Russia, Saudi Arabia and Switzerland. It means the inclusion of the RMB has expanded the efficient frontier of the SDR to the investors in these countries, while not to the investors in other 3 countries. Table 5 shows that for countries with an expanded SDR efficient frontier, there is a relatively large increase in the Sharpe ratio of SDR2 compared to that of SDR1. As we saw earlier, this result comes from the fact that the Sharpe ratio of the yuan-denominated bonds was somewhat higher than other currencies except the USD. Considering all these points comprehensively, the efficient frontier of SDR might be expanded by the inclusion of RMB as the SDR basket composition currency.

Table 8. Results of Spanning test

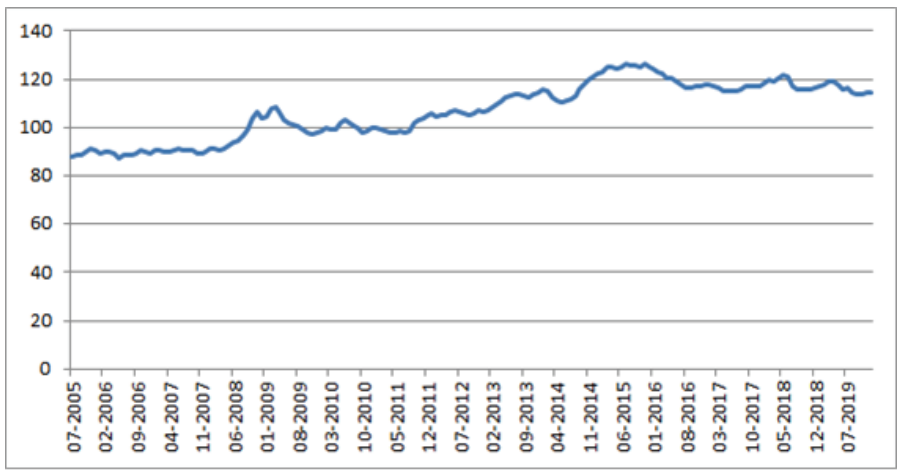
Sample period: 2016.10-2019.12		
Benchmark Asset: SDR1		
Test Asset: SDR2		
	F statistics	P value
Australia	0.256	0.774
Brazil	2.302	0.100
Canada	3.974	0.020
India	11.457	0.000
Korea	3.478	0.033
Mexico	0.178	0.836
Russia	3.672	0.027

Saudi Arabia	51.209	0.000
South Africa	0.099	0.905
Switzerland	4.489	0.012

Ironically, the yuan, which continued to strengthen until the first half of 2015, has started to weaken after it was decided to be included in the SDR composition currency. As shown in Figure 1 below, the yuan has been strong continuously since July 2005 when Chinese foreign exchange market was changed to the managed floating system, but has been converted to weakness from the second half of 2015.

This raises the question of how the yuan would have affected the SDR yields if it had been included in the SDR during the strong yuan period. Next part is prepared to answer this question.

Figure 1. Nominal Effective Exchange Rate of the RMB



Source: Bank for International Settlement

5.3 Strong RMB and the SDR return (2006.3-2016.9)

We compared the SDR and key currency-denominated bond yields with each other, using the sample period from March 2006 to September 2016 when the yuan, which was not yet included in the SDR, was mostly getting stronger.

Column (1) and (2) in Table 9 compares the investment performance of

SDR1 and SDR2. SDR1 is a bond that does not include the yuan, and is composed of the US dollar, euro, pound sterling, and Japanese yen, and SDR2 is the bond with the RBM added. Composition weights are same as shown in Table 1.

First, total return of the SDR2 is 0.08888% increased by 0.01034%-p compared to that of SDR1. The standard deviation for SDR2 was 1.15682%, which was 0.10275%-p lower compared to that of SDR1. Naturally, the Sharpe ratio of SDR2 (0.06358) was higher than that of SDR1 (0.05684), due to higher return and lower standard deviation. In other words, SDR bonds get higher risk-adjusted return by including the yuan.

