Discussion Paper Series

Graduate School of Economics and School of Economics

Meisei University

Discussion Paper Series, No.44

December, 2022

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Time-varying safe haven status of major currencies*

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Abstract

The main objective of this paper is to investigate the temporal variation of the safe haven status of the Japanese yen, Swiss franc, British pound and euro relative to the U.S. dollar. We define a safe haven currency as the currency investors prefer to purchase when exchange rate volatility is high, focusing on a time-varying degree of risk aversion for the four currencies. The temporal variation in investor risk aversion, which is usually unobservable, is simulated explicitly using a rolling GARCH-in-mean model to analyze the daily exchange rate from January 1, 2000 to November 30, 2018. At the time of the global financial crisis, the Swiss franc, British pound and euro were likely safe haven currencies, while the Japanese yen emerged as a safe haven sometime later. Moreover, we suggest that investor risk aversion is affected by the economic policies of each country, and find a strong relation among euro, British pound and Swiss franc investor risk attitudes. More specifically, the euro is often a substitute for the British pound and a complement for the franc during risk-off markets.

Keywords: GARCH-in-mean model, risk aversion, safe-haven currencies

JEL Classification: F31, G15, G17

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* This study was supported by Dr. Koichi Hamada of Yale University, Dr. Takatoshi Ito of Columbia University, and Dr. Yutaka Harada, a former board member of the Bank of Japan. We are immensely grateful to them for their comments on an earlier version of the manuscript. Economists Takashi Yoshimatsu, Hiroshi Miyazaki, Hiroki Shimatsu and Mikihiro Matsuoka provided deep insights that assisted the research. We would like to show our gratitude to them. We are also grateful for the insightful comments offered by anonymous peer reviewers. Nakata acknowledges financial support from JSPS, with a Grant-in-Aid for Scientific Research(C) 20K01757.

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1. Introduction

Investors tend to become risk averse when global financial risk increases and suddenly begin to short risk assets in favor of assets considered to be relatively safe. When financial markets experience such a risk-off episode, currency investors tend to purchase so-called safe haven currencies, designated hereinafter as SHCs.[1]

The conventional view had been that the U.S. dollar is an SHC for investors during periods of financial uncertainty or turmoil, but in recent years, a subject of discussion has been that the Japanese yen and other currencies, rather than the U.S. dollar are regarded as SHCs.[2] These discussions became particularly pronounced around the 2007–08 global financial crisis (GFC). For instance, the yen appreciated about 3% against the U.S. dollar during 10 days after BNP Paribas halted withdrawals

[1] Habib and Stracca (2012) define a SHC as a currency that functions as a hedge for a reference portfolio of risky assets conditional on movements in global risk aversion.

[2] Kaul and Sapp (2006) assess fund flows into safe havens by examining intraday bid–ask spreads in the U.S. dollar and euro intra-day spot and forward rate from December 1, 1999 to December 31, 2000.

in August 2007, and more than 20% during the three months following Lehman's bankruptcy in September 2008. It appreciated more than 3% in a single day, on May 6, 2010, because of severely heightened Greek default concerns preceding the Greek government's passage of austerity measures.

A central question is why was the yen purchased in risk-off episodes, especially given that the Bank of Japan (BoJ) has flooded the market with yen since the onset of "Abenomics" at the beginning of 2013? The Japanese yen was expected to lose value against other currencies in response to this monetary policy, and it did in fact weaken. However, it has been confirmed frequently that the Japanese yen appreciated sharply for short periods whenever market volatility peaked. If the yen is an SHC, then an SHC sometimes seems to be unrelated to economic fundamentals such as domestic and overseas interest rate differentials and the amount of currency in circulation.[3]

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[3] Brunnermeier et al. (2008) show that dramatic exchange rate movements induced by the sudden unwinding of currency carry trade positions coincide with increased global risk or risk aversion, and suggest strongly that higher volatility leads investors to curb their carry trade activities because of decreased funding liquidity. Other research on the carry trade has been reported by Christiansen et al. (2011), McCauley and McGuire

Some recent studies have examined which currencies exhibit SHC properties in foreign exchange markets. Fatum and Yamamoto (2016) examine SHC behavior for six developed country currencies during the GFC period, pre-crisis period, and post-crisis period. They also assess which currencies are "safest" during the respective periods. Their results show the Swiss franc as the safest currency during the pre-crisis period and the Japanese yen during the GFC period as well as in the post-crisis period. In other words, only the Japanese yen maintained its SHC status after the GFC.[4]

Masujima（2017）defines two Safe Asset Indices (long term and short term) and using these indices assesses the safe-haven status of several currencies and assets. From a long-term perspective, only the Japanese yen and the Swiss franc maintained their safe-haven status for the period 1997-2015. Short-term, however, using rolling OLS estimation, Masujima finds that the safe-haven status of currencies like the Japanese yen and the Swiss franc is in fact time-varying.

To summarize the findings reported in the literature, first, the leading

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(2009), and Menkhoff et al. (2012).

[4] Fatum and Yamamoto (2016) also test the nonlinearity of a coefficient derived from the VIX. They find that many currencies exhibit nonlinear properties until the GFC period, but these properties disappear or are resolved after the crisis.

candidates for SHC status are the Swiss franc and Japanese yen, followed by the British pound and then the euro. Second, an SHC exhibits time-variant tendencies depending on changes in market participants' risk perception. The CBOE volatility index (VIX) is often used in many studies as a risk proxy and has been used by Masujima (2017), Habib and Stracca (2012), De Bock and de Carvalho Filho (2013), and Fatum and Yamamoto (2016).[5]

This study was conducted to investigate several notable exchange rate series of the Japanese yen/ U.S. dollar (JPY), Swiss Franc/ U.S. dollar (CHF), British pound/ U.S. dollar (GBP) and euro/ U.S. dollar (EUR), to ascertain which can be empirically characterized as SHCs. Also, this study was to identify periods during which the leading SHC candidates function as SHCs. For this study investors are assumed to be sensitive to risk (or to have a kind of market sentiment), defined here as the degree of risk aversion. That sensitivity is time-variant, resulting in the periodic appreciation of the SHC during times of risk.[6] We seek to identify when the four safe-haven

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[5] VIX is a common abbreviation for the volatility index published by the Chicago Board Options Exchange (CBOE). It is a crowd-sourced estimate of the volatility of the U.S. S&P 500 Index. Habib and Stracca (2012) use the VIX as a proxy for global risk aversion.

[6] Numerous researchers have examined the theoretical and empirical possibility that risk aversion is

candidates become SHCs by estimating and plotting the degree of time-variant risk aversion. The degree of risk aversion of investors in FX markets is typically unobservable, but we explicitly obtain an observable time-variant coefficient by exploiting the rolling estimation properties of the GARCH-in-Mean (GARCH-M) model.

Numerous studies have used the GARCH family model to consider the time-variant risk premium in the FX market. For example, Domowitz and Hakkio (1985) estimate the ARCH-M model for five currencies (British pound, French franc, Deutsche mark, Japanese yen, Swiss franc) for 1973–1982. Jiang and Chiang (2000) investigate whether the foreign exchange risk premium is related to volatility in the FX market and volatility in equity markets for four currencies (British pound, Canadian dollar, Deutsche mark, and Japanese yen) for 1973–1990.

