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SAFEHAVENNESS OF CURRENCIES

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Safehavenness of Currencies[1]

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Abstract

This study assesses the "safehavenness" of a number of currencies with a view to providing a better understanding of how capital flow tends to react to a sharp increase in global risk aversion in times of financial crisis. It focuses on how the currencies are perceived by international investors or, more specifically, whether they are seen as safe-haven or risky currencies. To assess the safehavenness of the currency, we use risk reversal, which is the price difference between the call and put options of a currency, as it reflects how disproportionately market participants are willing to pay to hedge against its

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appreciation or depreciation. The relationship between the risk reversal of the currency and global risk aversion is estimated by means of parametric and non-parametric regressions that allow us to capture currency behaviour in times of extreme adversity, i.e., the tail risk. Our empirical results found the Japanese yen and, to a lesser extent, the Hong Kong dollar to be the only safe havens under stressful conditions among the 34 currencies vis-à-vis the US dollar.

Keywords: Safe-haven currency; risk reversal; quantile regression; mixture vector autoregression; tail risk; crash risk.

JEL codes: C21, C32, C58, F31

1. Introduction

The US subprime crisis in 2007 and 2008 was closely followed by a protracted sovereign debt crisis in Europe which began in 2009. Over the past five years, there have been several bouts of financial turbulence, causing sharp changes in risk assessment globally, with international investors fleeing risky assets, such as emerging market stocks and high-yielding currencies, to safe havens (e.g., US Treasury securities, gold and the Japanese yen). When this happened, the resulting capital flows were enormous, as reflected in the large swings in the foreign exchange market. The impact was considerable and even disturbing enough to cause some policymakers (e.g. the Swiss National Bank) to resort to adopting drastic policy actions (e.g., changing the country's exchange rate regime in the case of Switzerland).

The phenomenon and behaviour of safe-haven currencies have been discussed and studied extensively in the literature. Cumby (1988) and Froot and Thaler (1990) suggest how foreign investors viewed the US dollar as a safe haven in the early 1980s. Kaul and Sapp (2006) find evidence of safe-haven flows in the spot and forward markets of the euro-dollar towards the year of 2000. McCauley and McGuire (2009) attribute the rise of the US dollar exchange rate to US dollar shortages during the subprime crisis. Ranaldo and Soderlind (2010) find the Japanese yen, the Swiss franc, the euro and British pound may be regarded as safe havens during crisis episodes preceding the global financial crisis. Habib and Stracca (2012) investigate factors underlying a safe-haven currency using a large panel of 52 currencies in advanced and emerging countries over almost 25 years of data, but they find only few variables to be consistently and robustly significant enough as to characterise safe-haven behaviour. Hoque (2012) examines whether six major currencies are safe-haven or untrustworthy in times of crisis based on the relationship between the price of spot exchange rate against euro and its denominated sovereign bond price. He finds that, during the European debt crisis, the Japanese yen and US dollar are safe-haven currencies vis-à-vis the euro, while the Australian dollar and Canadian dollar are untrustworthy relatively. From the other side of the same concept, Brunnermeier et al. (2008) studies the crash risk of several major currencies. They argue that currency crashes are linked to sudden unwinding of carry trades and, hence, these traders are subject to the risk of such crashes.

Much of the literature focuses on identifying safe-haven currencies or their features, yet there has been no attempt to measure the degree of currencies that play the role of a safe haven. This is a very important piece of information for investors in making asset allocation or portfolio diversification decisions, as currencies that are viewed as (more of) safe havens will tend to appreciate (more) in times of market adversity, and those viewed as (more) risky will tend to take the blow (more). The information is also extremely useful for policymakers in formulating policies or building financial infrastructure to preserve financial stability, as it sheds light on the directions of international capital flow in times of financial turmoil. This study aims to fill the literature gap by assessing how well a currency is expected or perceived to perform the role of a safe haven. It is not an attempt to explain the phenomenon of capital flight or what makes a currency a safe haven. Instead, it takes the phenomenon, the market reaction, as the outcome of investor behaviour and proposes to use a financial indicator as a yardstick for gauging how the investor responds to sharp changes in market conditions. Based on the risk reversals of a wide range of currencies, three major findings emerge from this analysis. First, the US dollar is perceived to play the role of safe haven by dollar-based investors in general, although the country was the epicentre of the subprime crisis. Second, the Japanese yen has the highest safe-haven status, followed by the Swiss franc, the US dollar and most of the Asian currencies, from the perspective of euro-based investors. Finally, the Korean won and some currencies of the Europe, the Middle East and Africa (EMEA) and Latin America are regarded risky from the perspectives of dollar and euro-based investors.

This paper has three contributions. First, it is the first study assessing currency's safehavenness. The assessment covers 34 currencies from Asia Pacific, Europe, the Middle East, Africa and Latin America and utilises the past ten years of information encompassing two major financial crises. Second, we try to measure the degree of safehavenness of different currencies, as opposed to previous studies trying to differentiate between safe-haven and risky currencies (see Brunnermeir et al. (2008), Hui and Chung (2011), VanderLinden and Gramlich (2005) and VanderLinden and Nikolov (2006)). Finally, methodology wise, the empirical analysis employs two advanced statistical models that extend the normality assumption on the distribution of currency movements. This is important because foreign exchange markets tend to be volatile under extreme market conditions, making the homoscedasticity and normality assumptions too strong. As a result, the currency movements may not be adequately explained by conventional regression models (such as multiple regressions, panel data regressions, or vector autoregressive models, etc.) which can capture only the changes on average but not those at extreme.

The remainder of the paper is organised as follows. Sections II and III elaborate our contributions further by discussing the nature of a safe-haven asset, the information content of the risk reversal of a currency, and the behaviour and characteristics of the risk reversals of a number of currencies in the past decade. Section IV outlines the methodology with details of the quantile regression and MVAR model. Section V presents our data and the estimation results. Section VI concludes our findings.

2. Risk Reversal as a Yardstick of Safehavenness

Safe haven commonly refers to places or shelters where people can hide and protect themselves from being hurt in disastrous or catastrophic situations, such as wars and natural calamities. In financial markets, a safe haven is an asset that investors can use to protect their wealth from losing value in times of market turmoil. Therefore, to qualify as a safe haven, the asset is expected to be one that is more able, compared to other assets, to maintain, if not increase in, its value in times of turbulence. By *safehavenness*, we refer to the degree of a financial asset that plays the role of a safe haven, or the extent to which a financial asset is regarded by investors as a safe haven.

It is crucially important to emphasise that it is the expectation or perception of how an asset tends to behave in times of market turmoil that underscores the concept of safe haven. Safe haven does not always live up to people's expectations. Put another way, it provides no guarantee that one will not get hurt during a war, or that one will never lose money during a financial crisis. In the absence of perfect foresight, there is always some degree of uncertainty. This, coupled with the fact that changes in expectations often happen subtly and quickly, probably explains why past studies have failed to assess the safehavenness of the financial asset by examining the movements of its price or, in case of a currency, its exchange rate.

Recognising the importance of the expectation dimension, we look to the options market for clues. As is well known, options are tools that financial market participants use to hedge against the risk of the price of an asset going in an undesirable direction. The price of an option reflects the market expectation of the likelihood of such an adverse outturn happening. A call option gives the right to buy the asset at a certain price and a put option the right to sell. Hence, the buyer of a call bets on the asset to rise above the strike price within a certain period, while the seller thinks it may not and accepts a payment for taking the risk. A put option works exactly the other way round. However, an increase in the price of an option, call or put, during market turmoil is not good evidence of an asset being a safe or risky one. What is important is the change in the difference between the two, i.e., the prices of the call and the put. Note that the price of an out-of-the-money call is not necessarily the same as that of the out-of-the-money put given the same maturity and delta (i.e. sensitivity to a change in the price of the underlying asset), because there may be heavier betting for a rise in the asset than for a fall, or the other way round.

The price difference between the two, often known as the risk reversal, measures how asymmetric the market is in expecting a rise and fall in the asset. In the currency market, the asymmetry reflects how much more market participants are willing to pay to insure against the crash risk of a currency, a risk of loss resulting from a large and sudden movement of the exchange rate in one direction than the other of an equal magnitude. Carry traders, for instance, are subject to such a risk as identified from currency option prices according to Brunnermeier et al (2008). In studying the crash risk of the euro during the European debt crisis, Hui and Chung (2011) take the risk reversal of the euro vis-à-vis the US dollar as the crash risk premium of the currency.

Currency crash and safe haven are two sides of the same concept. The crash of a currency necessarily implies that the currency investors flee to is a safe haven. In our view, the willingness of the market to pay more in hedging against an appreciation of a currency vis-à-vis another currency can shed light on the safehavenness of the currency or the riskiness of the other. In times of turmoil, the prices, or the implied volatilities to be exact, of both the call and put options tend to rise. A currency with a larger price increase in the call suggests that the currency is probably looked upon by investors as a safe haven. Similarly, a currency with a large price increase in the put means the currency must be considered riskier. Kohler (2010) also thinks risk reversal may help identify safe-haven currencies, as he observes that in three crisis episodes market participants disproportionately sought to hedge against an appreciation of the Japanese yen and Swiss franc vis-à-vis the US dollar and, at the same time, against a large depreciation of the Australian dollar and South African rand.[4]

3. Risk Reversals at a Glance

Figures 1-5 plot the risk reversals of a group of selected currencies vis-à-vis the US dollar and that of gold, from January 2001, the earliest the data became available. The risk reversal data, drawn from a database compiled by JP Morgan Chase, are on a daily basis with a three-month maturity and a 25-delta moneyness level.[5] The three-month maturity conveys both short-term and long-term views of market participants, while the 25-delta level reflects the option being out-of-the-money.[6]

[4] The three episodes are the Asian financial crisis of 1997-98, the crisis that followed the Russian debt default in August 1998 and the global financial crisis of 2007-2009.

[5] Bloomberg also collects risk reversal data but the data, which display similar patterns and characteristics, have a much shorter history.

[6] Delta is a normalised measure provided by the Black–Scholes model showing the extent to which an option price will move

Figures 1, 2 and 3 show the risk reversals of Asian currencies. The Japanese yen stands out as the only currency in the region that has consistently registered a positive risk reversal, although it has declined moderately over the past few years. The Chinese renminbi, whose risk reversal vis-à-vis the US dollar was positive in recent years, has dipped into negative territory in jittery market conditions since the second half of 2011. The risk reversal of the Hong Kong dollar has been positive, since the economy recovered from the severe acute respiratory syndrome (SARS) epidemic in 2003 and increasing expectations of the Chinese renminbi revaluation led to appreciation expectations of the Hong Kong dollar. Other Asian currencies are all seen riskier relative to the US dollar.

Figure 4 shows the risk reversals of three relatively well-known higher yielding or commodity currencies. The risk reversals of the Australian and New Zealand dollars have generally been negative. That of the Canadian dollar has broadly followed a similar trend, though oscillating around zero before the crisis. When the market experienced turbulence, all three risk reversals dipped further in the negative territory.

Figure 5 shows the risk reversals of six European currencies. The risk reversal of the British pound behaved similarly to that of the commodity currencies, though to a smaller extent. The euro generally had a positive risk reversal before the European debt crisis hit. The Scandinavian currencies tracked

given a small change in the price of the underlying asset. An option with a 25-delta means the option price will move 25% for a 100% movement in the exchange rate of the underlying currency. A deeply out-of-the-money option will have a delta very close to zero, while a deeply in-the-money option will have a delta very close to 100%.

the euro closely. For the Swiss franc, the market perception or assessment has changed dramatically over the past few years. Perhaps, the most interesting parts were when the European debt crisis began to escalate in the second half of 2010 with the risk reversal shooting up sharply and when the market assessment changed again following the shift in the exchange rate regime in September 2011. This sharp change is also noticeable in the risk reversal of the Swiss franc vis-à-vis the euro during the episode. Figure 6 depicts the time series of the risk reversal and the spot exchange rate.[7] The episode provides an invaluable opportunity to observe the behaviour of the exchange rate and the risk reversal of a currency under both the floating and fixed exchange rate regimes. The exchange rate and the risk reversal only broadly went in different directions but did not exactly mirror each other, even under the floating exchange rate regime. The reason is that the risk reversal, which reflects market expectations of the direction in which the currency is more likely to move, is not necessarily translated into buying or selling pressure in the foreign exchange market. There were many upward movements in the risk reversal of the Swiss franc before 6 September 2011 that were not followed by currency appreciation. Under the new regime, one can tell little about market pressure from exchange rate movements because the exchange rate was capped, but risk reversal provides a useful gauge for the amount of pressure building up.

[7] Following the onset of the European debt crisis towards the end of 2009, the Swiss franc against the euro constantly came under upward pressure, as international investors, mostly euro-based, sought safe haven. This was reflected in the upward trend of the risk reversal as well as the appreciation of the currency. In summer 2011, the pressure grew particularly acute, forcing the Swiss National Bank (SNB) to ease monetary policy several times in August, lowering interest rates to practically zero. The actions, however, met with little success in curbing the strength of the currency, with the nominal and real effective exchange rates both surging to unprecedented levels. At the same time, the risk reversal rocketed to record highs, reflecting that the market had never been so one-sided in betting for a stronger Swiss franc. In view of the potential negative impact on real activity and increasing risk of deflation, the SNB decided on 6 September 2011 to curb further appreciation of the currency by imposing a strong-side limit. A series of interventions in the spot, forward and option markets brought the Swiss franc below 1.2 against the euro and forced the volatility of the exchange rate sharply lower.

Finally, the risk reversal of gold is plotted in Figure 7 for reference. As expected, it has generally stayed positive throughout the period.

4. Methodology

4.1 Dual econometric approach

A currency that costs more to hedge against its appreciation than its depreciation (i.e., one that has a positive risk reversal) cannot qualify as a safe haven if it becomes less costly to do so when crisis hits. Similarly, a currency that costs more to hedge against its depreciation than its appreciation (i.e., one that has a negative risk reversal) may be regarded a safe haven if it becomes cheaper to do so in times of turbulence. Therefore, while the level of the risk reversal of a currency is important, the change in it, in response to changes in market conditions, matters more in determining the safe-haven status of the currency.

To assess the safehavenness of a currency, we estimate how investors react to changes in market conditions through examining the behaviour of the risk reversal of the currency in times of crisis or market turbulence. Theoretically, when risk in global financial markets increases or is perceived to be higher, investors would flee the currencies that are regarded risky to those perceived to be safe havens; when risk falls, or is perceived to be lower, investors would find more comfort in holding assets denominated in riskier currencies. Therefore, if risk reversal is of any use in predicting such investor behaviour, it should bear a positive relationship with risk aversion if the currency is thought to be safe (or its downside risk is lower) or a negative relationship if it is considered risky (or its downside risk is higher).

The relationship is first estimated by means of quantile regression, a simple non-parametric technique that allows us to capture the relationship under extreme market conditions, in other words, the tail risk.[8] Rather than modelling mean relationships using ordinary least squares (OLS) regression, quantile regression can evaluate the estimated functional relationship at a very high quantile, which can indicate how heteroskedastic the pattern between the risk reversal and risk aversion could be, or equivalently, how extremely the risk reversal could increase when financial markets experience distress or extreme adversity.

The relationship is also estimated by the mixture vector autoregressive (MVAR) model proposed by Fong et al. (2007).[9] While quantile regression is a non-parametric approach to estimating the risk reversal's distribution, the MVAR model is a parametric approach to estimating the distribution with distinct probability densities for different market conditions. The model has been applied to

[8] A relationship estimated by means of ordinary least squares is a mean relationship, which may be interpreted as one under general or normal market conditions. Clearly, such an "average" relationship cannot fully capture the true relationship in times of crisis or market turbulence, as the variables are generally expected to display much stronger tendency to co-move amid tail events. Theoretical details of the method can be found in Koenker and Bassett (1978).

[9] Proposed by Fong et al. (2007), the MVAR model extends the unimodal probability distribution of dependent variable to a mixture of normal distributions.

macro-prudential stress tests in Luxemburg and Hong Kong and proves to be capable of capturing tail losses under adverse market conditions.[10] Details of the specification are discussed in the next subsection.

4.2 Quantile regression

Quantile regression, first suggested by Koenker and Bassett (1978) and further employed in the financial literature, including Brunnermeier et al. (2008), Fong and Wong (2012), and Ma and Pohlman (2008), is estimated given that it assumes no parametric distribution of currency movements. Thus, it allows different distributions under varying market conditions and potentially extreme movements under different quantile specifications.

The technique is appealing due to its simplicity and robustness in exploring relationships between variables evaluated at their extremes, which is useful in assessing co-movements of nonlinearly-related variables and risk spillover effects.[11] Like in standard least squares regressions, the response variable is expressed as a function of explanatory variables in quantile regression. Specifically, the empirical model of a change in risk reversal is defined as:

[10] Fong and Wong (2008) firstly applied the model to capturing banks' credit loss during stressful periods in Hong Kong's macro stress test exercise, in which the credit loss is found to be substantially larger than those estimated by classical models in times of financial crisis. Guarda et al. (2012) also found in Luxemburg's macro-prudential stress tests that the model allows for a better assessment of counterparty credit risk, the real economy and banks' capital requirements under adverse macroeconomic shocks.

[11] Some empirical applications include the CoVaR measure proposed by Adrian and Brunnermeier (2016), and some countrywide comparison of risk spillover discussed in Wong and Fong (2011), and Fong and Wong (2012).

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

where RR_{it} denotes the risk reversal of currency i at time t; *RiskAversion* denotes the index of risk aversion; *const* and ε_{it} denote the constant and error term respectively; and Δ is the first difference operator. The lag of ΔRR_{it} is used to control for serial correlation.

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

4.3 The MVAR model

As non-parametric methods may arguably be inefficient in estimation, a parametric model is also estimated for comparison. This is a mixture vector autoregressive (MVAR) model firstly proposed by Fong et al. (2007) and applied by Fong and Wong (2008) and Guarda et al. (2012) in macroeconomic stress tests. Different from the uni-modal distribution assumed by the classical models, the MVAR model assumes a multi-modal distribution (i.e. mixture of several uni-modal distributions) on the currency movements. This captures the movements at different regimes under different market conditions, consistent with some major studies suggesting currency movements are regime-switching during speculative attacks (e.g., Martinez Peria M (2002) and Kruse et al. (2012)).

