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Abstract

This paper investigates what factors are the determinants of a safe haven currency's ability to appreciate during the risk-off episodes. I assess how the safe-haven status and related determinants of 14 currencies changed over time from 2002 until 2017, using a safe-haven index that shows the time-variant tendency of exchange rate movement in response to changes in market uncertainty, measured using the CBOE volatility index (VIX). The panel regression results suggest safe-haven determinants shifted from external sustainability factors (current account surplus) to market driven factors (carry trade opportunity and high liquidity) during and after the Global Financial Crisis. The results highlight the increasing effects that changes in monetary policy stance and market risk appetites have on a currency's safe-haven status. That said, in addition to affecting the exchange rate, the shift between monetary tightening and easing by the Federal Reserve and local central banks may also change the interaction between the appetite for market risk and a currency's safe-haven status.

Keywords: Safe-Haven Currency, Risk Appetite, Uncertainty, Liquidity, Carry Trade

JEL classification: E44; F31; G15

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1. Introduction

Global investors always need a safe-haven to flee from risks. The Japanese yen and the Swiss franc are often quoted as a safe-haven currency — a currency that appreciates when the global investors' behavior tends to be more risk-averse. The safe-haven status of the two currencies has been weighing on exports with stronger currency value as the uncertainty of economic policy and outlook increase. The U.S. dollar traditionally tend to appreciate with a surge in geopolitical risks in the globe, regarded as the most reliable international currency. A currency's safe-haven status has a vital role in changing exchange rates, but few study focuses on the changing status of the safe-haven currencies as most of studies assume that the safe-haven currency status is given and permanent. What factor determines a safe-haven currency? Does the determinant of a safe-haven currency shift to an alternative factor over-time? These are main questions that this paper tries to answer.

The status of safe-haven currencies is traditionally linked to a country that has large current account surplus, low sovereign risks, and/or its high share in trade settlements. The economic fundamentals-based determinants for the safe-haven currency may have shifted to market -driven behavior in the aftermath of the 2008–2009 financial crisis. That could reflect cross-asset correlations broadly rose in the financial crisis, driven by global central bank interdependence and investor risk sentiment. The Federal Reserve Chair Ben Bernanke's comment on tapering the Fed's purchases of Treasury and mortgage securities on 22 May 2013 highlighted risk assets with no direct relationship to Fed purchases (such as emerging market currencies) were crushed under the forced unwind of carry trades across the market landscape (Zhao and Sharef, 2016). The cross-asset co-movement and higher policy uncertainty magnified the exchange rate moves.

The yen tends to rise with higher financial market volatility. Despite mushrooming Japan's government debts and trade deficits, the Japanese yen had been appreciating in early 2010s. This tendency—clearly evident when the currency surged after the U.K. European Union membership referendum result of 23 June 2016 (the Brexit shock)—has strengthened since mid-2015 (Masujima 2016). While widening yield differentials between the U.S. and Japan are a force to weaken the yen, the currency is vulnerable to sudden gains on higher risk aversion. The Swiss monetary authorities have been suffered from its currency's safe-haven status. Strong appreciation pressure on the currency forced the Swiss National Bank to introduce the exchange rate-peg against the euro in 2011 amid the European sovereign debt crisis. The central bank's board member Andrea Maechler said on April 5, 2018, "The pressure on the Swiss franc is still there, the currency has devalued and the overvaluation has reduced, but the franc is still a safe-haven."

The safe-haven status may signal in advance shifts in risk appetite in the foreign exchange market. The VIX-- Chicago Board Options Exchange (CBOE) volatility index, calculated using S&P 500 index options, is often used as the proxy of global financial risk outlook. There are a number of possible explanations for the close relationship between the VIX and the safe-haven currencies. Higher volatility in U.S. stocks could affect expectations about the future monetary policy stances of major central banks, resulting in shifts of capital out of dollars and into yen. For example, the Brexit shock resulted in a surge in the VIX, associated with a delay in the Fed's rate hike. That led to yen appreciation due to higher safe-haven demand and narrowing government bond yield differentials between U.S. and Japan. So, the safe-haven status is a driver of exchange rate moves. A question is what factors characterize the safe-haven currency.

Low interest rates—the funding source of carry-trade opportunity—, higher

liquidity of currency, and current account surplus are common factors across the yen and the Swiss franc. The safe-haven behavior of the currency moves tends to dampen a safe-haven country's exports during a crisis, weighing on its economic recovery. Thus, tracking a currency's safe-haven status and investigating its determinants provide a clear economic and financial market guidance for financial authorities, investors, and corporates.

Recent political uncertainty generated unexpected shocks—from the U.S. protectionism on global trade to Federal Reserve interest rate decisions and political events in Europe—that could affect sentiment toward the yen, the Swiss franc, and relatively vulnerable currencies of commodity exporters and emerging markets, while increasing potential safe-haven demand for alternative assets such as gold and bitcoin.

This paper investigates what factor determines a safe-haven currency, considering the exchange rate and asset price co-moves from shocks with changing market uncertainty. This study extends safe-haven indexes developed by Masujima (2017). The empirical results suggest safe-haven determinants shifted from traditional sustainability measurement (current account surplus) to market-driven gauges (carry trade opportunities and bid ask spreads) during and after a crisis period. That may suggest a currency's safe-haven status isn't necessarily persistent and could change more frequently than before.

2. Review of Save Haven and Safe Asset Literature

Safe-haven currencies tend to be associated with four conditions: low interest rates, large net foreign asset positions reflecting persistent current account surplus, and highly liquid financial markets. Japan and Switzerland meet all the criteria. Habib and Stracca

(2012) find that safe-haven status is, after controlling for the carry trade, associated with greater net foreign asset positions, less relevant to the stock market capitalization. For advanced countries, the government debt to Gross Domestic Products ratio, financial development indicators, and the liquidity of foreign exchange are also associated with safe-haven status.

Policymakers in safe-haven countries face the challenge of dealing with sharp real appreciations or surges in capital flows when risk-off episodes recur. As the real appreciation and surge in capital flows continue, the potential for vulnerabilities tends to be built up in either private or public sector balance sheets (Sorsa et al. 2007). In economies with low inflation and close to the zero interest rates, real appreciations driven by risk-off episodes could feed deflation risks and place downward pressures on aggregate demand (International Monetary Fund 2012a; Carvalho Filho 2015). Transitory real appreciation may lead to strong adjustment costs to the economic dislocation when exchange rates eventually revert back (Bussière, Lopez and Tille 2013).

High uncertainty may change exchange rate movements to shocks via two channels – safe-haven effects and uncovered interest rate parity (UIP). That increases the importance of measuring uncertainty. Fatum and Yamamoto (2014) find all currencies except the yen have significant market uncertainty thresholds. Ismailov and Rossi (2017) suggest that UIP is more likely to hold in low uncertainty environments, relative to high uncertainty ones, based on the assessment of a new exchange rate uncertainty index. Decomposing the uncertainty of a typical forecaster into common and idiosyncratic uncertainty, Ozturk and Sheng (2017) point to persistent effects on economic activity from common uncertainty and short-lived effects from idiosyncratic uncertainty.

Despite development of new uncertainty index, the VIX is still more reliable and

high frequency uncertainty measurement (See Appendix I). For example, 12 weeks after the start of a VIX spike, net non-commercial positions on the yen on the Chicago Mercantile Exchange are 20 billion U.S. dollars longer than would be the case absent the rise in the VIX (Botman, de Carvalho Filho, and Lam 2013).

Several studies confirmed the yen's safe-haven status. De Bock and de Carvalho Filho (2013) find that the yen and the Swiss franc are the only two currencies that appreciates against the U.S. dollar on average during risk-off episodes. Ranaldo and Söderlind (2010) see that the yen appreciate against the U.S. dollar when U.S. stock prices decrease and U.S. bond prices and foreign exchange rate volatility increase. Botman, de Carvalho Filho, and Lam (2013) well documented the literature related to the yen's safe have behavior. Grisse and Nitschka (2015) pointed out that the currency's safe-haven status has been changing over-time and the Swiss franc appreciates against the euro in response to increases in global risk, but depreciates against the US dollar, the yen and the British pound.

3. Data and the Model

3.1. Development of Safe-haven Index

Indexes for the safe-haven status of a currency is developed under the assumption that capital flows driven by excess returns from the currency carry trade, rather than uncovered interest rate parity (UIP). This paper's view is close to Brunnermeier, Nagel, and Pedersen (2013)'s carry trade hypothesis that defines the currency carry trade, which consists of selling low interest-rate currencies "funding currencies" and investing in high interest-rate currencies "investment currencies." They find that carry trades losses money on average in times of rising VIX. While the UIP hypothesizes that the carry gains

due to the interest-rate differential is offset by a commensurate depreciation of the investment currency, empirically the reverse holds. The investment currency appreciates a little on average despite with a low predictive R^2 (Fama 1984). This violation of the UIP – often referred to as the "forward premium puzzle" – is precisely what makes the carry trade profitable on average.

The UIP is defined as

$$(1 + i_{\$}) = \frac{E_t(e_{t+k})}{e_t} \quad (1 + i_{LCY}) \quad (1)$$

where the $\imath$ is nominal interest rates, e is nominal exchange rates – the number of local currency units per the U.S. dollar. '$' indicates the U.S. dollar and 'LCY' means the local currency. Adding the gauge of market risk sentiment to predict the future spot exchange rate changed the equation into

$$\Delta E_t(e_{t+k}) = \Delta(i_{\$} - i_{LCY}) + \Delta x \quad (2)$$

where the x is the gauge of the market risk sentiment. That said, a change in expected exchange rate is explained by a change in interest rate differentials and the market risk sentiment. Different from the UIP, though, this paper's model follows the simultaneous adjustment on exchange rates on daily basis. During the intraday, a change in uncertainty gauge affects invertor's risk appetite and its exchange rate expectation, resulting in a change in exchange rate via trading within a day. To capture the impacts of a change in the market risk sentiment on exchange rates, a rolling OLS regression of a daily change in the VIX and the two-year yield differential between a local currency and the U.S. dollar on a percentage change in local currency per dollar is conducted. The sample period starts from the beginning of 2001 at earliest, depending on data availability by currency, through 31 December 2017, with a 250-business day window.

The VIX is a good measure of investors' risk sentiment. Increases in the VIX are associated with higher volatility in Japanese and Germany stock prices, as measured by the Nikkei Volatility Index (VI) and VDAX—new volatility index of Deutsche Börse DAX, as well as in the yen's exchange rate to dollar (Figure 1). The VIX correlates to the Nikkei VI at 0.83, to the VDAX at 0.87 and to implied volatility on 1-month at-the-money yen-dollar options at 0.71. Movement of equity volatility indexes has been more closely associated with exchange rate index since September 2008. Following Masujima (2017), the standard model is:

$$dln\left(\frac{LCY}{USD}t\right) = \alpha + \beta_1 d(USDLCY\_2Y_t) + \beta_2 d(VIX_t) + \varepsilon_t \quad (3)$$

where $dln(LCY/USD_t)$ shows daily returns of bilateral exchange rates against the U.S. dollar[2], *USDLCY_2Y* is two-year government bond yield differential[3], *VIX* denotes the implied volatility of S&P 500 index options[4], ε is an error term. The UIP assumes the sign of the coefficient of *USDLCY_2Y* is negative, while the carry trade hypothesis sees its sign positive during a normal period. So, the determinants of its sign are answers from an empirical question, rather than a theory. In the case of the yen, the negative sign holds in the most of the sample period. The coefficient of the *VIX* is defined as the Safe-Haven Index (*SH*) and assessed the safe-haven status as follows:

- *SH* > 0: Period and country specific "safe-haven" type tendency.
- *SH* < 0: Period and country specific "vulnerable currency" type tendency.
- *SH* = 0 or insignificant: exchange rate movement doesn't follow specific tendency.