As Engle et al. (1987) point out, the ARCH-M model generates a time-varying risk premium based on economic theory. Following Engle et al. (1987), our study also uses the GARCH-M model to obtain the degree of risk aversion theoretically, unlike the studies investigating SHC described above. Although some of these studies emphasize that the degree of risk aversion might be related to the risk off appreciation of

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time-varying, including Campbell and Cochrane (1999), Brunnermeier and Nagel (2008), and Guiso et al. (2018).

currencies, they rely on an estimated VIX coefficient to gauge risk sensitivity.[7] The drawback of this approach is that the VIX reflects risks affecting the U.S. stock market: although the U.S. stock market is sufficiently large to indirectly capture uncertainty in financial markets worldwide, the VIX might be insufficient when examining financial market turmoil only local to specific regions.[8]

The main contributions of this research paper are the following. First, we conclude that, among the four currencies we examine, the value of SHC varies depending on the period, in line with Masujima (2017). For example, the euro was the SHC in the early 2000s, but British pound became an SHC at around 2007. Later, the euro and franc joined the pound as SHCs immediately before the September 2008 GFC. Also, the Japanese yen briefly demonstrated safe haven properties in the period immediately thereafter. Furthermore, whereas the euro and franc were still SHCs when the Greek debt crisis emerged in October 2009, the Swiss franc appeared to lose its safe haven status following the franc's flash crash and the China shock in the first

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7 For example, work reported by Masujima (2017) and Fatum and Yamamoto (2016).

8 Hiraki and Fukunaga (2012) argue that fear over the bond market has remained unlinked to the exchange rate market since August 2011 using a Volatility index for both the bond and exchange rate market.

half of 2015, as did the euro.

Second, we discover that foreign exchange intervention by the Japanese government around 2004 altered the risk aversion of investors trading Japanese yen. That helped JPY to follow the government's intentions for policy. Similarly, intervention by the Swiss National Bank starting in 2011 altered investors' attitudes about risk, but it altered the risk aversion of investors trading the euro or British pound, not the Swiss franc. In addition to foreign exchange intervention, risk aversion of investors has apparently been affected by the economic policy implemented by each country, including the United States.

Third, our empirical findings suggest a robust relationship among investor risk attitudes towards the euro, British pound and Swiss franc. Investors likely view the euro as an alternative to the British pound and as a complement to the Swiss franc.

The remainder of the paper is organized as explained below. Section 2 presents a description of the estimation methods applied to obtain the degree of risk aversion and to analyze its dynamics referencing the JPY, GBP, CHF and EUR. Section 3 presents an evaluation, based on estimation results, of which currency is performing as the SHC. Section 4 summarizes the conclusions of the paper.

2. Estimating the Degree of Risk Aversion

2.1 Methodology

We use foreign exchange rate data and employ the generalized autoregressive conditionally heteroskedastic process in the GARCH-M model to investigate the time-varying risk aversion of investors. A simple GARCH (1,1)-M is expressed as

$$rp_t = \mu + \gamma\sigma_t^2 + \epsilon_t, \quad \epsilon_t|\Omega_{t-1} \sim N(0, \sigma_t) \tag{1}$$

$$\sigma_t^2 = \omega + \alpha\epsilon_{t-1}^2 + \beta\sigma_{t-1}^2, \ \ \omega > 0, \quad \alpha > 0, \quad \beta > 0 \tag{2}$$

where rp_t stands for the risk premium or excess return, ϵ_t expresses a random error, σ_t^2 denotes the conditional variance of ϵ_t at time t, Ω_{t-1} signifies the information at time t-1, and $\mu, \gamma,\ \omega,\ \alpha$, and β are parameters. $\omega,\ \alpha,$ and β must be non-negative to ensure positive volatility. Moreover, the measure of shock persistence $\alpha + \beta$ must be less than unity for stability to hold (stability condition of volatility clustering). Also, γ in equation (1) is interpreted as investors' sensitivity to risk or the coefficient of relative risk aversion. Engle et al. (1987) show that the sign and magnitude of γ depends on the utility function of investors in asset markets. If $\gamma = 0$, then investors are indifferent to volatility (risk) σ_t^2. Also, if $\gamma > 0$, then higher volatility will lead investors to demand a higher risk premium. μ in equation (1) is interpreted as the constant and average risk premium.

After producing evidence that an investor's degree of risk aversion is time-variant, we next analyze whether the currencies presented above are indeed SHCs and elucidate when the degree of risk aversion of a particular currency changes. Therefore, we apply a rolling estimation to the above GARCH-M and obtain the estimated γ in equation (1).[9] The left-hand side in equation (1), the foreign exchange risk premium rp_t in this study, is defined as[10]

$$rp_t = E[S_{t+1}|\Omega_t] - F_t \tag{3}$$

where S_{t+1} represents the logarithm of the spot exchange rate at time t+1, F_t stands for the logarithm of the time t forward exchange rate for delivery at time t+1, and $E[\cdot|\Omega_t]$ denotes the expectation operator on all information available at time t. Also, S_{t+1} and F_t are expressed as units of the currency per U.S. dollar.

Equation (3) shows a positive risk premium, meaning that investors enter into forward rate contracts at a lower forward rate than the expected spot rate at time t, whereas a negative risk premium indicates that investors enter into forward rate

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[9] Chou et al. (1992) and Cotter and Hanly (2010) are among the researchers who used rolling estimation to estimate the ARCH-M or GARCH-M's time-varying parameter.

[10] The definition of the foreign exchange risk premium is provided by Engle (2016), Fama (1984), Canova and Marrinan (1993), etc.

contracts at a higher forward rate than the expected spot rate at time t.

In general, the expected rate of return for a risky asset is higher than that for a safe asset if investors are assumed to be risk averse. In the FX market, trading the U.S. dollar at the forward rate is interpreted as trading the safe asset. Trading the U.S. dollar at the spot rate in the future is interpreted as trading the risky asset for domestic investors. Accordingly, if investors in the FX market are assumed to be risk averse and rational[11], then $rp_t > 0$ indicates that more investors are trading the U.S. dollar at a lower forward price against the local currency than expected. However, when $rp_t < 0$ is observed, more investors are trading the local currency at a lower forward price in terms of the U.S. dollar than expected.

The sign of risk aversion γ affects the sign of the risk premium. If $\gamma > 0$, then increased risk σ_t^2 results in $rp_t > 0$. The local currency is regarded as the SHC. Investors consequently purchase the local currency to temporarily flee the U.S. dollar because of losses arising from holding the U.S. dollar when the FX market is undergoing a risk-off episode. Similarly, if $\gamma < 0$, then the U.S. dollar is regarded as the SHC, and if $\gamma = 0$, investors are indifferent to the currency versus the U.S. dollar.

[11] We postulate that there exist few risk-lover investors.

2.2 Data

For the SHCs used for this study, we use daily exchange rate closing-price data for the New York market, as reported by Bloomberg. The data are three-month forward and spot data for the JPY, CHF, GBP and EUR (local currencies pairs with the dollar) from January 1, 2000 through November 30, 2018.