Specifically, we let $z_t = (\Delta RR_{,it}, \Delta RiskAversion_t)'$ be a two-dimensional vector. Their relationships are modelled by a two-component MVAR model, denoted by MVAR (2, p_1, p_2), which is defined as

$$z_t \mid \Im_{t-1} \sim \begin{cases} \Phi(\Omega_1^{-1/2}(Z_t - \Theta_{10} - \Theta_{11} Z_{t-1} - \ldots - \Theta_{1p_1} Z_{t-p_1})) \\ \Phi(\Omega_2^{-1/2}(Z_t - \Theta_{20} - \Theta_{21} Z_{t-1} - \ldots - \Theta_{2p_2} Z_{t-p_2})) \end{cases} \text{with probability} \begin{matrix} \alpha_1 \\ \alpha_2 \end{matrix} \tag{2}$$

where $\Im_{t-1}$ indicates the information given up to time t-1, $\Phi(.)$ is the bivariate cumulative distribution function of the Gaussian distribution with a zero mean and identity variance-covariance matrix.[12] For the *k*-th component (k = 1 or 2), p_k is specified as the AR order, α_k is the probability and $\alpha_1 + \alpha_2 = 1$, Θ_{k0} is a two-dimensional vector, $\Theta_{k1}, \ldots, \Theta_{kp_k}$ are 2×2 coefficient matrices, and Ω_k is the 2×2 variance covariance matrix. For identifiability, it is assumed that $\alpha_1 \geq \alpha_2 \geq 0$.[13] The resulting model in equation (2) can also be viewed as a mixture of two Gaussian VAR models with probabilities α_1 and α_2 respectively, which can be represented by

$$Z_t = \begin{cases} \Theta_{10} + \Theta_{11} Z_{t-1} + \ldots + \Theta_{1p_1} Z_{t-p_1} + \varepsilon_{1t} & \text{with probability } \alpha_1 \\ \Theta_{20} + \Theta_{21} Z_{t-1} + \ldots + \Theta_{2p_1} Z_{t-p_2} + \varepsilon_{2t} & \phantom{\text{with probability }} \alpha_2 \end{cases} \quad (3)$$

where $\varepsilon_{1t} \sim MVN(0, \Omega_1)$ and $\varepsilon_{2t} \sim MVN(0, \Omega_2)$, given the information up to the period t -1 (= $\Im_{t-1}$).[14] To be parsimonious, the MVAR (2,1,1) model is considered.[15] Moreover, since the primary interest is the regression of ΔRR_{it} on $\Delta RiskAversion_t$ but not the other way round, we focus only on one relationship of the MVAR model when reporting. Hence, the specification is:

$$\Delta RR_{it} = \begin{cases} const + \beta_i^{I} \Delta RiskAversion_{t-1} + \gamma_i^{I} \Delta RR_{i,t-1} + e_{it}^{I} & \text{with probability } \alpha_1 \\ const + \beta_i^{II} \Delta RiskAversion_{t-1} + \gamma_i^{II} \Delta RR_{i,t-1} + e_{it}^{II} & \phantom{\text{with probability }} \alpha_2 \end{cases} \quad (4)$$

where e_{it}^{I} and e_{it}^{II} follow different normal distributions under different market conditions.

The main contribution of the above generalisation is to allow the unimodal distribution to split into two in mixture, in which each distribution of the mixture may reflect different market

12 Note that a mixture of more than two components for a short time series is not common and is not easy to provide a straightforward interpretation. In view of this, we only consider a mixture of two components in this paper.

13 Intuitively these avoid the problem of non-identifiability due to the interchange of component labels. See Titterington et al. (1985) and McLachlan et al. (1988) for details.

14 In fact, a random variable drawn from a simple AR(p) model can be said to follow a one-component mixture Gaussian distribution conditional on past information.

15 While a multimodal distribution with a higher autoregressive (AR) order can be specified in the MVAR model, in this study, a bi-modal distribution with an AR(1) order is specified. The reason is that a more complicated MVAR specification will substantially increase the number of parameters in estimation but may not be interpreted easily.

conditions. A graphical presentation of the mixture distribution is depicted in Figure 8. Under the assumption that the first component has a higher probability of occurrence, the first component of the MVAR model will reflect the dynamic relationship between the ΔRR_{it} and $\Delta RiskAversion_t$ in the range of their changes more commonly observed. Separately, the lower possibility of extreme changes in the two variables can be modelled by the second component. As shown in Figure 8, a thicker upper tail features in the distribution to capture the probability of having more sharp increases in the risk reversal. With this additional component, the distribution for normal changes in the two variables would not be biased by extreme changes.

4.3 Risk aversion index

We use stock market volatility to proxy risk aversion in financial markets. In literature, stock market volatility which, often dubbed as investors' fear gauge (e.g., Whaley (2000) and Giot (2005)), is probably the most widely used indicator of risk aversion in stock markets. Apart from equity and equity-options markets, the stock market volatility of S&P 500 stock index, commonly known as the VIX Index calculated by the Chicago Board Option Exchange (CBOE), is a useful measure of global risk appetite in corporate credit markets (Collin-Dufresne, Goldstein, and Martin (2001)), and sovereign credit default swap (CDS) markets (Pan and Singleton (2008)).

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

5. Data and Empirical Findings

5.1 Sample data

In the assessment, we examine the relationship between the three-month 25-delta risk reversals of 34 currencies (and gold for reference) and an index of risk aversion. They cover six major currencies (the US dollar, euro, British pound, Japanese yen, Canadian dollar, and Swiss franc), and 28 emerging market currencies, which are available for download from the database.[16]

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

Covering the period from 1 January 2001 to 30 May 2012, the risk reversals of these currencies in daily frequency are mainly obtained from the database of JP Morgan Chase with a few others from Bloomberg (Table 1).[17] The descriptive statistics of the risk reversals against the US dollar and euro are given in Tables 2a and 2b respectively. Except for the Chinese renminbi, Hong Kong dollar and Japanese yen, most of the mean and median values of the risk reversals against US dollar are negative. Most of the risk reversals against euro are negative, although those of Asian currencies tend to be higher and slightly positive on average. In general, this suggests that most of the currencies are expected to depreciate during the sample period.

The unit root tests are employed to examine whether the sample data are stationary over time. The test is based on the generalised least squared Dickey Fuller test, which is a modification of the augmented Dickey-Fuller test.[18] The test results on dollar and euro-based risk reversals are presented in Tables 3a and 3b respectively. In terms of level (see column C), most of the tests cannot be rejected at the 1% significance level (i.e. 25 out of 33 currencies vis-à-vis USD, and 21 out of 33 currencies vis-à-vis euro), meaning that these risk reversals have a unit root and are required to be first-differenced. The rest of the risk reversals are found to have no unit root at the 1% significance level (i.e. eight out of 33 currencies vis-à-vis USD, and 12 out of 33 currencies vis-à-vis euro), meaning that first differencing is not necessary. In terms of first difference (see column D), almost all the risk

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

[18] Developed by Elliott, Rothenberg and Stock (1992), the test is regarded asymptotically point optimal.

reversals have no unit root (except for seven out of 33 currencies vis-à-vis USD, and two out of 33 currencies vis-à-vis euro), meaning no further differencing is necessary to achieve stationarity. To ensure stationarity and consistent comparison, all risk reversals are first differenced in estimation given that only a small number of currencies have no unit root in level terms.

The risk aversion index is constructed by the principal component method. Here, specifically, the risk aversion index is proxied by the first principal component constructed by nine stock market volatility indices comprising the S&P 500, Dow Jones Industrial Average, NASDAQ, Euro Stoxx 50, DAX, CAC 40, FTSE 100, NIKKEI 225, and Hang Seng index (Figure 9). These indices are chosen since they measure the risk appetite of major stock markets in developed and emerging market economies. The data sources and descriptive statistics of all these volatility indices are reported in Tables 4a and 4b respectively. The weights of each principal component are reported in Table 5. As shown in the second column of the table, the first principal component, which has a nearly equal weight on each stock volatility index, explains 85.5% of the total variation of the nine indices. Hence, this risk aversion index arguably reflects the risk appetite of global financial markets in general. Note that this index is found to have no unit root in terms of level at the 1% significance level (see rows of "Reference" in Tables 3a and 3b), meaning that the index is integrated of order zero. Therefore, no cointegrating relationship between the risk aversion and all of the risk reversals is expected in the regression analysis.

5.2 Estimation results

The estimation results of the OLS regression are reported in Table 6. The estimated coefficients are found to be negative in general, suggesting that the risk reversals tend to decline on average when global risk aversion increases. To examine the possible responsiveness given a market condition ranging from extremely complacent (at the 5th percentile) to extremely fearful (at the 95th percentile), the specification in equation (1) is estimated at a quantile from 0.05 to 0.95. The estimated coefficients (i.e. β_i) of all these quantile regressions are depicted in Figure 10. It shows that, of the currency risk reversals vis-à-vis the US dollar (i.e. upper panel), most of the coefficients are negative, suggesting that they are regarded riskier by dollar-based investors when financial market volatility increases. This suggests that the US dollar is perceived to play the role of a safe haven by dollar-based investors during crisis periods. The Japanese yen is probably the most notable exception whose coefficient is significantly positive at all quantiles, reflecting its higher safe-haven status as perceived by dollar-based investors. Of the risk reversals vis-à-vis euro (i.e. lower panel), about 40% of the coefficients are positive, with that of the Japanese yen again being the most significant, followed by those of the Swiss franc, the US dollar and most of the Asian currencies. This suggests that, in times of market turmoil, these currencies are regarded as safe havens by euro-based investors. At extreme quantiles (such as 0.05 and 0.95), the coefficient's magnitude tends to be larger in absolute terms than those at the middle, suggesting that the responsiveness to financial market volatility could be much larger under extreme market conditions. These results suggest that the Japanese yen has the highest safe-haven status, followed by the Swiss franc, the US dollar and most of the Asian currencies, from the perspective of euro-based investors.

The estimation results of the MVAR model are reported in Table 7. Diagnostic test statistics show most of the estimated MVAR models are accepted to have no residual correlation at the 1% significance level (see columns E and H), suggesting the models are adequate to describe all risk reversals in general. For comparison, the coefficients of quantile regression estimated at the 5% extremity are also reported in Table 7 and scatter plots of the two sets of estimated coefficients are depicted in Figure 11. In the two scatter plots, most of the coefficients cluster around the 45-degree line with a high correlation of around 0.82, which suggests that the two sets of estimation results are highly consistent. Along this line, the Japanese yen, gold and most of the Asian currencies, including the Hong Kong dollar, are safe havens from the perspectives of dollar and euro-based investors.

One possible factor underlying the result that the Japanese yen enjoys the highest safe-haven status is that foreign investors arguably are more likely to sell a country's government bonds with rising default risk than home investors. As foreign investors hold a much smaller amount of Japanese government bonds than US Treasury securities, the latter tends to come under greater selling pressure in times of crisis, which makes the yen a safer currency.[19] This conjecture is also in line with Hoque (2012), which suggests that the price of Japanese yen-denominated government bonds tends to increase given a stronger demand for the currency during the European debt crisis. To some extent, the finding that the Hong Kong dollar is a safe haven may be attributable to the fact that international investors tend to use the currency as a proxy of the US dollar under the Linked Exchange Rate system.[20]

At the other end of the spectrum, the Korean won is found to position at the left-hand corner, followed by some currencies of EMEA and Latin America such as the Mexican peso, Brazilian real and Turkish lira, suggesting that these currencies could be viewed as risky assets from the perspectives of dollar and euro-based investors. The findings may reflect that these countries tend to suffer a relatively higher degree of financial or fiscal instability. To a lesser extent, high yield currencies (e.g. Australian and New Zealand dollars) are also regarded as risky currencies. This may be attributable to the fact that heightening uncertainty in global financial markets usually triggers the unwinding of carry trade positions, weighing on the price of high yield currencies. These results suggest that the Korean won and some of the EMEA and Latin American currencies are regarded risky by dollar and euro-based investors.

[19] Foreign investor holdings accounted for 7% of outstanding Japanese government bonds and 47% of outstanding US Treasury securities as of the end of 2011.

[20] Hui et al. (2011) find that during the subprime crisis, the Hong Kong banking system was judged to be safer than its US counterpart in terms of lower default risk.

5.3 Robustness checks using quantile regressions

We conduct three sensitivity analyses to assess the robustness of our empirical results in this section. First, in addition to stock market volatility, we also use sovereign CDS spread to proxy risk aversion in financial markets.[21] Second, we control for the effect of actual exchange rate movements in the risk reversal. Finally, we test whether the safehavenness is different before and after the 2008 global financial crisis. Given that both quantile regressions and MVAR models have similar results in the previous section, we use the quantile regressions in this section for simplicity.

Sovereign CDS spread

The spread is useful for gauging the extent to which investors are risk averse to increases in sovereign credit risk (e.g. Pan and Singleton (2008)). The sovereign creditworthiness has also been proved to link closely with exchange rate stability in international finance literature (e.g. Eichergreen et al. (1996), Frankel and Rose (1996), Kaminsky et al. (1998), Kumar et al. (2003), and Hui and Fong (2015)). Theoretically speaking, a substantial increase in sovereign credit risk arising from economic-political instability could trigger investors to sell securities denominated in the sovereign’s currency and to

[21] Sovereign CDS spread is the price of a sovereign CDS contract that insures the contract holder against the sovereign default.

repatriate funds from the sovereign, resulting in a strong selling pressure on the currency and increasing depreciation expectation of the currency.

Consistently, the second risk aversion index is constructed by the first principal component, based on the five-year sovereign CDS spreads (Figure 12) downloaded from various databases (Table 8). The descriptive statistics of these spreads are reported in Table 9. However, some of economies are not chosen in constructing the principal components because they have a shorter time series with most of them starting from 2008. If they are also taken into account, the final index will begin in 2009, which cannot cover the 2008 global financial crisis. Having considered the trade-off between covering longer time series and more economies, we choose 25 economies (i.e. around 75% of all 34 economies) and the sample period starting from 13 June 2005 in this analysis (Figure 13).[22]

The weights of each principal component are reported in Table 10. As shown in the second column of the table, the first principal component, which has a nearly equal weight on each stock volatility index, explains 73.1% of the total variation of the spreads. From the unit root test, we find that the index has a unit root at any reasonable significance level (see rows of "Reference" in Tables 3a and 3b), meaning that it is integrated of order one. Since most of the risk reversals are also integrated of order one (see columns E and F in Tables 3a and 3b), it is possible that the risk reversals and the risk

[22] This proposed index (using 25 economies in construction) has a correlation of 0.9983 with the one using all economies' sovereign CDS spreads in construction (in which the first observation is on 3 June 2009), which suggests that the information content of the two indices are not substantially different from each other.

aversion index are cointegrated. Therefore, we conduct the Engle-Granger cointegration test for each risk reversal. The test results are reported in Table 11. As shown in the table, most of the test results (23 out of 33 currencies against USD and euro) show that the null hypothesis of no cointegration can be rejected at the 5% significance level, meaning that most of the risk reversals are cointegrated with this risk aversion index. Therefore, our estimations for safehavenness are required to control for this cointegration effect. Given that only a few of the risk reversals are not cointegrated with the risk aversion index, for consistency, we control all the risk reversals for the cointegration effect. This "blanket control" may not be too restrictive for those risk reversals without cointegration effect because, if there is no cointegration between a risk reversal and the risk aversion index, the error correction term will be found insignificant as a control variable. To control for these cointegrating relationships in the analysis, we re-estimate the specifications (1) and (2) using an adjusted risk reversal in change. Specifically, we consider a two-step approach: first (i) estimate the long-run relationship between the risk reversal and risk aversion index, and extract the error correction term from this relationship; and second (ii) estimate the regression of the risk reversal in change on the error correction term, and take the residual as the adjusted risk reversal in change.

The estimated responsiveness of the risk reversals to the respective sovereign CDS spreads after controlling for the cointegration effects are reported in Table 12 (see columns C and F for dollar and euro-based risk reversals respectively). For ease of comparison of this responsiveness with those to the stock market volatilities (i.e. those found in Section 5.2), the two responsivenesses are depicted in Figure 14. All the risk reversals on the x-axis are ranked by the responsiveness to the stock market volatilities in the chart. Generally speaking, both sets of risk reversals have a similar ranking of estimated responsiveness, except for a few euro-based risk reversals. This suggests that both sets of the estimation results are largely consistent. In other words, the US dollar is perceived to play the role of safe haven against almost all of the selected currencies, except the Japanese yen, from dollar-based investors' perspective, while the Japanese yen, the US dollar, Swiss franc and most of the Asian currencies from euro-based investors' perspective.

Spot exchange rate movement

In the second robustness check, we test whether the risk reversal is mainly driven by the spot exchange rate movement but not the global risk aversion. Therefore, we re-examine the responsiveness using an adjusted risk reversal rather than the original one in estimation to assess the robustness of our results. Specifically, for each currency, we regress the change in the risk reversal on the change in its underlying spot exchange rate, and the residual extracted from this regression can be regarded as the risk reversal adjusted for the effect of actual exchange rate movements.

All the relevant estimation results of the adjusted risk reversals are also summarised in Table 12 (see columns D and G for dollar and euro-based risk reversals), and depicted in Figure 15 for ease of comparison with those to the stock market volatilities (i.e. found in Section 5.2). Again, the risk reversals on the x-axis are ranked by the responsiveness to the stock market volatilities in the chart. Except for a few euro-based risk reversals, both sets of responsiveness have a similar ranking, which suggests that the estimation results remain largely consistent with our previous findings.

Before and after 2008 global financial crisis

The third robustness check is to test whether the safehavenness is different before and after the 2008 global financial crisis. Since the global financial crisis mainly occurred in 2008, the pre-crisis period is chosen to be from 2 Jan 2001 to 31 Dec 2007, and the post-crisis period from 1 July 2009 to 31 May 2012.

All estimation results are reported in Table 13 and depicted in Figures 16 and 17 for ease of comparison. As shown in the charts of the USD-based risk reversals (Figure 16), most of the European risk reversals have a positive responsiveness prior to 2008 but not after 2008. This reflects that the European currencies, which were previously regarded as a safe haven by USD-based investors, have become risky currencies after the global financial crisis. In the charts of euro-based risk reversals (Figure 17), some Asian risk reversals are negative before 2008 but turn positive after 2008. This implies that these Asian currencies were considered risky before 2008 but then became safe havens after 2008 from euro-based investors' perspective. The results suggest that the global financial crisis was an important event as it had fundamentally changed the safehavenness, or the perception or assessment of international investors about the safety, of a number of currencies.