We investigated whether the investment performance of the yuan bond is higher than other currencies. From the column (3) to (7) in Table 9, we can confirm that the yuan bond return is 0.14590%, which is absolutely higher than those of other currencies. This is 0.04416%-p higher than that of the second-highest-yielding JYP bond, and is even three times higher than that of the pound sterling. On the contrary, the standard deviation is the lowest. As a result, the Sharpe ratio is 0.12299, which is exceedinglyhigh for other currencies. Specifically, Saudi Arabian investors would have got the biggest increase of risk-adjusted return from investing the SDR in whichif the RMB were included. In conclusion, the stable and highly profitable yuan makes the SDR bond more attractive to investors.

Table 9. Return, standard deviation and Sharpe ratio, 2006.3-2016.9 (Weekly Average)

	SDR1 (1)	SDR2 (2)	By currency				
	SDR1 (1)	SDR2 (2)	USD (3)	EUR (4)	GBP (5)	JPY (6)	RMB (7)
Total Return (%)							
Average	0.07854	0.08888	0.08468	0.07483	0.04277	0.10174	0.14590
Australia	0.01917	0.02719	0.02688	0.01345	-0.01884	0.04494	0.08784
Brazil	0.10625	0.11421	0.11313	0.10141	0.06934	0.13181	0.17442
Canada	0.04764	0.05544	0.05372	0.04408	0.01085	0.07149	0.11495
India	0.09377	0.10137	0.09843	0.09186	0.05940	0.11553	0.15984
Korea	0.04634	0.05413	0.05254	0.04234	0.01077	0.06979	0.11376
Mexico	0.13544	0.14310	0.14065	0.13253	0.09920	0.16013	0.20190
Russia	0.17822	0.18608	0.18468	0.17431	0.14212	0.20138	0.24569
Saudi Arabia	0.01708	0.02442	0.02004	0.01737	-0.01555	0.03633	0.08169

	South Africa	0.17523	0.18320	0.18255	0.16985	0.13797	0.20069	0.24362
	Switzerland	-0.03374	-0.00025	-0.02579	-0.03890	-0.06759	-0.01467	0.03529
Standard Deviation (%)								
Average		1.25957	1.15682	1.36089	1.36922	1.43474	1.87407	1.35628
	Australia	1.35882	1.38123	1.59239	1.28691	1.33505	2.07867	1.56505
	Brazil	1.69715	1.71124	1.84633	1.68978	1.73957	2.30750	1.83880
	Canada	1.02292	1.02872	1.18300	1.13904	1.11256	1.75588	1.16723
	India	0.90914	0.89293	0.94436	1.18756	1.22764	1.55613	0.94069
	Korea	1.28198	1.28643	1.42283	1.34270	1.43921	1.90454	1.40914
	Mexico	1.29048	1.28455	1.35916	1.42967	1.40264	1.97548	1.34334
	Russia	1.70437	1.71136	1.82786	1.75500	1.80087	2.18895	1.80042
	Saudi Arabia	0.55021	0.47414	0.17407	1.15275	1.15049	1.17974	0.28291
	South Africa	1.77372	1.78726	1.93906	1.74054	1.79949	2.35370	1.91727
	Switzerland	1.00694	0.01043	1.31986	0.96824	1.33987	1.44007	1.29792
Sharpe ratio (= TR/STDV)								
Average		0.05684	0.06454	0.06590	0.04825	0.02537	0.05093	0.12299
	Australia	0.01411	0.01968	0.01688	0.01045	-0.01411	0.02162	0.05613
	Brazil	0.06261	0.06674	0.06127	0.06001	0.03986	0.05712	0.09486
	Canada	0.04658	0.05389	0.04541	0.03870	0.00975	0.04071	0.09848
	India	0.10315	0.11352	0.10423	0.07735	0.04839	0.07424	0.16991
	Korea	0.03615	0.04208	0.03693	0.03153	0.00748	0.03665	0.08073
	Mexico	0.10495	0.11140	0.10348	0.09270	0.07072	0.08106	0.15029
	Russia	0.10457	0.10873	0.10104	0.09932	0.07892	0.09200	0.13646
	Saudi Arabia	0.03104	0.05151	0.11511	0.01507	-0.01351	0.03079	0.28874
	South Africa	0.09879	0.10250	0.09414	0.09758	0.07667	0.08527	0.12707
	Switzerland	-0.03350	-0.02456	-0.01954	-0.04018	-0.05044	-0.01019	0.02719

We examined the causes of high return and low volatility of the yuan by analyzing the foreign exchange gain and interest rate factors.