First, we generate a series of risk premiums at time *t* in equation (3) from the spot rate at time *t*+ three months and the 3 month-forward rates at time *t* for the four currencies.[12] Table 1 presents results of the descriptive statistics, a Ljung–Box test, and a Jarque–Bera test of the generated rp_t. As presented in Table 1, normality is rejected at the 1 percent significance level by the Jarque–Bera test. The existence of serial correlation is also suggested strongly by results obtained from the Ljung–Box (10) for all four currencies. This finding suggests that a risk premium can exist for all four currencies and that the risk premium is time-variant.[13] Therefore, application of

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[12] Forward and spot exchange rate data used herein are only for business days. They exclude weekends and national holidays. Accordingly, when the settlement date for the three-month ahead forward data from time "*t*" is not on a business day, there is no corresponding three-month ahead spot rate. In this case, we use data for the preceding business day and match it with the spot rate to calculate the risk premium.

[13] In addition, the kurtosis for the series of risk premiums for all three currencies is three or higher, indicating the likelihood that volatility is changing every day. Chan et al. (2013) also reported

the GARCH-M model is suitable for the sample.

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Insert Table 1 about here

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Second, we estimate equations (1) and (2) (based on Quasi-Maximum Likelihood estimation) using the above generated rp_t. The sample is then rolled forward by the end of each month starting from January 31, 2003 while keeping the window length of 804 business days unchanged.[14] We obtain 188 rolling estimates for each currency, with $\hat{\omega}$, $\hat{\alpha}$ and $\hat{\beta}$, all satisfying the required sign conditions. Stability conditions of volatility clustering $\hat{\alpha}+\hat{\beta}$ for JPY, CHF, GBP and EUR are presented in Figure 1. Dates used for the graphs in this study, including those shown in Figure 1, are intermediate dates for the estimation window. For example, when January 2002 is displayed at the bottom of the graph, the estimation window is the 804 business days

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positive excess kurtosis for major currency pairs versus the U.S. dollar.

[14] For our analysis we use a window length containing 804 samples. GARCH estimations have demonstrated that a larger number of samples produce more stable results. For the window length, we compared the results obtained when we have 543 (approximately 2 years) and 804 samples (approximately 3 years). The findings indicate that the stability condition $\alpha+\beta<1$ was better satisfied when we used 804 samples.

before and after that date. As Figure 1 shows, the stability condition for all currencies holds throughout the entire sample period, supporting our view that GARCH-M estimation fits the data well.

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Insert Figure 1&2 about here

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The estimated volatility $\hat{\sigma}_t^2$ of the three currencies in the foreign exchange market is shown in Figure 2. Estimated volatility is the rolling average for the estimated $\hat{\sigma}_t^2$ resulting from the rolling estimation. In Figure 2, we also show the simple monthly average values for the VIX as well as the rolling average for the VIX that matches the rolling GARCH-M window.[15] Our analysis reveals that a rise in the rolling average for the VIX starts from the first half of 2007 and that it accelerates in the second half of 2010. The September 2008 GFC, which disrupted financial markets severely, is wedged between these two periods. However, the estimated volatility of the JPY starts to rise sharply from the middle of 2005, followed by a similar movement in

[15] Sample values for the VIX were calculated from VIX daily closing prices at the following URL: https://www.cboe.com/tradable_products/vix/vix_historical_data/

the other two currencies from the first half of 2007. Moreover, although volatility for all three currencies peaks significantly around 2009, CHF volatility remains high until the middle of 2011. From the middle of 2011, JPY volatility rises again.

Our model reveals that the two volatility parameters moved similarly until the lead up to the GFC (September 2008) but deviate slightly thereafter. Specifically, we confirm that the rolling average of the VIX is flat but the estimated volatility of the JPY rises from the first half of 2015 (Chinese stock market flash crash).

These findings indicate that, despite the average rolling 804 business day estimated volatility window, the simulation adequately captures the VIX average monthly movements. The results also imply that idiosyncratic geopolitical risks, such as the Chinese stock market flash crash, have a much greater effect on the JPY rate than on either the EUR or the CHF. Although the original purpose of this study was identification of which currency acts as an SHC when the "global financial market" is risk-off, exactly when the global financial market is risk-off has in fact remained unclear. No composite global economic index captures these episodes. Many recent studies have sought to use the VIX to capture these episodes. However, it is apparent that the estimated volatility from our model can capture both U.S. stock market idiosyncratic risk and financial risk that is not idiosyncratic to the US stock market.[16]

3. Empirical Findings

3.1 Japanese Yen

Figure 3 (1) depicts the investor risk appetite for JPY. The dates referenced here are analogous to those used in the graph, but we caution readers to note that the date for the estimation period is the intermediate of 804 business days.

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Insert Figure 3(1) about here

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From the start of the sample period to immediately before the GFC in September 2008, $\hat{\gamma}$ is either negative or zero at approximately the 5% significance level. The JPY value shows a tendency to fall when volatility is high (that is, when the US dollar is deemed to be the SHC). For example, $\hat{\gamma}$ becomes significant and negative around the second half of 2003, but the monthly spot rate sharply appreciates. This

[16] The strong correlation with US financial markets is not surprising given that the exchange rates used for our study are given in relation to the U.S. dollar.

appreciation can be interpreted by the lower estimated volatility of the JPY in the same period of Figure 2. In other words, the JPY trend has been determined by its fundamentals because this period is risk-on.

Around the first half of 2004, $\hat{\gamma}$ turns markedly negative. The estimated volatility also remains low, but the observed spot rate decreases slightly. This period included large-scale foreign exchange intervention by the Japanese government to sell the JPY to disrupt the yen's rapid appreciation[17]. Our analysis indicates that changes in the value of the yen during this period follow the policy aims pursued by the Japanese government's intervention, which also simultaneously induced $\hat{\gamma}$ to decrease. The negative $\hat{\gamma}$ causes investors to attempt to purchase U.S. dollars and to short the yen in risk-off circumstances. The intervention in this period is interesting in that it altered the attitudes of investors in the FX market as well[18].

During the GFC, even though the JPY appreciated sharply, $\hat{\gamma}$ is not statistically significantly different from zero: its 95% confidence interval band is wide. Masujima (2017) also insist that the JPY is not an SHC for this period and this is

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[17] The Japanese government's heavy intervention to curb the Japanese yen's rise continued from January 2003 through March 2004.

[18] Ito (2005) presents a discussion of intervention by the Japanese government during this period.

consistent with our results. A review of financial policy data during this period reveals that, apart from Japan, six Western central banks lowered their policy interest rates around October 8, 2008 (immediately after the GFC), and that the FRB began easing operations in November of that year[19]. Consequently, JPY appreciation during this period was likely not attributable to the yen's status as an SHC, but was instead driven by changes in fundamentals such as widening interest rate differentials and the decrease in the growth rate of Japan's monetary base relative to that of the U.S.