6. Conclusion

This paper studies the safehavenness of currency or the extent to which a currency plays the role of a safe-haven asset. It is measured by the responsiveness of the risk reversal to a global risk aversion index. The relationship between these two market indicators is estimated by quantile regression and MVAR models, which are popular means of studying extreme but plausible market relationships in the literature.

Using risk reversal, or changes in risk reversal in times of crisis to be exact, to assess currency safehavenness, our econometric findings suggest that the Japanese yen and, to a lesser extent, the Hong Kong dollar (and gold) are the only safe havens out of 34 currencies perceived by dollar-based investors. From euro-based investors' perspective, the safehavenness of the Japanese yen is again the most significant, followed by the Swiss franc, the US dollar and most Asian currencies, including the Hong Kong dollar. Some robustness tests are done to assess how currencies' safehavenness responds to sovereign CDS spread changes, spot exchange rate movements, and the pre- and post-crisis episodes. They show that our findings on currencies safehavenness are reasonably robust and there is a fundamental structural break after the global financial crisis in 2008.

The findings of the study also provide useful insights into some interesting puzzles about currency movements that have taken place over the past few years. For instance, the US dollar rose sharply against almost all currencies following the Lehman collapse in September 2008, even though the country was the epicentre of the subprime crisis, and the Japanese yen unexpectedly strengthened in the aftermath of the Tōhoku earthquake/tsunami in March 2011.[23]

[23] The shortage of dollar funding caused by the subprime crisis, which prompted financial institutions in Europe and elsewhere to use the FX swap market obtain dollar funding, was also a major source of upward pressure on the US dollar (McCauley and McGuire, 2009).

References

Adrian T, Brunnermeier MK (2016) CoVaR. *American Economic Review* 106(7): 1705-1741.

Borio C, Disyatat P (2011) Global imbalances and the financial crisis: Link or no link?. *BIS Working Papers* 346, Bank for International Settlements.

Brunnermeier MK, Nagel S, Pedersen LH (2008) Carry trades and currency crashes. *NBER Macroeconomics Annual* 23 (1): 313-348.

Bruno V, Shin HS (2014) Cross-border banking and global liquidity. *BIS Working Papers* 458, Bank for International Settlements.

Collin-Dufresne P, Goldstein RS, Martin JS (2001) The Determinants of Credit Spread Changes. *Journal of Finance* 56(6): 2177-2207.

Cumby R (1988) Is it risk? Explaining deviations from interest rate parity. *Journal of Monetary Economics* 22: 279-299.

Eichengreen B, Rose AK, Wyplosz C (1996) Contagious Currency Crises. *NBER Working Papers* 5681.

Elliott G, Rothenberg TJ, Stock JH (1996) Efficient Tests for an Autoregressive Unit Root. *Econometrica* 64(4): 813-36.

Fong TPW, Wong ACS (2008) Stress testing of banks' credit risk using mixture vector autoregressive models. A book chapter of "Stress-testing for Financial Institutions" edited by Daniel Rosch and Harald Scheule, 173-193 London: Incisive Media.

Fong TPW, Li WK, Yau CW, Wong CS (2007) On a mixture vector autoregressive model. *The Canadian Journal of Statistics* 35: 135-150.

Fong TPW, Wong AYT (2012) Gauging potential sovereign risk contagion in Europe. *Economics Letters* 115: 496–499.

Forbes, KJ, Warnock FE (2012) Capital FlowWaves: Surges, Stops, Flight and Retrenchment. *Journal of International Economics* 88(2): 235-251.

Frankel JA, Rose AK (1996) Currency crashes in emerging markets: An empirical treatment. *Journal of International Economics* 41: 351-366.

Froot K, Thaler R (1990) Anomalies: foreign exchange. *Journal of Economic Perspectives* 4: 179-192.

Gourinchas PO, Obstfeld M (2012) Stories of the Twentieth Century for the Twenty-First. *American Economic Journal: Macroeconomics* 4(1): 226-65.

Guarda P, Rouabah A, Theal T (2012) An MVAR framework to capture extreme events in macro-prudential stress tests. European Central Bank, Working paper series 1464 / August 2012.

Giot P (2005) Relationships between implied volatility indexes and stock index returns. Are implied volatility indexes leading indicators?. *Journal of Portfolio Management* : 92-100.

Habib MM, Stracca L (2012) Getting beyond carry trade: What makes a safe haven currency?. *Journal of International Economics* 87: 50–64.

Hoque, A., (2012), The Effects of the European Sovereign Debt Crisis on Major Currency Markets. *International Research Journal of Finance and Economics* 101: 75-80.

Hui CH, Chung TK (2011) Crash risk of the euro in the sovereign debt crisis of 2009–2010. *Journal of Banking & Finance* 35: 2945–2955.

Hui CH, Fong TPW (2015) Price cointegration between sovereign CDS and currency option markets in the financial crises of 2007–2013. *International Review of Economics and Finance* 40: 174–190.

Hui CH, Genberg H, Chung TK (2011) Funding liquidity risk and deviations from interest-rate parity during the financial crisis of 2007-2009. *International Journal of Finance and Economics* 16: 307-323.

Kaminsky G, Lizondo S, Reinhart CM (1998) Leading indicators of currency crises. *International Monetary Fund Staff Papers* 45: 1–48.

Kaul A, Sapp S (2006) Y2K fears and safe haven trading of the U.S. dollar. *Journal of International Money and Finance* 25: 760-779.

Koenker R, Bassett G (1978) Regression quantiles. *Econometrica* 46: 33–50.

Kohler M (2010) Exchange rates during financial crises. *BIS Quarterly Review*, March, 39-50.

Kruse R, Frommel M, Menkhoff L, Sibbertsen P (2011) What do we know about real exchange rate nonlinearities?. *Empirical Economics* 43: 457-474.

Kumar M, Moorthy U, Perraudin W (2003) Predicting emerging market currency crashes. *Journal of Empirical Finance* 10(4): 427–454.

Ma L, Pohlman L (2008) Return forecasts and optimal portfolio construction: a quantile regression approach. *European Journal of Finance* 14(5): 409-425.

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

McLachlan GJ, Basford KE (1988) Mixture Models: Inference and Application to Clustering. Marcel Dekker, New York.

Martinez Peria M (2002) A regime-switching approach to the study of speculative attacks: A focus on EMS crises. Empirical Economics 27: 299-334.

Obstfeld, Maurice (2012a) Financial Flows, Financial Crises, and Global Imbalances. *Journal of International Money and Finance* 31: 469-480.

Obstfeld, Maurice (2012b) Does the Current Account Still Matter? *American Economic Review* 102(3): 1-23.

Pan J, Singleton JK (2008) Default and Recovery Implicit in the Term Structure of Sovereign CDS Spreads. *Journal of Finance*, 63: 2345–2384.

Ranaldo A, Soderlind P (2010) Safe haven currencies. *Review of Finance* 14: 385–407.

Rey H (2015) Dilemma not Trilemma: The global financial cycle and monetary policy independence. *NBER Working Paper* 21162.

Titterington DM, Smith AFM, Makov UE (1985) Statistical Analysis of Finite Mixture Distributions. Wiley, New York.

VanderLinden, D. and Gramlich, J.D. (2005) Enhancing risk-controlled returns on excess Japanese yen. *Managerial Finance* 31: 35-47.

VanderLinden, D. and Nikolov, K. (2006) Enhancing returns on yen: minimizing risk reversal costs. *Applied Financial Economics* 15: 1203-1211.

Whaley RE (2000) The investor fear gauge. *Journal of Portfolio Management* 26: 12-17

Wong AYT, Fong, TPW (2011) Analysing interconnectivity among economics. *Emerging Markets Review* 12: 432–442.

Table 1: Data source of risk reversal

		USD-based		Euro-based	
Economy	**Currency**	**Source**	**Data label or ticker**	**Source**	**Data label or ticker**
Asia					
China	Chinese renminbi	JPM	CNY/USD	BBG	EURCNY25R3M Curncy
Hong Kong	Hong Kong dollar	JPM	HKD/USD	JPM	HKD/EUR
India	Indian rupee	JPM	INR/USD	JPM	INR/EUR
Indonesia	Indonesian rupiah	JPM	IDR/USD	JPM	IDR/EUR
Japan	Japanese yen	JPM	JPY/USD	JPM	JPY/EUR
Malaysia	Malaysian ringgit	JPM	MYR/USD	JPM	MYR/EUR
Philippines	Philippines peso	JPM	PHP/USD	BBG	EURPHP25R3M Curncy
Singapore	Singapore dollar	JPM	SGD/USD	JPM	SGD/EUR
South Korea	Korean won	JPM	KRW/USD	JPM	KRW/EUR
Taiwan	New Taiwan dollar	JPM	TWD/USD	JPM	TWD/EUR
Thailand	Thai baht	JPM	THB/USD	JPM	THB/EUR
Higher yielding currency					
Australia	Australian dollar	JPM	AUD/USD	JPM	AUD/EUR
New Zealand	New Zealand dollar	JPM	NZD/USD	JPM	NZD/EUR
Canada	Canadian dollar	JPM	CAD/USD	JPM	CAD/EUR
Europe					
Eurozone	Euro	JPM	EUR/USD	*NA*	*NA*
Denmark	Danish krone	JPM	DKK/USD	JPM	DKK/EUR
Norway	Norwegian krone	JPM	NOK/USD	JPM	NOK/EUR
Sweden	Swedish krona	JPM	SEK/USD	JPM	SEK/EUR
Switzerland	Swiss franc	JPM	CHF/USD	JPM	CHF/EUR
UK	British pound	JPM	GBP/USD	JPM	GBP/EUR
EMEA					
South Africa	South African rand	JPM	ZAR/USD	JPM	ZAR/EUR
Russia	Russian ruble	JPM	RUB/USD	JPM	RUB/EUR
Hungary	Hungarian forint	JPM	HUF/USD	JPM	HUF/EUR
Poland	Polish zloty	JPM	PLN/USD	JPM	PLN/EUR
Turkey	Turkish lira	JPM	TRY/USD	JPM	TRY/EUR
Israel	Israeli New shekel	JPM	ILS/USD	BBG	EURILS25R3M Curncy
Slovakia	Slovak koruna	JPM	SKK/USD	BBG	EURSKK25R3M Curncy
Latin America					
Argentina	Argentina peso	JPM	ARS/USD	JPM	ARS/EUR
Brazil	Brazilian real	JPM	BRL/USD	JPM	BRL/EUR
Chile	Chilean peso	JPM	CLP/USD	JPM	CLP/EUR
Colombia	Colombian peso	JPM	COP/USD	BBG	EURCOP25R3M Curncy
El Salvador	Salvadoran colon	JPM	SLV/USD	JPM	SLV/EUR
Mexico	Mexican peso	JPM	MXN/USD	JPM	MXN/EUR
Reference					
Gold		JPM	GLD/USD	JPM	GLD/EUR
US	US dollar	NA	NA	JPM	USD/EUR

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

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

Economy	Currency	Mean	Med.	Max.	Min.	SD	1st sample date	Sample size
Asia								
China	Chinese renminbi	0.51	0.50	5.33	-7.50	1.58	02-Jan-01	2,857
Hong Kong	Hong Kong dollar	0.41	0.40	2.69	-0.78	0.52	02-Jan-01	2,857
India	Indian rupee	-1.65	-1.21	1.24	-18.09	2.35	04-Mar-04	2,064
Indonesia	Indonesian rupiah	-3.69	-2.49	-0.20	-27.00	4.21	06-May-04	2,020
Japan	Japanese yen	1.51	1.08	10.07	-1.64	1.63	02-Jan-01	2,857
Malaysia	Malaysian ringgit	-0.40	-0.43	1.10	-5.16	1.37	02-Jan-01	2,857
Philippines	Philippines peso	-2.04	-1.75	-0.01	-13.45	1.69	20-Feb-03	2,323
Singapore	Singapore dollar	-0.37	-0.20	1.26	-4.47	0.91	12-Mar-01	2,809
South Korea	Korean won	-1.97	-0.53	1.69	-27.00	3.13	02-Jan-01	2,857
Taiwan	New Taiwan dollar	0.02	0.35	2.29	-3.50	1.00	02-Jan-01	2,857
Thailand	Thai baht	-0.75	-0.74	1.20	-4.63	0.96	02-Jan-01	2,857
Higher yielding currency								
Australia	Australian dollar	-1.39	-0.69	0.74	-8.25	1.55	02-Jan-01	2,857
New Zealand	New Zealand dollar	-1.46	-0.83	0.64	-8.00	1.50	02-Jan-01	2,857
Canada	Canadian dollar	-0.40	-0.10	0.90	-4.18	0.84	02-Jan-01	2,857
Europe								
Eurozone	Euro	-0.33	0.10	1.38	-4.35	1.13	02-Jan-01	2,857
Denmark	Danish krone	-0.34	0.08	1.39	-4.35	1.13	02-Jan-01	2,857
Norway	Norwegian krone	-0.40	0.00	1.39	-4.35	1.15	02-Jan-01	2,857
Sweden	Swedish krona	-0.42	-0.02	1.39	-4.35	1.16	02-Jan-01	2,857
Switzerland	Swiss franc	0.28	0.35	2.00	-2.40	0.66	02-Jan-01	2,857
UK	British pound	-0.57	-0.20	0.85	-4.00	0.94	02-Jan-01	2,857
EMEA								
South Africa	South African rand	-3.69	-3.25	-1.00	-11.00	1.67	02-Jan-01	2,857
Russia	Russian ruble	-2.83	-2.13	0.10	-16.00	3.10	17-Jan-06	1,596
Hungary	Hungarian forint	-2.76	-2.72	1.39	-9.25	2.13	02-Jan-01	2,857
Poland	Polish zloty	-2.54	-1.94	-0.34	-11.74	1.78	02-Jan-01	2,857
Turkey	Turkish lira	-4.30	-4.21	-1.80	-10.25	1.37	31-Dec-04	1,856
Israel	Israeli New shekel	-1.16	-0.84	0.46	-2.63	0.74	02-Jan-01	2,857
Slovakia	Slovak koruna	-0.90	-0.92	1.02	-4.35	0.88	02-Jan-01	2,857
Latin America								
Argentina	Argentina peso	-5.25	-3.75	-0.66	-28.00	4.72	12-Feb-02	2,578
Brazil	Brazilian real	-4.47	-3.75	-1.50	-23.00	2.63	02-Jan-01	2,857
Chile	Chilean peso	-2.65	-2.30	0.00	-13.00	1.75	02-Jan-01	2,857
Colombia	Colombian peso	-3.38	-2.75	-0.50	-10.00	1.73	28-May-04	2,004
El Salvador	Salvadoran colon	2.70	3.25	9.25	-5.73	2.56	27-Feb-01	2,818
Mexico	Mexican peso	-2.78	-2.39	0.15	-18.75	2.53	02-Jan-01	2,857
Reference								
Gold		2.49	2.36	9.24	-1.10	1.73	27-Feb-01	2,818
US	US dollar	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

Table 2b: Descriptive statistics of risk reversals vis-à-vis euro

Economy	Currency	Mean	Med.	Max.	Min.	SD	1st sample date	Sample size
Asia								
China	Chinese renminbi	0.85	1.52	3.70	-3.00	1.93	30-Mar-09	795
Hong Kong	Hong Kong dollar	0.46	0.15	4.53	-1.38	1.16	02-Jan-01	2,857
India	Indian rupee	-0.74	-0.21	2.54	-17.40	2.26	04-Mar-04	2,064
Indonesia	Indonesian rupiah	-3.09	-2.10	1.55	-26.85	3.89	03-Feb-03	2,335
Japan	Japanese yen	1.79	1.06	10.80	-1.48	1.98	02-Jan-01	2,857
Malaysia	Malaysian ringgit	-0.30	-0.25	2.74	-3.51	1.05	02-Jan-01	2,857
Philippines	Philippines peso	-0.16	-0.70	13.25	-3.45	2.63	05-Sep-03	2,186
Singapore	Singapore dollar	0.09	-0.10	2.84	-1.50	0.75	02-Jan-01	2,857
South Korea	Korean won	-1.44	-0.48	2.00	-26.50	2.78	02-Jan-01	2,857
Taiwan	New Taiwan dollar	0.23	0.33	4.21	-7.92	1.80	02-Jan-01	2,857
Thailand	Thai baht	-0.35	-0.20	3.31	-4.47	1.24	02-Jan-01	2,857
Higher yielding currency								
Australia	Australian dollar	-0.81	-0.64	0.53	-5.20	0.74	02-Jan-01	2,857
New Zealand	New Zealand dollar	-0.90	-0.78	0.55	-4.71	0.72	02-Jan-01	2,857
Canada	Canadian dollar	-0.04	-0.09	2.19	-1.47	0.55	02-Jan-01	2,857
Europe								
Eurozone	Euro	NA	NA	NA	NA	NA	NA	NA
Denmark	Danish krone	-0.13	-0.23	0.54	-0.98	0.30	02-Jan-01	2,857
Norway	Norwegian krone	-0.55	-0.39	0.45	-3.65	0.72	02-Jan-01	2,857
Sweden	Swedish krona	-0.71	-0.50	0.50	-4.20	0.76	02-Jan-01	2,857
Switzerland	Swiss franc	0.81	0.51	5.16	-0.49	0.86	02-Jan-01	2,857
UK	British pound	-0.25	-0.23	2.17	-3.50	0.63	02-Jan-01	2,857
EMEA								
Russia	Russian ruble	-2.38	-1.30	-0.20	-16.50	3.03	30-Dec-05	1,606
Hungary	Hungarian forint	-2.36	-2.32	3.55	-9.25	2.02	02-Jan-01	2,857
Poland	Polish zloty	-1.86	-1.39	0.80	-8.53	1.55	02-Jan-01	2,857
Turkey	Turkish lira	-4.50	-4.65	4.47	-9.50	1.69	02-Jan-01	2,857
Israel	Israeli New shekel	-0.29	-0.30	1.69	-2.10	0.66	01-Oct-03	2,168
Slovakia	Slovak koruna	-0.43	-0.30	1.30	-1.40	0.36	01-Oct-03	2,168
Latin America								
Argentina	Argentina peso	-6.35	-4.78	-0.66	-28.40	4.40	11-Feb-02	2,579
Brazil	Brazilian real	-4.46	-3.73	-1.60	-23.25	2.74	07-Nov-01	2,642
Chile	Chilean peso	-2.73	-2.15	-0.20	-13.73	2.23	19-Feb-03	2,324
Colombia	Colombian peso	-2.25	-2.85	-0.32	-2.85	0.91	07-Mar-05	1,812
El Salvador	Salvadoran colon	1.68	2.59	10.15	-6.47	3.58	27-Feb-01	2,818
Mexico	Mexican peso	-2.32	-1.41	0.72	-19.45	2.72	02-Jan-01	2,857
Reference								
Gold		2.62	2.38	10.02	-0.52	1.59	27-Feb-01	2,818
US	US dollar	0.33	-0.10	4.35	-1.38	1.13	02-Jan-01	2,857