[2] In the UIP, the exchange rate is the future value. So, daily returns at the time t+1 are usually applied. But a change in the VIX and the two countries' yield differentials is often associated with a change in the exchange rate during an intraday. So, the time *t* is used here instead of *t+1*. See Appendix II for the estimation of the emerging Asia currencies, which daily returns at time t+1 are applied as the UIP assumes.

[3] In case of non-currency such as the gold, the bitcoin, and the crude oil, the U.S. yields are applied.

[4] The VIX, which often referred to as the fear index or the fear gauge, is calculated by the Chicago Board Options Exchange (CBOE), representing the market's expectation of stock market volatility over the next 30-day period.

3.2. Movement of Safe-haven Index

Movements of safe-haven index vary among currencies. This section described the movement of these groups' safe-haven status.

3.2.1. Advanced Economies' Safe-haven Status

The safe-haven index suggests the yen has kept its safe-haven status during the global crises. The results of the ordinary least square rolling (OLS) regression in daily data supported this scenario. The yen's safe-haven status has been held since 2007 except a period of the aftermath of the Great East Japan Earthquake and the downgrade of the U.S. sovereign rating provided by Standard and Poor's (Figure 2). Still, when the yen had the vulnerable status, the coefficient of the VIX wasn't always statistically significant. This tendency isn't just for the yen, but other currencies. The share of currencies, that are statistically significant at the 10% level on their safe-haven status, dropped below 10% in 2005-06, while their share boosted to over 80% in 2007 (Figure 3). Recent literature suggests the safe have effects are pronounced during a crisis period, so this index's tendency is consistent with the past study.

Since market participants tended to expect higher possibility of massive monetary easing as the part of the Abenomics in late 2012, the yen's safe status has been strengthening. The index shows that each one percentage point rise in the VIX is associated with a 0.13% appreciation in the yen as of December 2017, while one percentage point increase in two-year interest rate differential between the U.S. and Japan is accompanied to an 11.6% appreciation in the yen. The negative coefficients of U.S.-Japan interest differentials held in almost all the time of the sample period. These movements support the carry trade hypothesis rather than the UIP[5].

[5] During a crisis period, the UIP doesn't appear to hold. Ismailov and Rossi (2017) points out since arbitrage opportunity gains become more uncertain in a highly unpredictable environment, thus blurring the relationship

The Swiss franc tends to be a safe-haven currency over the, though the currency's safe-haven status cannot avoid negative impacts from regional turbulence. In the European sovereign crises of 2011, the yen was purchased aggressively as a safe-haven currency[6] and finally reached the historical high value, 75.54 yen per dollar and remained around 80 yen. Still, the East Japan Earthquake and the meltdown of nuclear power plants increased a concern from investors. Coupled with a concern about Japan, high demand for the U.S. dollar from the European banks pushed up the U.S. dollar as the most reliable safe-haven currency in 2011-2012 (Table 1). In January 2015, the Swiss National Bank (SNB) abolished its exchange rate cap against the euro, meaning that the SNB stopped intervening by purchasing the Swiss franc against the euro. As a result, the Swiss franc was appreciated against U.S. dollar by 30% within 10 minutes. At the same time the yen and the Singapore dollar were appreciated by 1% as investors needed to sell the euro and buy some safe currencies instead of the Swiss franc that was limited liquidity and capacity compared to the euro.

3.2.2. China's Safe-haven Status

The offshore traded renminbi (CNH) may relatively well capture investors' risk appetites and their preference to a safe-haven currency, while the safe-haven status of the domestically traded renminbi (CNY) and the Hong Kong dollar (HKD) may be distorted due to the restriction of capital flows and/or exchange rate movement[7]. All the three

between exchange rates and interest rate differentials. Fukuda (2016) finds EU bank credit risk and global market risk had asymmetric effect on the deviations from the covered interest parity, differentiating features between the Sterling pound and the Danish kroner during a crisis.

[6] See IMF (2012b) for the detailed reason for the lack of safe assets globally.

[7] Fatum, Yamamoto, and Zhu (2017) find evidence of some degree of safe-haven currency behavior of the renminbi during the early part of their sample, which do not support the suggestion that the renminbi is currently a safe-haven currency. This paper developed, close to their study, safe haven gauges both onshore renminbi (CNY) and offshore renminbi (CNH), but safe haven determinants are tested only for CNY.

currencies tended to be vulnerable to shocks, not acting as a safe-haven until 2016 (Figure 4). Still, the CNH appeared to be more vulnerable to shocks, compared to the CNY and HKD. As the HKD is pegged to the U.S. dollar in the quite narrow range under the currency board system its safe-haven status has been close to neutral through the sample period.

The CNY doesn't meet the criteria of high convertibility and liquidity as a safe-haven currency, but the CNH might have met the criteria since July 2010[8]. Investors can open renminbi bank accounts in an offshore renminbi clearing center Hong Kong and transfer funds into and out of these accounts without any restrictions, although cross-border fund transfers to and from Mainland China are subject to regulations in Mainland China. The renminbi's inclusion into the SDR basket represents its internationalization[9], making the renminbi a reserve currency alongside the USD, the JPY, the EUR, and the GBP. Still, the renminbi was depreciated by 4% between its announcement on November 30, 2015 and actual inclusion on October 1, 2016.

Fatum, Yamamoto, and Zhu (2017) neither suggest that the CNH is currently a safe-haven currency, nor that the CNH is progressing towards safe-haven status. Still, this paper's safe-haven indexes capture CNY and CNH's transition in their status between safe-haven and vulnerable currency.

3.2.3. Safe-haven Status of Commodity Exporters

[8] As of April 2015 the daily turnover of renminbi foreign exchange transactions in Hong Kong alone reached the equivalent of USD 93 billion, thereby implying that the offshore renminbi market is highly liquid.

[9] More illustrative of the current state of the internationalization of the renminbi are the economically significant facts that the renminbi is currently traded in official offshore clearing centers in 17 locations outside of Mainland China, as of March 2016 the renminbi is the fourth most used global payments currency by value, and the total investment quota for renminbi Qualified Foreign Institutional Investors (RQFIIs) is more than doubled as of October 31, 2016 since People's Bank of China announced the first allocation to the US (in the amount of CNY 250 billion).

Commodity exporter currencies such as the Australian dollar (AUD), the Canadian dollar (CAD), the Indonesia rupiah (IDR), and the Malaysian rupiah (MYR) tend to be vulnerable to shocks, associated with crude oil's safe-haven index, though its vulnerable status of the crude oil looks greater than the commodity currencies (Figure 5). The vulnerable status of crude oil prices seems to be stronger when the prices fell[10] (Figure 6). Still, as the emerging Asia has been developing, Indonesia and Malaysia have been turning into commodity importers from exporters. The safe-haven indexes of the two countries have been losing high correlation to AUD and CAD, shifting to higher co-movement with the other emerging Asia as the launch of the ASEAN Economic Community (AEC) increases the depth of regional economic network.

3.2.4. Asia Emerging's Safe-haven Status

The emerging Asian currencies such as the Korean won (KRW), the Thai baht (THB), the Singapore dollar (SGD), the IDR, and the MYR also tend to be vulnerable through the sample period (Figure 7). The SGD and the THB were less vulnerable to shocks than the other three currencies. The KRW appears to be the most vulnerable currency just behind the AUD and the CAD, despite the Korean central bank's intervention to the exchange market and the current account surplus[11].

3.2.5. Safe-haven Assets-Alternatives

Increasing political uncertainty in the global market and weakness of the

[10] The U.S. dollar's safe-haven status partly come from the vulnerability of commodity currencies as the trade share of commodity exporters to the U.S. is high. So, higher commodity prices tend to appreciate the U.S. effective (trade-weighted) exchange rates.

[11] Ryoo, Kwon, and Lee (2013) pointed to the source of its vulnerability comes from the Korea's high degree of capital market openness, to its geopolitical risks, and to the large amount of banks' external debt and their maturity mismatches despite the current account surplus and the Korean central bank's intervention to the exchange market.

renminbi in 2016 may increase demand for alternative assets, though the size and liquidity of the markets haven't developed well yet and they are vulnerable to regulatory changes. Different from currencies issued by a country, these assets aren't backed up by tax revenues, but their scarcity, limited restriction (regulation) to exchange across borders, and business cycles could determine their asset values for investors . So, tracking the safe-haven status of the three assets provides signals to track investors' risk appetites.

Gold is traditionally regarded as a safe asset. The safe have index suggest that its movement is more sensitive to the U.S. interest rates rather than the market risk, implying that it might be alternative assets when U.S. interest rates are low, rather than a safe-haven. Reboredo (2013) finds gold can act as an effective safe-haven due to symmetric tail dependence, while on average gold is a hedging instrument of the U.S. dollar. That supports the evidence that gold might have been working as a safe-haven asset since the Brexit vote of June 2016. The strength of the status was upgraded after the U.S. presidential election in November 2016. In contrast, the gold kept its vulnerable status relative to the yen during the same period, i.e., the yen is assessed as a safe-haven relative to the gold.

Gold could be considered as a good asset in the diversification of Chinese portfolios. It ranked at the second place, following the yen in 2017, increasing the correlation between the yen and the gold as both has almost no interest payment and are regarded as safe-havens. Wong and Zhu (2015) find, however, it is only for risk-seeking investors and in crisis periods on the Shanghai Gold Exchange in the diversification of Chinese portfolios. So, there are limited studies that regard bitcoin and gold as a safe-haven, while this paper pointed out some possibility that their safe-haven tendency might be increasing, particularly relative to the renminbi under high policy uncertainty.

The bitcoin — a cryptocurrency and a payment system — has been emerging as the non-national currency. The size of bitcoin transaction has been increasing. The value of its weekly transaction reached about 50 billion dollar. The renminbi has dominated the share of the counter party currency to bitcoin since the mid-2014. The bitcoin price tends to be accompanied by the weaker renminbi. The appeal of bitcoin lies in the capacity to skirt China's capital controls and move funds out of the country (Orlik and Jimenez 2017). So, it could be used as the loophole of China's capital restrictions[12]. The safe-haven index suggests the bitcoin had the safe-haven status relative to the renminbi after the China's stock market crush in the early 2016, while it also had the safe-haven status relative to the U.S. dollar after the U.S. presidential election in November 2016. It would be too early to say that the bitcoin worked as a safe-haven or not. Still, the result may signal the new trend of investors' preference to alternative assets under global policy uncertainty.

From early 2016 until mid-2017, the bitcoin's safe-haven status was strengthened as the CNH's vulnerable status became more evident (Figure 8). That may have reflected a capital flight to the bitcoin from the renminbi[13]. A bitcoin price surged in late 2016 as the renminbi depreciates[14], but it tumbled to $789 on January 11, 2017, down 28% from a peak of $1,091 on January 4, 2017. The proximate cause – signals from China's central bank that they are paying close attention to irregularities in the market. The bitcoin price peaked at $18,674 on December 17, 2017. Even so, the safe-haven ranking shows it has rapidly lost its safe-haven status (Masujima 2018).