Table 10 shows the results regarding the foreign exchange gain. During the sample period, investors of 10 countries got highest weekly average gain of 0.09857% from the yuan, 0.09850% from the yen, and very limited gain from the other currencies. China experienced a huge current account surplus and inflow of foreign capital during this time, and the yuan has been under the pressure of appreciation. Therefore, if international investors had invested in the yuan at this time, they could have earned very high foreign exchange gains. On thecontrary, the gain of the euro and the pound sterling is so low that investors of some countries such as Australia, Saudi Arabia and Switzerland would have even suffered from foreign exchange loss by investing in those currencies.

Despite the high return, the standard deviation of the exchange rate of

the yuan is the lowest at 1.35379%, which is attributed to the Chinese authority's limiting the fluctuation of daily exchange rate to less than 2% as mentioned earlier. Meanwhile, the standard deviation of the yen, whose foreign exchange gain was relatively high, was the largest at 1.87388% during the sample period. It seems due to the frequent in- and outflow of large amount of capital from the international investors who consider the yen to be a safe asset during the global financial crisis.

Based on high appreciation rate and low volatility, the yuan's foreign exchange gain divided by standard deviation was the highest at 0.07616, while the yen stays at 0.04912, scarcely reaching two-thirds of the yuan because of the high volatility despite the fairly high appreciation rate.

Table 10. Foreign Exchange Gain, 2006.3-2016.9(Weekly Average)

	USD	EUR	GBP	JPY	RMB
FX Gain (%)					
Average	0.06508	0.05272	0.01139	0.09850	0.09857
Australia	0.00729	-0.00865	-0.05021	0.04171	0.04053
Brazil	0.09354	0.07931	0.03797	0.12857	0.12707
Canada	0.03413	0.02198	-0.02052	0.06825	0.06764
India	0.07883	0.06975	0.02802	0.11229	0.11251
Korea	0.03293	0.02020	-0.02065	0.06655	0.06645
Mexico	0.12103	0.11041	0.06779	0.15689	0.15455
Russia	0.16509	0.15221	0.11075	0.19814	0.19832
Saudi Arabia	0.00043	-0.00472	-0.04691	0.03309	0.03441
South Africa	0.16291	0.14770	0.10653	0.19744	0.19623
Switzerland	-0.04537	-0.06097	-0.09892	-0.01791	-0.01197
Standard Deviation (%)					
Average	1.36126	1.36731	1.43392	1.87388	1.35379
Australia	1.59305	1.28427	1.33339	2.07843	1.56162
Brazil	1.84779	1.68882	1.73969	2.30735	1.83566
Canada	1.18417	1.13714	1.11209	1.75572	1.16430
India	0.94615	1.18598	1.22757	1.55596	0.93804
Korea	1.42200	1.33768	1.43514	1.90405	1.40671
Mexico	1.35946	1.42768	1.40163	1.97537	1.34146
Russia	1.83027	1.75535	1.80265	2.18897	1.79834
Saudi Arabia	0.17098	1.15111	1.15000	1.17955	0.28121
South Africa	1.93805	1.73756	1.79682	2.35339	1.91428
Switzerland	1.32069	0.96750	1.34018	1.43997	1.29630
FX Gain/STDV					
Average	0.04219	0.03154	0.00286	0.04912	0.07616
Australia	0.00458	-0.00674	-0.03766	0.02007	0.02595

	Brazil	0.05062	0.04696	0.02183	0.05572	0.06922
	Canada	0.02882	0.01933	-0.01845	0.03887	0.05809
	India	0.08332	0.05881	0.02283	0.07216	0.11994
	Korea	0.02315	0.01510	-0.01439	0.03495	0.04723
	Mexico	0.08903	0.07733	0.04837	0.07942	0.11521
	Russia	0.09020	0.08671	0.06144	0.09052	0.11028
	Saudi Arabia	0.00252	-0.00410	-0.04079	0.02806	0.12238
	South Africa	0.08406	0.08500	0.05929	0.08390	0.10251
	Switzerland	-0.03435	-0.06301	-0.07381	-0.01244	-0.00923