Table 3a. Unit root tests for risk reversal vis-à-vis US dollar

Economy (A)	Currency (B)	2 Jan 2001 – 31 May 2012 Level (C)		1st Difference (D)		8 Jun 2005 – 31 May 2012 Level (E)		1st Difference (F)	
Asia									
China	Chinese renminbi	-1.55		-5.84	**	-0.60		-19.64	**
Hong Kong	Hong Kong dollar	-3.28	**	-6.94	**	-3.97	**	-16.66	**
India	Indian rupee	-2.17	*	-18.76	**	-2.02	*	-17.28	**
Indonesia	Indonesian rupiah	-2.44	*	-15.91	**	-1.96	*	-14.85	**
Japan	Japanese yen	-2.05	*	-6.30	**	-1.84		-18.32	**
Malaysia	Malaysian ringgit	-0.43		-23.05	**	-1.65		-18.15	**
Philippines	Philippines peso	-3.35	**	-19.89	**	-2.18	*	-17.19	**
Singapore	Singapore dollar	-1.99	*	-23.54	**	-1.05		-12.44	**
South Korea	Korean won	-3.40	**	-8.71	**	-2.30	*	-16.32	**
Taiwan	New Taiwan dollar	-1.32		-1.32		-1.40		-9.25	**
Thailand	Thai baht	-1.80		-7.96	**	-1.62		-15.55	**
Higher yielding currency									
Australia	Australian dollar	-1.62		-6.32	**	-1.55		-15.83	**
New Zealand	New Zealand dollar	-1.57		-3.41	**	-1.57		-17.49	**
Canada	Canadian dollar	-2.10	*	-18.56	**	-1.25		-18.29	**
Europe									
Eurozone	Euro	-1.37		-6.98	**	-1.33		-12.09	**
Denmark	Danish krone	-1.40		-7.24	**	-1.35		-12.06	**
Norway	Norwegian krone	-1.60		-4.07	**	-1.59		-12.77	**
Sweden	Swedish krona	-1.55		-2.58	**	-1.54		-12.64	**
Switzerland	Swiss franc	-3.52	**	-9.91	**	-2.64	**	-12.72	**
UK	British pound	-1.66		-2.55	*	-1.40		-18.08	**
EMEA									
South Africa	South African rand	-2.88	**	-3.18	**	-1.64		-16.88	**
Russia	Russian ruble	-1.76		-15.18	**	-1.76		-15.18	**
Hungary	Hungarian forint	-1.48		-20.88	**	-1.86		-15.36	**
Poland	Polish zloty	-2.43	*	-7.63	**	-1.36		-17.68	**
Turkey	Turkish lira	-3.27	**	-2.20	*	-2.71	**	-10.51	**
Israel	Israeli New shekel	-1.34		-1.37		-1.16		-15.60	**
Slovakia	Slovak koruna	-2.48	*	-22.76	**	-1.99	*	-17.75	**
Latin America									
Argentina	Argentina peso	-1.76		-1.35		-1.92		-12.91	**
Brazil	Brazilian real	-2.62	**	-19.91	**	-2.82	**	-14.55	**
Chile	Chilean peso	-2.56	*	-1.94	*	-1.80		-9.19	**
Colombia	Colombian peso	-2.17	*	-1.50		-1.96	*	-1.26	
El Salvador	Salvadoran colon	-2.54	*	-21.92	**	-1.60		-16.47	**
Mexico	Mexican peso	-3.49	**	-9.04	**	-2.31	*	-13.41	**
Reference									
Gold		-3.81	**	-21.64	**	-1.90		-14.49	**
US	US dollar	*NA*		*NA*		*NA*		*NA*	**
9 stock vol. (1st pr. comp.)		-3.35	**	-18.65	**	*NA*		*NA*	
25 sov. CDS spreads (1st pr. comp.)		*NA*		*NA*		-1.47		-19.15	**

Notes: (1) It is based on the sample period from 1 Jan 2001 to 31 May 2012. (2) The unit root test refers to the Dickey Fuller GLS test with constant term in the specifications. (3) ** and * denote significance at a level of 1% and 5% respectively, with the critical values -2.57 and -1.94 respectively.

Table 3b. Unit root tests for risk reversal vis-à-vis euro

Economy (A)	Currency (B)	2 Jan 2001 – 31 May 2012 Level (C)		1st Difference (D)		8 Jun 2005 – 31 May 2012 Level (E)		1st Difference (F)	
Asia									
China	Chinese renminbi	-1.19		-11.83	**	-1.19		-11.83	**
Hong Kong	Hong Kong dollar	-1.19		-7.02	**	-1.27		-18.05	**
India	Indian rupee	-2.97	**	-18.50	**	-2.60	**	-17.03	**
Indonesia	Indonesian rupiah	-3.17	**	-17.49	**	-2.67	**	-15.15	**
Japan	Japanese yen	-1.26		-20.92	**	-1.48		-16.91	**
Malaysia	Malaysian ringgit	-3.65	**	-4.98	**	-3.04	**	-17.50	**
Philippines	Philippines peso	-1.47		-17.67	**	-2.07	*	-16.43	**
Singapore	Singapore dollar	-2.95	**	-6.98	**	-2.35	*	-19.32	**
South Korea	Korean won	-2.44	*	-5.64	**	-2.89	**	-16.37	**
Taiwan	New Taiwan dollar	-0.30		-0.87		-3.01	**	-18.93	**
Thailand	Thai baht	-1.03		-9.71	**	-1.70		-17.37	**
Higher yielding currency									
Australia	Australian dollar	-3.33	**	-7.66	**	-2.23	*	-17.50	**
New Zealand	New Zealand dollar	-3.19	**	-7.21	**	-2.05	*	-18.47	**
Canada	Canadian dollar	-2.90	**	-4.58	**	-3.11	**	-17.16	**
Europe									
Eurozone	Euro	*NA*		*NA*		*NA*		*NA*	
Denmark	Danish krone	-1.18		-22.17	**	-0.64		-17.39	**
Norway	Norwegian krone	-1.91		-8.42	**	-1.06		-5.70	**
Sweden	Swedish krona	-1.76		-7.16	**	-1.15		-3.60	**
Switzerland	Swiss franc	-2.96	**	-15.80	**	-1.86		-17.50	**
UK	British pound	-2.52	*	-11.68	**	-1.68		-18.36	**
EMEA									
South Africa	South African rand	-3.57	**	-3.14	**	-2.00	*	-17.26	**
Russia	Russian ruble	-1.90		-15.14	**	-1.90		-15.14	**
Hungary	Hungarian forint	-2.00	*	-9.02	**	-2.54	*	-15.66	**
Poland	Polish zloty	-1.50		-6.88	**	-1.32		-18.15	**
Turkey	Turkish lira	-3.06	**	-24.86	**	-2.64	**	-17.77	**
Israel	Israeli New shekel	-2.56	*	-22.79	**	-2.83	**	-20.74	**
Slovakia	Slovak koruna	-2.67	**	-27.28	**	-1.63		-25.03	**
Latin America									
Argentina	Argentina peso	-2.08	*	-1.38		-2.51	*	-12.91	**
Brazil	Brazilian real	-2.92	**	-19.01	**	-2.84	**	-14.53	**
Chile	Chilean peso	-2.53	*	-20.01	**	-1.72		-10.20	**
Colombia	Colombian peso	-0.57		-16.63	**	-0.56		-16.33	**
El Salvador	Salvadoran colon	-2.53	*	-24.79	**	-1.65		-20.21	**
Mexico	Mexican peso	-2.50	*	-12.23	**	-2.14	*	-16.11	**
Reference									
Gold		-4.29	**	-22.35	**	-2.21	*	-18.00	**
US	US dollar	-1.37		-6.98	**	-1.33		-12.09	**
9 stock vol. (1st pr. comp.)		-3.35	**	-18.65	**	*NA*		*NA*	
25 sov. CDS spreads (1st pr. comp.)		*NA*		*NA*		-1.47		-19.15	**

Notes: (1) It is based on the sample period from 1 Jan 2001 to 31 May 2012. (2) The unit root test refers to the Dickey Fuller GLS test with constant term in the specifications. (3) ** and * denote significance at a level of 1% and 5% respectively, with the critical values -2.57 and -1.94 respectively.

Table 4a: Data sources and descriptive statistics of stock volatility indices

Stock market	Data source	Ticker
S&P 500 volatility	Bloomberg	VIX Index
Dow Jones volatility	Bloomberg	VXD Index
NASDAQ volatility	Bloomberg	VXN Index
Euro Stoxx 50 volatility	Bloomberg	V2X Index
DAX volatility	Bloomberg	VDAX Index
CAC 40 volatility	Bloomberg	VCAC Index
FTSE 100 volatility	Bloomberg	VFTSE Index
NIKKEI 225 volatility	Bloomberg	VNKY Index
Hang Seng volatility	Bloomberg	VHSI Index

Table 4b: Data sources and descriptive statistics of stock volatility indices

Stock market	Mean	Med.	Max.	Min.	SD	1st sample date	Sample size
S&P 500 volatility	22.09	20.10	80.86	9.89	9.66	02-Jan-01	2,857
Dow Jones volatility	20.52	18.85	74.60	9.28	8.93	02-Jan-01	2,857
NASDAQ volatility	28.99	24.61	80.64	12.61	13.13	02-Feb-01	2,835
Euro Stoxx 50 volatility	26.40	24.06	87.51	11.60	10.99	02-Jan-01	2,857
DAX volatility	23.82	21.21	74.00	10.98	9.64	02-Jan-01	2,857
CAC 40 volatility	24.70	22.55	78.05	9.24	9.98	02-Jan-01	2,857
FTSE 100 volatility	21.74	19.66	78.69	9.10	9.52	02-Jan-01	2,857
NIKKEI 225 volatility	26.26	24.65	92.03	11.18	10.14	04-Jan-01	2,855
Hang Seng volatility	25.35	22.00	104.29	10.86	10.90	02-Jan-01	2,857
9 Stock vol. (1st pr. comp.)	0.00	-0.49	15.13	-3.69	2.78	02-Feb-01	2,835

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

	Principal component								
Volatility index	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
VIX (S&P500)	0.35	0.11	-0.01	0.17	-0.61	0.17	0.08	0.10	0.64
VXD (Dow Jones)	0.36	0.03	0.02	0.15	-0.48	0.24	-0.08	-0.24	-0.71
VXN (NASDAQ)	0.29	-0.20	0.89	0.20	0.20	-0.07	0.04	0.02	0.03
V2X (Euro Stoxx 50)	0.35	-0.28	-0.20	-0.06	0.04	-0.10	0.18	0.81	-0.21
VDAX (DAX)	0.34	-0.36	-0.19	-0.12	0.38	0.64	-0.33	-0.15	0.17
VCAC (CAC 40)	0.34	-0.27	-0.25	-0.01	0.14	-0.28	0.65	-0.48	0.06
VFTSE (FTSE 100)	0.35	-0.05	-0.17	0.10	0.02	-0.63	-0.64	-0.12	0.08
VNKY (NIKKEI 225)	0.32	0.41	0.17	-0.83	0.01	-0.04	0.01	-0.02	0.00
VHSI (Hang Seng Index)	0.29	0.70	-0.13	0.43	0.44	0.10	0.11	0.08	-0.04
Proportion of total variation explained (%)	85.54	6.99	4.40	1.32	0.92	0.41	0.25	0.13	0.04

Table 6: Least squares estimation results of responsiveness of risk reversals to the risk aversion index

Economy	Currency	vis-à-vis USD	vis-à-vis euro
Asia			
China	Chinese renminbi	-0.0612 **	0.054 **
Hong Kong	Hong Kong dollar	0.0028	0.0574 **
India	Indian rupee	-0.2175 **	-0.1124 **
Indonesia	Indonesian rupiah	-0.2184 **	0.0328
Japan	Japanese yen	0.1643 **	0.1810 **
Malaysia	Malaysian ringgit	-0.0364 **	0.0358 **
Philippines	Philippines peso	-0.1027 **	0.0569 **
Singapore	Singapore dollar	-0.0603 **	0.0583 **
South Korea	Korean won	-0.3974 **	-0.3115 **
Taiwan	New Taiwan dollar	-0.0434 **	0.0533 **
Thailand	Thai baht	0.0024	0.0418 **
Higher yielding currency			
Australia	Australian dollar	-0.1721 **	-0.0938 **
New Zealand	New Zealand dollar	-0.1655 **	-0.0678 **
Canada	Canadian dollar	-0.1021 **	-0.0148 **
Europe			
Eurozone	Euro	-0.0555 **	*NA*
Denmark	Danish krone	-0.0542 **	-0.0029 **
Norway	Norwegian krone	-0.0532 **	-0.0286 **
Sweden	Swedish krona	-0.0518 **	-0.0463 **
Switzerland	Swiss franc	-0.0397 **	0.0662 **
UK	British pound	-0.0533 **	-0.0120 **
EMEA			
South Africa	South African rand	-0.1102 **	-0.1075 **
Russia	Russian ruble	-0.2041 **	-0.1988 **
Hungary	Hungarian forint	-0.0887 **	-0.1086 **
Poland	Polish zloty	-0.1168 **	-0.1056 **
Turkey	Turkish lira	-0.2267 **	-0.1779 **
Israel	Israeli New shekel	-0.0136 **	0.0021
Slovakia	Slovak koruna	-0.0642 **	-0.0006
Latin America			
Argentina	Argentina peso	-0.0588 **	0.0482 **
Brazil	Brazilian real	-0.2141 **	-0.2041 **
Chile	Chilean peso	-0.0431 **	-0.0462 **
Colombia	Colombian peso	-0.0290 **	0.0006
El Salvador	Salvadoran colon	-0.0339 **	-0.0373
Mexico	Mexican peso	-0.2076 **	-0.2838 **
Reference			
Gold		0.0302 **	0.0200
US	US dollar	*NA*	0.0555 **

Note: ** and * denote significance at a level of 5% and 10% respectively.

Table 7: Estimation results of responsiveness of risk reversals to the risk aversion index

		vis-à-vis the US dollar			vis-à-vis euro		
Economy (A)	Currency (B)	QR estimate[2] (C)	MVAR estimate (D)	MVAR adequacy[3] (E)	QR estimate[2] (F)	MVAR estimate (G)	MVAR adequacy[3] (H)
Asia							
China	Chinese renminbi	-0.0826 **	-0.1213 **	0.01	0.1076 **	0.4721	0.17
Hong Kong	Hong Kong dollar	0.0212 *	0.0350 **	0.05	0.0776 **	0.0997 **	0.20
India	Indian rupee	-0.2328 **	-0.3360 **	0.28	-0.0890 **	-0.2309 **	0.03
Indonesia	Indonesian rupiah	-0.2829 **	-0.3810 **	0.18	0.0417	0.0613 *	0.04
Japan	Japanese yen	0.2078 **	0.2544 **	0.19	0.2278 **	0.2788 **	0.05
Malaysia	Malaysian ringgit	-0.0603 **	-0.0753 **	0.68	0.0426 *	0.0393 **	0.26
Philippines	Philippines peso	-0.1329 **	-0.2374 **	0.04	0.0464 **	0.1239 **	0.54
Singapore	Singapore dollar	-0.1052 **	-0.0920 **	0.01	0.0874 **	0.0945 **	0.60
South Korea	Korean won	-0.3385 **	-0.7483 *	0.10	-0.2930 **	-0.7742 *	0.35
Taiwan	New Taiwan dollar	-0.0823 **	0.0000 **	0.00	0.1127 **	0.0740 **	0.34
Thailand	Thai baht	-0.0105 **	0.0107 **	0.00	0.0758 **	0.0650 **	0.11
Higher yielding currency							
Australia	Australian dollar	-0.2094 **	-0.2665 **	0.00	-0.1169 **	-0.1495 **	0.09
New Zealand	New Zealand dollar	-0.2024 **	-0.2502 **	0.01	-0.0845 **	0.0030 **	0.88
Canada	Canadian dollar	-0.1399 **	-0.1651 **	0.71	-0.0319 **	0.0001 **	0.79
Europe							
Eurozone	Euro	-0.0812 **	-0.1047 **	0.19	*NA*	*NA*	*NA*
Denmark	Danish krone	-0.0775 **	-0.0941 **	0.05	-0.0004	-0.0187 **	0.00
Norway	Norwegian krone	-0.0850 **	-0.0856 **	0.84	-0.0421 **	0.0004 **	0.94
Sweden	Swedish krona	-0.0772 **	-0.0914 **	0.44	-0.0700 **	0.0000 **	0.01
Switzerland	Swiss franc	-0.0590 **	-0.0737 **	0.93	0.1044 **	0.1046 **	0.18
UK	British pound	-0.0824 **	-0.0818 **	0.24	-0.0409 **	-0.0234 **	0.57
EMEA							
South Africa	South African rand	-0.1735 **	0.0001 **	0.45	-0.1781 **	0.0001 **	0.95
Russia	Russian ruble	-0.2673 **	-0.2854 **	0.11	-0.2738 **	-0.2793 **	0.81
Hungary	Hungarian forint	-0.1313 **	-0.1277 **	0.40	-0.1667 **	-0.2063 *	0.98
Poland	Polish zloty	-0.1810 **	-0.1731 **	0.61	-0.1410 **	-0.1631 **	0.76
Turkey	Turkish lira	-0.3338 **	-0.2478 **	0.29	-0.2788 **	-0.1564 **	0.22
Israel	Israeli New shekel	-0.0345 **	-0.0246 **	0.89	-0.0300	0.0121 **	0.00
Slovakia	Slovak koruna	-0.0991 **	0.0003 **	0.09	0.0000	-0.0116 *	0.18
Latin America							
Argentina	Argentina peso	-0.0128	-0.1616 *	0.00	-0.0110	0.1792 *	0.00
Brazil	Brazilian real	-0.2852 **	-0.3124 **	0.48	-0.2713 **	-0.2927 **	0.24
Chile	Chilean peso	-0.0782 **	-0.2356 **	0.00	-0.0920 **	-0.1604 *	0.00
Colombia	Colombian peso	-0.0137 **	-0.1515 *	0.00	*NA*	*NA*	*NA*
El Salvador	Salvadoran colon	-0.1298 **	-0.0626 **	0.18	-0.1668 **	-0.0439 **	0.35
Mexico	Mexican peso	-0.2599 **	-0.4153 **	0.24	-0.2602 **	-0.5593 **	0.62
Reference							
Gold		0.0766 *	0.0967 **	0.94	0.0813 *	0.0418 **	0.92
US	US dollar	*NA*	*NA*		0.0812 **	0.1047	0.19

Notes: (1) ** and * denote significance at a level of 5% and 10% respectively. (2) Positive coefficient is estimated at a quantile level of 0.95 (i.e. a sharp rise in risk reversal), while negative coefficient is estimated at a quantile level of 0.05 (i.e. a sharp fall). (3) The column reports the p-value of the Portmanteau test which checks whether the residual correlations are serially uncorrelated under the null hypothesis.