[12] Bitcoin prices tumbled to $903 on Jan. 10, down 17% from a peak of $1,091 on Jan. 4 (Figure 20). The proximate cause – signals from China's central bank that they are paying close attention to irregularities in the market.

[13] Orlik and Jimenez (2017) see the small size of the market makes bitcoin impractical as a channel for large-scale capital flight.

[14] China's bitcoin transactions account for some 99% of the total on global exchanges as of end of 2016, according to Bitcoinity.

3.3. Standardization of Safe-haven Index and Safe-haven Ranking

In this section, the standardization of the safe-haven index and the safe-haven ranking is conducted. The safe-haven index in the previous section is practically useful to monitor the level of the safe-haven status as the index shows by how much one percent increase in the VIX likely changes the exchange rate of the currencies. Still, the standardization of the safe-haven index is likely to increase the accuracy of comparison of safe-haven status across currencies, even asset classes. Higher volatility of the prices of the bitcoin, the gold, and the crude oil are than exchange rates means the larger absolute value of these assets' safe-haven index.

3.3.1. Standardization of Safe-haven Index

The standardized safe-haven index (*SSH*) is a safe-haven index divided by standard deviation of daily percentage change in FX rate for the past 250 business days:

$$SSH_{i,t} = SH_{i,t} \Big/ \sqrt{\sum_{i=t-249}^{t}(x_{i,t} - \bar{x})/249} \quad (4)$$

where the *x* is daily percentage change in nominal exchange rate against dollar

3.3.2. Safe-haven Ranking

The safe-haven ranking index (SHR) is estimated by daily ranking of SSH among 14 currencies (plus CNH and three assets are included for comparison). If the SSH isn't available at time *t*, the currency is excluded from the ranking. The monthly and annual rankings are estimated as the average of daily estimates of the SHRs. The rankings of safe-haven indexes and their standardized gauges look similar (Table 2). The major differences come from currencies that aren't under free floating regime such as SGD (the currency basket system), CNY (the daily trading range with capital flow control), HKD (currency board). These currencies' rankings fell after standardization.

The liquidity of currencies matters for safe-haven status, while the comparison of the safe-haven ranking to the currency liquidity measurement may suggest high liquidity is necessary condition for safe-haven currency, but it's not sufficient (Table 3). Even so, after controlling a country's fixed effects, the liquidity is imperative.

3.4. Empirical Models for Safe-haven Determinants

In this section, empirical models to test determinants of safe-haven currency are developed. The current account surplus, low interest rates—the funding source of carry-trade opportunity are candidates for its determinant. The panel regression with fixed effects (ID = country *i*) are conducted in the following models.

$$SSH_{i,t} = \alpha_{i,t} + \beta_z X_{z,i,t} + \varepsilon_{i,t} \quad (5)$$

$$SHR_{i,t} = \alpha_{i,t} + \beta_z X_{z,i,t} + \varepsilon_{i,t} \quad (6)$$

where the *SSH* is the standardized safe-haven index, the *SHR* is the ranking variable of the standardized safe-haven index, *X* is explanatory variables such as current account balance as percentage of nominal GDP (*CA*), two-year yields (*IR*), yield differential (*YG*), the U.S. and a country *i*'s two-year yield differentials – the local currency yield minus the U.S. yield, and the carry trade dummy (*D_YG* =1 if the *YG* <0, otherwise 0), *t* = time variable, the bid-ask spread of exchange rates – the percentage of its value against the dollar as a proxy of liquidity. The source of all data is Bloomberg.

In the equation (5), all the SSHs of the United States take zero as the U.S. dollar is a base currency, while in the equation (6) the Unites States is the part of the samples as the U.S. SHRs are changing overtime. As all the explanatory variables are the same for CNY and CNH, CNH is excluded from the regressions. The signs of explanatory variables

test the hypothesis below:

- $CA < 0$: the hypothesis of the current account as the proxy of external sustainability, assuming the larger current account surplus enhances its safe-haven status.
- $IR > 0$: the hypothesis of the carry trade opportunity holds as lower local currency yields reduces the funding costs, enhancing its safe-haven status.
- *IR * D_YG (interaction term) > 0*: the hypothesis that lower local currency yields enhance its safe-haven status further when local currency yields are lower than the U.S. dollar yields.
- $LQ > 0$: the hypothesis of liquidity hypothesis holds that narrower bid-ask spread of the exchange rate, i.e., higher liquidity is associated with the safe-haven status.

4. Results

The empirical results of the full-sample regression of safe-haven determinants on the standardized safe-haven indexes and safe-haven rankings shows current account balance, carry-trade opportunity (low interest rates or lower yields than the U.S. bond yields, financial liquidity (bid-ask spread of foreign exchange rates) played a vital role in determining the safe-haven status of currency moves, while their significance has been changing over-time. The full sample regressions show the signs of the coefficients of the current account balance and liquidity (bid-ask spreads) follow the hypothesis, while the signs of carry trade terms don't satisfy their sign conditions (Table 5). In the safe-haven index model (4), the negative coefficient of current account balance mean the hypothesis of the net foreign asset and the carry trade opportunity for safe-haven currencies holds. One percentage point increase in the current account balance over nominal GDP reduces the safe have index by 0.334. The positive coefficient of liquidity terms suggests liquidity hypothesis holds. One percentage point increase in bid-ask spread relative to exchange

rates boosts safe-haven indexes by 4.359. However, the negative coefficient of two-year yield differentials and its interaction term with carry trade dummy means the carry trade hypotheses don't hold in the samples of both ex- and post 2008-2009 financial crisis. Similar results are shown on the regression models on safe-haven rankings. Therefore, the hypotheses are tested in the ex-crisis and the in-and-post crisis sub samples.

The result of the sub-sample regression --pre-crisis (January 2002 - August 2008) and post-crisis (September 2008 – December 2017) periods-- on the standardized safe-haven index shows carry-trade opportunity and liquidity hypothesis were in general hold during and after the crisis period, while the sustainability hypothesis in the current account surplus holds during the pre-crisis period (Table 6). The coefficients of two-year yield and its interaction terms with carry trade opportunity turned positive in the sub-sample regression during and the post- crisis period, while current account terms became insignificant in the same period. The R^2 in the post-crisis subsample model increase to 0.786 in the model (16) from its value in the full sample model (4) (R^2: 0.653) and in the pre-crisis sample model (12) (R^2: 0.617). The models with post-crisis sub samples show more robust results than the models with the ex-crisis (Table 7). These results can imply that determinant factors for safe-haven status shifted from a traditional determinant (current account surplus) to market driven and risk sentiment factors (carry trade, liquidity). One possible explanation for a shift in determinants of the safe have effect is a rapid development algorithmic trading. Once one currency is strongly recognized as a safe-haven currency, its price response to shocks may be memorized in the algorithm, regardless of changing economic fundamentals, increasing co-movement across assets.

As a robustness test of these results, dataset that includes the U.S. data in the safe-haven ranking models Implication from the results is the same overall (Table 8).

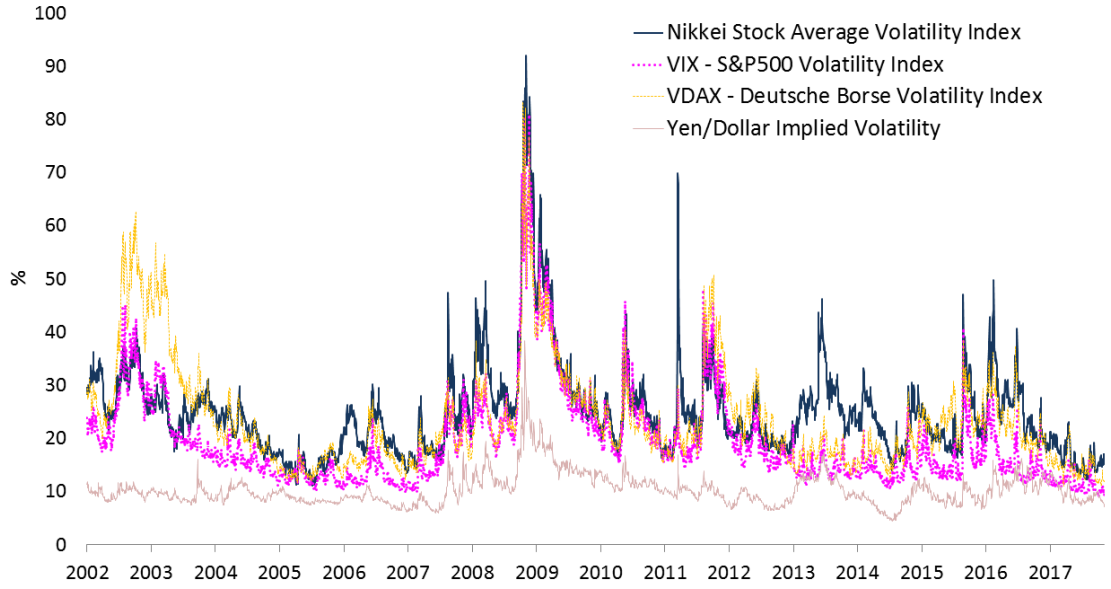
5. Conclusion

This paper investigates what factor determines a safe-haven currency and how its status changes over the sample period. Developing safe-haven index and safe-haven ranking, the determinants of a safe-haven currency are tested, tracking a transition of a currency's safe-haven status overtime. Movements of safe-haven index vary among currencies, responding to a change in the yields and the uncertainty. Moreover, regional factors and trade structures may characterize a trend of exchange rate movements. Higher market uncertainty with policy swings may increase safe-haven demand for alternative assets such as gold and bitcoin, while not substituting the yen and the dollar due to limited liquidity or no tax revenue to guarantee their value.

The empirical results suggest safe-haven determinants may have shifted from a traditional safe-haven factor such as current account surplus to market-oriented factors such as carry trade opportunity (low interest rates) and FX liquidity during and after a crisis period. The over-the-counter (OTC) liquidity for bond yields, country risk factors, aren't tested and there are room to improve the treatment of exchange rates and liquidity of the U.S. dollars. That leaves for the future research at this point.

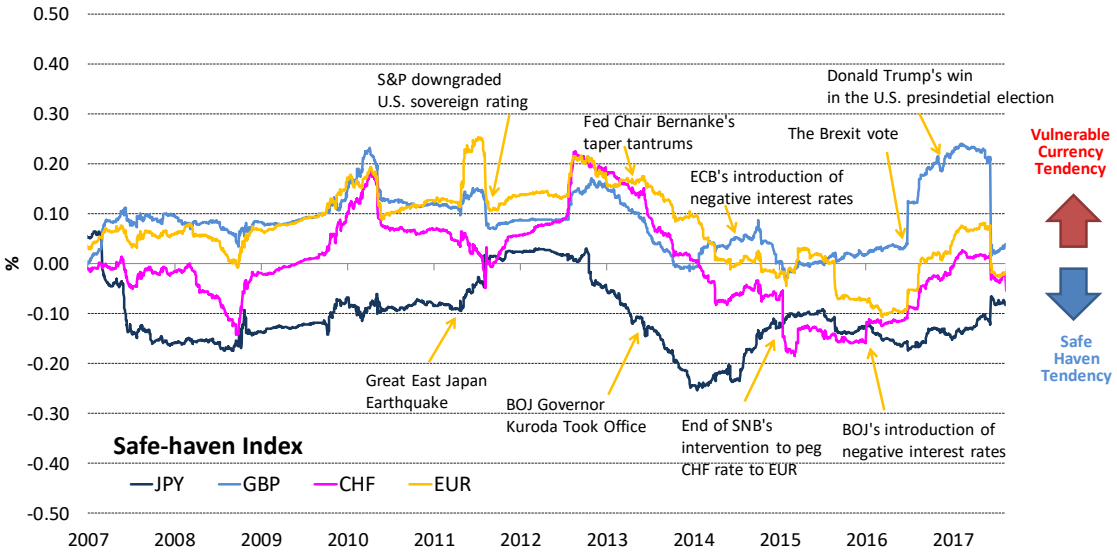
Policy implication from the results is even high importance of a shift in monetary policy on the exchange rate movement because a country's interest rates and a yield differential against the U.S. dollar affect its safe-haven status. The Fed have been shifting monetary tightening, and the European Central Bank ends the quantitative easing, though no hike in its policy rates. The Bank of Japan will probably stay in hold its monetary easing in the near term. A shift in monetary policy in major advanced economies may change the status of safe-haven currency.

