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SAFEHAVENNESS OF THE CHINESE RENMINBI

Key Points:

- *This paper investigates how safe (or risky) the Chinese renminbi is as an international currency from the perspectives of dollar-based and euro-based investors. It estimates the "safehavenness" of the currency, defined as the extent to which the currency plays the role of a safe haven, in both its onshore and offshore markets alongside twenty most-traded currencies in the world, including those in the Special Drawings Rights (SDR) basket.*

- *We find that the Chinese renminbi has generally registered a high level of safehavenness among the most-traded currencies since it became actively traded in the offshore market. Compared with the other SDR currencies, it consistently ranks below the Japanese yen and US dollar but above the British pound and euro on the scale of safehavenness. Despite market fragmentation, the safehavenness of the CNY is very similar to, albeit marginally lower, that of the CNH, attributable possibly to a stronger price discovery process in the latter market.*

- *These estimation results show striking consistency between dollar-based and euro-based investors in their assessment, regardless of the various time periods (determined by structural breaks) covered by the study.*

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I. INTRODUCTION

A quarter century of phenomenal growth has landed China as a major economic power on the world stage. According to the World Bank, China's GDP accounted for 12% of the world total and contributed to 30% of the global economic growth in 2015.[1] Parallel to the country's economic significance, the Chinese renminbi has also played an increasingly prominent role in the international arena. In fact, the currency has long been looked upon as an important one due to China's considerable expansion of external trade and cross-border investment. The International Monetary Fund (IMF) reports that China has now become the world's largest trading nation, accounting for more than 12% of world exports and 10% of world imports.[2] This, coupled with a more-than-twofold expansion of foreign direct investment in China from 2005 to 2015, has made the Chinese renminbi one of the most commonly used currencies for international payments.[3] Based on the Society for Worldwide Interbank Financial Telecommunication (SWIFT), it currently ranks as the world's sixth most-used payment currency, accounting for 1.68% of global payments.[4]

More recently, the currency has also attracted considerable attention as a currency for investment and official reserve purposes. This may to a large extent be attributable to the efforts of the country in internationalizing the renminbi alongside major economic reforms both internally and on the external front. One of these efforts is the promotion of the use and circulation of the renminbi outside mainland China, making it possible for foreign investors to hold financial assets denominated in the currency. The currency has also gained popularity among central banks. In particular, the number of countries holding renminbi assets as official reserves increased to a level comparable to the number of countries holding assets denominated in Swiss franc for the same purpose, according to an IMF survey conducted in late 2014/ early 2015.[5] Along with the inclusion of the renminbi in the IMF's Special Drawing Right basket in October 2016, there is no doubt that the currency is now widely recognized as an international one.

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1 The figures refer to *GDP at market prices (constant 2010 US$)* reported in the World Development Indicators. They can be retrieved from the World Bank's website at http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.

2 Details can be found in IMF (2016a).'

3 The "foreign direct investment" refers to "*FDI flows"* compiled by OECD. It can be retrieved from https://data.oecd.org/fdi/fdi-flows.htm.

4 The figure is reported in *RMB Tracker* published by SWIFT's February 2017 report.

5 Details can be found in IMF (2016b).

Against this backdrop, we assess how safe this currency is as a financial asset. In the paper, we estimate its "safehavenness" and compare it with those of other major currencies, especially those in the SDR basket. The remainder of the paper is organized as follows. In section 2 we explain what we mean by currency safehavenness and discuss some common difficulties experienced by other studies in measuring it and how we can overcome them. Section 3 outlines the methodology in estimating the safehavenness. Section 4 discusses our data and presents the estimation results. Section 5 concludes our findings.

II. WHAT IS SAFEHAVENNESS AND HOW TO MEASURE IT?

By safehavenness of a currency, we refer to the extent to which the currency plays the role of a safe haven from the perspective of the investor. A safe haven usually refers to a place or shelter where one can hide or protect oneself from being hurt in disastrous or catastrophic situations such as wars and natural calamities. A safe-haven currency can be thought of being a currency that can be used to protect one's purchasing power in times of financial turmoil. It is important to recognize that safe haven is a relative concept. The fact that a place is regarded as a safe haven implies that other places are thought to be relatively dangerous. In the context of foreign investment, the investor tends to flee assets denominated in risky currencies to those considered as safe in times of market turmoil.

However, it is not easy to detect the response of the investor from exchange rate changes to news or events that boosts or shakes his confidence about a currency. The reason is that in most cases one does not normally invest in currencies in the form of callable bank deposits, which can easily be shifted from one currency to another. The bulk of international portfolio investment takes the form of properties, stocks, bonds, mutual funds, derivatives and other financial instruments. Most of these instruments cannot be sold or liquidated easily or at least not without incurring a significant transaction cost, while news or events that have implications for a currency often have effects lasting for only a short spade of time. Moreover, the implications for the currency may not be consistent with those for the financial instrument or asset. For example, news that suggests a possible outbreak of war may mean that the currency may fall sharply but benefits the shares of the companies that produce military goods. Furthermore, despite unfavorable currency implications pertaining to a certain piece of news, the investor who is confident of the long-term prospect of his investment may regard the news as having only a

short-term impact and, hence, choose not to take any action, especially when transaction cost is taken into account.

Nonetheless, there is a market that can help us gauge the change in confidence or sentiment about currencies, namely, the currency options market. This market provides the investor with a much faster and more efficient means of taking a position in a currency or hedging against the exchange rate risk of a foreign investment. To do so, there is also no need for the implications of the news or event for the currency and his investment to be the same, or for the implications to last for the same horizon. The investor can reverse his position at any time at a relatively low cost. Hence, we believe that currency safehavenness can best be detected and measured using prices of currency options. This is consistent with Wong & Fong (2016) who underscore the importance of the expectation dimension of the role of safe haven played by the currency. The reason is that while a currency may be looked upon as a safe haven, the actual outcome can never be guaranteed. In other words, the currency can still fall in foreign currency terms in times of turbulence. There is no difference between this and a real-life safe haven where one can still get hurt in a natural calamity.

In this paper, we study currency safehavenness, focusing on the behavior of the risk reversal of the currency and how it reacts in times of financial turbulence. Risk reversal is the price difference between a call and a put option. It is imperative to note that the price of a call or put alone cannot indicate whether a currency is safe or risky one. The reason is that in times of turbulence the prices of both the call and the put are likely to increase, as volatility rises. What is important, however, is which one increases more, i.e., whether there is heavier betting for the currency to rise or to fall. We argue that a currency is regarded by investors as a safe haven when the risk reversal of the currency increases in times of market turmoil.

