Exchange Rates and Sovereign Risk*

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Abstract

We empirically investigate the relation between exchange rates and sovereign risk, as measured by credit default swap (CDS) spreads. An increase in a country's CDS spread is accompanied by a significant depreciation of its exchange rate as well as an increase of its currency volatility and crash risk. This link is mainly driven by exposure to global sovereign risk shocks and also emerges in a predictive setting for currency risk premia. Sovereign risk forecasts excess returns to trading exchange rates, volatility and skewness. Moreover, we find that carry and momentum strategies generate high (low) returns across countries with high (low) sovereign risk.

JEL Classification: F31, G12, G15.

Keywords: Exchange rates, currency risk premium, sovereign risk, CDS spreads.

I. Introduction

This paper documents a strong link between exchange rates and sovereign risk, as measured by the spreads on sovereign credit default swaps (CDS). Sovereign CDS contracts allow investors to buy protection against the event of a sovereign default at a market price (the CDS spread) that reflects the state of the local and the global economy as well as investor risk aversion (e.g., Longstaff et al., 2011). We show that the information embedded in sovereign CDS spreads matters for the distribution of currency returns, even for countries with floating exchange rates that are far from default.

As an illustrative example for this link, consider the period preceding the widely anticipated UK downgrade on February 22nd 2013, after all major rating agencies had previously set their outlook to negative.[1] Figure 1 shows that from December 1st 2012 onwards the spread on UK government credit default swaps (CDS) increased from 31 to 52 basis points with the pound (GBP) depreciating by more than 5% against the US dollar (USD). In derivatives markets, investors positioned against the GBP, with net speculator positions changing from about 30,000 contracts long to 30,000 contracts short. The implied volatilities of USD/GBP-options surged, and more so for put relative to call options, reflecting the market's perception of tail risks and increased cost of crash insurance. Notably, the downgrade was only one notch down from AAA, so the UK was far away from actually defaulting on its debt.

Figure 1 about here

While this simple example suggests that sovereign risk matters for exchange rates, research on how sovereign risk relates to exchange rates and currency risk premia is scant. To fill this gap, we empirically investigate the relationship between sovereign risk and spot exchange rate changes, currency excess returns, and higher-order moments of exchange rates implied by currency option data. Using a broad set of 20 exchange rates of developed and emerging countries against the USD from January 2003 to November 2013, we present

[1] For coverage in the financial press, see e.g., "Sterling hits two-year low on downgrade", Financial Times, February 22nd 2013; "UK is stripped of triple-A rating", Wall Street Journal, February 22nd 2013; "Sterling falls, bruised by UK credit rating downgrade", Reuters, February 25th 2013.

the following key findings. First, countries that experience increasing sovereign risk show a significant *contemporaneous* depreciation as well as higher volatility, more negative skewness, and higher kurtosis implied by currency option data. Second, exchange rate changes are strongly correlated with changes in global sovereign risk whereas innovations in local sovereign risk play a minor role. Third, countries' currency exposures to global sovereign risk are related to their external asset-liability position, inflation rate, and interest rate level. Fourth, sovereign risk *forecasts* future currency excess returns and the excess returns to trading on volatility and skewness of exchange rates. Finally, we provide evidence that sovereign risk also matters for excess returns of benchmark strategies, by showing that carry and momentum trades are significantly more profitable in high CDS countries than in low CDS countries.

To explore the relation between exchange rates and sovereign risk, we rely on sovereign CDS data and document a strong inverse relation between *contemporaneous* changes in sovereign CDS spreads and exchange rate changes at the daily, weekly, and monthly frequency. For example, in our benchmark pooled regression using monthly data we find a significantly negative slope coefficient, with the economic effect being that a 50 basis points increase in the CDS spread is associated with an exchange rate depreciation of approximately 3.7%. The regression R^2 is about 26% and orders of magnitude higher than the R^2 of about 0.1% from a similar regression of exchange rate changes on changes in interest rate differentials.