Figure 1. Equity and Exchange Volatility Indexes Started to Co-move in 2007



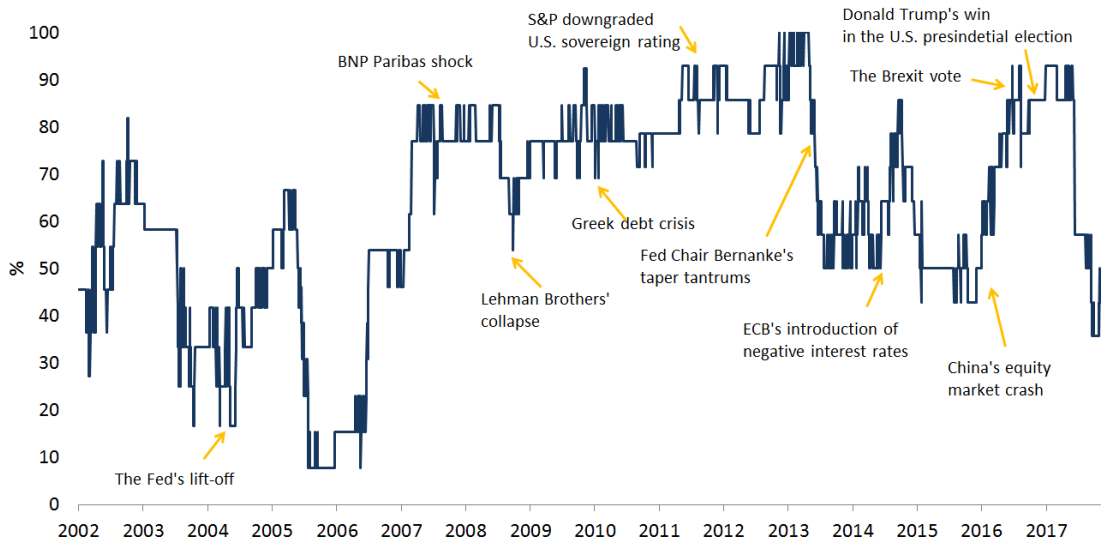
Source: Bloomberg

Figure 2. Yen's Safe-haven Status Have Enhanced since 2007



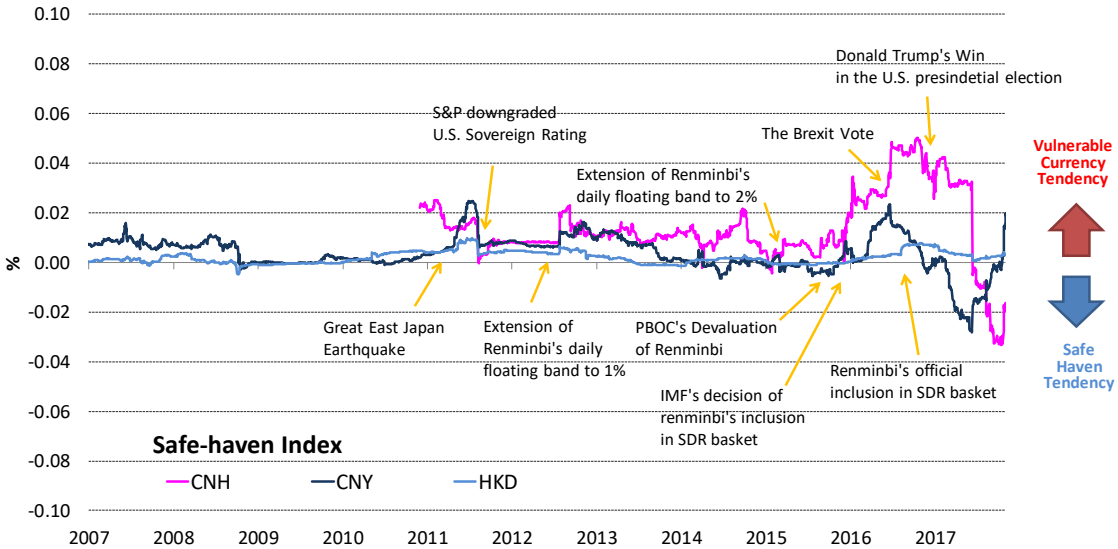
Note: A safe-haven index shows the impact of a 1-ppt rise in VIX on percent change of exchange rates. Its negative value means a safe-haven currency that appreciates when the VIX rises. Its positive value shows a currency that weakens when the VIX rises.
Source: Bloomberg Economics, author's estimation

Figure 3. Safe-haven Effects Tend to Be Strengthened during a Crisis Period



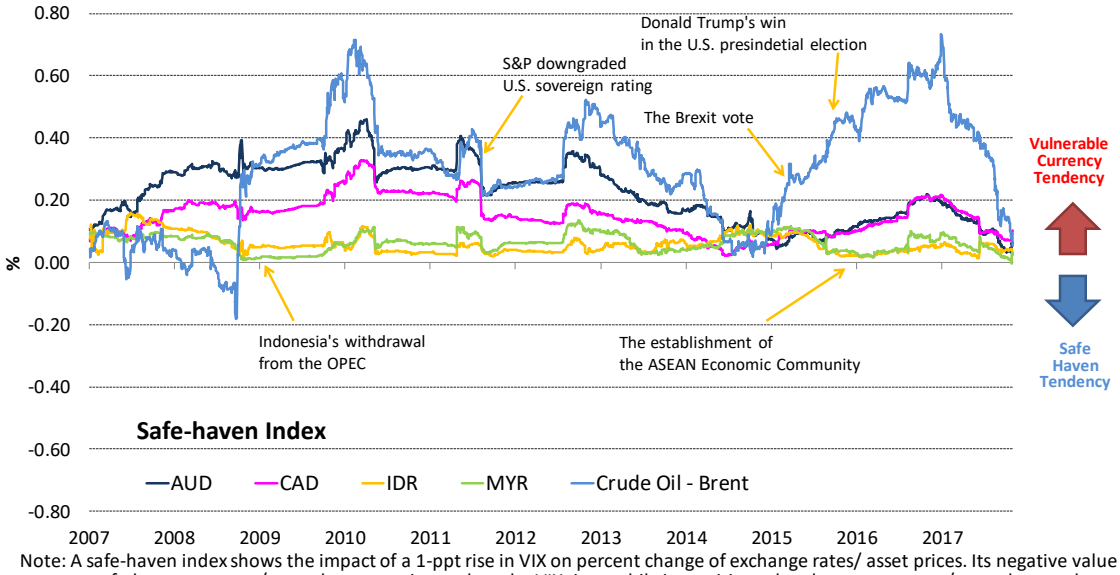
Note: Share of currencies that are statistically significant at the 10% level on their safe haven indexes.
Source: author's estimation

Figure 4. Safe-haven Status of CNY and CNH Has Been Diverged since 2016



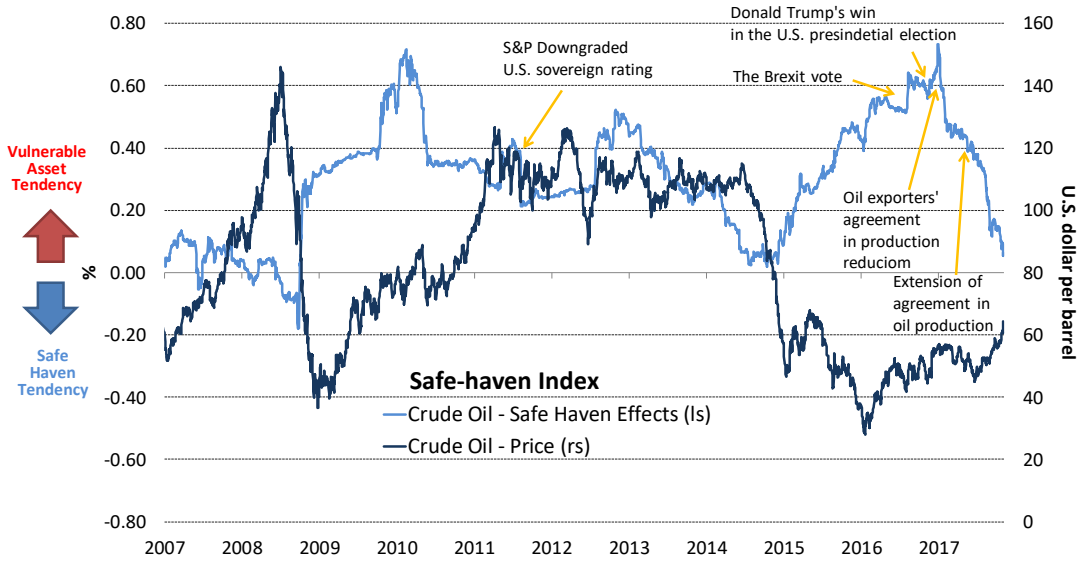
Note: A safe-haven index shows the impact of a 1-ppt rise in VIX on percent change of exchange rates. Its negative value means a safe-haven currency that appreciates when the VIX rises. Its positive value shows a currency that weakens when the VIX rises.
Source: Bloomberg Economics, author's estimation

Figure 5. Commodity Exporter Currencies Remain Vulnerable



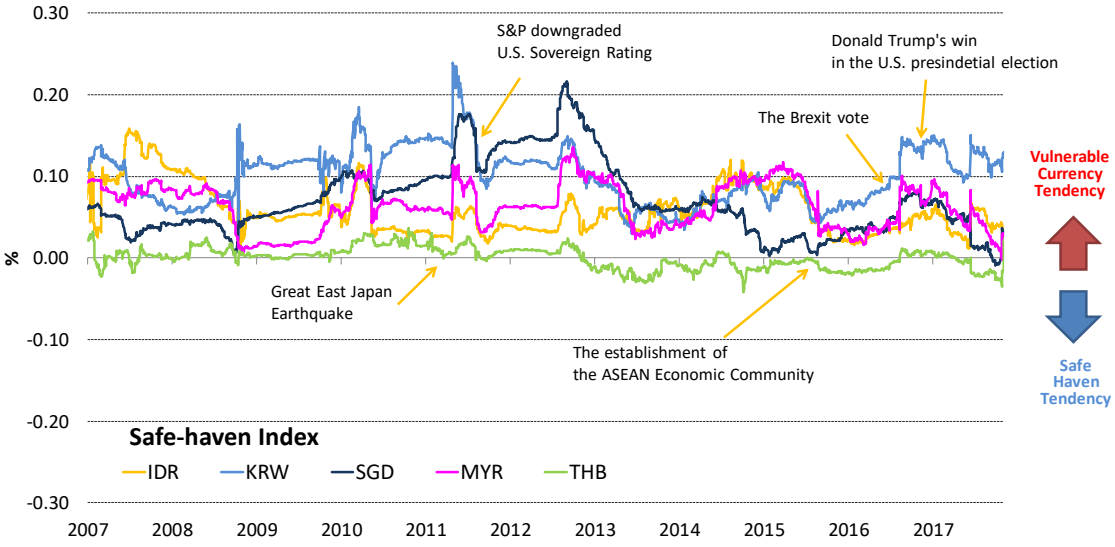
Note: A safe-haven index shows the impact of a 1-ppt rise in VIX on percent change of exchange rates/ asset prices. Its negative value means a safe-haven currency/asset that appreciates when the VIX rises, while its positive value shows a currency/asset that weakens.
Source: Bloomberg Economics, author's estimation