III. METHODOLOGY

We estimate how investors react to changes in market conditions through examining the behavior of the risk reversal of the currency in times of crisis or market turbulence. Theoretically, when risk in global financial markets increases, investors would flee currencies regarded risky to those perceived to be safe havens; and when risk reduces, investors would find it more comfortable in holding assets denominated in riskier currencies. Therefore, if risk reversal is of any use in predicting such

investor behavior, it should bear a positive relationship with risk aversion if the currency is thought to be safe (or its downside risk is lower) or a negative relationship if it is considered risky (or its downside risk is higher).

The relationship is estimated by means of quantile regression, a simple non-parametric technique that allows us to capture the relationship under extreme market conditions, in other words, the tail risk.[6] Rather than modelling mean relationships using ordinary least squares (OLS) regression, quantile regression can evaluate the estimated functional relationship at a very high quantile, which can indicate how heteroskedastic the pattern between the risk reversal and risk aversion could be, or equivalently, how extremely the risk reversal could increase when financial markets experience distress or extreme adversity.[7]

Specifically, the empirical model of a change in risk reversal is defined as:

$$\Delta RR_{it} = const + \beta_i \, \Delta RiskAversion_t + \gamma_i \Delta RR_{i,t-1} + \varepsilon_{it} \qquad (1)$$

where RR_{it} denotes the risk reversal of currency i at time t; *RiskAversion* denotes the index of risk aversion; *const* and ε_{it} denote the constant and error term respectively; and Δ is the first difference operator. The risk aversion in financial markets is constructed by major stock market volatility indices.[8] The lag of ΔRR_{it} is used to control for serial correlation.

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[6] Quantile regression, first suggested by Koenker and Bassett (1978), is used in this analysis given that it assumes no parametric distribution of currency movements. Therefore, it allows different distributions under varying market conditions and potentially extreme movements under different quantile specifications. The technique is appealing due to its simplicity and robustness in exploring relationships between variables evaluated at their extremes, which is useful in assessing co-movements of nonlinearly-related variables and risk spillover effects. There are many other empirical applications, includinig the CoVaR measure proposed by Adrian and Brunnermeier (2008), some countrywide comparisons of risk spillover discussed in Wong and Fong (2011) and Fong and Wong (2012), and other financial applications such as Brunnermeier et al. (2008) and Ma and Pohlman (2008).

[7] A relationship estimated by means of ordinary least squares is a mean relationship, which may be interpreted as one under general or normal market conditions. Clearly, such an "average" relationship cannot fully capture the true relationship in times of crisis or market turbulence, as the variables are generally expected to display much stronger tendency to co-move amid tail events.

[8] In literature, stock market volatility which, often dubbed as investors' fear gauge (e.g., Whaley (2000) and Giot (2005)), is probably the most widely used indicator of risk aversion for stock markets. Apart from equity and equity-options markets, the stock market volatility of S&P 500 stock index, commonly known as the VIX Index calculated by the Chicago Board Option Exchange (CBOE), is a useful measure of global risk appetite in corporate credit markets (Collin-Dufresne, Goldstein, and Martin (2001)), and sovereign CDS markets (Pan and Singleton (2008)). Recent studies have found that the VIX index is closely linked to currency market movements. One strand of the literature regards stock market volatility

Under this specification, safehavenness is measured by the parameter β_i, which is the responsiveness of ΔRR_{it} to $\Delta RiskAversion$. A positive (negative) β_i means that the currency's risk reversal is positively (negatively) correlated with global risk aversion, which suggests the currency can be viewed as a safe-haven (risky) asset. The coefficient can be simply obtained by minimizing the sum of residuals $\sum_t (q - I_{\varepsilon \le 0}) \cdot \varepsilon_{it}$, where $I_{\varepsilon \le 0}$ is an indicator function equal to one if $\varepsilon_{it} \le 0$ and zero otherwise, given a quantile level of q. In each quantile regression, q is chosen to be either 0.95 or 0.05, depending on the sign of β_i estimated additionally by the OLS method. If the sign of the OLS coefficient is significantly positive, the responsiveness is expected to be positive at their extremes, so q will be set to be 0.95 so as to find the maximum response of the risk reversal to global risk aversion. On the other hand, if the sign is significantly negative, q will be set to 0.05. In the case of insignificance, q will be chosen to be the one giving a larger β_i in absolute value when estimating the quantile regression.

IV. DATA AND EMPIRICAL FINDINGS

4.1 Sample data

In the assessment, we examine the relationship between the three-month 25-delta risk reversals of 20 currencies (and gold for reference) and an index of risk aversion. These currencies are the top twenty mostly traded ones: the five in the special-drawing-right (SDR) basket (i.e., US dollar, euro, British pound, Japanese yen, and Chinese renminbi onshore (CNY)), African rand, Australian dollar, Brazilian real, Canadian dollar, Hong Kong dollar, Indian rupee, Korean won, Mexico peso, New Zealand dollar, Norwegian krone, Russian ruble, Singapore dollar, Sweden krona,

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as a signal of global banks' leverage cycle, which drives banking sector capital flows and global liquidity conditions (e.g., Borio and Disyatat (2011), Obstfeld (2012a, 2012b), Gourinchas and Obstfeld (2012), Bruno and Shin (2014), and Rey (2015)). Hence, a higher leverage of the banking sector could be associated with more cross-border capital flows, hence greater currency depreciation expectations. Another strand regards the stock market volatility as an important component of global risk that is significantly associated with extreme capital flow waves (e.g., Forbes and Warnock (2012)). Thus, increases in risk aversion could cause a collapse in exchange rates and currency depreciation expectations.

Swiss franc, and Turkish lira.[9] The Chinese renminbi offshore (CNH) is also included in the assessment.