Table 8: Data source of sovereign CDS spreads

Economy	Currency	Source	Data label or ticker
Asia			
China	Chinese renminbi	JPM	CN Credit Swap 5Yr Spread (Mid)(%)
Hong Kong	Hong Kong dollar	TR	HKGV5YUSAC=FN
India	Indian rupee	TR	INGV5YUSAC=FN
Indonesia	Indonesian rupiah	JPM	ID Credit Swap 5Yr Spread (Mid)(%)
Japan	Japanese yen	JPM	JP Credit Swap 5Yr Spread (Mid)(%)
Malaysia	Malaysian ringgit	JPM	MY Credit Swap 5Yr Spread (Mid)(%)
Philippines	Philippines peso	JPM	PH Credit Swap 5Yr Spread (Mid)(%)
Singapore	Singapore dollar	TR	STEL5YUSAC=R
South Korea	Korean won	JPM	KR Credit Swap 5Yr Spread (Mid)(%)
Taiwan	New Taiwan dollar	TR	TWGV5YUSAC=FN
Thailand	Thai baht	JPM	TH Credit Swap 5Yr Spread (Mid)(%)
Higher yielding currency			
Australia	Australian dollar	JPM	AU Credit Swap 5Yr Spread (Mid)(%)
New Zealand	New Zealand dollar	JPM	NZ Credit Swap 5Yr Spread (Mid)(%)
Canada	Canadian dollar	TR	CAGV5YUSAC=R
Europe			
Eurozone	Euro	TR	"DEGV5YUSAC=R;"&"PTGV5YUSAC=R;"&"ESGV5YUSAC=R;"&"BEGV5YUSAC=R;"&"IEGV5YUSAC=R;"&"ATGV5YUSAC=R;"&"GRGV5YUSAC=R;"&"FRGV5YUSAC=R;"&"ITGV5YUSAC=R;"
Denmark	Danish krone	JPM	Denmark USD 5 Year IMM Market Coupon 2003 Spread
Norway	Norwegian krone	JPM	Norway USD 5 Year IMM Market Coupon 2003 Spread
Sweden	Swedish krona	TR	SEGV5YUSAC=R
Switzerland	Swiss franc	BBG	SWISS CDS USD SR 5Y D14 Corp
UK	British pound	JPM	UK USD 5 Year IMM Market Coupon 2003 Spread
EMEA			
South Africa	South African rand	JPM	ZA Credit Swap 5Yr Spread (Mid)(%)
Russia	Russian ruble	JPM	RU Credit Swap 5Yr Spread (Mid)(%)
Hungary	Hungarian forint	JPM	HU Credit Swap 5Yr Spread (Mid)(%)
Poland	Polish zloty	JPM	PL Credit Swap 5Yr Spread (Mid)(%)
Turkey	Turkish lira	JPM	TR Credit Swap 5Yr Spread (Mid)(%)
Israel	Israeli New shekel	JPM	IL Credit Swap 5Yr Spread (Mid)(%)
Slovakia	Slovak koruna	JPM	SK Credit Swap 5Yr Spread (Mid)(%)
Latin America			
Argentina	Argentina peso	JPM	AR Credit Swap 5Yr Spread (Mid)(%)
Brazil	Brazilian real	JPM	BR Credit Swap 5Yr Spread (Mid)(%)
Chile	Chilean peso	JPM	CL Credit Swap 5Yr Spread (Mid)(%)
Colombia	Colombian peso	JPM	CO Credit Swap 5Yr Spread (Mid)(%)
El Salvador	Salvadoran colon	JPM	SV Credit Swap 5Yr Spread (Mid)(%)
Mexico	Mexican peso	JPM	MX Credit Swap 5Yr Spread (Mid)(%)
Reference			
US	US dollar	BBG	US CDS EUR SR 5Y D14

Notes: (1) “JPM”, “BBG” and “TR” refer to databases of JP Morgan Chase, Bloomberg, and Thomson Reuters respectively. (2) The Eurozone’s spread is the median of nine sovereign CDS spreads of the zone including Austria, Belgium, France, Germany, Ireland, Italy, Portugal, Spain, and Greece.

Table 9: Descriptive statistics of sovereign CDS spreads

Economy	Mean	Med.	Max.	Min.	SD	1st sample date	Sample size	Selected
Asia								
China	0.59	0.41	2.65	0.09	0.47	15-Mar-02	2,556	Yes
Hong Kong	45.32	45.00	132.50	0.00	30.97	04-Jan-05	1,854	Yes
India	77.35	71.00	218.50	31.00	31.15	10-Jun-05	1,745	Yes
Indonesia	2.79	2.08	12.50	0.90	2.02	02-Sep-03	2,189	Yes
Japan	0.35	0.18	1.59	0.03	0.37	03-Oct-01	2,666	Yes
Malaysia	0.77	0.73	4.60	0.12	0.60	29-Jan-03	2,338	Yes
Philippines	3.06	2.60	8.00	0.90	1.51	11-Jan-01	2,849	Yes
Singapore	69.84	60.00	150.00	25.00	31.38	14-Dec-07	1,116	
South Korea	0.89	0.70	6.75	0.14	0.80	26-Feb-02	2,569	Yes
Taiwan	191.64	211.00	400.50	18.00	92.32	13-Dec-06	1,367	
Thailand	0.88	0.69	4.60	0.24	0.64	03-Apr-03	2,293	Yes
Higher yielding currency								
Australia	0.25	0.04	1.80	0.02	0.33	03-Oct-01	2,666	Yes
New Zealand	0.77	0.67	1.95	0.28	0.32	11-Aug-08	952	
Canada	42.25	41.69	95.00	15.00	14.12	21-Jul-08	967	
Europe								
Eurozone	67.95	20.00	420.00	0.14	85.64	04-Jan-05	1,854	Yes
Denmark	64.27	44.48	169.97	9.95	39.03	11-Aug-08	952	
Norway	24.78	22.99	54.70	4.78	11.00	11-Aug-08	952	
Sweden	51.38	46.00	159.00	9.50	27.94	18-Jul-08	968	
Switzerland	49.97	46.51	167.50	30.39	15.84	06-Mar-09	811	
UK	39.96	21.94	156.57	2.44	39.03	04-Jan-05	1,854	Yes
EMEA								
Russia	1.38	1.31	6.22	0.23	0.89	25-Mar-02	2,550	Yes
Hungary	2.66	1.87	11.25	0.33	2.34	02-Jan-01	2,856	Yes
Poland	1.44	0.38	7.41	0.10	1.71	02-Jan-01	2,856	Yes
Turkey	0.81	0.48	4.10	0.08	0.78	02-Jan-01	2,856	Yes
Israel	3.97	2.65	14.40	1.17	2.93	02-Jan-01	2,856	Yes
Slovakia	0.89	0.73	2.80	0.15	0.62	02-Mar-04	2,066	Yes
Latin America								
Argentina	9.08	6.20	43.00	1.79	9.23	08-Jun-05	1,747	Yes
Brazil	4.88	1.99	39.60	0.60	6.42	02-Jan-01	2,856	Yes
Chile	0.81	0.67	3.25	0.12	0.66	04-Mar-02	2,565	Yes
Colombia	3.31	2.05	13.80	0.65	2.56	02-Jan-01	2,856	Yes
El Salvador	3.37	3.00	7.60	0.80	1.41	10-Oct-07	1,161	
Mexico	1.51	1.25	5.90	0.28	0.91	02-Jan-01	2,856	Yes
Reference								
US	14.90	0.00	100.00	0.00	21.48	02-Jan-01	2,856	Yes
25 Sov. CDS spreads (1st pr. comp.)	0.00	-0.25	18.12	-5.17	4.25	13-Jun-05	1,745	-

Table 10: Principal component analysis of the 25 sovereign CDS spreads (the first 9 out of 25 components)

	Principal component								
Soveriegn CDS spread	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Argentina	0.20	0.14	-0.30	0.15	-0.17	0.46	0.25	0.26	-0.14
Australia	0.22	-0.13	-0.04	0.21	-0.04	0.17	0.02	0.27	-0.18
Brazil	0.14	0.31	0.44	0.36	0.09	0.05	0.07	-0.03	-0.01
Chile	0.23	0.02	-0.11	0.01	-0.13	0.00	-0.04	-0.07	0.10
China	0.23	-0.05	0.04	-0.09	-0.02	-0.11	-0.04	-0.25	-0.29
Colombia	0.16	0.31	0.16	0.21	0.22	0.12	-0.27	0.05	0.09
Eurozone	0.14	-0.32	0.40	-0.11	-0.20	0.25	0.23	-0.05	0.08
Hong Kong	0.20	-0.10	-0.14	-0.29	0.72	0.34	-0.20	-0.07	-0.15
Hungary	0.20	-0.22	0.14	-0.06	-0.10	0.14	0.07	0.17	0.21
India	0.21	0.10	-0.03	-0.29	0.25	-0.02	0.65	-0.11	0.24
Indonesia	0.18	0.29	-0.02	-0.06	-0.20	-0.03	0.08	0.02	-0.15
Israel	0.21	-0.16	0.01	0.03	0.01	-0.08	0.05	0.35	0.30
Japan	0.16	-0.32	0.18	0.13	0.14	-0.30	-0.12	0.36	-0.13
Malaysia	0.23	0.05	-0.09	-0.18	0.00	-0.25	0.02	0.10	-0.23
Mexico	0.22	0.11	-0.15	0.11	0.01	0.11	-0.17	0.15	0.11
Philippines	0.13	0.36	0.37	0.09	0.19	-0.17	0.20	-0.01	-0.12
Poland	0.22	-0.17	0.05	0.11	-0.04	0.06	-0.08	-0.14	0.00
Russia	0.22	0.12	-0.15	0.04	-0.29	0.12	-0.08	-0.41	-0.10
South Africa	0.22	0.09	-0.19	-0.16	-0.02	-0.12	-0.02	-0.07	0.35
South Korea	0.23	0.08	-0.14	-0.04	-0.14	-0.10	-0.05	0.20	-0.12
Slovakia	0.19	-0.23	0.34	-0.20	-0.16	0.18	-0.14	-0.24	-0.17
Thailand	0.23	-0.02	-0.07	-0.18	-0.04	-0.36	0.06	0.06	-0.36
Turkey	0.18	0.23	0.16	-0.36	-0.16	-0.06	-0.44	0.07	0.37
UK	0.20	-0.18	-0.14	0.38	0.10	0.01	-0.07	-0.28	0.06
US	0.20	-0.19	-0.15	0.34	0.09	-0.34	0.07	-0.29	0.25
Proportion of total variation explained (%)	73.05	17.82	2.91	1.98	1.12	0.71	0.50	0.29	0.28

Table 11: Test for cointegrating relationship between risk reversal and risk aversion index constructed by the sovereign CDS spread

Economy	Currency	vis-à-vis USD		vis-à-vis euro	
Asia					
China	Chinese renminbi	-3.76	**	-1.82	
Hong Kong	Hong Kong dollar	-5.42	**	-1.93	
India	Indian rupee	-4.03	**	-3.14	*
Indonesia	Indonesian rupiah	-4.42	**	-3.89	**
Japan	Japanese yen	-2.17		-3.68	**
Malaysia	Malaysian ringgit	-2.87	*	-4.43	**
Philippines	Philippines peso	-4.80	**	-2.55	
Singapore	Singapore dollar	-3.33	*	-3.30	*
South Korea	Korean won	-4.03	**	-3.75	**
Taiwan	New Taiwan dollar	-3.25	*	-3.60	**
Thailand	Thai baht	-4.30	**	-1.64	
Higher yielding currency					
Australia	Australian dollar	-3.34	*	-3.78	**
New Zealand	New Zealand dollar	-3.73	**	-4.02	**
Canada	Canadian dollar	-1.82		-3.25	*
Europe					
Eurozone	Euro	-1.87		*NA*	
Denmark	Danish krone	-1.87		-1.29	
Norway	Norwegian krone	-2.40		-3.82	**
Sweden	Swedish krona	-2.35		-3.16	*
Switzerland	Swiss franc	-2.86		-3.23	*
UK	British pound	-3.02	*	-1.71	
EMEA					
South Africa	South African rand	-3.67	**	-2.96	*
Russia	Russian ruble	-4.04	**	-3.59	**
Hungary	Hungarian forint	-4.82	**	-4.85	**
Poland	Polish zloty	-3.82	**	-3.63	**
Turkey	Turkish lira	-3.25	*	-2.62	
Israel	Israeli New shekel	-2.64		-3.03	*
Slovakia	Slovak koruna	-2.04		-4.82	**
Latin America					
Argentina	Argentina peso	-3.53	**	-3.26	*
Brazil	Brazilian real	-3.98	**	-4.04	**
Chile	Chilean peso	-5.15	**	-3.81	**
Colombia	Colombian peso	-3.63	**	-0.76	
El Salvador	Salvadoran colon	-2.27		-2.44	
Mexico	Mexican peso	-3.91	**	-3.61	**
Reference					
Gold		-2.62		-3.55	**
US	US dollar	*NA*		-1.87	

Notes: (1) The test refers to Engle-Granger cointegration test. Under the null hypothesis, the risk reversal is considered to be not cointegrated with the sovereign CDS spread. (2) The sample period is from 8 June 2005 to 31 May 2012. (3) ** and * denote significance at a level of 0.01 and 0.05 respectively

Table 12: Estimated responsiveness of risk reversals to risk aversion index using quantile regressions

		vis-à-vis the US dollar		vis-à-vis euro	
Economy (A)	**Currency (B)**	**Sov. spreads as RiskAversion (C)**	**RR adjusted by spot FX (D)**	**Sov. spreads as RiskAversion (F)**	**RR adjusted by spot FX (G)**
Asia					
China	Chinese renminbi	-0.1171 **	-0.0850 **	0.1694 **	0.0917 **
Hong Kong	Hong Kong dollar	0.0084	0.0160	0.1515 **	0.0755 **
India	Indian rupee	-0.3993 **	-0.1416 **	-0.2113 **	0.0410
Indonesia	Indonesian rupiah	-0.3754 **	-0.1577 **	-0.0799	-0.1278
Japan	Japanese yen	0.2587 **	0.1286 **	0.3259 **	0.1521 **
Malaysia	Malaysian ringgit	-0.1071 **	-0.0506 **	0.1236 **	0.0545 **
Philippines	Philippines peso	-0.2027 **	-0.0916 **	0.0188	0.0504 **
Singapore	Singapore dollar	-0.1564 **	-0.0785 **	0.1415 **	0.0848 **
South Korea	Korean won	-0.5926 **	-0.1795 **	-0.4836 **	-0.2087 **
Taiwan	New Taiwan dollar	-0.0881 **	-0.0655 **	0.1367 **	0.1074 **
Thailand	Thai baht	0.0002	-0.0173	0.0590 **	0.0810 **
Higher yielding currency					
Australia	Australian dollar	-0.3431 **	-0.1085 **	-0.1836 **	-0.0689 **
New Zealand	New Zealand dollar	-0.3159 **	-0.1417 **	-0.1226 **	-0.0787 **
Canada	Canadian dollar	-0.1888 **	-0.0816 **	0.0266	0.0016
Europe					
Eurozone	Euro	-0.1616 **	-0.0606 **	*NA*	*NA*
Denmark	Danish krone	-0.1612 **	-0.0631 **	-0.0003	-0.0006
Norway	Norwegian krone	-0.1544 **	-0.0438 **	-0.0912 **	-0.0418 **
Sweden	Swedish krona	-0.1495 **	-0.0590 **	-0.0822 **	-0.0567 **
Switzerland	Swiss franc	-0.1547 **	-0.0618 **	0.1372 **	0.0669 **
UK	British pound	-0.1296 **	-0.0502 **	0.0003	0.0012
EMEA					
South Africa	South African rand	-0.2853 **	-0.1227 **	-0.2940 **	-0.1184 **
Russia	Russian ruble	-0.3706 **	-0.1377 **	-0.3689 **	-0.2717 **
Hungary	Hungarian forint	-0.2690 **	-0.0830 **	-0.2865 **	-0.0959 **
Poland	Polish zloty	-0.2767 **	-0.1289 **	-0.2452 **	-0.1143 **
Turkey	Turkish lira	-0.3740 **	-0.1526 **	-0.3644 **	-0.2426 **
Israel	Israeli New shekel	-0.0484 **	-0.0267 *	-0.0449 *	0.0000
Slovakia	Slovak koruna	-0.1551 **	-0.0859 **	0.0042 **	-0.0009 **
Latin America					
Argentina	Argentina peso	-0.0557 **	-0.0258 *	-0.0053	-0.0110
Brazil	Brazilian real	-0.4246 **	-0.1788 **	-0.4569 **	-0.1841 **
Chile	Chilean peso	-0.1090 **	-0.0461 *	-0.0835 **	-0.0699 **
Colombia	Colombian peso	-0.0078	0.0077	*NA*	*NA*
El Salvador	Salvadoran colon	-0.1617 **	-0.1331 *	-0.1535 *	-0.1390 *
Mexico	Mexican peso	-0.4449 **	-0.1718 **	-0.5263 **	-0.1836 **
Reference					
Gold		-0.0535 *	0.0663	-0.0754	0.0821
US	US dollar	*NA*	*NA*	0.1616 **	0.0610 **

Notes: (1) ** and * denote significance at a level of 5% and 10% respectively. (2) Positive coefficient is estimated at a quantile level of 0.95 (i.e. a sharp rise in risk reversal), while negative coefficient is estimated at a quantile level of 0.05 (i.e. a sharp fall).