Figure 6. Oil's Safe-haven Effects Depend on Its Price Level



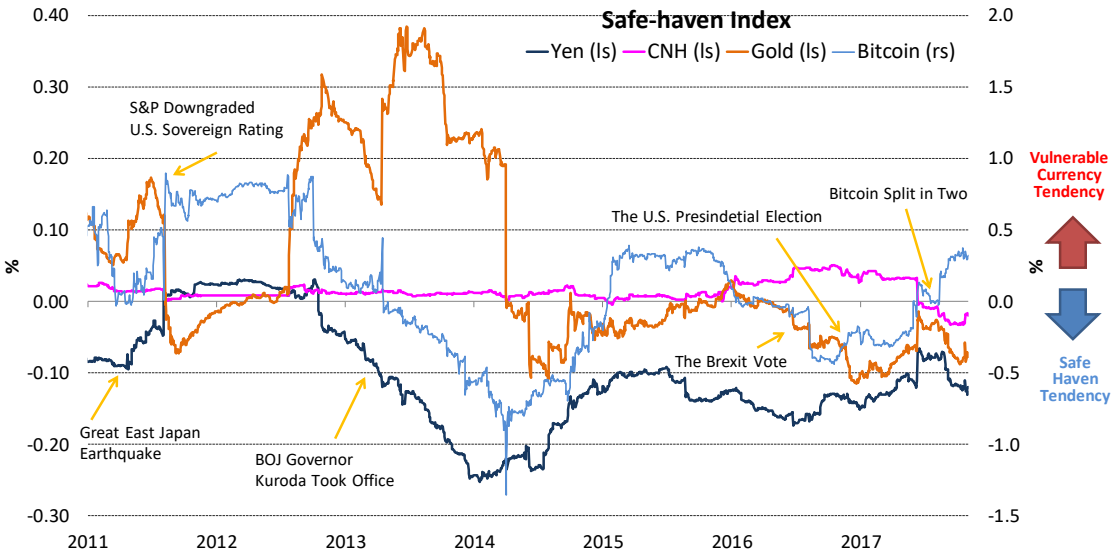
Note: A safe-haven index shows the impact of a 1-ppt rise in VIX on percent change of exchange rates/asset prices. Its negative value means a safe-haven asset that appreciates when the VIX rises, while its positive value shows an asset that weakens.
Source: Bloomberg Economics, author's estimation

Figure 7. Safe-haven Status of Emerging Asia Tend to Be Vulnerable



Note: A safe-haven index shows the impact of a 1-ppt rise in VIX on percent change of exchange rates. Its negative value means a safe-haven currency that appreciates when the VIX rises. Its positive value shows a currency that weakens when the VIX rises.
Source: Bloomberg Economics, author's estimation

Figure 8. PBOC Announcement May Have Crashed Bitcoin's Safe-haven Status



Note: A safe-haven index shows the impact of a 1-ppt rise in VIX on percent change of exchange rates/ asset prices. Its negative value means a safe-haven currency/asset that appreciates when the VIX rises, while its positive value shows a currency/asset that weakens.
Source: Bloomberg Economics, author's estimation

Table 1. Safe-haven Ranking

Year	Advanced Economies							ASEAN				East Asia			
						Commodity Exporters									
	USD	JPY	CHF	EUR	GBP	AUD	CAD	IDR	MYR	SGD	THB	KRW	HKD	CNY	CNH
2002	7	3	1	2	4	9	11			5	6	10	8		
2003	7	6	1	2	3	10	11	9		5	4	12	8		
2004	6	11	1	2	3	12	7	10		8	4	9	5		
2005	5	12	6	7	3	10	11	9	4	8	1	13	2	14	
2006	4	12	1	6	2	13	10	5	11	8	3	14	7	9	
2007	4	1	2	8	9	14	13	12	10	7	3	11	5	6	
2008	4	1	2	8	12	14	13	11	9	7	3	10	5	6	
2009	4	1	5	10	11	14	13	8	7	9	6	12	2	3	
2010	2	1	10	11	13	15	14	7	8	9	4	12	5	3	6
2011	1	2	7	13	10	15	14	8	9	11	6	12	3	5	4
2012	1	4	11	14	9	15	12	6	8	13	7	10	2	3	5
2013	3	1	12	14	7	15	13	9	8	11	6	10	2	4	5
2014	4	1	2	6	8	15	10	14	12	11	9	13	5	3	7
2015	6	2	1	5	7	13	15	11	14	9	10	12	4	3	8
2016	3	1	2	4	12	15	14	8	10	11	9	13	5	6	7
2017	4	1	2	7	12	13	15	10	11	8	9	14	6	3	5
Total	4.4	3.7	4.1	7.5	7.9	12.9	11.9	8.8	9.4	8.7	5.8	11.1	4.8	4.9	5.8
2002-07	6.0	7.3	2.1	4.6	4.7	10.5	10.0	8.8	9.3	6.8	3.6	10.7	6.1	7.9	-
2008-17	3.4	1.6	5.3	9.2	9.9	14.3	13.0	8.8	9.4	9.9	7.2	11.3	3.9	4.2	5.8

Note: Safe-haven currency annual ranking based on the averages of daily safe-haven ranking. The last three lines show the average of the sample periods.
Source: Author's estimation

Table 2. Safe-haven Ranking – Standardized

Year	Advanced Economies							ASEAN				East Asia			
						Commodity Exporters									
	USD	JPY	CHF	EUR	GBP	AUD	CAD	IDR	MYR	SGD	THB	KRW	HKD	CNY	CNH
2002	7	5	1	2	4	9	11			3	6	10	8		
2003	7	6	1	3	5	10	12	8		4	2	11	9		
2004	6	11	1	3	4	12	7	10		8	5	9	2		
2005	4	11	6	7	5	9	12	8	3	10	1	13	2	14	
2006	4	12	1	6	3	9	10	5	13	8	2	14	7	11	
2007	4	1	2	7	8	14	10	11	13	9	3	12	5	6	
2008	4	1	2	7	10	14	13	12	11	9	3	8	5	6	
2009	3	1	5	11	10	14	13	8	7	12	6	9	2	4	
2010	2	1	8	11	12	15	14	6	9	13	3	10	7	4	5
2011	1	2	3	11	10	15	13	8	9	14	6	12	7	5	4
2012	1	2	7	12	11	15	13	5	9	14	8	10	6	4	3
2013	2	1	11	12	7	15	14	4	8	13	10	9	3	5	6
2014	4	1	2	5	9	14	10	8	13	15	11	12	6	3	7
2015	6	1	2	5	7	11	15	13	14	9	10	12	3	4	8
2016	4	1	2	3	11	14	15	7	6	9	12	13	8	5	10
2017	4	1	2	6	12	13	15	9	8	7	11	14	10	3	5
Total	4.4	3.66	3.74	7.0	7.7	12.6	12.1	8.2	9.5	10.0	6.1	10.8	6.0	5.4	6.5
2002-07	6.0	7.6	2.5	4.8	4.8	10.5	10.3	8.9	11.0	7.6	3.2	11.3	6.4	9.0	-
2008-17	3.4	1.2	4.5	8.4	9.5	13.8	13.2	7.8	9.1	11.5	7.9	10.5	5.8	4.5	6.5

Note: Safe-haven currency annual ranking based on the averages of daily safe-haven ranking standardized by standard deviation during the sample period. The last three lines show the average daily ranking of the sample periods.
Source: Author's estimation

Table 3. Share of Turnover of OTC Foreign Exchange Instruments, by Currency

Currency	2001		2004		2007		2010		2013		2016	
	Share	Rank	Share	Rank	Share	Rank	Share	Rank	Share	Rank	Share	Rank
USD	89.9	1	88.0	1	85.6	1	84.9	1	87.0	1	87.6	1
EUR	37.9	2	37.4	2	37.0	2	39.0	2	33.4	2	31.4	2
JPY	23.5	3	20.8	3	17.2	3	19.0	3	23.0	3	21.6	3
GBP	13.0	4	16.5	4	14.9	4	12.9	4	11.8	4	12.8	4
AUD	4.3	7	6.0	6	6.6	6	7.6	5	8.6	5	6.9	5
CAD	4.5	6	4.2	7	4.3	7	5.3	7	4.6	7	5.1	6
CHF	6.0	5	6.0	5	6.8	5	6.3	6	5.2	6	4.8	7
CNY	0.0	35	0.1	29	0.5	20	0.9	17	2.2	9	4.0	8
SGD	1.1	12	0.9	14	1.2	13	1.4	12	1.4	15	1.8	12
HKD	2.2	9	1.8	9	2.7	8	2.4	8	1.4	13	1.7	13
KRW	0.8	15	1.1	11	1.2	14	1.5	11	1.2	17	1.7	15
THB	0.2	24	0.2	22	0.2	25	0.2	26	0.3	27	0.4	24
MYR	0.1	26	0.1	30	0.1	28	0.3	25	0.4	25	0.4	25
IDR	0.0	28	0.1	27	0.1	29	0.2	30	0.2	30	0.2	31

Source: BIS(2016)