The Japanese yen emerged clearly as an SHC from around the first half of 2009 to roughly the middle of that year. Accordingly, the JPY appreciated. It is possible that, because currency investors regarded the BoJ's monetary easing stance as passive, the consensus that "the Japanese yen is a safe haven" spread gradually throughout financial markets. This could account for the change in investor risk aversion in our simulation.

One other interesting period was from the first half of 2012 to the end of 2014 (excluding the first half of 2013), a period when investor risk aversion remained

[19] The BoJ action lagged the European and the U.S central banks. Although the BoJ lowered the policy rate by 0.2% (not 0.25%) from 0.5% to 0.3% on October 31, 2010, this was still small compared to actions taken by the European and U.S. central banks.

significant and positive. Immediately before investor risk aversion turns positive (that is, when the yen becomes an SHC), credit rating companies including Standard and Poor's (S&P) downgraded their ratings of U.S. sovereign debt. Also, the Swiss National Bank (SNB) began to intervene to sell its currency in unlimited quantities (details later). Both events likely induced investors to prefer the Japanese yen. During this period, there were often sudden bouts of JPY appreciation. Some researchers have attributed this phenomenon to Japanese yen repatriation by carry traders. Our results are also interpreted as suggesting a strong likelihood of Japanese yen repatriation during this period because investor risk aversion remains significant and positive.[20]

This period overlaps with both the third round of quantitative monetary easing (QE3) by the FRB and the policy stance change of the BoJ.[21] The BoJ had started to step up its massive monetary easing policy from the first half of 2013. The JPY spot rate is roughly flat during this period, except for the first half of 2013, because both the U.S. and Japan implemented monetary easing policies. In fact, the

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[20] Chantapacpedong et al. (2017) and Chuffart and Dell'Eva (2020) investigate quantitative easing and the carry trade in Japan during this period.

[21] The FRB implemented the QE3 from September 2012 to October 2014 aimed at exercising low inflation.

JPY depreciates sharply; $\hat{\gamma}$ becomes nonsignificant during the first half of 2013. This period is consistent with the start of the Abenomics, which suggests that Abenomics strongly affected market sentiment initially.

3.2 Swiss franc, British pound, and Euro

Figure 3 (2) shows the degree of investor risk aversion in relation to the CHF. From immediately before the GFC, including Greek's debt crisis (October, 2011), until the first half of 2011, the degree of investor risk aversion was positive at the 5% significance level.[22] As the figure shows, with the exception of a brief period immediately after the Greek debt crisis, the observed spot rate continued to appreciate until an announcement by the SNB to buy foreign currencies in unlimited quantities in September 2011.[23] This trend in the spot rate coincided with a positive degree of

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[22] Another important event that coincides with a positive risk aversion value in the first half of 2002 is the WorldCom accounting scandal in the United States.

[23] The Greek debt crisis emerged after the GFC. The spillover effects led to increased buying of the Swiss franc. The SNB intervened in the FX market to stop the appreciation of the Swiss franc at this time, and began "unlimited" foreign exchange buying (the SNB set an exchange rate target of 1.2 francs to the euro) from September 2011. However, the SNB announced suddenly that it would end the scheme in January 2015. The announcement caused the exchange rate of the franc against the

investor risk aversion along with high volatility from August 2008. The CHF spot rate depreciated sharply immediately after the beginning of unlimited intervention by the SNB. Thereafter, it depreciated slightly or remained largely flat. This modest depreciation might be attributable to the fact that the degree of investor risk aversion remained positive, although partially not significant.

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Insert Figure 3(2) to 3(4) about here

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The noticeable spike around the last half of 2013 might have been caused by the European Central Bank's (ECB) forward guidance, which signaled the ECB's intention to lower key interest rates. It also implies a strong link between the euro and franc against the dollar.

To summarize, whereas the Swiss franc was interpreted as an SHC from the start of the GFC and mostly until the Swiss Franc Shock in the first half of 2015, the currency plausibly lost its position as an SHC thereafter.[24] Other researchers have

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euro to fall as much as 40% in only 20 min after the announcement ("Swiss Franc Shock").

[24] The SNB introduced a negative interest rate policy. The policy likely has a stronger effect on the degree of investor risk aversion than unlimited intervention to sell Swiss franc.

pointed out that while the franc remained a favorite among carry traders after the GFC (similar to yen), it fell out of favor after the Swiss Franc Shock.[25] Those conclusions are supportive of our results.

Figure 3 (3) shows the observed spot rate of the GBP and its estimated degree of risk aversion. For the GBP, the degree of investor risk aversion is positive at the 5% significance level from the second half of 2007 through the second half of 2009. Actually, the British pound might have lost its safe haven status for approximately three years, starting from the first half of 2010, after markets grasped the implications of the Greek debt crisis. Thereafter, the pound regains its status intermittently from September 2012, which coincides with the start of QE3 by the FRB, through the end of the sample period.

The observed spot rate for the GBP decreases sharply after the GFC, although the degree of investor risk aversion is significantly positive and its volatility is high (Fig. 2). It is somewhat inconsistent with the degree of risk aversion. However, the Swiss franc and euro (described later) were also simultaneously SHCs and likely more attractive than the pound.

[25] Tomio and Vallet (2020) present a relevant discussion.

In addition, the spot rate for the GBP starts to decrease dramatically from mid-2014 after it appeared that the Brexit referendum would pass in the UK. Results of our analyses indicate the pound is an SHC at this time, but the GBP depreciates because its volatility is low.

It is noteworthy that once the SNB began intervening in the exchange rate market, the GBP's degree of investor risk aversion turned positive and statistically significant for a few months. This phenomenon is evidence that the SNB intervention affects the GBP.

Figure 3 (4) shows risk aversion effects for the EUR. The degree of investor risk aversion is positive at the 5% significance level from the beginning of the sample period (January 2000) to the first half of 2004, and from the GFC until the second half of 2015 (China shock). The exception is in 2011: the period of the protracted Greek debt crisis.

When the euro was first introduced as the official currency for the EU in January 1999, it was initially the single currency for 11 countries, but was later adopted by 10 new countries in 2004 with their migration to the EU. Our analyses show that the euro was possibly an SHC until the first half of 2004. It was highly trusted among global investors. Although the euro lost its SHC status from the last half of 2004, only the U.S. dollar became an SHC as an alternative to the euro until the GFC because neither the yen, franc, nor the pound showed signs indicating SHC status. In addition, our analyses suggest that the euro regained its SHC status in September 2011 with the start of the SNB's unlimited foreign currency market intervention policy to sell the Swiss franc and buy the euro. This strengthens the conjecture that the SNB's unlimited intervention policy, perhaps unsurprisingly, affected EUR investor risk aversion.

In the first half of 2016 after the China shock, the strong possibility exists that Brexit disrupted Eurozone stability. The euro became an SHC for a short period immediately leading up to Brexit. But thereafter, both the euro and Swiss franc seemed to lose their SHC status. Immediately after Brexit, the pound rose again. In short, our results imply that the euro is a substitute for the British pound and a complement for the Swiss franc.