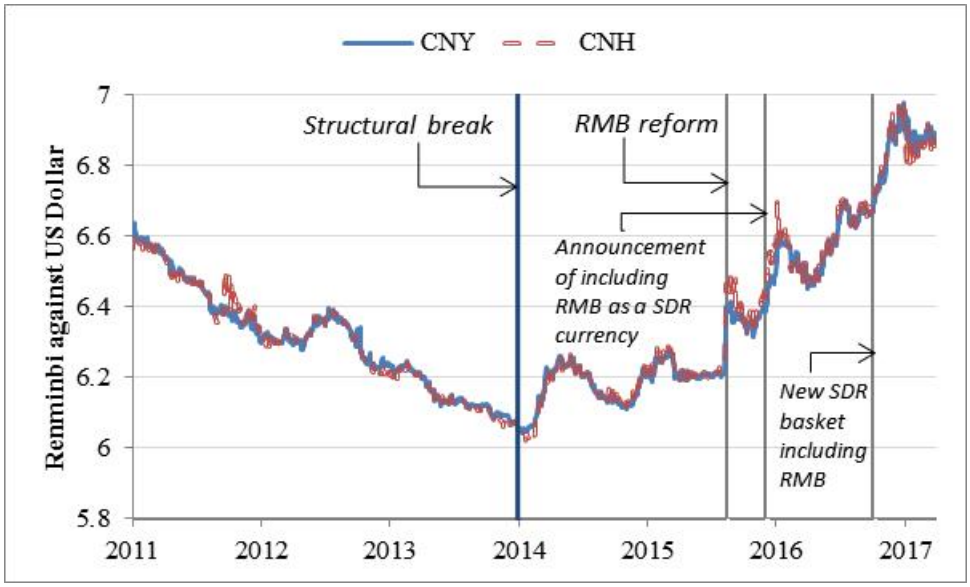
The study covers the period from 27 July 2011 till now. The history of the offshore renminbi dates back to 2003 but the currency has only been traded actively in the Hong Kong interbank market since 2010.[10] Bloomberg and the JP Morgan Chase database have records of data of CNH option prices only from July 2011. Hence data availability basically underlies the choice of the period we cover. Within this period, there was a significant change in the trend of the exchange rates of the CNH and CNY (Figure 1). As can be seen, the currency was broadly on an appreciating trend until the end of 2013 and has, since about the beginning of 2014, been on a depreciating trend. Indeed, statistical tests show that there was a major structural break at the turn of the year.[11] Hence, in this study, we present the results for the period as a whole as well as those for the periods before and after the break (referred to as the appreciation and depreciation phases respectively hereafter).

[9] The ranking is based on the currencies' daily average turnover reported in the BIS Triennial Survey in April 2016.

[10] Upon approval from the State Council, the People's Bank of China (PBoC) agreed to provide clearing arrangements for banks in Hong Kong to conduct personal renminbi business on a trial basis in November 2003. Bloomberg has records of CNH exchange rate data only from July 2010.

[11] The Quandt-Andrews breakpoint test is first used to locate the range of break points. The test results show that the null hypothesis of "no breakpoints within Oct 2013 and April 2014 cannot be rejected at any conventional level of significance. The Bai-Perron's multiple breakpoint test is then conducted and three breakpoints are identified at 31 Dec 2013, 20 Feb 2014, and 20 Mar 2014. As these breakpoints cluster mainly around the beginning of 2014, we choose 1 January 2014 as the cut-off point for the sake of simplicity.

Figure 1. Renminbi against US dollar



Source: Bloomberg

The risk reversals of these currencies in daily frequency are obtained from the database of JP Morgan Chase with a few others supplemented from Bloomberg (Table 1).[12,13] The descriptive statistics of the risk reversals against the US dollar and euro are reported in Tables 2 and 3 respectively. Among the currencies against the US dollar, all the median values of the risk reversals are negative, except for the Hong Kong dollar and Japanese yen. Among the currencies against the euro, 55% has a negative risk reversal in median. These suggest that most of the currencies are expected to depreciate against the US dollar and more than half of them are expected to decline in value against the euro in the whole sample period. The Chinese renminbi, onshore or offshore, has negative median values of risk reversal against the US dollar but positive against the euro, reflecting that, generally speaking, the currency is regarded riskier by dollar-based investors but safer by euro-based investors in the sample period.

[12] To ensure the data quality, we screen out some currencies with unreasonable fluctuations (e.g., no movement or extreme spikes) in the currency selection.

[13] While the risk reversals can be downloaded directly from the database, both out-of-the-money call- and put-options are also available from the database. Overlapping data and risk reversals calculated based on option prices are all consistent.

Table 1. Data source of risk reversal

		USD-based		Euro-based	
Economy	**Currency**	**Source**	**Data label or ticker**	**Source**	**Data label or ticker**
Australia	Australian dollar	JPM	AUD/USD	JPM	AUD/EUR
Brazil	Brazilian real	JPM	BRL/USD	JPM	BRL/EUR
Canada	Canadian dollar	JPM	CAD/USD	JPM	CAD/EUR
China CNY	Onshore renminbi	JPM	CNY/USD	BBG	EURCNY25R3M Curncy
China CNH	Offshore renminbi	JPM	CNH/USD	BBG	EURCNH25R3M Curncy
Eurozone	Euro	JPM	EUR/USD	*NA*	*NA*
Hong Kong	Hong Kong dollar	JPM	HKD/USD	JPM	HKD/EUR
India	Indian rupee	JPM	INR/USD	JPM	INR/EUR
Japan	Japanese yen	JPM	JPY/USD	JPM	JPY/EUR
Mexico	Mexican peso	JPM	MXN/USD	JPM	MXN/EUR
New Zealand	New Zealand dollar	JPM	NZD/USD	JPM	NZD/EUR
Norway	Norwegian krone	JPM	NOK/USD	JPM	NOK/EUR
Russia	Russian ruble	JPM	RUB/USD	JPM	RUB/EUR
Singapore	Singapore dollar	JPM	SGD/USD	JPM	SGD/EUR
South Africa	South African rand	JPM	ZAR/USD	JPM	ZAR/EUR
South Korea	Korean won	JPM	KRW/USD	JPM	KRW/EUR
Sweden	Swedish krona	JPM	SEK/USD	JPM	SEK/EUR
Switzerland	Swiss franc	JPM	CHF/USD	JPM	CHF/EUR
Turkey	Turkish lira	JPM	TRY/USD	JPM	TRY/EUR
UK	British pound	JPM	GBP/USD	JPM	GBP/EUR
US	US dollar	*NA*	*NA*	JPM	USD/EUR
Gold		JPM	GLD/USD	JPM	GLD/EUR

Note: "JPM", "BBG" and "TR" refer to databases of JP Morgan Chase, Bloomberg, and Thomson Reuters respectively