Table 4. Safe-haven Ranking with Alternative Assets - Standardized

Ranking	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	CHF	CHF	CHF	THB	CHF	CHF	JPY	JPY	JPY	USD	USD	JPY	JPY	JPY	JPY	JPY
2	EUR	GOLD	Crude Oil	HKD	THB	JPY	CHF	HKD	USD	JPY	JPY	Bitcoin	CHF	CHF	CHF	GOLD
3	SGD	EUR	HKD	Crude Oil	GBP	THB	THB	USD	THB	GOLD	GOLD	HKD	Bitcoin	HKD	Bitcoin	CHF
4	GOLD	THB	EUR	MYR	USD	USD	USD	CNY	CNY	Bitcoin	CNH	USD	CNY	GOLD	EUR	CNY
5	GBP	SGD	GOLD	USD	IDR	HKD	HKD	CHF	Bitcoin	CHF	CNY	IDR	USD	EUR	GOLD	USD
6	JPY	GBP	GBP	GBP	EUR	Crude Oil	Crude Oil	THB	IDR	CNH	IDR	CNY	GOLD	CNY	USD	CNH
7	THB	Crude Oil	THB	CHF	Crude Oil	CNY	CNY	MYR	HKD	CNY	Bitcoin	CNH	EUR	USD	CNY	Bitcoin
8	USD	JPY	USD	EUR	HKD	EUR	GOLD	GOLD	CNH	THB	HKD	GBP	HKD	GBP	MYR	EUR
9	HKD	USD	CAD	IDR	AUD	GBP	EUR	IDR	CHF	HKD	CHF	MYR	CNH	CNH	IDR	SGD
10	AUD	IDR	KRW	AUD	SGD	SGD	KRW	KRW	GOLD	IDR	THB	KRW	IDR	SGD	HKD	MYR
11	Crude Oil	HKD	SGD	SGD	CAD	CAD	SGD	GBP	MYR	MYR	MYR	THB	GBP	Bitcoin	SGD	GBP
12	KRW	KRW	IDR	GOLD	CNY	GOLD	GBP	EUR	KRW	Crude Oil	Crude Oil	CHF	Crude Oil	THB	CNH	IDR
13	CAD	AUD	JPY	JPY	JPY	IDR	MYR	Crude Oil	EUR	GBP	KRW	GOLD	CAD	AUD	GBP	THB
14		CAD	AUD	CAD	KRW	KRW	IDR	SGD	GBP	EUR	GBP	Crude Oil	THB	IDR	THB	HKD
15				KRW	MYR	MYR	CAD	CAD	Crude Oil	KRW	EUR	EUR	MYR	KRW	KRW	Crude Oil
16				CNY	GOLD	AUD	AUD	AUD	SGD	CAD	CAD	SGD	KRW	Crude Oil	Crude Oil	AUD
17									CAD	SGD	SGD	CAD	SGD	MYR	AUD	KRW
18									AUD	AUD	AUD	AUD	AUD	CAD	CAD	CAD

Note: Safe-haven currency annual ranking based on the averages of daily safe-haven ranking standardized by standard deviation during the sample period.
Source: Author's estimation

Table 5. Panel Regressions for the Full Sample Period

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependant Variable	**Safe Haven Index**				**Safe Haven Ranking**			
Country	All excluding the United States							
Starting Date	2002 Jan.	2002 Jan.	2002 Jan.	2002 Jan.	2002 Jan.	2002 Jan.	2002 Jan.	2002 Jan.
End Date	2017 Dec.	2017 Dec.	2017 Dec.	2017 Dec.	2017 Dec.	2017 Dec.	2017 Dec.	2017 Dec.
Constant	11.679***	9.358***	11.257***	11.613***	9.246***	8.345***	9.073***	9.155***
Current account balance, % of GDP	-0.345***	-0.190***	-0.338***	-0.334***	-0.157***	-0.104***	-0.154***	-0.153***
Two-year government bond yield	-2.266***		-2.139***	-2.189***	-0.837***		-0.775***	-0.786***
*Two-year yield * Carry-trade dummy*		-0.428		-0.636**		-0.082		-0.148*
Bid-Ask Spread			4.594*	4.359*			1.564*	1.507*
Pooloed or Fixed Effects	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
R-squared	0.647	0.629	0.652	0.653	0.520	0.441	0.527	0.528
Number of country	13	13	13	13	13	13	13	13
Observations	2383	2383	2373	2373	2389	2389	2379	2379

Note: *, **, *** indicate the 10%, 5%, 1% significant level.

Table 6. Panel Regression of Safe-haven Index before and after a Crisis Period

	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Dependant Variable	**Safe Haven Index**							
Country	All excluding the United States							
Starting Date	2002 Jan.	2002 Jan.	2002 Jan.	2002 Jan.	2008 Sep.	2008 Sep.	2008 Sep.	2008 Sep.
End Date	2008 Aug.	2008 Aug.	2008 Aug.	2008 Aug.	2017 Dec.	2017 Dec.	2017 Dec.	2017 Dec.
Constant	10.738***	7.857***	6.637***	7.749***	8.820***	10.156***	8.726***	8.291***
Current account balance, % of GDP	-0.379***	-0.315**	-0.234*	-0.234*	0.042	-0.034	0.034	0.072
Two-year government bond yield	-0.916**		-0.482	-0.525	1.084***		0.967***	0.964***
*Two-year yield * Carry-trade dummy*		-0.952		-0.911***		2.832		2.953***
Bid-Ask Spread			-5.626	-5.773			4.085*	5.052*
Pooloed or Fixed Effects	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
R-squared	0.595	0.603	0.614	0.618	0.782	0.762	0.782	0.786
Number of country	13	13	13	13	13	13	13	13
Observations	918	937	927	927	1446	1446	1446	1446

Note: *, **, *** indicate the 10%, 5%, 1% significant level.

Table 7. Panel Regression of Safe-haven Ranking before and after a Crisis Period

	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
Dependant Variable	**Safe Haven Ranking**							
Country	All except the United states							
Starting Date	2002 Jan.	2002 Jan.	2002 Jan.	2002 Jan.	2008 Sep.	2008 Sep.	2008 Sep.	2008 Sep.
End Date	2008 Aug.	2008 Aug.	2008 Aug.	2008 Aug.	2017 Dec.	2017 Dec.	2017 Dec.	2017 Dec.
Constant	8.233***	8.139***	7.744***	8.089***	7.873***	8.347***	7.820***	7.704***
Current account balance, % of GDP	-0.144***	-0.088*	-0.065	-0.063	-0.024	-0.053**	-0.027	-0.017
Two-year government bond yield	-0.367***		-0.219	-0.222	0.356***		0.305***	0.323***
*Two-year yield * Carry-trade dummy*		-0.320***		-0.291***		0.667***		0.732***
Bid-Ask Spread			-1.800	-1.805			1.926**	1.779**
Pooloed or Fixed Effects	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
R-squared	0.457	0.466	0.476	0.481	0.744	0.719	0.745	0.747
Number of country	13	13	13	13	13	13	13	13
Observations	943	943	933	933	1446	1446	1446	1446

Note: *, **, *** indicate the 10%, 5%, 1% significant level.

Table 8. Panel Regression of Safe-haven Ranking Including the U.S. Dollar

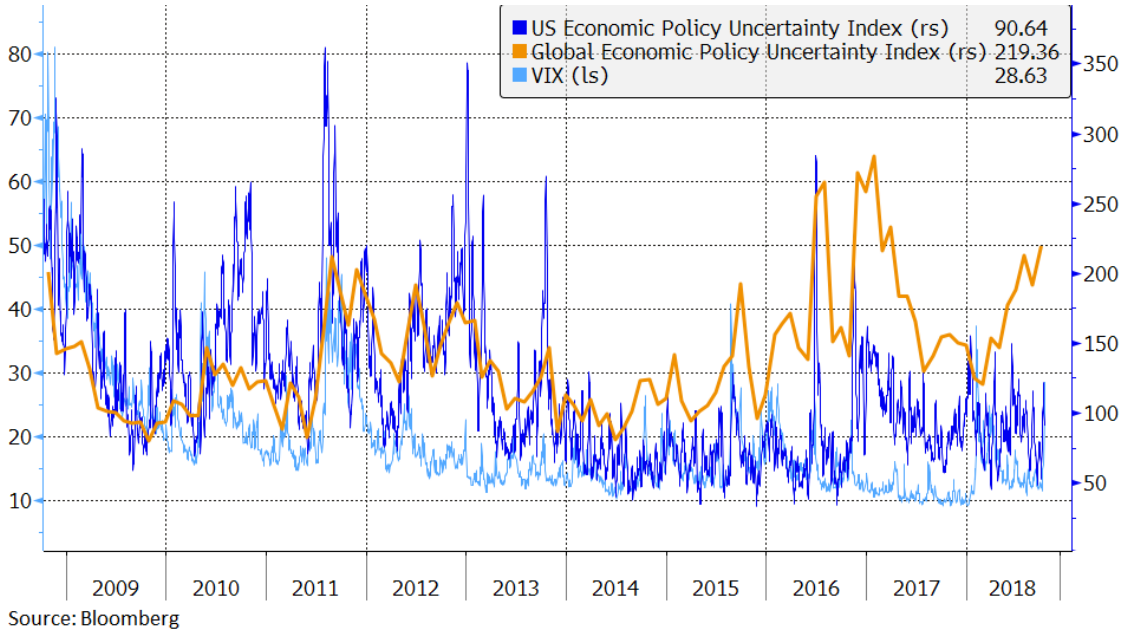
	(25)	(26)	(27)
Dependant Variable	**Safe Haven Ranking**		
Country	All the country		
Starting Date	2002 Jan.	2002 Jan.	2008 Sep.
End Date	2017 Dec.	2008 Aug.	2017 Dec.
Constant	9.913***	8.704***	7.150***
Current account balance, % of GDP	-0.158***	-0.043	-0.017
Two-year government bond yield	-0.742***	-0.379***	0.371***
Bid-Ask Spread	1.578*	-1.393	1.645**
Pooloed or Fixed Effects	Fixed	Fixed	Fixed
R-squared	0.531	0.467	0.752
Number of country	14	14	14
Observations	2571	1013	1558

Note: *, **, *** indicate the 10%, 5%, 1% significant level.

Appendix I Alternative Uncertainty Measurements

The market-based stock price volatility indexes aren't the only gauges to capture uncertainty. A text-mining technique has helped the development of news-based policy measurement. For example, Baker, Bloom, and Davis (2016) build indexes of policy-related economic uncertainty based on newspaper coverage frequency. They aim to capture uncertainty about who will make economic policy decisions, what economic policy actions will be undertaken and when, and the economic effects of policy actions (or inaction)—including uncertainties related to the economic ramifications of "noneconomic" policy matters. Their measures capture both near-term concerns (e.g., when will the Fed adjust its policy rate) and longer term concerns (e.g., how to fund entitlement programs), as reflected in newspaper articles. Monthly and daily EPU indexes are available for the United States from 1985 onward and then turn to indexes for specific policy categories, while only monthly indexes are available for other countries.