4. Conclusion

This research exploits the GARCH-M rolling estimation method to develop a theoretical degree of risk aversion coefficient that enables us to investigate whether risk aversion is time-variant. The coefficient is then used to ascertain whether the four currencies discussed herein are SHCs, and, if they are indeed SHCs, during which periods they exhibit safe haven characteristics. We conclude that the euro was clearly an SHC in the early 2000s, as was the British pound around the Paribas Shock in August 2007. The British pound, Swiss franc, and euro were SHCs at the time of the GFC in September 2008. The Japanese yen emerged slightly later in the first half of 2009 as an SHC. Additionally, the findings indicate that the Swiss franc and euro were possibly SHCs when Greece's debt problem first became public in October 2009. The SHC subsequently varied among the four currencies, but all of the currencies gradually stopped displaying SHC characteristics from the second half of 2015. Stated succinctly, different currencies are used as SHCs in different periods.

The core of this study is not to discover why one particular currency is adopted as an SHC. Undertaking such a challenge in previous studies uses factors that stimulate changes in the degree of investor risk aversion [26]. Such determinants are

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[26] Habib and Stracca (2012) investigate the fundamental qualities of SHC. Renaldo and Söderlind (2010) find that JPY, CHF, EUR and GBP tend to appreciate when U.S. stock prices decrease and U.S. bond prices and FX volatility increases. Additionally, Botman et al. (2013) find that neither capital inflows nor monetary policy expectations explain the JPY's safe haven behavior. However, they insist that changes in market participants' risk perceptions trigger derivatives trading. De Bock and de Carvalho Filho (2013) suggest that economic factors related to currency appreciation in risk-

usually observable economic fundamentals, such as the current account balance or net foreign asset position (ratio of GDP). However, our results raise the possibility that the degree of investor risk aversion is related strongly to unobservable factors that influence market sentiment, including those stemming from monetary policy announcements and political events. Therefore, future research should look for unobservable ones, as well as looking for observable economic fundamentals.

off episodes are the current account, net foreign asset position, and capital controls.

References

Angelo, R., Söderlind, P., 2010. Safe haven currencies. Rev. Financ. 14(3), 385–407.

Botman, D., de Carvalho Filho, I., Lam, W.R., 2013. The curious case of the yen as a safe haven currency: A forensic analysis. IMF Working Paper. wp/13/228.

Brunnermeier, M.K., Nagel, S., 2008. Do wealth fluctuations generate time-varying risk aversion? Micro-evidence on individuals' asset allocation. Am. Econ. Rev. 98(3), 713–736.

Brunnermeier, M.K., Nagel, S., Pedersen, L.H., 2008. Carry trade and currency crashes. NBER Working Paper. No. 14473.

Campbell, J., Cochrane, J., 1999. By Force of Habit: A consumption-based explanation of aggregate stock market behavior. J. Polit. Econ. 107(2), 205–251.

Canova, F., Marrinan, J., 1993. Profits, risk and uncertainty in foreign exchange markets. J. Monet. Econ. 32, 259–286.

Chan, K., Yang J., Zhou, Y., 2013. What makes safe-haven currencies? Evidence from conditional co-skewness. Mimeo.

Chantapacpedong, P., Ito, H., Kieran Hull, K., 2017. Carry trades in Asia and the Pacific: evidence on unconventional monetary policies of advanced economies. Asian Development Bank Institute Working Paper series. No. 795.

Chou, R., Engle, R.F., Kane, A., 1992. Measuring risk aversion from excess return on a stock index. J. Econom. 52, 201–224.

Christiansen, C., Ranaldo, A., Soderlind, P., 2011. The time-varying risk of carry trade strategies. J. Financ. Quant. Anal. 46 (4), 1107–1125.

Chuffart, T., Dell'Eva, C., 2020. The role of carry trades on the effectiveness of Japan's quantitative easing. Int. Econ. 161, 30–40.

Cotter, J., Hanly, J., 2010. Time varying risk aversion: An application to energy hedging. Energy Econ. 32, 432–441.

De Bock, R., de Carvalho Filho, I., 2015. The behavior of currencies during risk-off episodes. J. Int. Money Finance 53, 218–234.

Domowitz, I., Hakkio, C.S., 1985. Conditional variance and the risk premium in the foreign exchange market. J. Int. Econ. 19, 47–66.

Engle, C., 2016. Exchange rates, interest rates, and the risk premium. Am. Econ. Rev. 106(2), 436–474.

Engle, R.F., Lilien, D.M., Robins, R.P., 1987. Estimating time varying risk premia in the term structure: The Arch-M model. Econometrica 55(2), 391–407.

Fama, E.F., 1984. Forward and spot exchange rates. J. Monet. Econ. 14, 319–338.

Fatum, R., Yamamoto, Y., 2016. Intra-safe haven currency behavior during the global financial crisis. J. Int. Money Finance 66, 49–64.

Guiso, L., Sapienza, P., Zinggales, L., 2018. Time varying risk aversion. J. Financ. Econ. 128, 403–421.

Habib, M.M., Stracca, L., 2012. Getting beyond carry trade: What makes a safe haven currency? J. Int. Econ. 87(1), 50–64.

Hiraki, K., Fukunaga, I., 2012. Recent unusual correlation between VIX and country-specific volatility indices. Bank of Japan Review Series, 2012-J-2 (Japanese only).

Ito, T., 2005. Interventions and Japanese economic recovery. Int. Econ. Econ. Policy 2, 219–239.

Jiang, C., Chiang, T.C., 2000. Do foreign risk premium relate to volatility in the foreign exchange and equity markets? Appl. Financial Econ. 10, 95–104.

Kaul, A., Sapp, S., 2006. Y2K fears and safe haven trading of the U.S. dollar. J. Int. Money Finance 25(5), 760–779.

Masujima, Y., 2017. Safe haven currency and market uncertainty: Yen, renminbi, and alternatives. RIETI Discussion Paper Series. 17-E-048.

McCauley, R.N., McGuire, P., 2009. Dollar appreciation in 2008: safe haven, carry trades, dollar shortage and overhedging. BIS Quarterly Review. December. 85–93.

Menkhoff, L., Sarno, L., Schmeling, M., Schrimpf, A., 2012. Carry trades and global foreign exchange volatility. J. Finance 67 (2), 681–718.

Tomio, B.T., Vallet, G., 2020. Carry trade and negative policy rates in Switzerland. 46th Eastern Economic Association Annual Meeting, Feb 2020, Boston, United States.

Table 1 Descriptive Statistic, Ljung-Box Test, and Jarque-Bera Test

	JPY		GBP		CHF		EURO	
Number of observations	4869		4865		4868		4868	
Mean	0.006		0.001		-0.003		-0.001	
Standard deviation	0.051		0.047		0.049		0.051	
Minimum	-0.176		-0.179		-0.190		-0.145	
Maximum	0.172		0.233		0.226		0.227	
Skewness	0.056		0.788		-0.022		0.386	
Kurtosis	3.367		6.154		3.227		3.373	
LB (10)	41208	***	41364	***	38779	***	41261	***
JB	29.909	***	2519.5	***	10.885	***	149.28	***

LB (10) : Ljung-Box test statistic with 10 lags, JB : Jarque-Bera test statistic, ＊＊＊, ＊＊, *: for the 1%, 5% and 10% significant level, respectively.