Table 11 shows the interest rates of each currency. That of the yuan bond is weekly average of 0.04733%, which is the highest among the currencies. The interest rates of the dollar, euro and pound sterling bonds are farlow of around 0.02~0.03%, and that of the yen, which is relatively strong in foreign exchange factor, is the lowest at0.083%. This result is thought that, while the developed countries such as the US and Japan have adopted unprecedented quantitative easing policies in the process of overcoming the global financial crisis during 2008~2009, China has maintained a relatively high interest rate.

The standard deviation was the second-lowest in the yuan. This is attributed to China's gradual adjustment of interest rates according to the economic conditions based on the independence of monetary policy secured by capital regulation.

The foreign exchange factor and interest rate factor taken together, the yuan has outperformed other currencies.

Table 11. Interest rate, 2006.3-2016.9(Weekly Average)

		USD	EUR	GBP	JPY	RMB
Interest Rate (%)						
	Average	0.01960	0.02211	0.03138	0.00324	0.04733
	Australia	0.01959	0.02210	0.03137	0.00324	0.04732
	Brazil	0.01959	0.02210	0.03137	0.00324	0.04736
	Canada	0.01959	0.02210	0.03137	0.00324	0.04731
	India	0.01960	0.02211	0.03138	0.00324	0.04733
	Korea	0.01962	0.02214	0.03142	0.00324	0.04731
	Mexico	0.01962	0.02212	0.03140	0.00324	0.04734
	Russia	0.01959	0.02210	0.03137	0.00324	0.04737
	Saudi Arabia	0.01961	0.02209	0.03136	0.00324	0.04728
	South Africa	0.01965	0.02215	0.03144	0.00325	0.04739
	Switzerland	0.01958	0.02207	0.03134	0.00323	0.04726

Standard Deviation (%)						
Average		0.03380	0.03139	0.03945	0.00444	0.01589
	Australia	0.03377	0.03140	0.03945	0.00444	0.01593
	Brazil	0.03378	0.03139	0.03942	0.00443	0.01594
	Canada	0.03378	0.03137	0.03942	0.00443	0.01589
	Korea	0.03381	0.03146	0.03952	0.00444	0.01587
	India	0.03378	0.03138	0.03944	0.00443	0.01587
	Mexico	0.03383	0.03141	0.03947	0.00444	0.01587
	Russia	0.03378	0.03136	0.03940	0.00443	0.01592
	Saudi Arabia	0.03382	0.03135	0.03943	0.00443	0.01580
	South Africa	0.03389	0.03147	0.03955	0.00445	0.01594
	Switzerland	0.03377	0.03133	0.03938	0.00443	0.01584
IR/STDV						
Average		0.57994	0.70427	0.79554	0.73030	2.97880
	Australia	0.58006	0.70379	0.79535	0.72938	2.96945
	Brazil	0.57993	0.70413	0.79581	0.73057	2.97027
	Canada	0.57997	0.70437	0.79568	0.73006	2.97718
	India	0.58017	0.70453	0.79566	0.73090	2.98278
	Korea	0.58019	0.70383	0.79494	0.72990	2.98110
	Mexico	0.57988	0.70424	0.79557	0.72944	2.98358
	Russia	0.57996	0.70483	0.79630	0.73098	2.97468
	Saudi Arabia	0.57977	0.70464	0.79538	0.73087	2.99187
	South Africa	0.57974	0.70399	0.79509	0.72996	2.97268
	Switzerland	0.57979	0.70440	0.79563	0.73093	2.98441

5.3.1. Spanning test (2006.3-2016.9)

We retried the previous spanning test from March 2006 to September 2016. In other words, we wanted to verify whether the yield on the hypothetical SDR2 could have exceeded the yield on the SDR1 if the yuan had been included in the SDR's composition currency during this period. Justas same as before, the null hypothesis is that the "test asset is spanned by the benchmark assets," and if this null hypothesis is rejected, the test asset will have the effect of expanding the efficient frontier of the existing asset.