Table 2. Descriptive statistics of risk reversals vis-à-vis US dollar

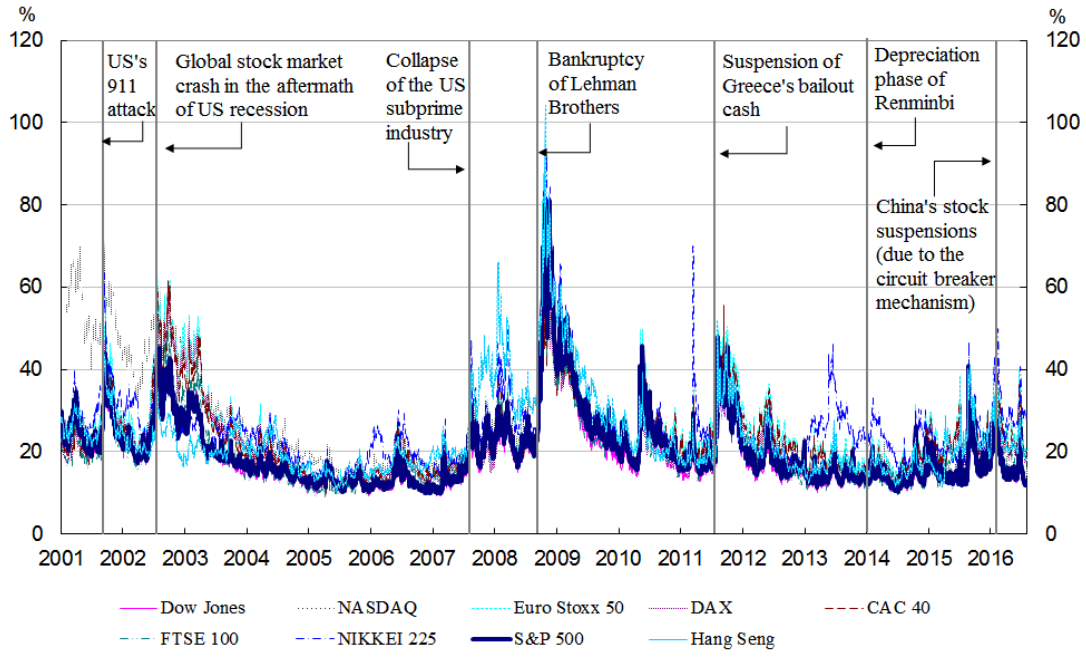
		Full sample period						Appreciation phase						Depreciation phase					
Economy	Currency	Mean	Med.	Max.	Min.	SD	Size	Mean	Med.	Max.	Min.	SD	Size	Mean	Med.	Max.	Min.	SD	Size
Australia	Australian dollar	-2.28	-1.89	-1.02	-7.50	1.12	1254	-2.89	-2.50	-1.32	-7.50	1.32	608	-1.70	-1.66	-1.02	-2.85	0.31	646
Brazil	Brazilian real	-3.71	-3.00	-1.75	-11.75	1.74	1254	-4.56	-4.00	-1.75	-11.75	2.11	608	-2.91	-2.75	-1.75	-5.25	0.63	646
Canada	Canadian dollar	-1.27	-1.13	-0.39	-4.18	0.65	1254	-1.64	-1.44	-0.75	-4.18	0.71	608	-0.92	-0.83	-0.39	-1.55	0.28	646
China (CNY)	Onshore renminbi	-1.03	-0.60	-0.03	-4.94	1.04	1254	-0.40	-0.30	-0.03	-2.25	0.36	608	-1.63	-1.24	-0.30	-4.94	1.11	646
China (CNH)	Offshore renminbi	-1.21	-0.95	-0.05	-4.50	0.99	1254	-0.63	-0.45	-0.05	-3.50	0.56	608	-1.75	-1.55	-0.22	-4.50	1.00	646
Eurozone	Euro	-1.46	-1.20	0.13	-4.35	0.88	1254	-1.76	-1.50	-0.25	-4.35	1.04	608	-1.17	-1.00	0.13	-2.75	0.56	646
Hong Kong	Hong Kong dollar	0.30	0.35	1.25	-2.13	0.48	1254	0.55	0.55	1.25	0.25	0.18	608	0.07	0.25	0.90	-2.13	0.55	646
India	Indian rupee	-1.88	-1.73	-0.35	-5.47	0.81	1254	-2.05	-2.29	-0.35	-5.47	1.06	608	-1.72	-1.65	-0.89	-3.13	0.40	646
Japan	Japanese yen	0.39	0.32	2.74	-1.50	0.84	1254	0.13	-0.02	2.43	-1.50	0.78	608	0.62	0.47	2.74	-0.90	0.82	646
Mexico	Mexican peso	-2.99	-2.65	-1.15	-9.50	1.27	1254	-3.79	-3.40	-1.95	-9.50	1.37	608	-2.24	-2.25	-1.15	-3.50	0.44	646
New Zealand	New Zealand dollar	-2.17	-1.85	-0.89	-7.42	1.12	1254	-2.74	-2.30	-1.12	-7.42	1.35	608	-1.63	-1.63	-0.89	-2.68	0.35	646
Norway	Norwegian krone	-1.56	-1.22	-0.25	-4.35	0.92	1254	-1.77	-1.50	-0.25	-4.35	1.04	608	-1.36	-1.10	-0.50	-4.18	0.75	646
Russia	Russian ruble	-4.34	-3.18	-1.35	-19.45	3.31	1254	-2.96	-2.59	-1.35	-7.64	1.33	608	-5.64	-4.04	-1.44	-19.45	4.01	646
Singapore	Singapore dollar	-1.33	-1.21	-0.49	-4.47	0.54	1254	-1.56	-1.37	-0.59	-4.47	0.65	608	-1.12	-1.10	-0.49	-1.70	0.25	646
South Africa	South African rand	-3.80	-3.52	-2.11	-8.57	1.15	1254	-4.14	-3.77	-2.11	-8.57	1.42	608	-3.47	-3.32	-2.31	-5.99	0.67	646
South Korea	Korean won	-2.52	-2.10	-0.69	-10.50	1.34	1254	-3.26	-2.90	-0.70	-10.50	1.58	608	-1.83	-1.85	-0.69	-2.85	0.38	646
Sweden	Swedish krona	-1.50	-1.17	-0.25	-4.35	0.90	1254	-1.76	-1.50	-0.25	-4.35	1.04	608	-1.25	-0.95	-0.50	-3.00	0.66	646
Switzerland	Swiss franc	-0.56	-0.65	3.10	-2.40	0.79	1254	-0.96	-0.95	2.00	-2.40	0.67	608	-0.18	-0.35	3.10	-1.35	0.70	646
Turkey	Turkish lira	-3.60	-3.50	-1.05	-7.33	1.09	1254	-3.49	-3.46	-1.05	-7.33	1.36	608	-3.71	-3.56	-2.41	-5.60	0.74	646
UK	British pound	-1.32	-1.10	-0.10	-6.40	1.03	1254	-1.27	-1.20	-0.30	-2.85	0.60	608	-1.36	-0.90	-0.10	-6.40	1.31	646
Gold		-0.65	-0.47	4.00	-5.46	1.63	1254	-0.76	-0.20	4.00	-5.46	1.84	608	-0.55	-0.98	3.04	-3.25	1.40	646