Table 13: Estimated responsiveness of risk reversals to risk aversion index in pre- and post-crisis period using quantile regressions

Economy (A)	Currency (B)	vis-à-vis the US dollar Pre-crisis (C)	vis-à-vis the US dollar Post-crisis (D)	vis-à-vis euro Pre-crisis (F)	vis-à-vis euro Post-crisis (G)
Asia					
China	Chinese renminbi	-0.0104	-0.0820 **	*NA*	0.1025 **
Hong Kong	Hong Kong dollar	0.0000	0.0130	-0.0788 **	0.1582 **
India	Indian rupee	-0.0883	-0.2340 **	0.0328	0.1289 **
Indonesia	Indonesian rupiah	-0.1415	-0.2880 **	-0.0495	0.0785
Japan	Japanese yen	0.2033 **	0.2490 **	0.1560 **	0.2728 **
Malaysia	Malaysian ringgit	-0.0139	-0.1163 **	-0.1470 **	0.1298 **
Philippines	Philippines peso	-0.0817	-0.1961 **	-0.0530 *	0.0432 **
Singapore	Singapore dollar	0.0008	-0.1817 **	-0.0974 **	0.1720 **
South Korea	Korean won	-0.0328	-0.4151 **	0.0706	-0.2692 **
Taiwan	New Taiwan dollar	-0.0319	-0.1062 **	0.0679	0.1396 **
Thailand	Thai baht	0.0399	0.0002	0.0311	0.1595 **
Higher yielding currency					
Australia	Australian dollar	-0.0567 **	-0.3476 **	-0.0922 **	-0.1465 **
New Zealand	New Zealand dollar	-0.0586 *	-0.3024 **	-0.0770 **	-0.1408 **
Canada	Canadian dollar	0.0063	-0.2164 **	-0.0976 **	-0.0257
Europe					
Eurozone	Euro	0.0747 **	-0.1605 **	*NA*	*NA*
Denmark	Danish krone	0.0790 **	-0.1605 **	0.0008 *	-0.0007
Norway	Norwegian krone	0.0948 **	-0.1607 **	-0.0273	-0.1060 **
Sweden	Swedish krona	0.0829 **	-0.1496 **	-0.0846 **	-0.0995 **
Switzerland	Swiss franc	0.0733 **	-0.1709 **	0.0787 **	0.1537 **
UK	British pound	0.0004	-0.1345 **	0.0089	0.0533 **
EMEA					
South Africa	South African rand	0.0324	-0.2615 **	0.0385	-0.2713 **
Russia	Russian ruble	0.0402	-0.3653 **	0.0001	-0.3763 **
Hungary	Hungarian forint	0.0000	-0.2563 **	-0.1237 **	-0.2741 **
Poland	Polish zloty	-0.0552	-0.2690 **	0.0014	-0.2099 **
Turkey	Turkish lira	-0.4137 **	-0.3154 **	-0.2267 **	-0.3051 **
Israel	Israeli New shekel	-0.0103	-0.0593 **	*NA*	0.0129
Slovakia	Slovak koruna	0.0018	-0.1605 **	0.0000	*NA*
Latin America					
Argentina	Argentina peso	0.0360	*NA*	0.0078	*NA*
Brazil	Brazilian real	-0.1297 *	-0.2756 **	-0.2103 **	-0.1864 **
Chile	Chilean peso	0.0402	-0.1980 **	0.0017	-0.1952 **
Colombia	Colombian peso	0.0192 **	-0.1493 **	NA	NA
El Salvador	Salvadoran colon	0.0852	-0.3076 **	-0.1016	-0.3572 **
Mexico	Mexican peso	-0.1414 **	-0.3575 **	-0.1363 **	-0.3408 **
Reference					
Gold		0.1790 *	0.0923	0.2361 **	0.0870
US	US dollar	*NA*	*NA*	-0.0747 **	0.1605 **

Notes: (1) ** and * denote significance at a level of 5% and 10% respectively. (2) Positive coefficient is estimated at a quantile level of 0.95 (i.e. a sharp rise in risk reversal), while negative coefficient is estimated at a quantile level of 0.05 (i.e. a sharp fall).

Figure 1: Risk reversals of northeast Asian currencies vis-à-vis the US dollar

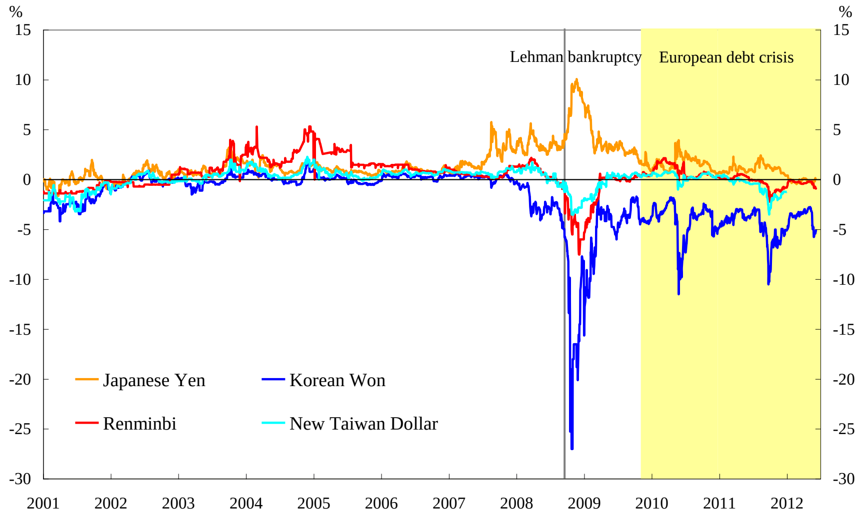


Figure 2: Risk reversals of other major Asian currencies vis-à-vis the US dollar

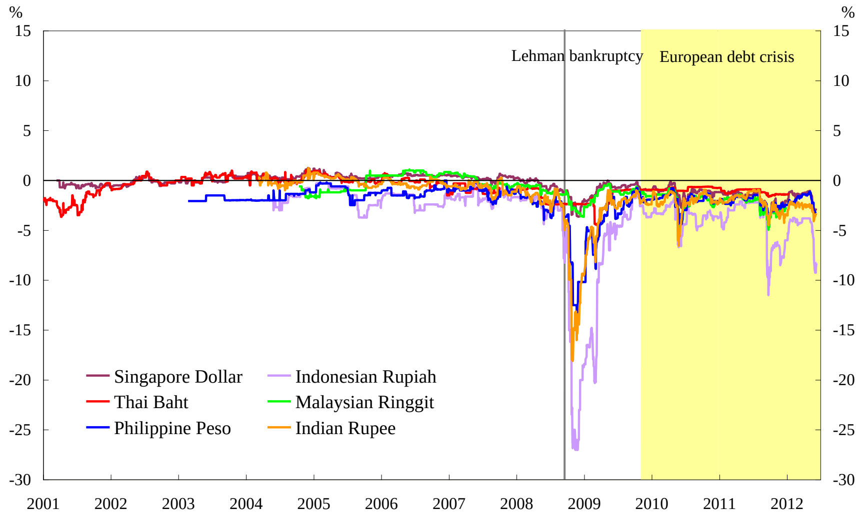


Figure 3: Risk reversal of the Hong Kong dollar vis-à-vis the US dollar

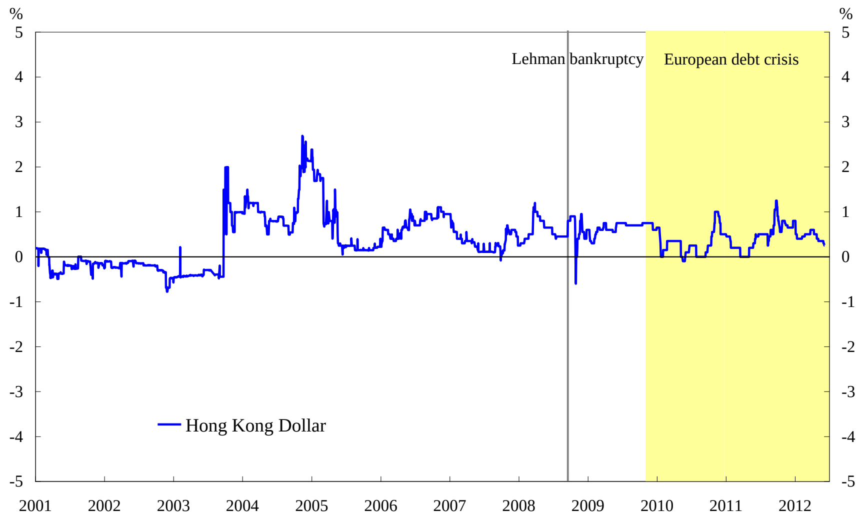


Figure 4: Risk reversals of commodity currencies vis-à-vis the US dollar

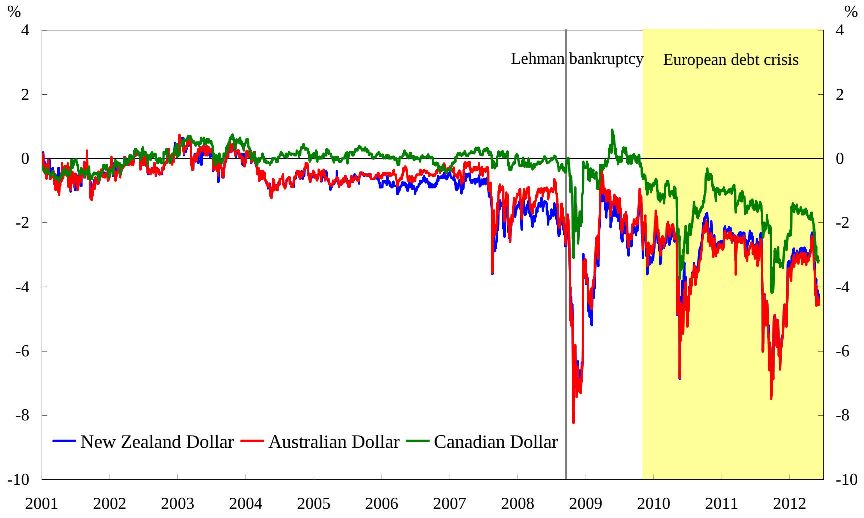


Figure 5: Risk reversals of European currencies vis-à-vis the US dollar

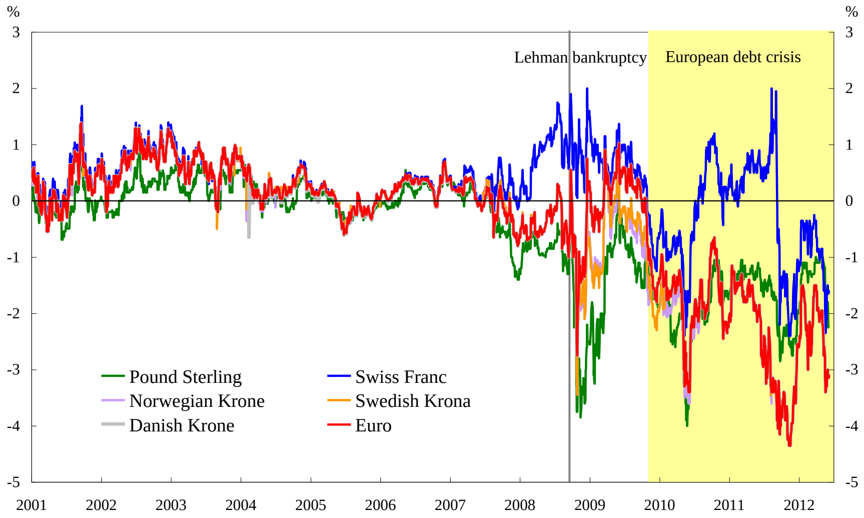
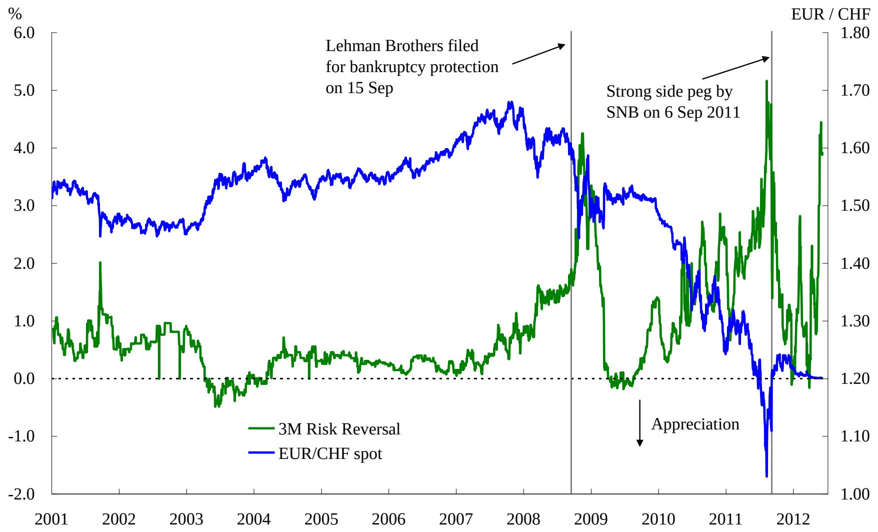
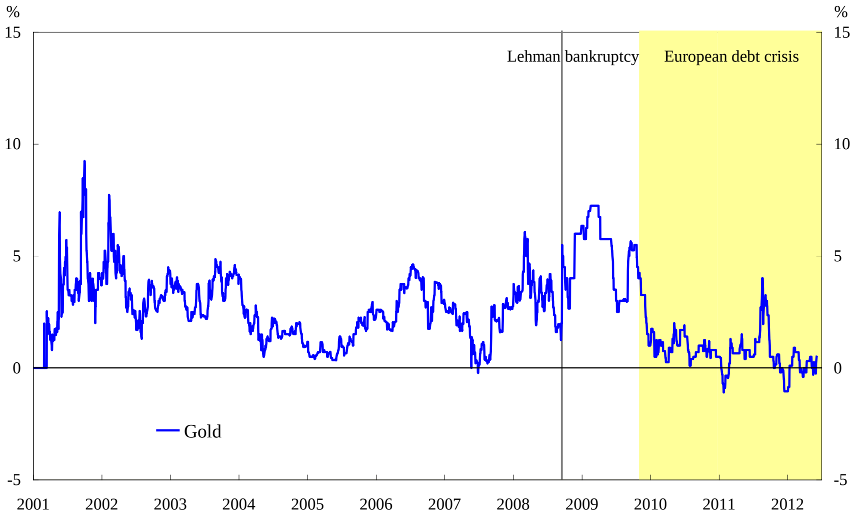


Figure 6: Exchange rate and risk reversal of Swiss franc vis-à-vis euro



Sources: JP Morgan Chase and Bloomberg.

Figure 7: Risk reversal of gold



Source: JP Morgan Chase.