As shown in Table 12, null hypothesis was rejected in 8 countries with 10% significance, and it means that the yuan-included SDR2 can give a higher risk-adjusted return to the investors in these countries. In addition, even in Canada and Korea, where the null hypothesis has not been rejected, the p-value is close to 0.1, suggesting that there is some expansion effect of the efficient frontier of SDR. These results can be interpreted as the expansion of efficient frontier of SDR was achieved by the addition of the yuan.

Table 12. Results of Spanning test

Sample period: 2006.3–2016.9		
Benchmark Asset: SDR1		
Test Asset: SDR2		
	F statistics	P value
Australia	14.63	0.000
Brazil	4.235	0.014
Canada	1.967	0.140
India	16.53	0.000
Korea	1.958	0.142
Mexico	4.574	0.010
Russia	2.629	0.073
Saudi Arabia	710.5	0.000
South Africa	5.527	0.004
Switzerland	42.18	0.000

6 Conclusion

Since October 2016, when the RMB was included in the SDR, the Sharpe ratio of SDRs has risen slightly in all 10 analyzed countries, and the spanning test has shown the effect of expanding efficient frontiers in seven countries. This was mainly due to relatively high yields on the RMB-denominated bonds.

On the other hand, as a result of hypothesizing that the RMB had been included into the SDR from March 2006 to September 2016, the Sharpe ratio of the SDR has significantly improved in all 10 countries and the countries which have shown expanded efficient frontier has increased to eight. This result is due to the high interest rate of RMB bonds and the wider foreign exchange gains of the RMB. In other words, China's current account surplus and FDI capital inflows sustained appreciation pressures on Chinese yuan during this period, which resulted in large foreign exchange gains of the RMB.

In conclusion, the RMB bond yield, as well as the exchange rate of the RMB against the other major currencies, especially against the USD, plays a key role in determining whether to expand the SDR efficient frontier and, in the analysis period of this paper, the efficient frontier of SDR was

expanded due to the inclusion of RMB.

Considering that the value of the RMB recently moves within a certain range due to various international financial environment factors such as the Chinese authorities' exchange rate management policy and the movements of the U.S. dollar, it is unlikely that the RMB will show the same one-sided strength and high level of foreign exchange gain as in the past. In particular, if capital mobility and the yuan exchange rate volatility increase due to China's full-scale opening of the financial market in the future, it is possible that the negative impact will also affect SDR's valuation, and this will be our next research topic. However, the RMB bonds are likely to continue to yield higher returns than other currency-denominated bonds, given China's still-high economic growth rate of around 5 percent and strong investment demand. In light of this, expansion of the efficient frontier of the SDR due to the inclusion of the RMB will likely continue for a considerable period of time.

References

Allen, Polly R., "The ECU: Birth of a New Currency," Occasional Papers No. 20. New York: Group of Thirty, 1986.

DeRoon, F. A., and T. E. Nijman, "Testing for Mean-Variance Spanning: A Survey," *Journal of Empirical Finance* 8 (2), 2001, 111-155.

De Roon and Nijman and Werker, "Testing for Mean-Variance spanning with short sales constraints and transaction costs: The case of emerging markets," *Journal of Finance* 56(2), 2001, 721-742.

Hoguet, George and Solomon Tadesse, "The role of SDR-denominated securities," BIS Papers No 58, 2011.

Huberman, G., and S. Kandel, "Mean-Variance Spanning," *Journal of Finance* 42, 1987, 873-888.

Mamun, A. and N. Visaltanachoti, "Diversification Benefits of Treasury Inflation Protected Securities: An Empirical Puzzle," Working Paper, University of Saskatchewan, 2006.

People's Bank of China, *2017 RMB INTERNATIONALIZATION REPORT*, China Financial Publishing House: Beijing, China, 2017, 52-53.

Shimizu, Junko and Eiji Ogawa, "Risk Properties of AMU denominated Asian Bonds," Hitotsubashi University Research Unit Discussion Paper

Series No. 45, 2004.