Appendix I - Figure 1

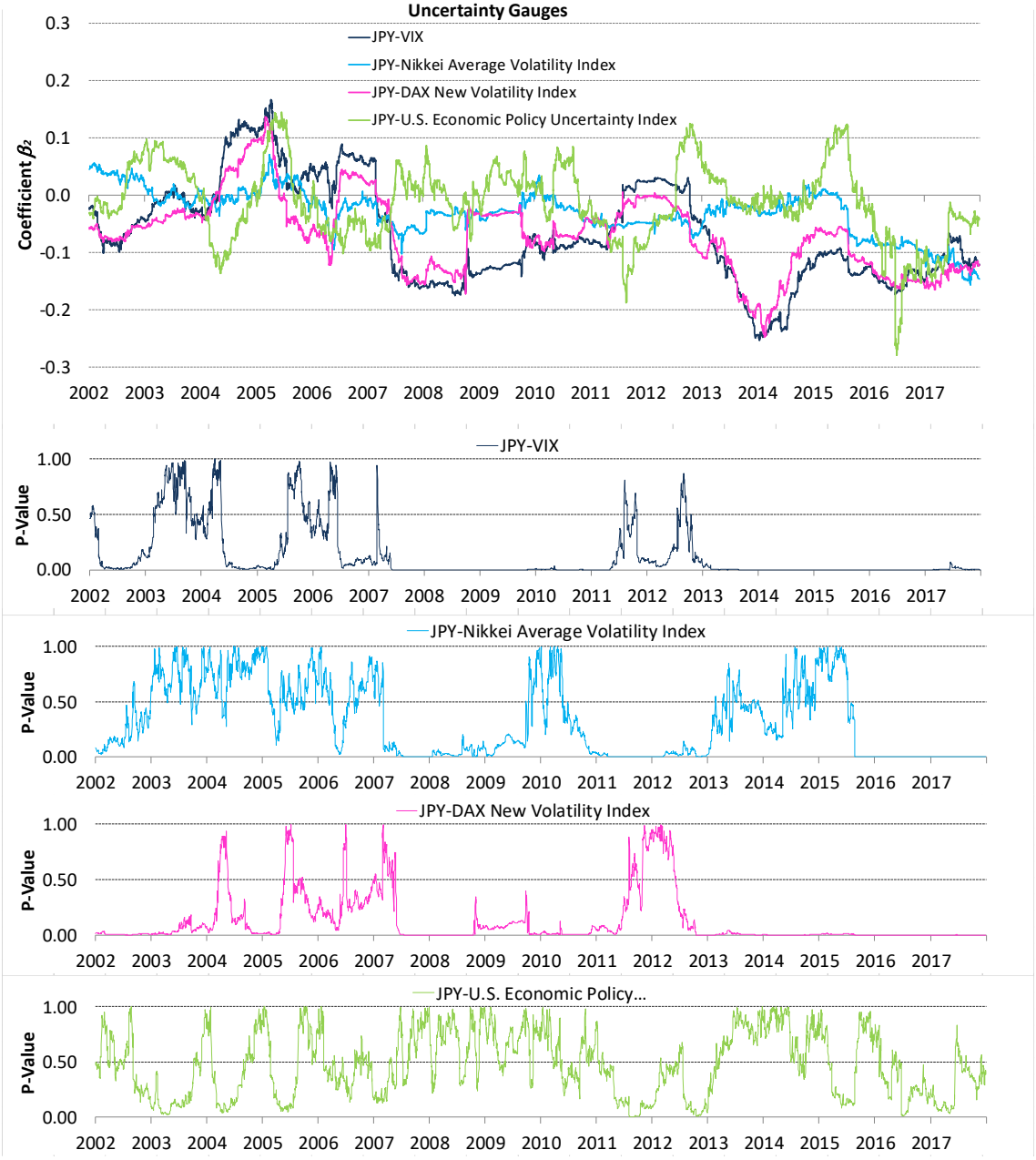


Source: Bloomberg

The comparison between uncertain gauges show the VIX shows relatively the better performance to capture a change in the currency's safe-haven status for the Japanese yen, the Swiss franc, and the euro than the news-based index and other regional equity volatility indexes do. Ozturk and Sheng (2017) show strong relationship between text-based uncertainty gauges and real economic activity such as household consumption, investment, and industrial production on monthly data. Even so, the *p*-values of rolling regressions with the 250 business day from window suggest the VIX is statistically significant – closer to zero – more often than the text-based uncertainty gauge.

In addition, I tested the core regional stock market volatility indexes such as the Nikkei average volatility index (Nikkei VI) and the new Volatility Indexes of DAX (VDAX) for the Japanese yen, the Swiss franc, and the euro. Some may argue that the Japanese yen and the euro are more closely associated with the Nikkei 225 and the DAX. In the case of the yen, the VIX's coefficients are much deeper negative values than the Nikkei VI's and the VIX's p-values are clearly more statistically significant than the Nikkei VI's (Figure 2). In the case of the Swiss franc and the euro, the VIX and the VDAX, the performance to capture safe-haven status are similar to each other throughout the sample period. To keep the consistency of the safe-haven index safe-haven indexes across all the currency, I decide to use the VIX as the proxy of the uncertainty and investors' risk appetite.

Appendix I - Figure 2 Safe-haven Indexes of Alternative Measurements (JPY)



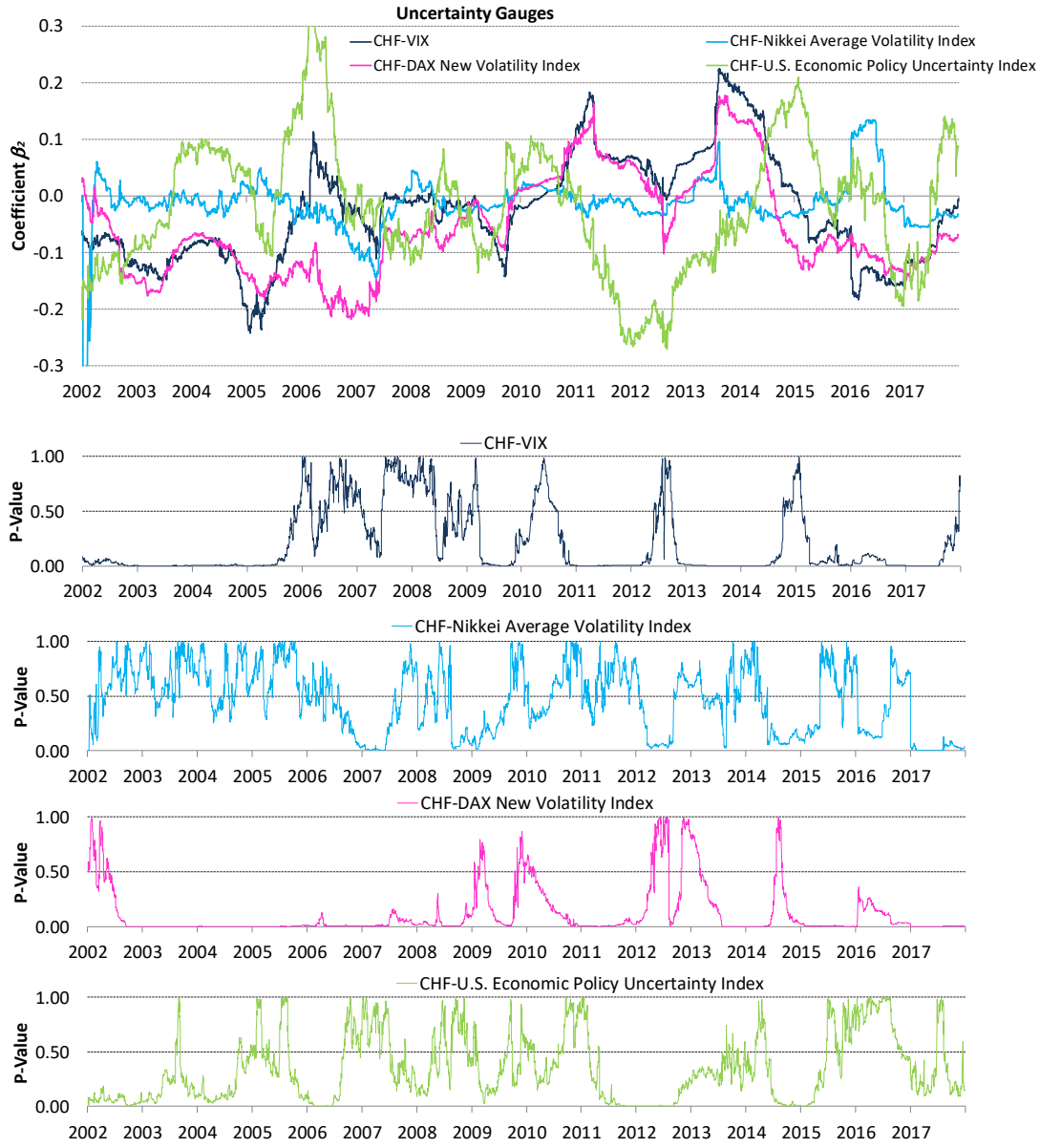
Source: Bloomberg Economics, author's estimation

Note: The charts above show the coefficients and p-values estimated from the rolling regression with a 250 business day window

$$\Delta \mathbf{ln}(\boldsymbol{s_t}) = \boldsymbol{\alpha_i} + \boldsymbol{\beta_1}\Delta(\boldsymbol{r_t} - \boldsymbol{r_t^*}) + \boldsymbol{\beta_2}\Delta(\boldsymbol{Uncertainty_t}) + \boldsymbol{\varepsilon_t}$$

where $\Delta\ln(s_t)$ denotes the log difference of the bilateral exchange rate in the Japanese yen per U.S. dollar, $\Delta(r_t - r_t)$ is a change in the two-year government bond yield differential between Japan and the United States and, $\Delta(Uncertainty_t)$ reflects a change in Uncertainty gauges such as the VIX, the Nikkei Average Volatility Index, DAX New Volatility Index, or the U.S. Economic Policy Uncertainty Index. The charts include the slope coefficients β_1 and β_2 as well as the *p*-values of the regressions. The sample period is the beginning of 2001 to end of 2017, which varies by currency.

Appendix I - Figure 3 Safe-haven Indexes of Alternative Measurements (CHF)



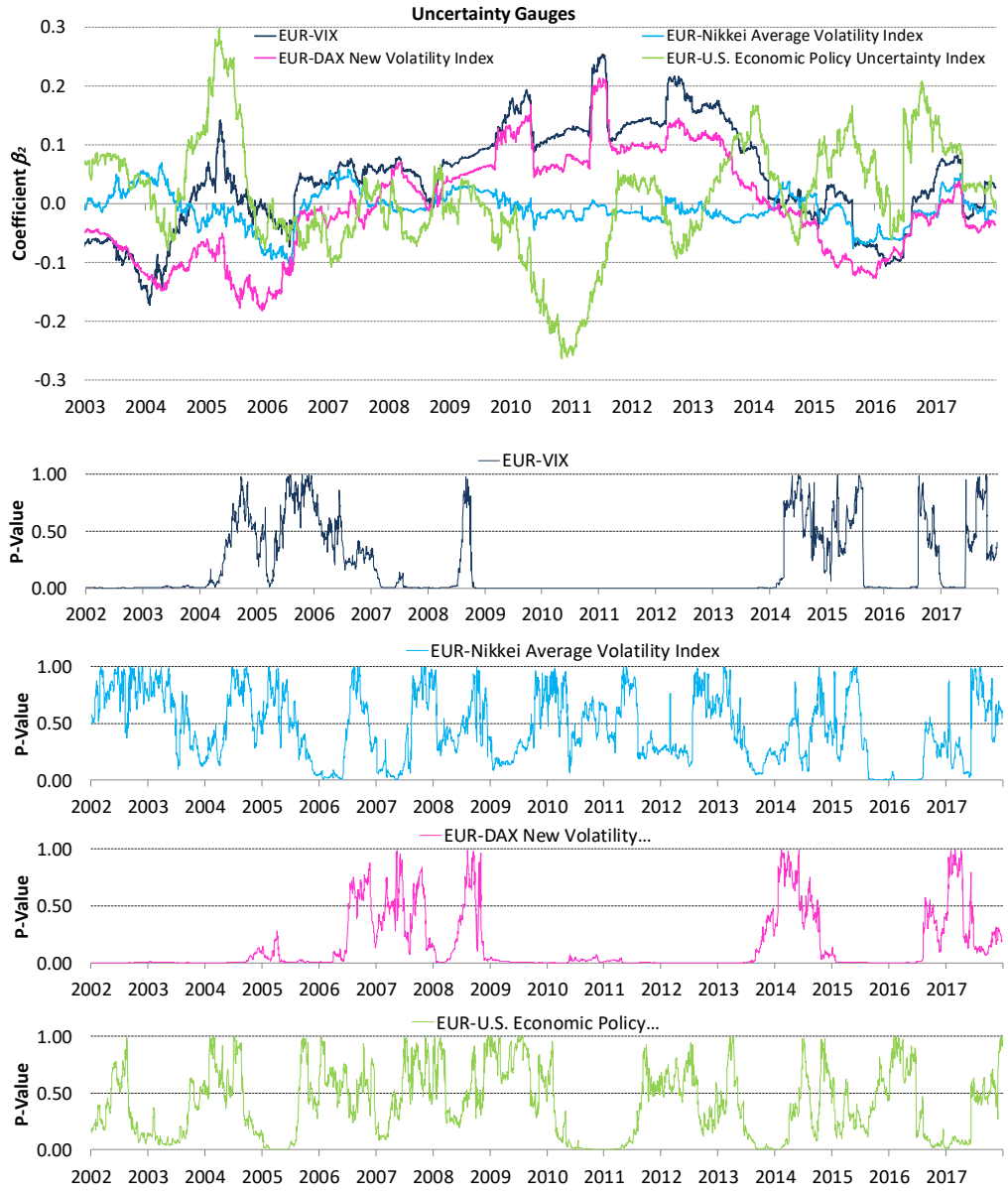
Source: Bloomberg Economics, author's estimation