Figure 8: Mixture of two components at a particular time point

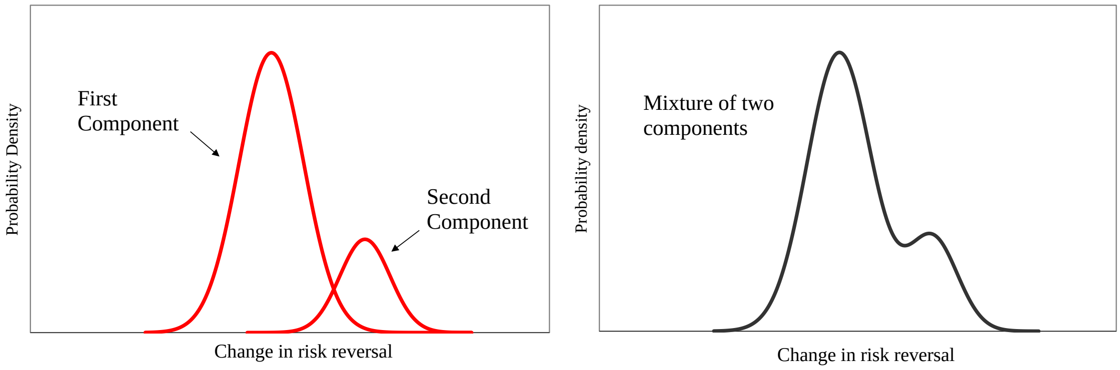
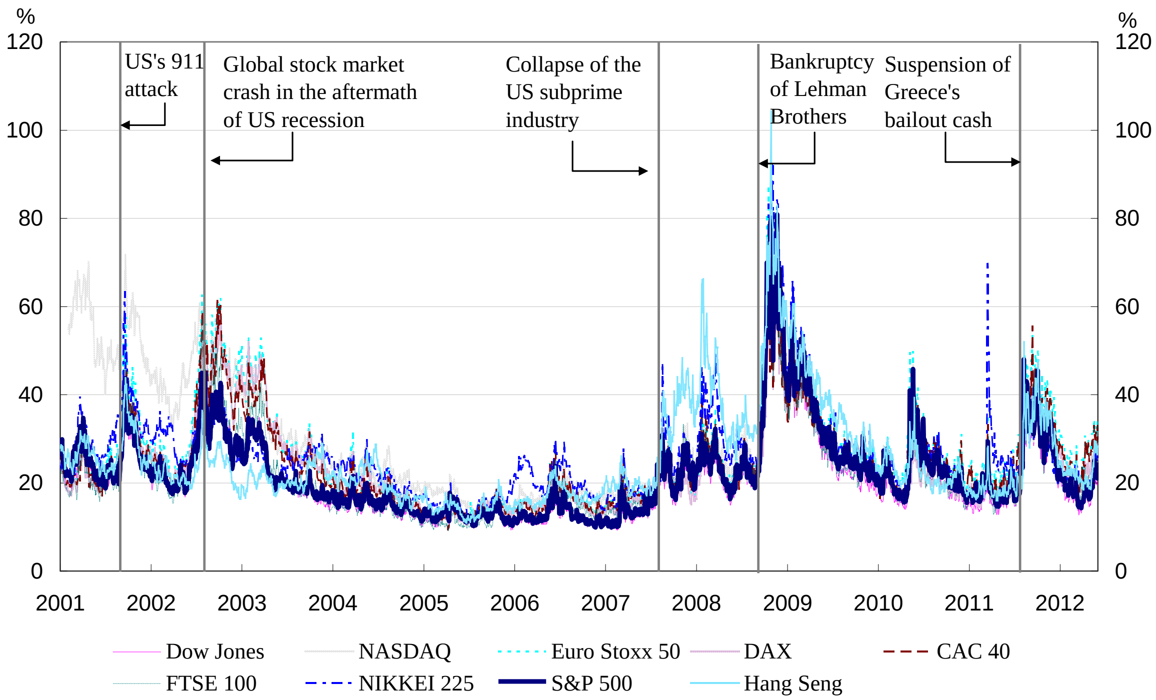


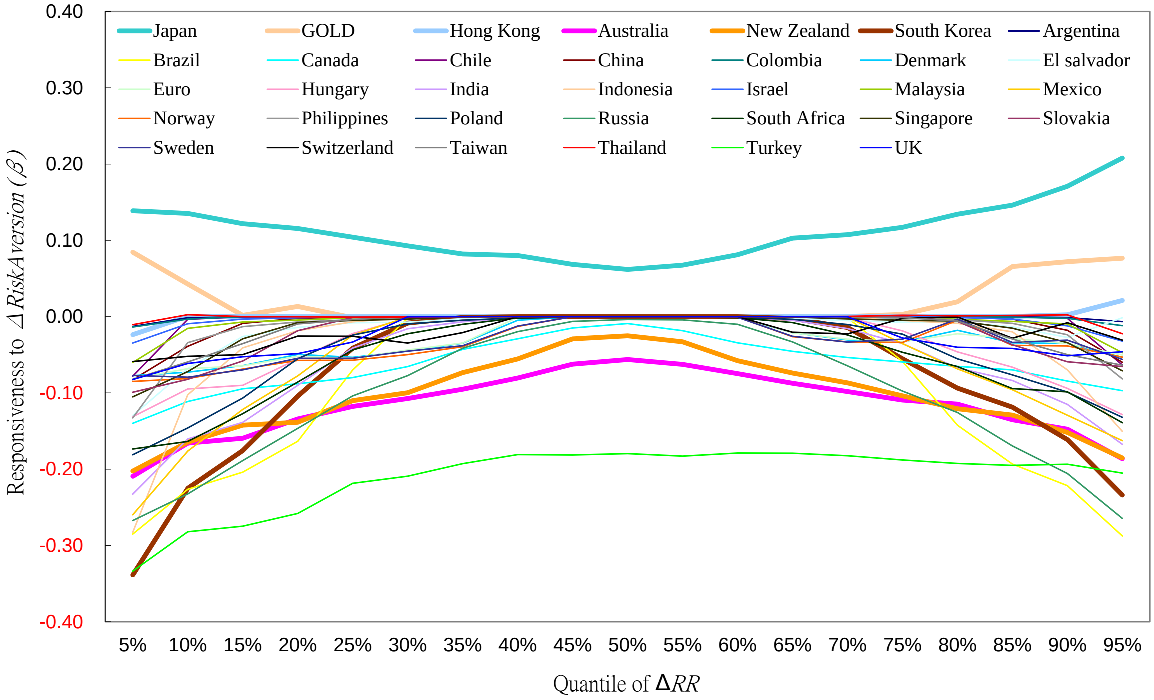
Figure 9: Stock market volatility indices



Source: Bloomberg.

Figure 10: Responsiveness of risk reversal to the global fear index

vis-à-vis the US dollar



vis-à-vis euro

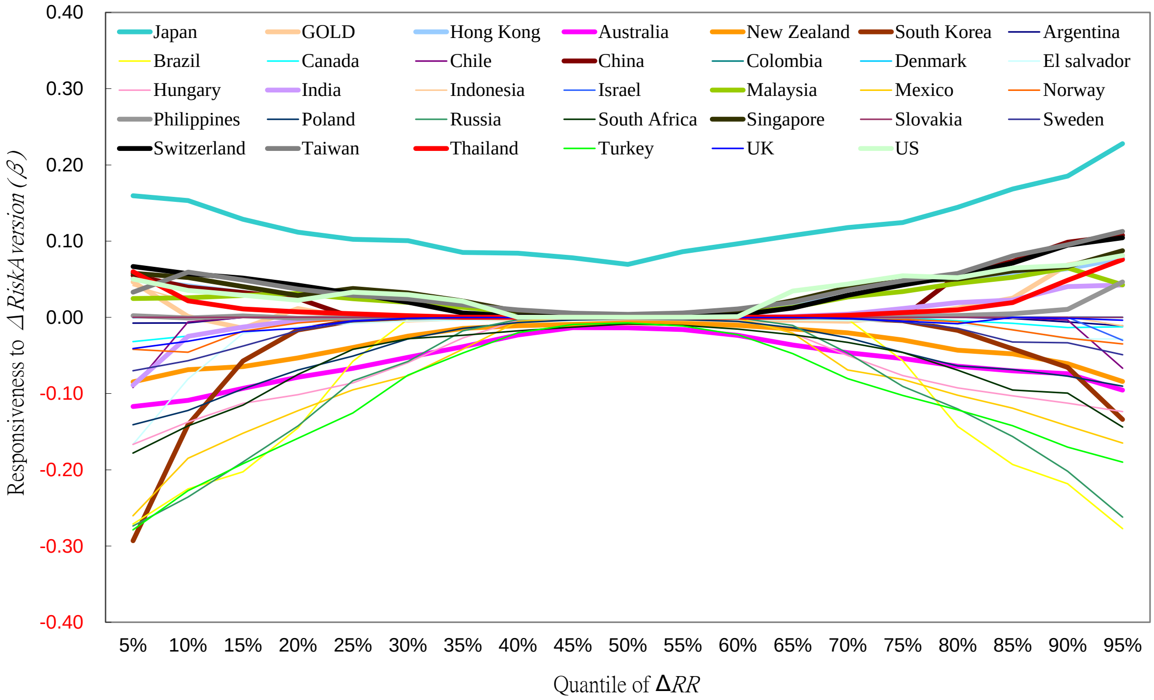
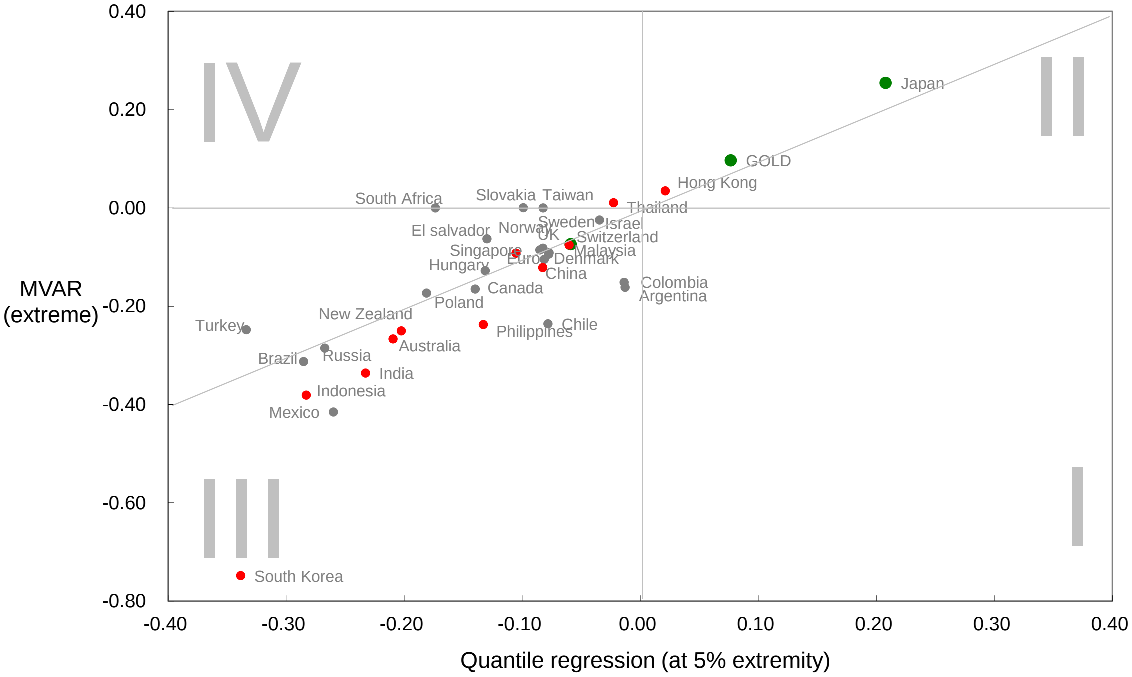


Figure 11: Responsiveness of risk reversal to the risk aversion using the MVAR model and quantile regression

vis-à-vis the US dollar (correlation = 0.8255)



vis-à-vis euro (correlation = 0.8229)

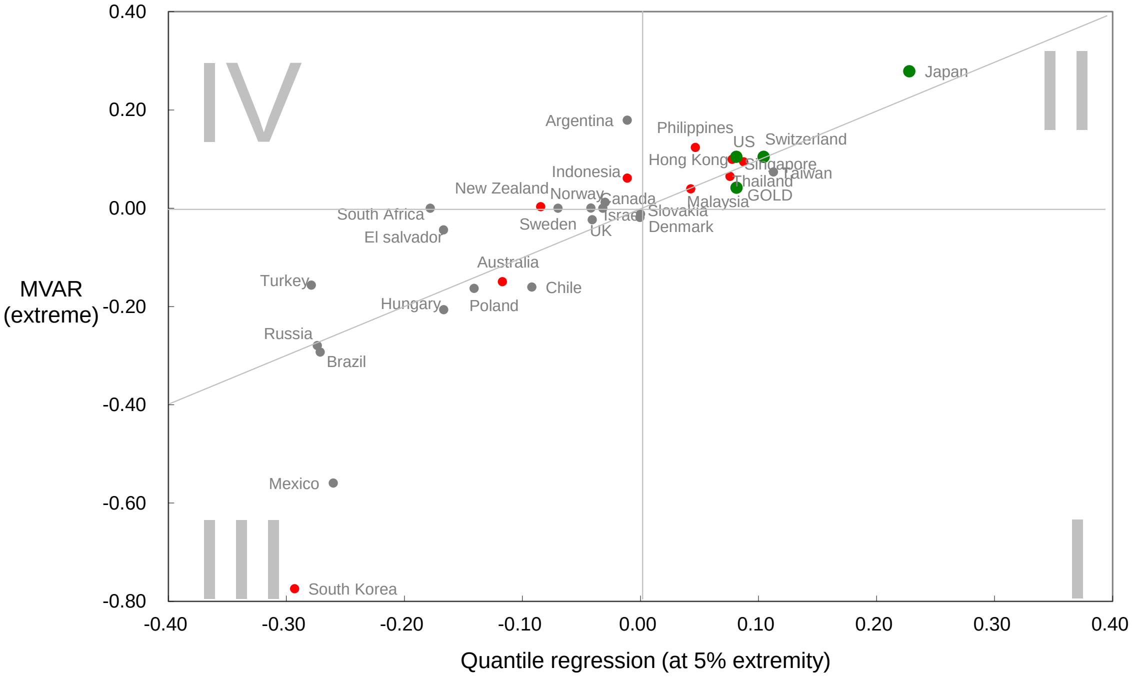
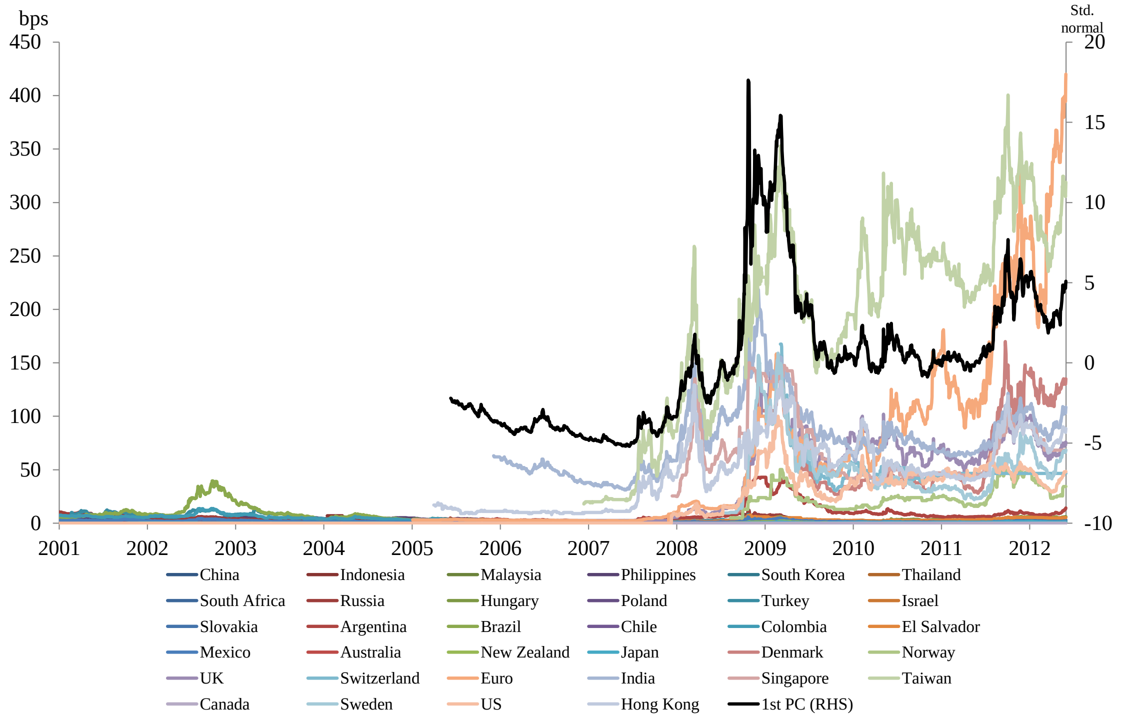


Figure 12: Sovereign CDS spreads



Sources: Bloomberg, Thomson Reuters, JP Morgan Chase.

Figure 13: Number of available sovereign CDS spreads over time

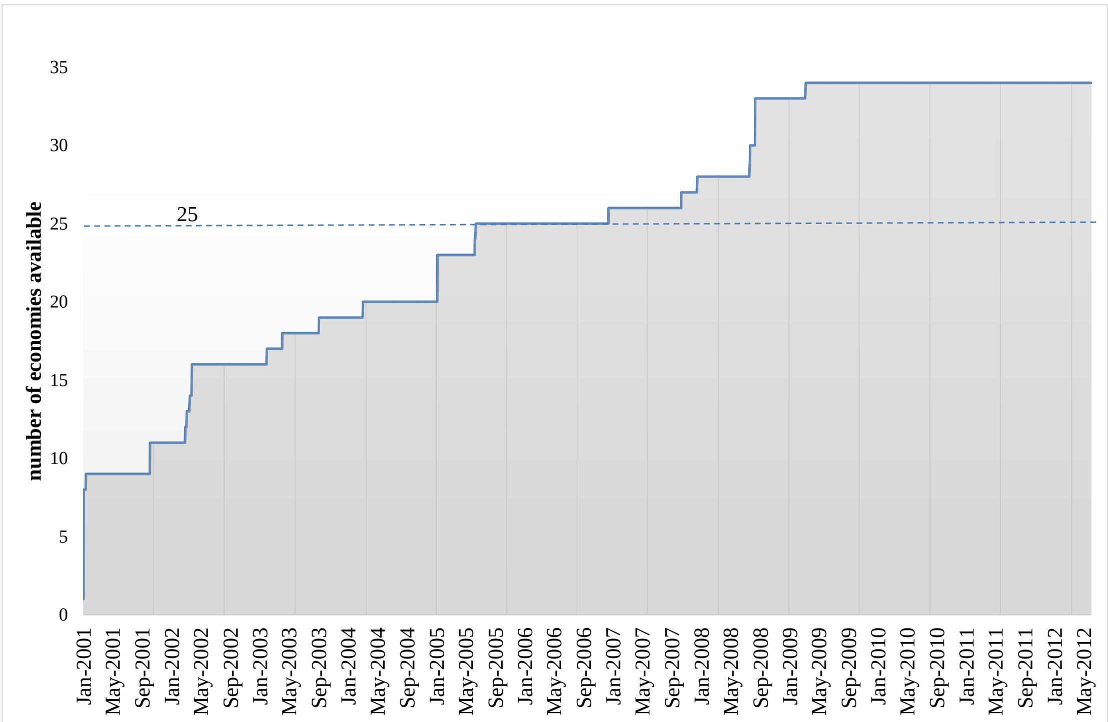
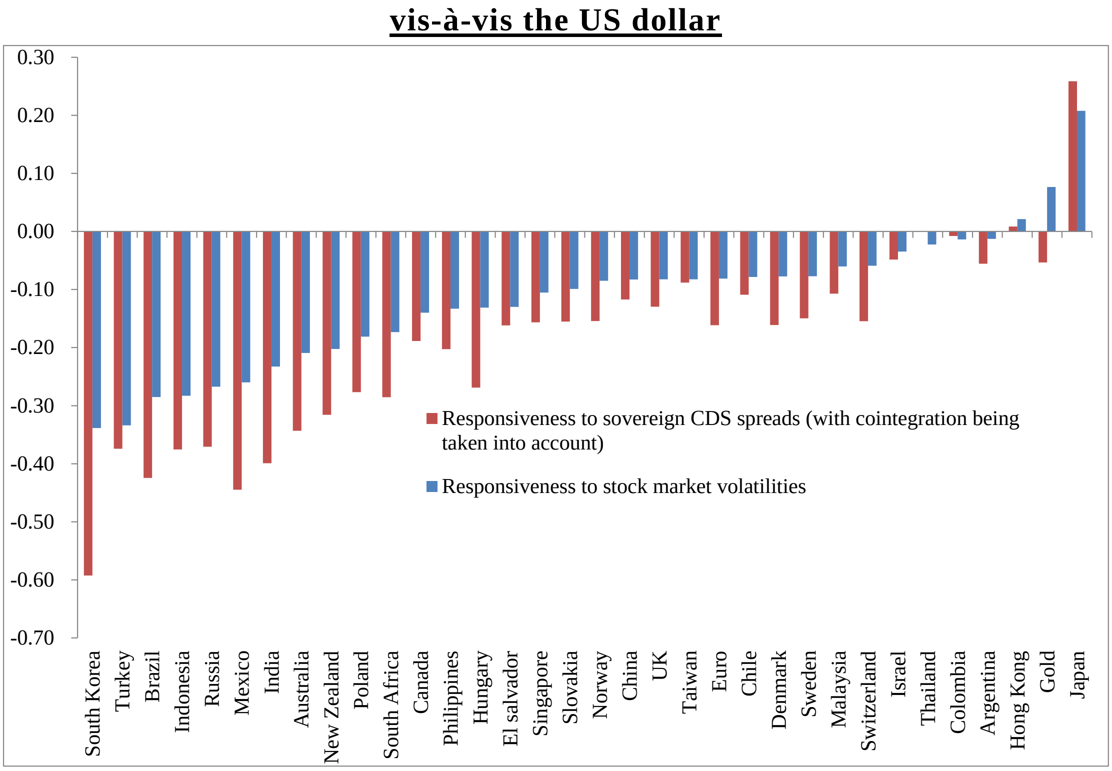