Table 3. Descriptive statistics of risk reversals vis-à-vis euro

		Full sample period						Appreciation phase						Depreciation phase					
Economy	Currency	Mean	Med.	Max.	Min.	SD	Size	Mean	Med.	Max.	Min.	SD	Size	Mean	Med.	Max.	Min.	SD	Size
Australia	Australian dollar	-0.96	-0.87	0.35	-3.06	0.54	1254	-1.05	-1.05	0.19	-2.81	0.47	608	-0.87	-0.73	0.35	-3.06	0.60	646
Brazil	Brazilian real	-3.60	-3.00	-1.25	-12.00	1.86	1254	-4.60	-4.25	-1.75	-12.00	2.17	608	-2.66	-2.50	-1.25	-5.00	0.69	646
Canada	Canadian dollar	0.19	0.15	2.19	-1.44	0.52	1254	0.39	0.22	2.19	-0.43	0.53	608	0.01	0.09	0.93	-1.44	0.43	646
CHINA (CNY)	Onshore renminbi	0.57	0.48	3.70	-4.20	1.18	1254	1.24	0.92	3.70	-0.45	0.97	608	-0.07	0.28	1.75	-4.20	1.00	646
CHINA (CNH)	Offshore renminbi	0.48	0.32	4.30	-4.20	1.38	1254	1.18	0.79	4.30	-0.65	1.26	608	-0.18	0.15	1.75	-4.20	1.13	646
Hong Kong	Hong Kong dollar	1.55	1.28	4.53	0.21	0.86	1254	1.90	1.62	4.53	0.36	1.01	608	1.21	1.09	3.12	0.21	0.50	646
India	Indian rupee	-0.56	-0.44	2.05	-2.72	0.72	1254	-0.45	-0.26	2.05	-2.72	0.87	608	-0.66	-0.52	0.67	-2.11	0.54	646
Japan	Japanese yen	1.94	1.60	7.06	-0.37	1.32	1254	2.31	1.96	7.06	-0.37	1.68	608	1.59	1.39	4.43	0.23	0.67	646
Mexico	Mexican peso	-2.30	-2.10	-0.70	-8.70	1.14	1254	-2.76	-2.50	-0.85	-8.70	1.42	608	-1.87	-1.85	-0.70	-3.25	0.49	646
New Zealand	New Zealand dollar	-0.92	-0.80	0.19	-2.95	0.54	1254	-0.98	-0.95	0.19	-2.53	0.46	608	-0.87	-0.65	0.11	-2.95	0.60	646
Norway	Norwegian krone	-0.93	-0.94	0.13	-3.62	0.54	1254	-0.68	-0.72	0.13	-1.42	0.38	608	-1.16	-1.19	-0.36	-3.62	0.57	646
Russia	Russian ruble	-3.91	-2.81	-0.56	-19.59	3.55	1254	-1.90	-1.67	-0.56	-6.04	0.90	608	-5.80	-4.62	-1.06	-19.59	4.04	646
South Africa	South African rand	-2.93	-2.73	-1.46	-7.01	0.84	1254	-3.07	-2.82	-1.46	-7.01	1.01	608	-2.80	-2.64	-1.56	-5.05	0.61	646
South Korea	Korean won	-1.05	-1.07	0.45	-5.00	0.70	1254	-1.25	-1.18	0.36	-5.00	0.80	608	-0.87	-0.96	0.45	-2.32	0.54	646
Singapore	Singapore dollar	0.31	0.15	2.66	-1.18	0.62	1254	0.55	0.35	2.66	-0.30	0.63	608	0.08	0.10	1.73	-1.18	0.52	646
Sweden	Swedish krona	-0.73	-0.69	-0.20	-1.79	0.33	1254	-0.69	-0.65	-0.20	-1.37	0.33	608	-0.76	-0.71	-0.23	-1.79	0.32	646
Switzerland	Swiss franc	0.69	0.80	5.47	-2.20	1.66	1254	0.28	0.19	5.16	-2.20	1.90	608	1.07	1.07	5.47	-1.10	1.28	646
Turkey	Turkish lira	-2.75	-2.77	-0.88	-5.41	0.90	1254	-2.48	-2.24	-0.88	-5.41	1.04	608	-3.00	-2.91	-1.84	-4.87	0.65	646
UK	British pound	0.17	0.35	2.17	-5.49	1.12	1254	0.61	0.44	2.17	-0.45	0.66	608	-0.25	0.26	1.47	-5.49	1.28	646
US	US dollar	1.46	1.20	4.35	-0.13	0.88	1254	1.76	1.50	4.35	0.25	1.04	608	1.17	1.00	2.75	-0.13	0.56	646
GOLD		0.12	0.39	4.51	-4.78	1.32	1254	-0.06	0.46	4.51	-4.78	1.56	608	0.29	0.26	3.20	-1.78	1.01	646

The risk aversion index is constructed by the principal component method. Specifically, the index is proxied by the first principal component constructed by nine stock market volatility indices comprising the S&P 500, Dow Jones Industrial Average, NASDAQ, Euro Stoxx 50, DAX, CAC 40, FTSE 100, NIKKEI 225, and Hang Seng index (Figure 2). These indices are chosen since they measure the risk appetite of major stock markets in developed and emerging market economies. Descriptive statistics of these volatility indices are reported in Table 4. The weights of each principal component are reported in Table 5. As can been seen, the first principal component, which has a nearly equal weight on each stock volatility (except for NIKKEI 225 in the appreciation phase), explains over 80% of the total variation of the stock volatility indices (87% for the appreciation phase and 83% for the depreciation phase). Hence, this risk aversion index arguably reflects the risk appetite of global financial markets quite well in general.