Figure 1: Stability conditions of volatility clustering

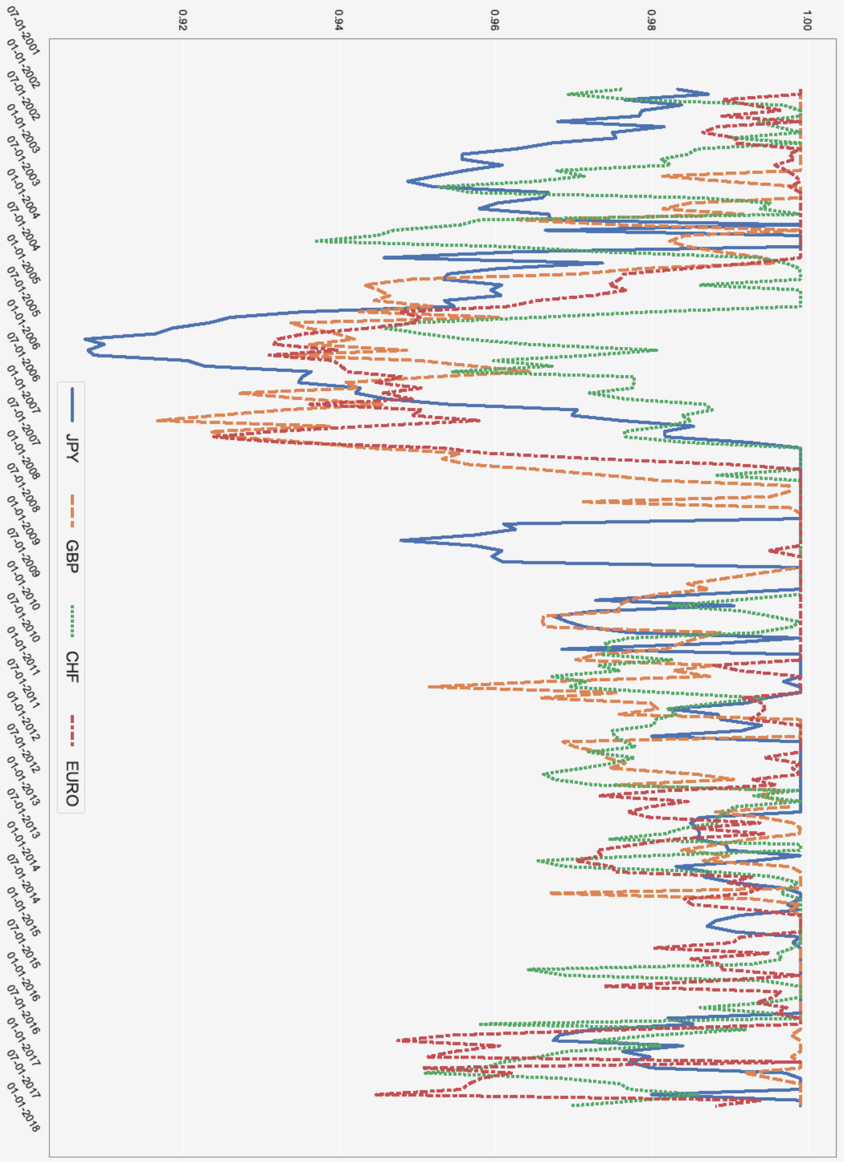
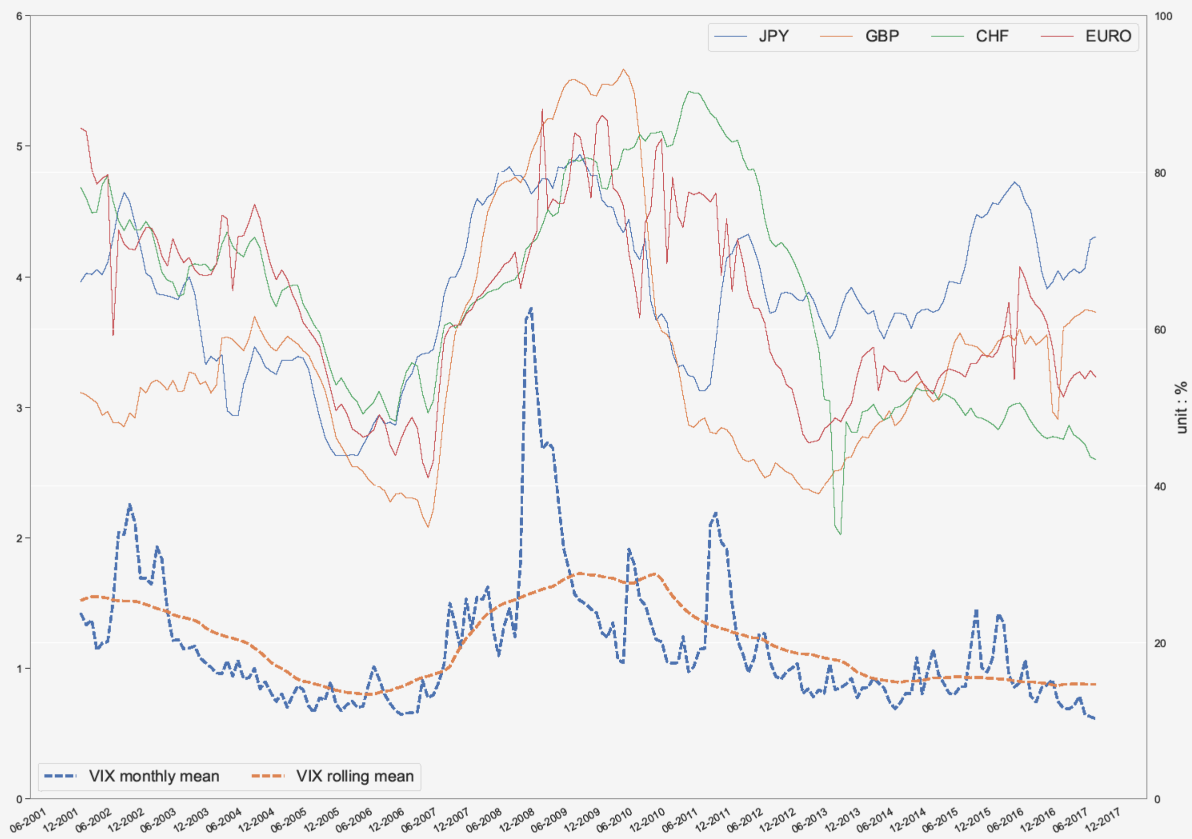
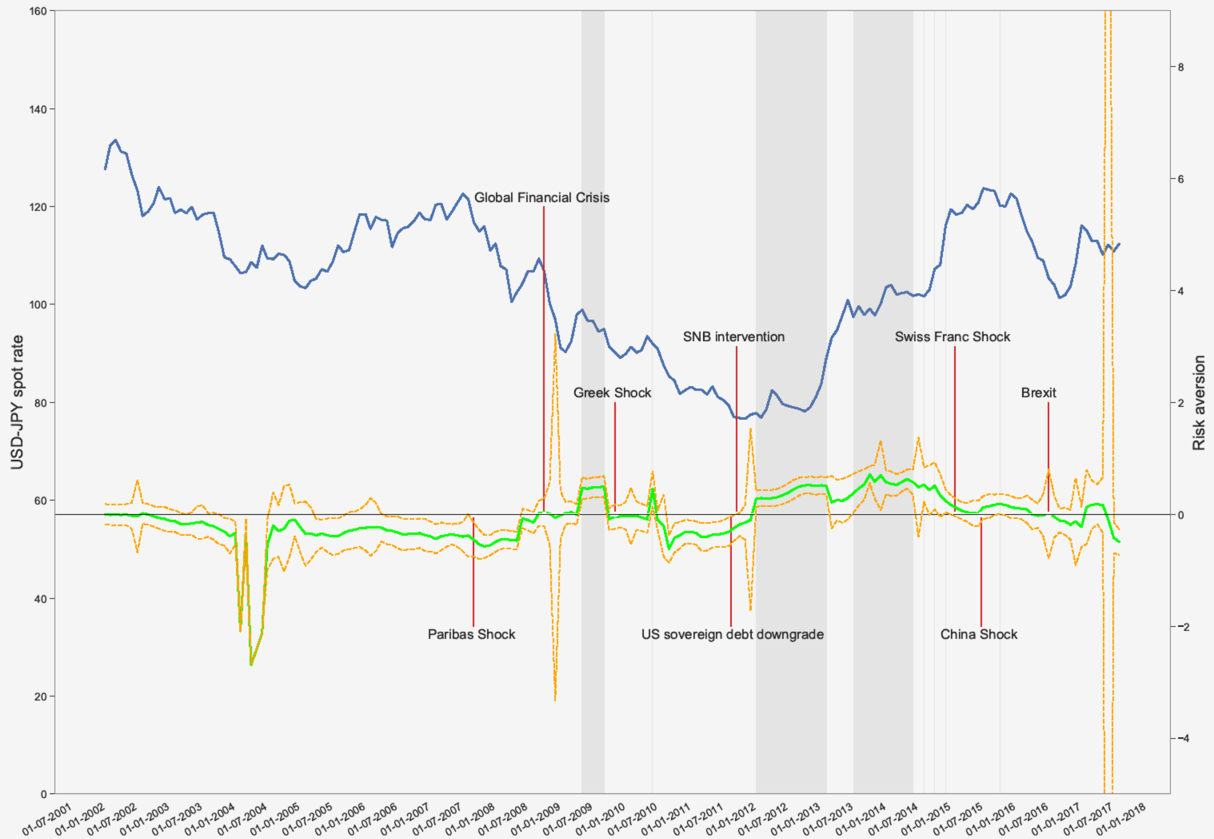