Note: The charts above show the coefficients and p-values estimated from the rolling regression with a 250 business day window

$$\Delta \ln(s_t) = \alpha_i + \beta_1 \Delta(r_t - r_t^*) + \beta_2 \Delta(Uncertainty_t) + \varepsilon_t$$

where $\Delta\ln(s_t)$ denotes the log difference of the bilateral exchange rate in the Swiss Franc per U.S. dollar, $\Delta(r_t - r^*_t)$ is a change in the two-year government bond yield differential between Switzerland and the United States and, $\Delta(Uncertainty_t)$ reflects a change in Uncertainty gauges such as the VIX, the Nikkei Average Volatility Index, DAX New Volatility Index, or the U.S. Economic Policy Uncertainty Index. The charts include the slope coefficients β_1 and β_2 as well as the *p*-values of the regressions. The sample period is the beginning of 2001 to end of 2017, which varies by currency.

Appendix I - Figure 4 Safe-haven Indexes of Alternative Measurements (EUR)



Source: Bloomberg Economics, author's estimation

Note: The charts above show the coefficients and p-values estimated from the rolling regression with a 250 business day window

$$\Delta \ln(s_t) = \alpha_i + \beta_1 \Delta(r_t - r_t^*) + \beta_2 \Delta(Uncertainty_t) + \varepsilon_t$$

where $\Delta\ln(s_t)$ denotes the log difference of the bilateral exchange rate in the euro per U.S. dollar, $\Delta(r_t - r^*_t)$ is a change in the two-year government bond yield differential between Germany and the United States and, $\Delta(Uncertainty_t)$ reflects a change in Uncertainty gauges such as the VIX, the Nikkei Average Volatility Index, DAX New Volatility Index, or the U.S. Economic Policy Uncertainty Index. The charts include the slope coefficients β_1 and β_2 as well as the *p*-values of the regressions. The sample period is the beginning of 2001 to end of 2017, which varies by currency.

Appendix II Trading Hour Difference

Trading hours in exchange rates and equity volatility indexes are different in the worldwide. Hard currencies like the U.S. dollar and Japanese yen are available for 24-hour trading, while regional currencies have limited trading hours. The daily data is based on the closing rate of trading hours. That means the fluctuation of the VIX may not be associated with Asian currencies on the same day. So, this paper used the previous day's change in the VIX for the estimation of the emerging Asia currencies. The lagged VIX change shows the better performance to capture the daily exchange arte returns than its same day change. The lagged VIX's performance is also better than a change in the Economic Policy Uncertainty Index.

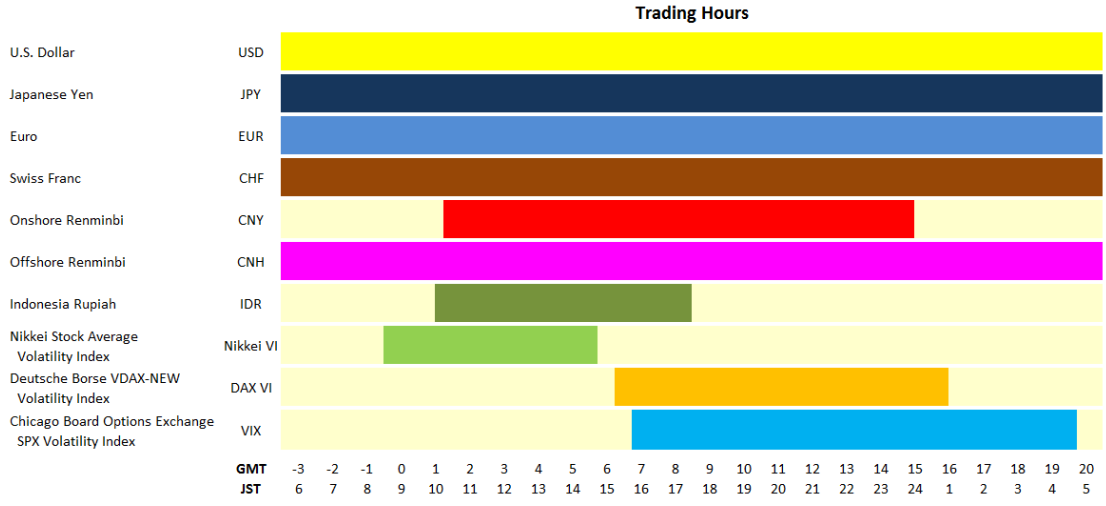
Model for Soft Currency (traded during day time only)

$$dln\left(\frac{LCY}{USD}t\right) = \alpha + \beta_1 d(USDLCY\_2Y_{t-1}) + \beta_2 d(VIX_{t-1}) + \varepsilon_t$$

LCY: local currency [t](or alternative assets)
USDLCY_2Y: Two-year U.S. government bond yield [t-1] minus local currency yield [t]
VIX: a measure of implied volatility of S&P 500 index [t-1]

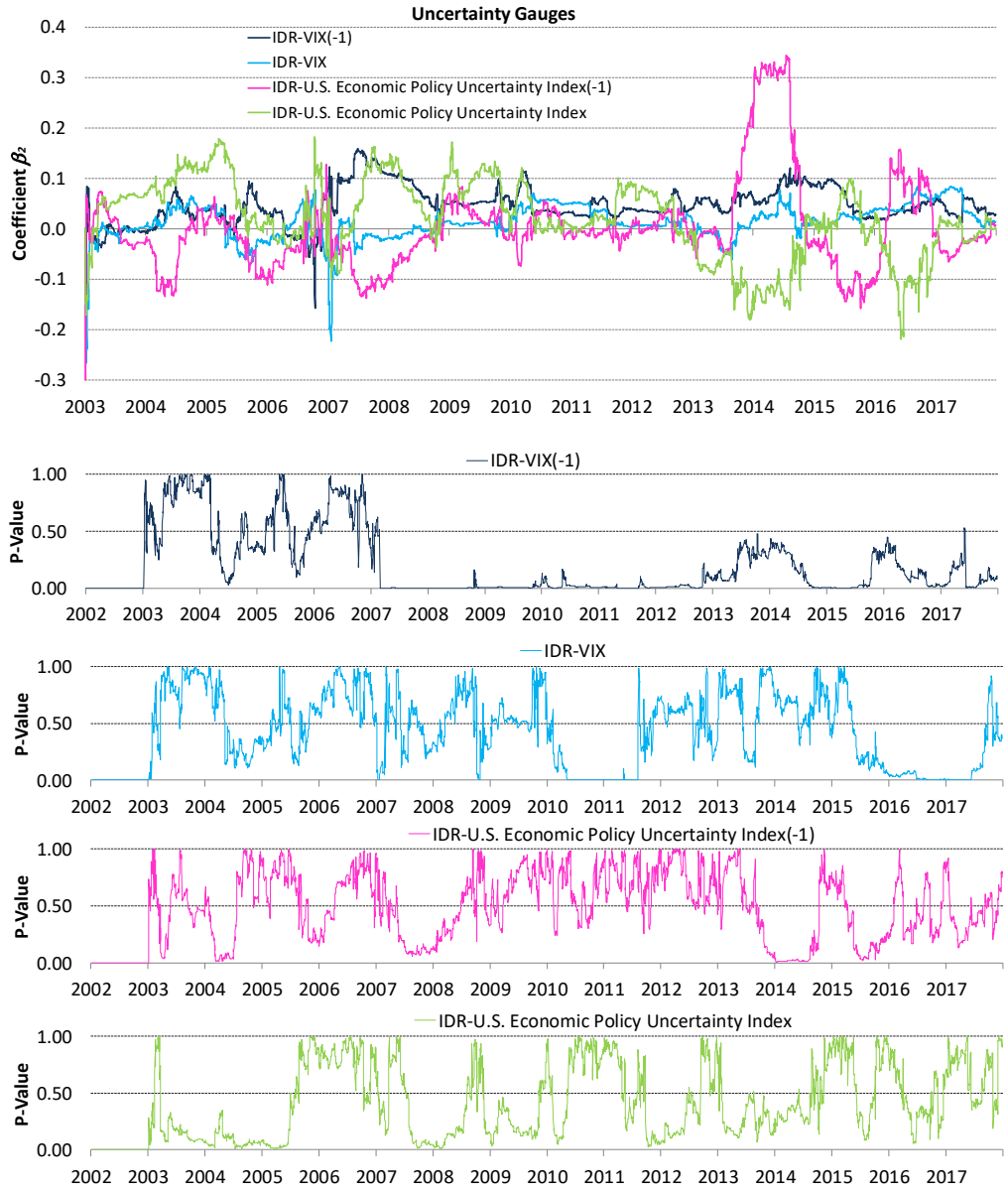
Implement a rolling OLS regression with a 250 business day window

Appendix II - Figure 1



Note: Data availablility during a day on the Bloomberg terminal. It's not necessarily the same as the official trading hours.
Source: Bloomberg

Appendix II Figure 2 – Safe-haven Indexes of Alternative Measurements (IDR)



Source: Bloomberg Economics, author's estimation

Note: The charts above show the coefficients and *p*-values estimated from the rolling regression with a 250 business day window

$$\Delta \boldsymbol{ln}(\boldsymbol{s_t}) = \boldsymbol{\alpha} + \boldsymbol{\beta_1}\Delta(\boldsymbol{r_t} - \boldsymbol{r_t^*}) + \boldsymbol{\beta_2}\Delta(\boldsymbol{Uncertainty_t}) + \boldsymbol{\varepsilon_t}$$

$$\textbf{Or } \Delta \boldsymbol{ln}(\boldsymbol{s_t}) = \boldsymbol{\alpha} + \boldsymbol{\beta_1}\Delta(\boldsymbol{r_t} - \boldsymbol{r_{t-1}^*}) + \boldsymbol{\beta_2}\Delta(\boldsymbol{Uncertainty_{t-1}}) + \boldsymbol{\varepsilon_t}$$

where $\Delta ln(s_t)$ denotes the log difference of the bilateral exchange rate in the Indonesian rupiah per U.S. dollar, $\Delta(r_t - r^*_t)$ is a change in the two-year government bond yield differential between Indonesia and the United States, and $\Delta(Uncertainty_t)$ reflects a change in Uncertainty gauges such as the VIX or the U.S. Economic Policy Uncertainty Index. The charts include the slope coefficients β_1 and β_2 as well as the *p*-values of the regressions. The sample period is the beginning of 2001 to end of 2017, which varies by currency.

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