Figure 2. Stock market volatility indices



Source: Bloomberg

Table 4. Descriptive statistics of stock volatility indices

Stock market	Volatility index	Mean	Med.	Max.	Min.	SD	Size
Full sample							
S&P 500	VIX	17.32	15.42	48.00	10.32	5.91	1254
Dow Jones	VXD	16.22	14.65	41.45	9.71	5.23	1254
NASDAQ	VXN	18.76	17.15	46.61	11.36	5.62	1254
Euro Stoxx 50	V2X	23.48	21.83	53.55	12.71	7.09	1254
DAX	VDAX	20.25	18.90	47.30	10.88	6.25	1254
CAC 40	VCAC	21.93	20.40	55.59	11.82	6.70	1254
FTSE 100	VFTSE	17.31	15.68	43.61	9.67	5.85	1254
NIKKEI 225	VNKY	24.46	23.55	49.84	14.00	5.73	1254
Hang Seng	VHSI	20.48	18.95	51.97	11.53	6.36	1254
Appreciation phase							
S&P 500	VIX	18.88	16.49	48.00	11.30	7.11	608
Dow Jones	VXD	17.27	15.01	41.45	10.08	6.36	608
NASDAQ	VXN	19.82	17.78	46.61	12.03	6.67	608
Euro Stoxx 50	V2X	24.74	22.14	53.55	14.12	8.46	608
DAX	VDAX	20.88	18.27	47.30	11.47	7.72	608
CAC 40	VCAC	22.97	20.56	55.59	12.98	7.88	608
FTSE 100	VFTSE	18.46	16.14	43.61	10.50	6.84	608
NIKKEI 225	VNKY	24.83	23.65	46.19	16.71	5.69	608
Hang Seng	VHSI	21.15	18.84	51.97	12.28	7.14	608
1st principal component		0.00	-0.97	9.70	-2.94	2.81	608
Depreciation phase							
S&P 500	VIX	15.84	14.57	40.74	10.32	3.98	646
Dow Jones	VXD	15.23	14.27	34.51	9.71	3.60	646
NASDAQ	VXN	17.76	16.85	42.95	11.36	4.17	646
Euro Stoxx 50	V2X	22.29	21.46	40.80	12.71	5.22	646
DAX	VDAX	19.65	19.49	32.55	10.88	4.39	646
CAC 40	VCAC	20.93	20.26	39.27	11.82	5.19	646
FTSE 100	VFTSE	16.23	15.35	32.48	9.67	4.47	646
NIKKEI 225	VNKY	24.12	23.40	49.84	14.00	5.74	646
Hang Seng	VHSI	19.83	19.16	41.01	11.53	5.46	646
1st principal component		0.01	-0.49	11.58	-4.71	2.74	646

Table 5. Principal component analysis of the selected stock market volatility indices

	Principal component								
Volatility Index	1	2	3	4	5	6	7	8	9
Appreciation phase									
VIX	0.35	-0.04	-0.43	0.00	0.09	-0.21	-0.23	-0.01	-0.76
VXD	0.35	-0.05	-0.45	0.00	0.08	-0.31	-0.35	-0.25	0.62
VXN	0.35	-0.10	-0.47	0.03	0.03	0.49	0.59	0.22	0.11
V2X	0.35	-0.11	0.28	0.27	0.13	-0.09	-0.26	0.78	0.11
VDAX	0.35	-0.09	0.34	0.03	0.24	-0.55	0.58	-0.22	-0.02
VCAC	0.35	-0.13	0.33	0.43	0.18	0.50	-0.23	-0.48	-0.06
VFTSE	0.35	0.03	0.14	0.03	-0.92	-0.05	0.02	-0.05	-0.02
VNKY	0.16	0.97	0.01	0.13	0.10	0.02	0.03	0.01	0.01
VHSI	0.34	0.04	0.26	-0.85	0.13	0.22	-0.15	0.00	0.01
Proportion of total variation explained (%)	0.87	0.09	0.02	0.01	0.00	0.00	0.00	0.00	0.00
Depreciation phase									
VIX	0.34	0.37	-0.33	-0.10	-0.01	-0.23	-0.02	0.75	0.10
VXD	0.34	0.29	-0.30	0.06	0.15	-0.33	0.58	-0.49	-0.04
VXN	0.34	0.42	-0.20	0.02	0.17	0.58	-0.47	-0.27	-0.09
V2X	0.35	-0.34	-0.01	-0.28	0.05	-0.33	-0.30	-0.05	-0.69
VDAX	0.33	-0.47	0.00	-0.01	0.39	0.51	0.44	0.25	-0.02
VCAC	0.35	-0.36	-0.06	-0.21	0.10	-0.24	-0.32	-0.20	0.70
VFTSE	0.35	-0.06	0.07	-0.18	-0.86	0.25	0.19	-0.06	0.03
VNKY	0.28	0.34	0.86	-0.15	0.18	-0.08	0.07	0.04	0.04
VHSI	0.32	-0.14	0.13	0.90	-0.11	-0.13	-0.14	0.06	-0.03
Proportion of total variation explained (%)	0.83	0.07	0.05	0.03	0.01	0.01	0.00	0.00	0.00

4.2 Estimation results

Figures 3 and 4 depict the estimated coefficient (i.e., β_i) of the quantile regression for all the currencies specified in equation (1) which measures the responsiveness of dollar-based and euro-based investors in terms of how much they are willing to pay to hedge against the downside risk of a currency under extreme market conditions. In Figure 3, of the currency risk reversals vis-à-vis the US dollar, most of the coefficients are negative in the sample periods, suggesting that these currencies are regarded riskier than the US dollar by dollar-based investors when financial market volatility surges to a very high level. Hence, the US dollar is generally perceived to be a safe haven by dollar-based investors in turbulent times. The Japanese yen is probably the most notable exception whose coefficient

is significantly positive, reflecting its higher safe-haven status. During the appreciation phase, the Chinese renminbi is regarded riskier than the US dollar (and definitely more so to the Japanese yen) but the safest among the riskier currencies. During the depreciation phase, the riskiness of the currency onshore increases slightly, while that of the offshore one remains largely the same.

Of the risk reversals vis-à-vis the euro, there are comparatively more positive coefficients, with that of the Japanese yen being the largest, followed by those of the US dollar, Swiss franc, and a few Asian currencies (Figure 4). This suggests that, in times of market turmoil, these currencies are regarded as safe havens by euro-based investors. The Chinese renminbi is generally regarded as safer than the euro. The CNH even ranks the second during the appreciation phase. In all cases, the CNY and CNH rank higher than the British pound. The British pound, which was conventionally regarded as safer than the euro, has a negative coefficient in the depreciation phase, probably reflecting increased concerns of euro-based investors about the currency amid the fallout of the Brexit vote.

It is interesting to note that the CNY and CNH register very similar levels of safehavenness from the perspectives of both dollar-based and euro-based investors, despite the fragmented markets. The CNH consistently enjoys a higher safe-haven status than the CNY albeit only marginally, which may be attributable to the stronger price discovery process of the offshore market (Cheung et al., 2016; Cheung et al. 2017).

Finally, Figure 5 provides the scatter plots of the safehavenness vis-a-vis the US dollar against that vis-a-vis the euro, with which one can compare dollar-based and euro-based investors as to how they view the safehavenness of different currencies. Their behavior is strikingly consistent. As can be seen, the slope of the best-fitted regression line is very close to one in the whole sample period or when the period is divided into the appreciation or depreciation phases. This means that the safehavenness of a currency is, on average, viewed to be the same by dollar-based and euro-based investors.

If the intercept is zero, then the US dollar and euro are evaluated as having the same safehavenness. Hence, the fact that it is always positive suggests that the US dollar is consistently regarded as safer

than the euro, no matter which period we focus on. Given that the appreciation phase overlaps with the European debt crisis to a significantly extent, it is readily understandable why the intercept is more positive for this period.