Figure 2: Estimated volatility and the VIX (monthly & rolling)



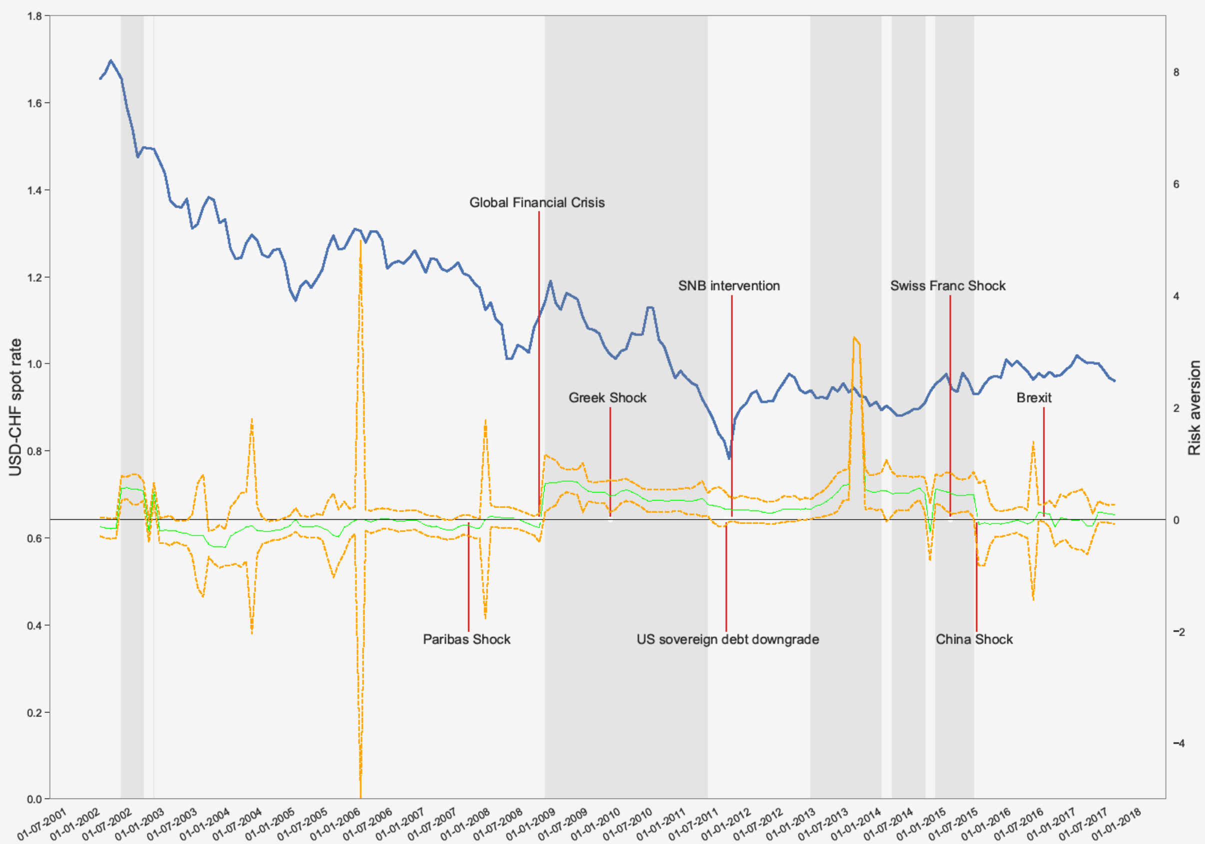
'VIX monthly mean' refers to the monthly mean while the 'VIX rolling mean' is the VIX rolling mean adjusted to match the window length of rolling GARCH-M data. Currency volatility is measured on the left axis and VIX on the right axis.