Figure 14: Responsivenesses of risk reversal to two alternative risk aversion indices using the quantile regression



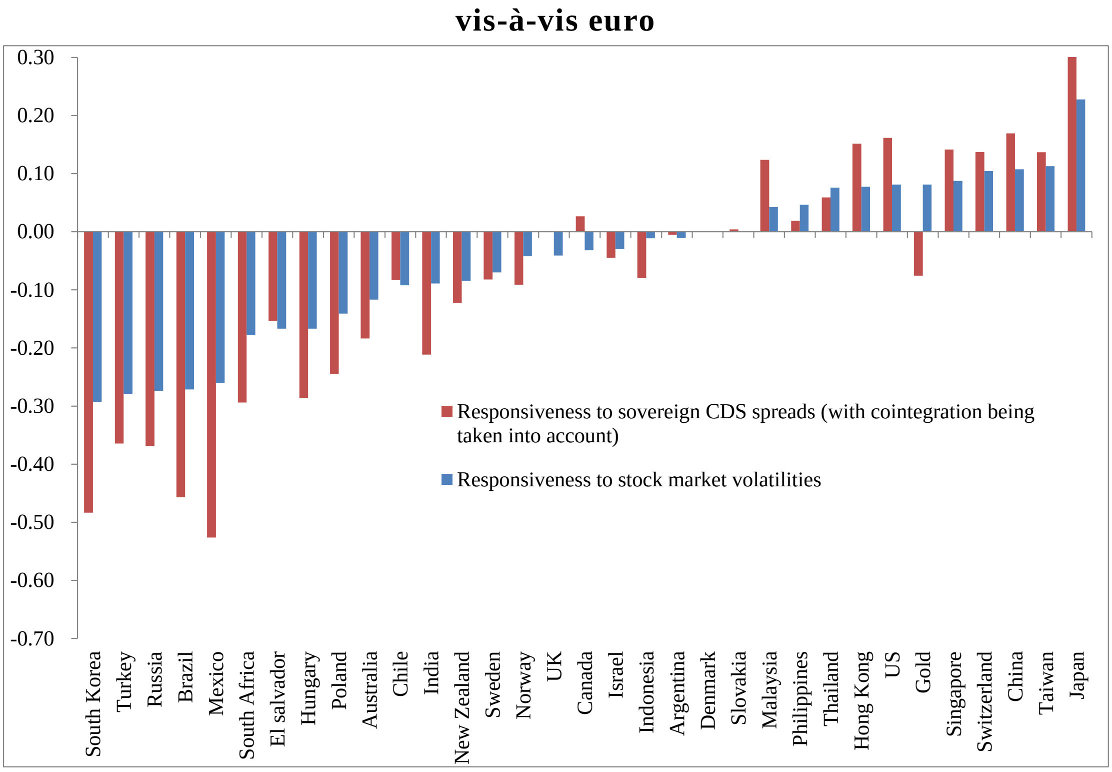
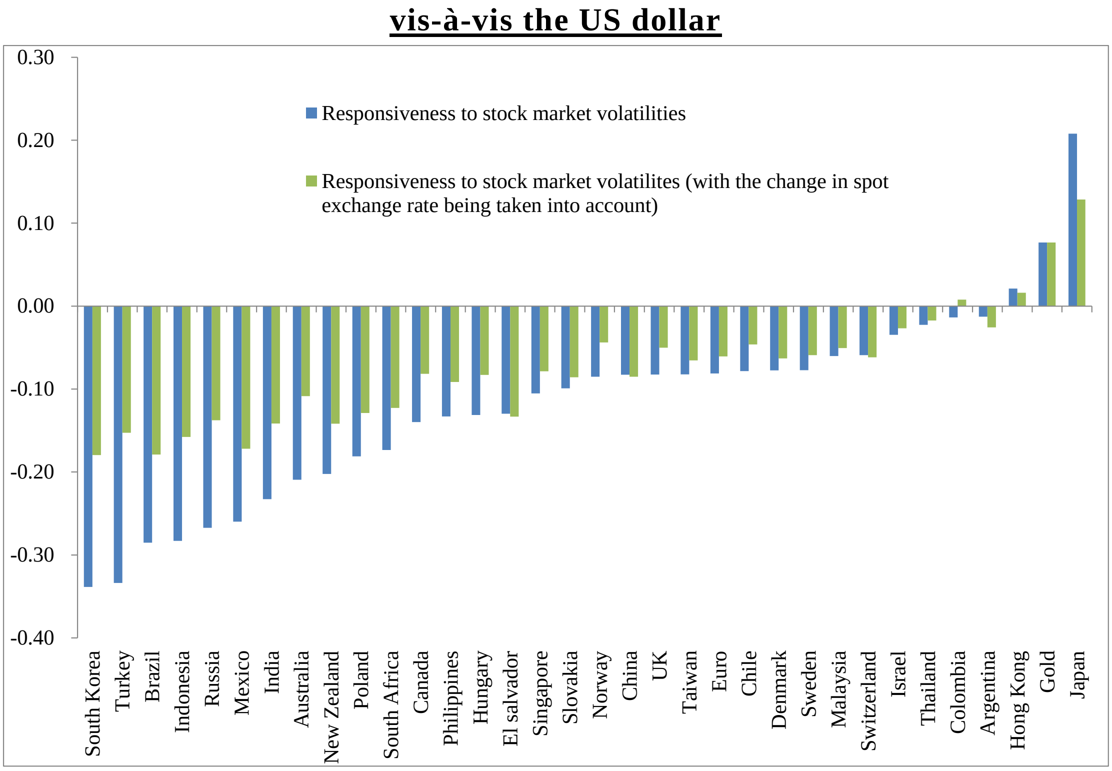


Figure 15: Responsivenesses of risk reversal with/without controlling for the spot exchange rate change using the quantile regression



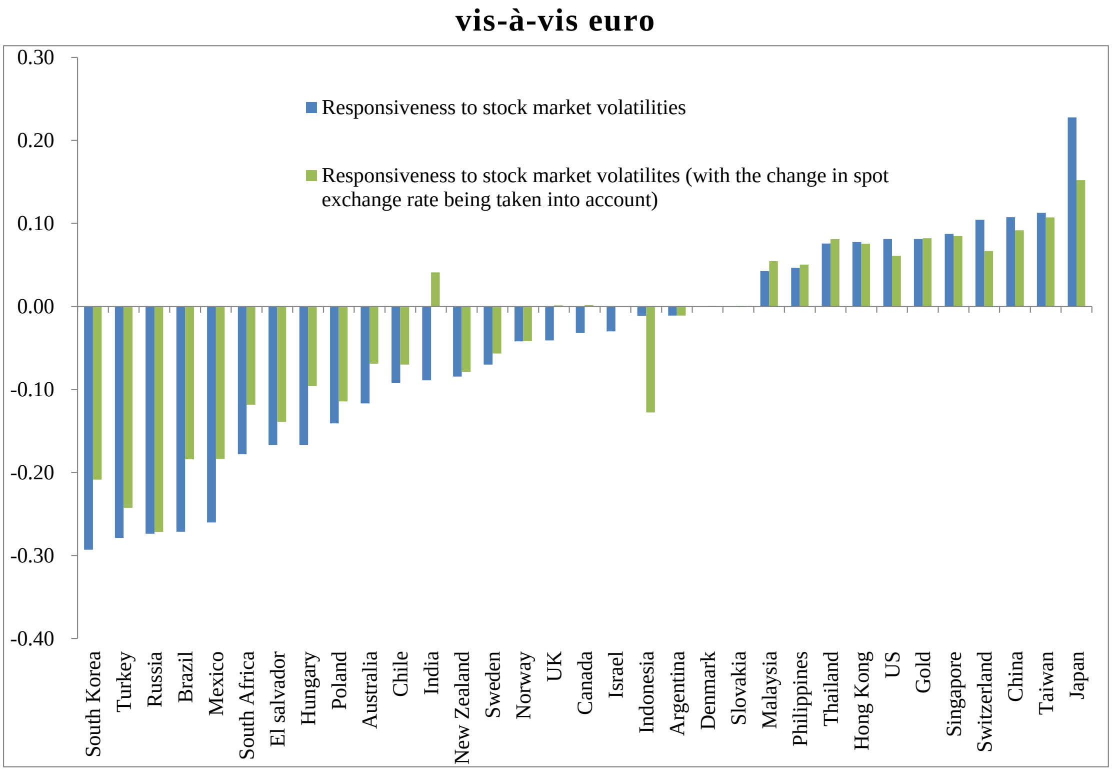
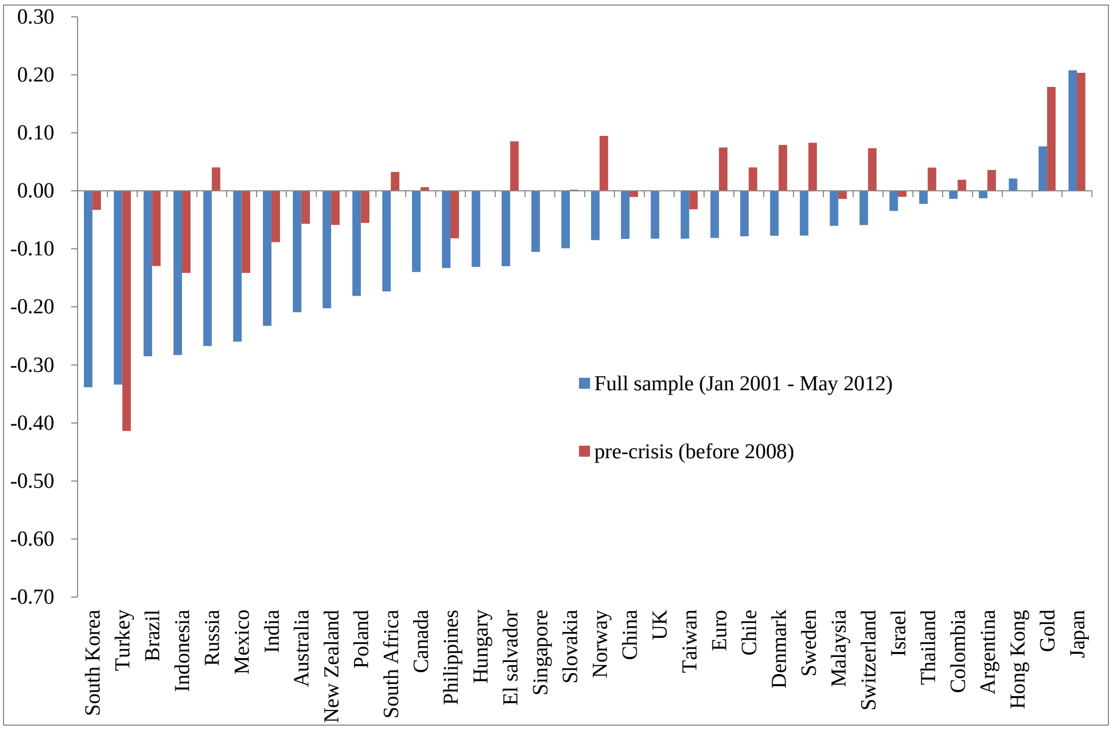


Figure 16: Responsiveness of risk reversal against US dollar to the risk aversion using the quantile regression in the pre- and post- crisis periods

Pre-crisis period



Post-crisis period

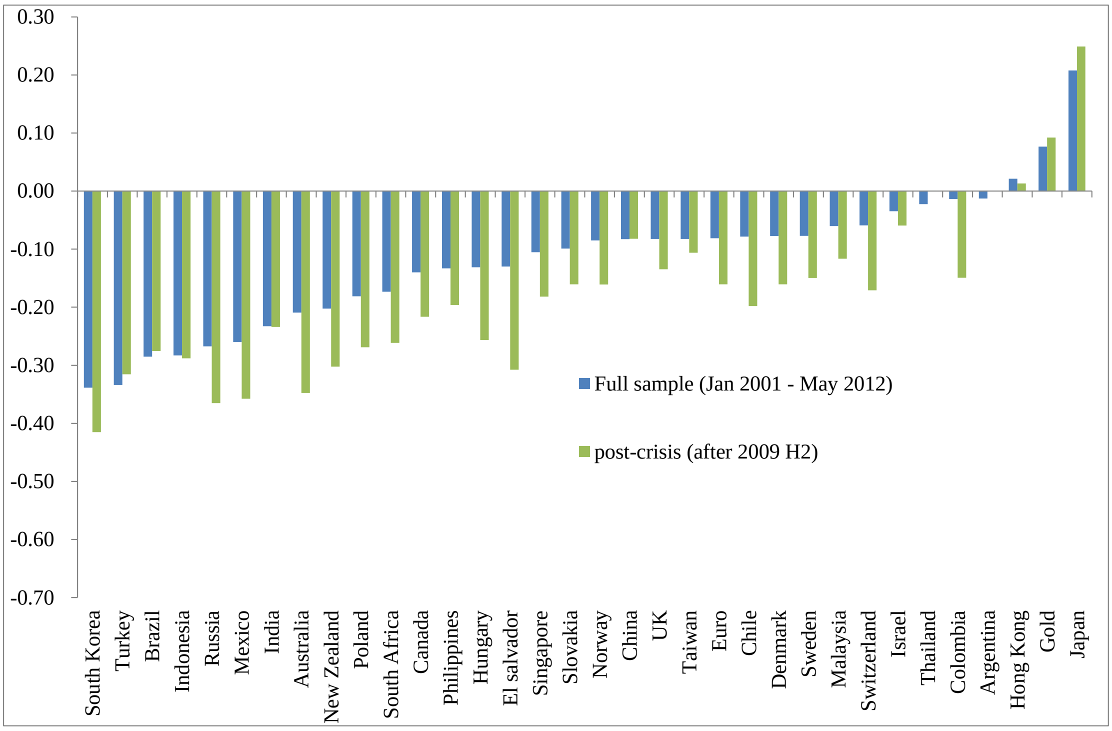
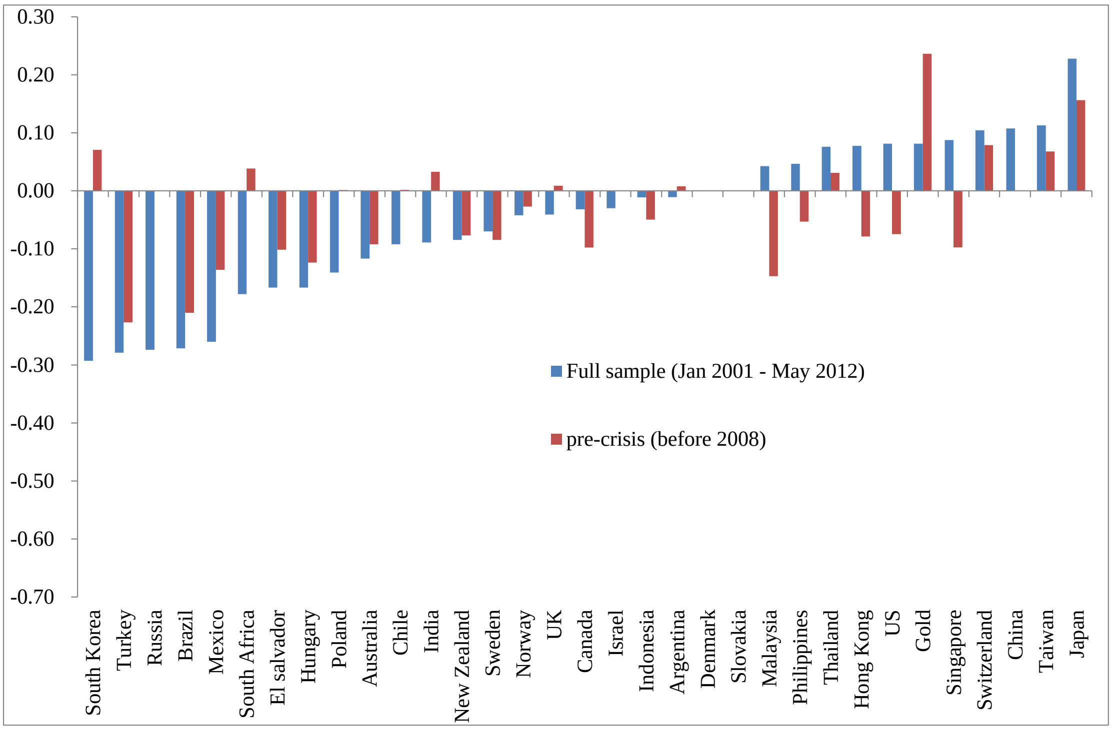


Figure 17: Responsiveness of risk reversal against euro to the risk aversion using the quantile regression in the pre- and post-crisis periods

Pre-crisis period



Post-crisis period