V. CONCLUSION

The paper estimates the safehavenness of the Chinese renminbi in its onshore and offshore markets along with twenty most traded currencies, including those in the SDR basket, based on the behavior of their risk reversals under extreme market conditions. The empirical results found that the CNY and CNH rank consistently quite high on the scale of currency safehavenness by both dollar-based and euro-based investors. Compared with other SDR currencies, they are regarded as riskier than the US dollar and Japanese yen but safer than the euro and British pound.

Figure 3. Responsiveness of risk reversal (vis-à-vis USD) to risk aversion index in three sample periods (using the quantile regression)

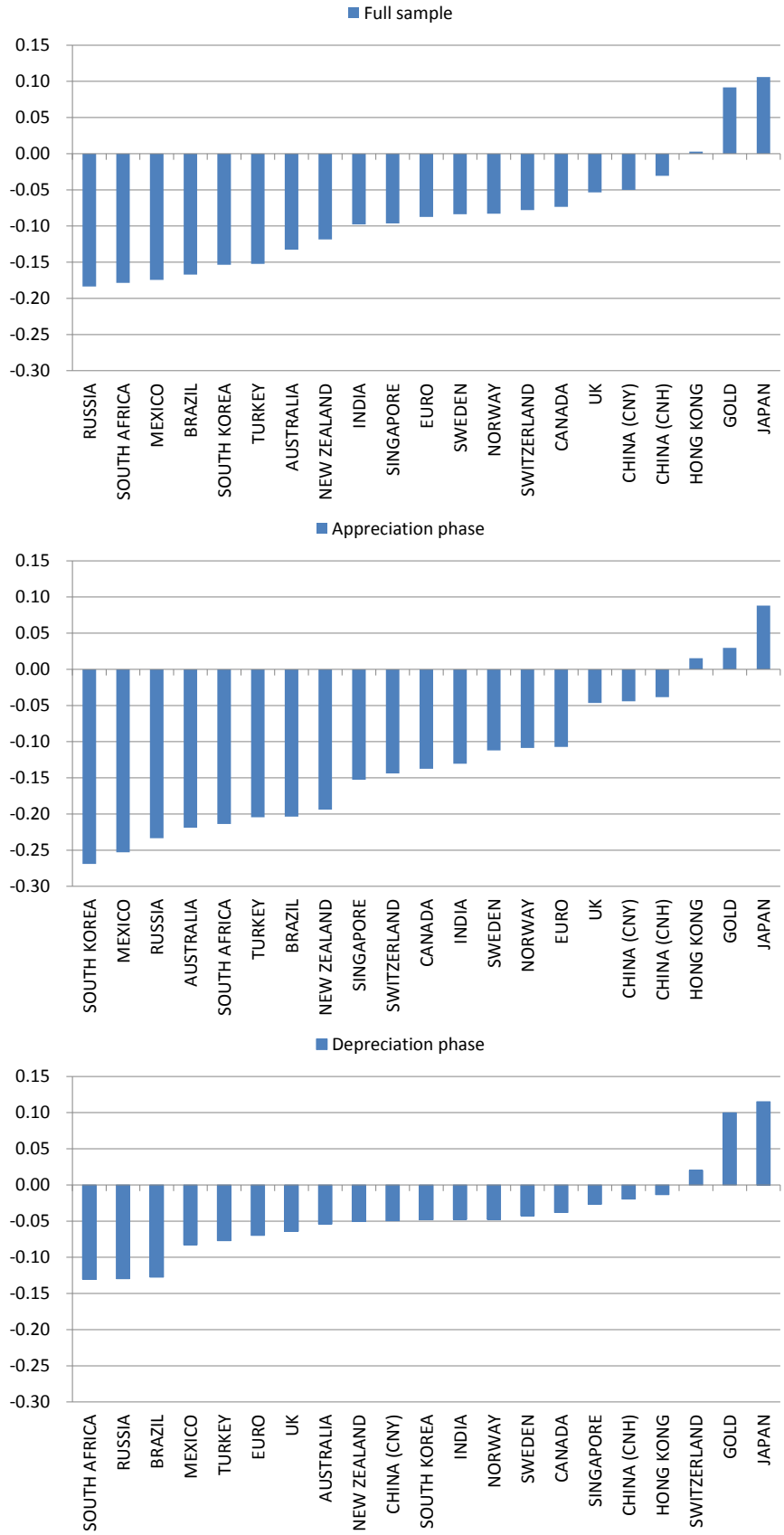


Figure 4. Responsiveness of risk reversal (vis-à-vis euro) to risk aversion index in three sample periods (using the quantile regression)