Figure 3 (1): (JPY) Estimated investor's degree of risk aversion γ



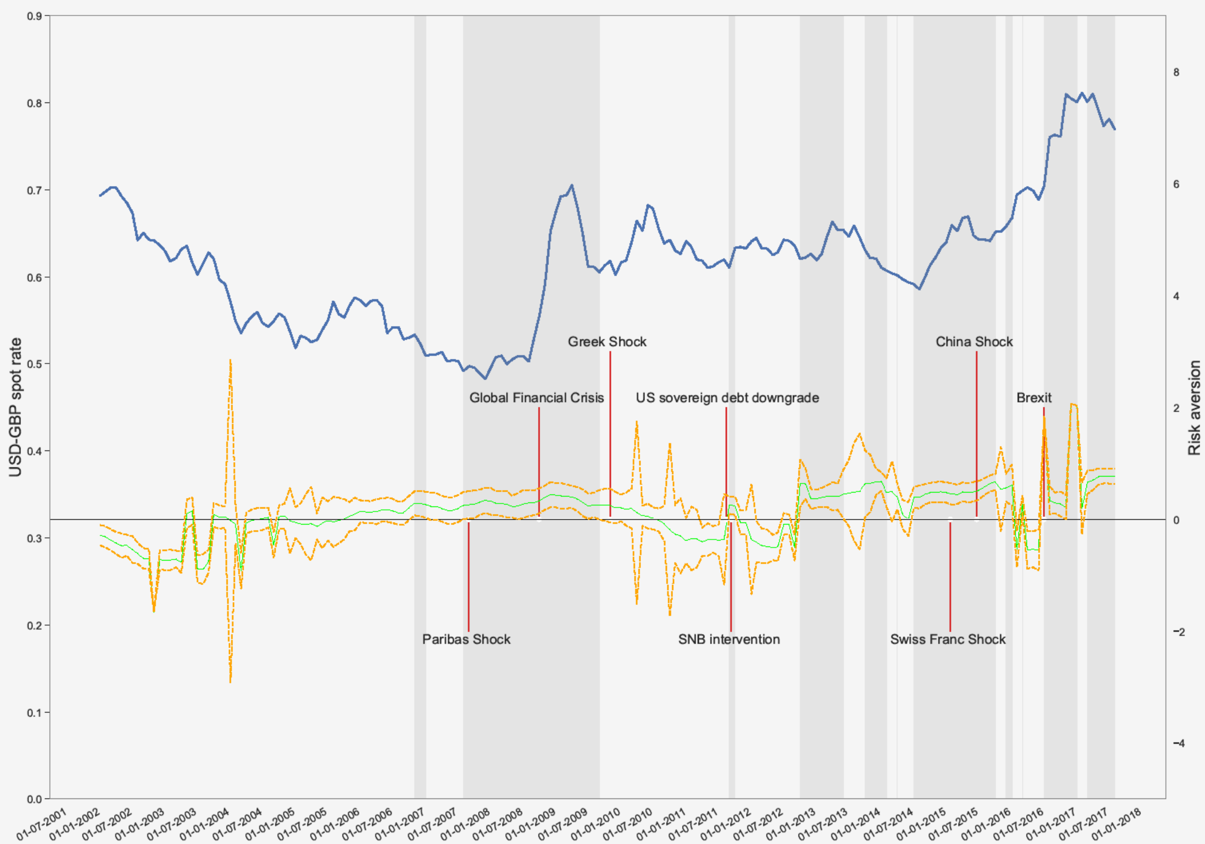
The blue line is the monthly mean spot rate and the green line is the estimated investor risk aversion (The light gray background is when significanlty positive).
The dotted orange line represents the 95% confidence interval, calculated based on robust standard errors.

Figure 3 (2): (CHF) Estimated investor's degree of risk aversion γ



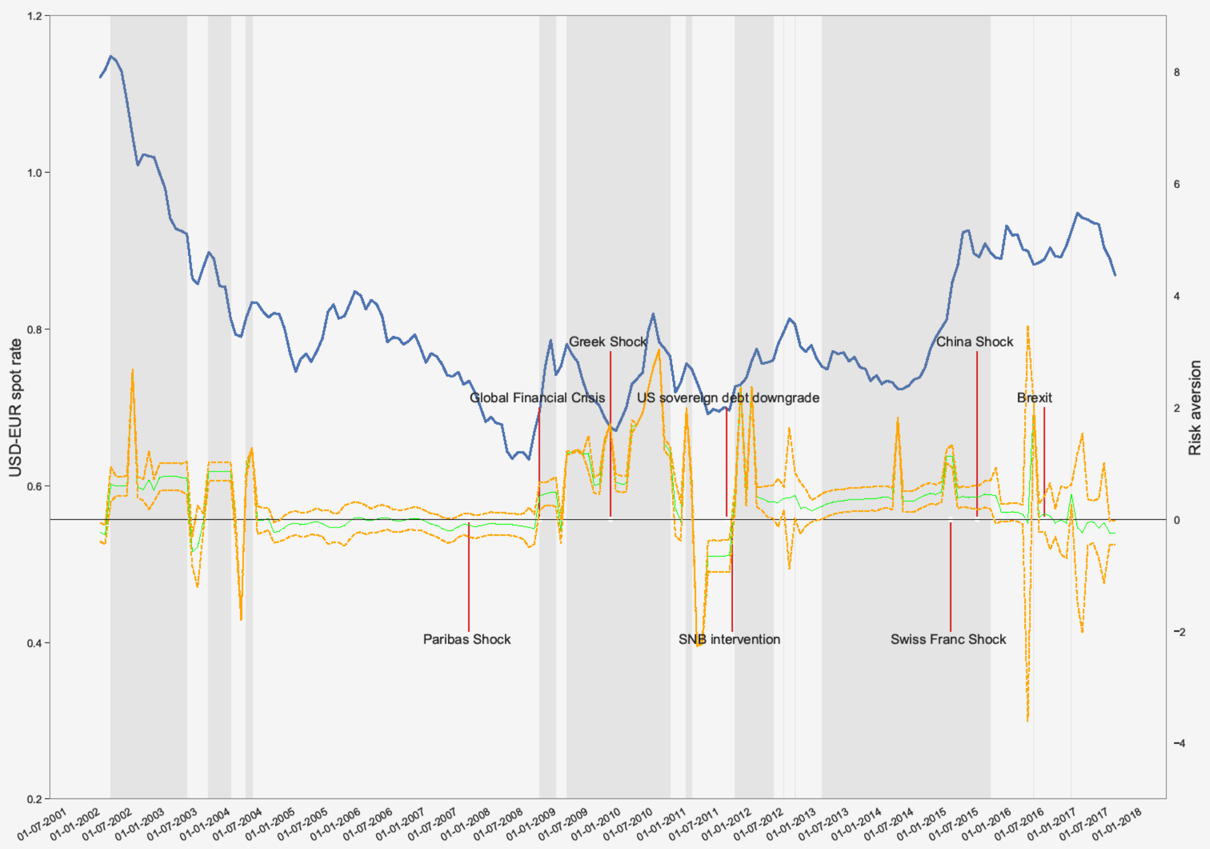
The blue line is the monthly mean spot rate and the green line is the estimated investor risk aversion (The light gray background is when significanlty positive).
The dotted orange line represents the 95% confidence interval, calculated based on robust standard errors.

Figure 3 (3): (GBP) Estimated investor's degree of risk aversion γ



The blue line is the monthly mean spot rate and the green line is the estimated investor risk aversion (The light gray background is when significanlty positive).
The dotted orange line represents the 95% confidence interval, calculated based on robust standard errors.

Figure 3 (4): (Euro) Estimated investor's degree of risk aversion γ



The blue line is the monthly mean spot rate and the green line is the estimated investor risk aversion (The light gray background is when significanlty positive).
The dotted orange line represents the 95% confidence interval, calculated based on robust standard errors.