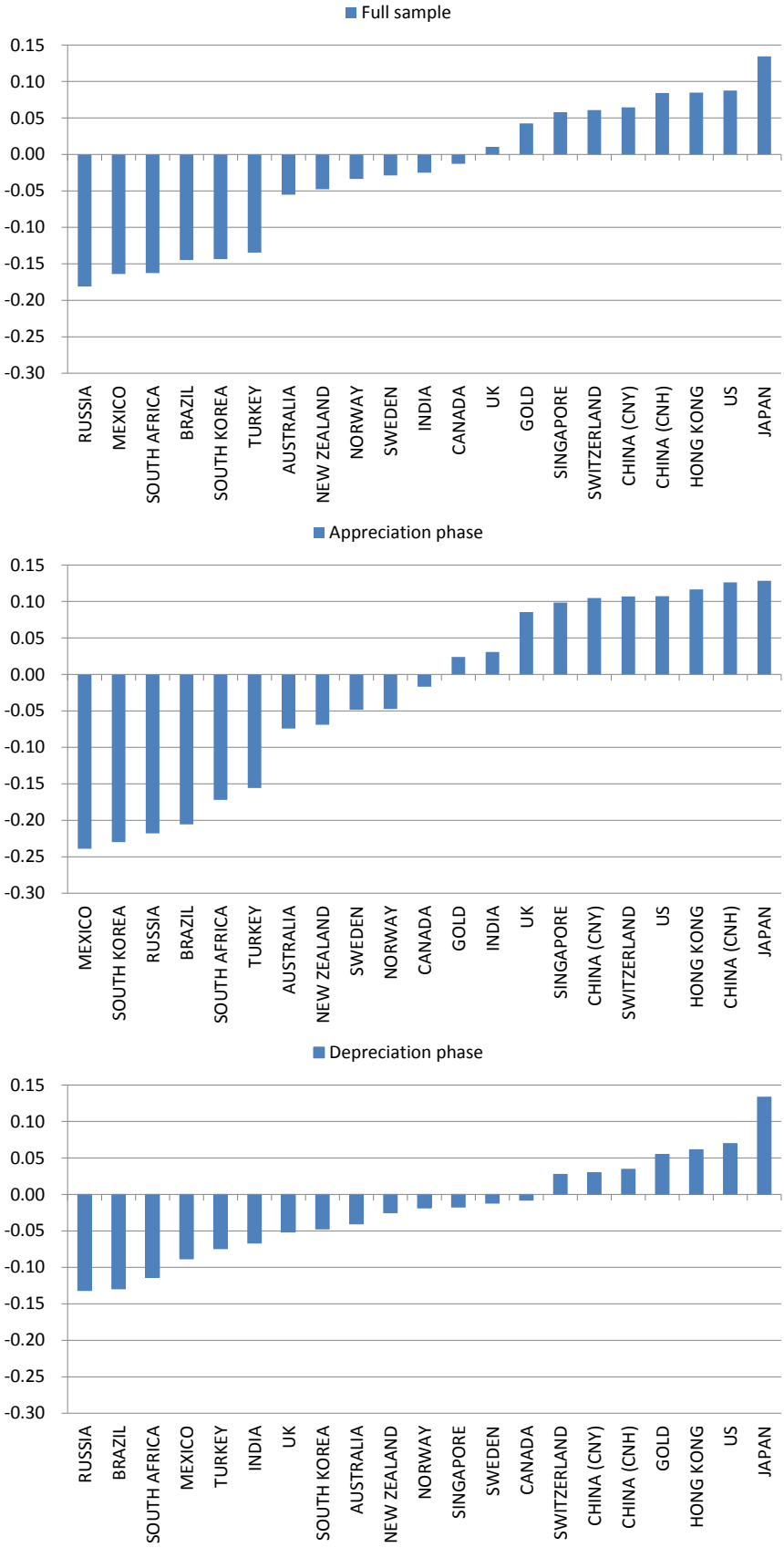
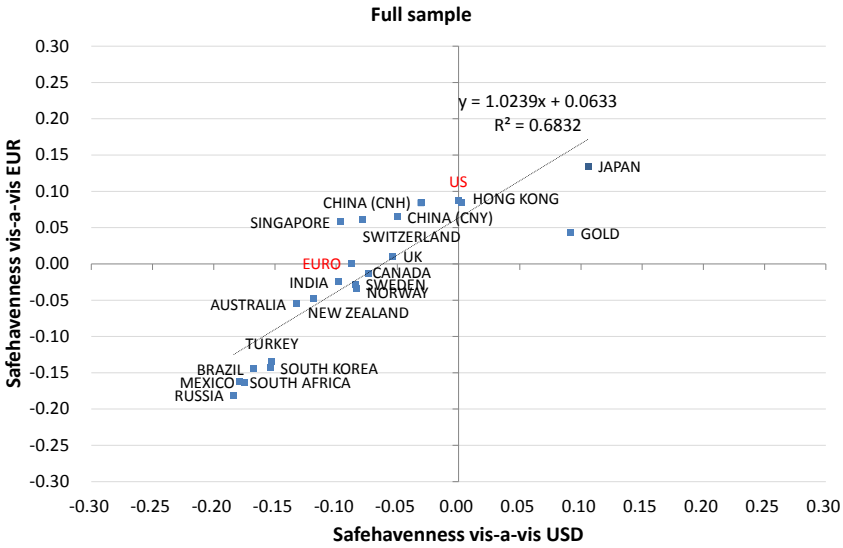
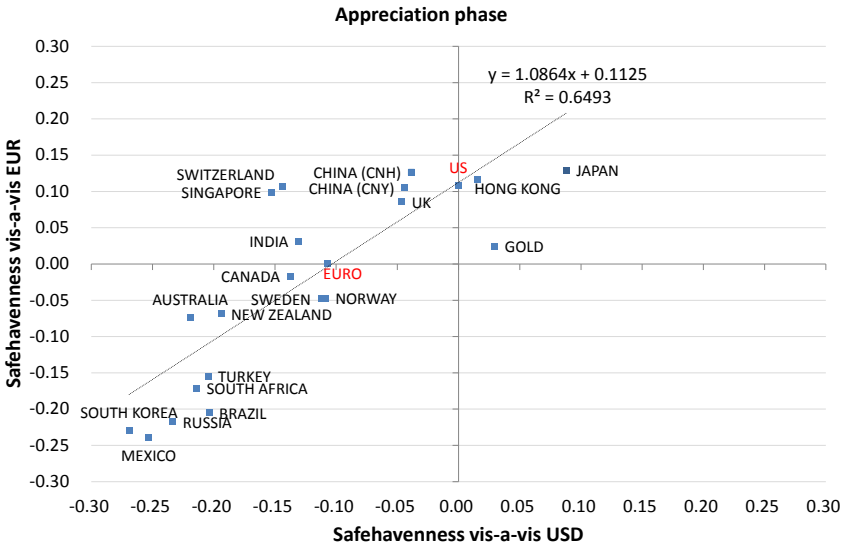
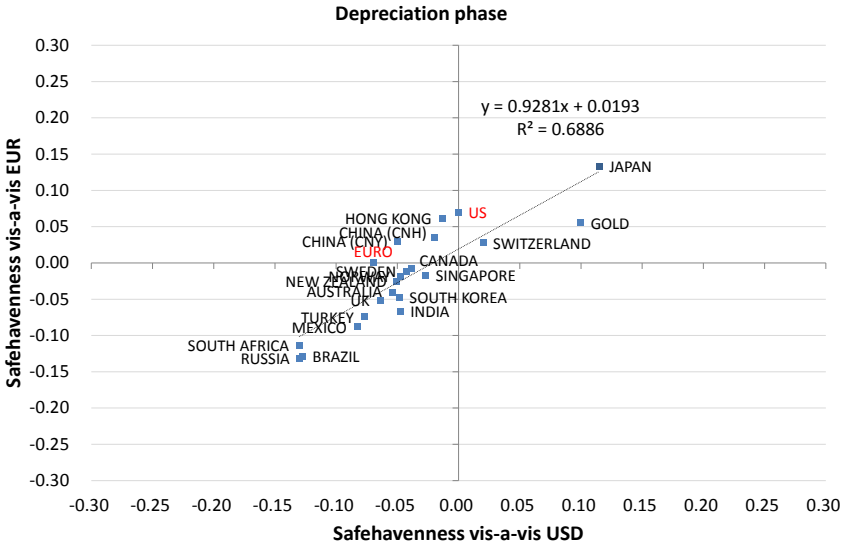


Figure 5. Scatter plots of currency safehavenness vis-à-vis the US dollar against that vis-à-vis euro







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