We confirm the link between exchange rate changes and CDS spread changes in individual country regressions and show that *global* shocks play a key role for the contemporaneous link between exchange rates and sovereign risk. Regressions of bilateral exchange rate changes on changes in global sovereign risk (measured as the cross-country average CDS spread) generate significantly negative slope estimates and high R^2s for all countries except Japan. Country-specific sovereign risk matters much less and only for a subset of countries, mainly emerging markets. These results line up with previous findings that sovereign CDS spreads have a strong common component (Longstaff et al., 2011) and that exposure to global factors matters for exchange rates (e.g. Lustig et al., 2011; Verdelhan, 2015). Moreover, we show that innovations in sovereign risk are also related to the higher moments of the exchange rate return distribution: using option-implied measures of currency volatility, skewness, and kurtosis, we find that an increase in sovereign risk is accompanied by higher foreign exchange (FX) volatility, a shift in skewness such that FX crash insurance becomes more expensive, as well as fattening tails of the FX distribution.

A straightforward explanation for these findings could be a risk-based channel where an increase in the sovereign risk of a country leads investors to demand a higher risk premium for holding that currency. Such an explanation would suggest that measures of a country's sovereign risk *forecast* excess returns to holding that currency, as investors in high risk currencies should be compensated for bearing this risk. To test this conjecture, we form currency portfolios based on countries' exposures to global sovereign risk (measured by rolling betas of local on global CDS spread changes) and based on countries' (lagged) CDS spread levels. We find that both portfolio strategies deliver significantly positive excess returns with high Sharpe ratios for trading exchange rates, FX volatility, and FX skewness. In fact, the returns to both strategies are highly correlated, indicating that countries' CDS spread levels and countries' global exposures contain essentially the same information for risk premia. Moreover, we provide evidence that the information embedded in CDS spreads also matters for the performance of other benchmark trading strategies: currency carry and momentum strategies are significantly more profitable when applied to currencies of high CDS countries than for currencies of low CDS countries. Taken together, these results imply that sovereign CDS spreads, which capture the state of the macroeconomy as well as investor risk aversion, are informative for currency risk premia.

We conduct extensive robustness checks to corroborate our conclusions and present additional empirical results, including the following. Our measure of global default risk contains substantially more currency-relevant information than the VIX, which is commonly used as a measure of global uncertainty or risk aversion. Moreover, we provide evidence that sovereign CDS spreads are also related to the dynamics of currency demand, with increases in sovereign risk being associated with contemporaneous and subsequent reductions of speculators' positions in FX derivative markets. We also show that all our results are robust to accounting for transaction costs and when changing the base currency.

Relation to literature. Since we are using data on credit default swaps, our work can be related to studies on the link between sovereign debt defaults and currency crisis. Given the focus in that literature, these papers mainly deals with actual defaults and currency crises in emerging markets with fixed exchange rate regimes. A comprehensive study is Reinhart (2002), which finds that sovereign default events are often followed by currency crises but that sovereign credit *ratings* systematically fail to predict currency crises. Our paper extends this line of literature along several dimensions which we discuss below. For instance, we are interested in the link between sovereign risk *expectations* and exchange rate dynamics in general, and do not condition on actual defaults and currency crises in fixed regimes. Our results show that sovereign risk generally matters for exchange rates, even for developed countries and when there is no actual default, and that sovereign CDS spreads forecast currency excess returns as well as the excess returns to trading on FX volatility and skewness.[2]

Our results, therefore, also contribute to the emerging literature on *currency risk premia in the cross-section* pioneered by Lustig and Verdelhan (2007).[3] The finding that countries' global sovereign risk exposures forecast currency excess returns supports the conclusion of Lustig et al. (2011) that exposure to global shocks matters for currency risk premia. Since we find that the level of sovereign risk across countries is highly correlated with global exposure to sovereign risk, our results also square well with Longstaff et al. (2011), who show that there is a strong global component in individual countries' CDS spreads. Similarly, our paper contributes to recent work on crash risk in currency markets (see, e.g., Brunnermeier et al., 2009; Gurio et al., 2013; Chernov et al., 2014; Farhi and Gabaix, 2014; Farhi et al., 2014; Jurek, 2014; Jurek and Xu, 2014; Daniel et al., 2015) as sovereign

[2] While research on the general link between sovereign risk and exchange rates is scant, a few specific empirical results have been reported in recent papers. Pu and Zhang (2012) and Mano (2013) compare USD- and EUR-denominated sovereign CDS spreads for Eurozone countries to investigate whether the differential (the quanto CDS) conveys information for the EUR, with Mano (2013) focussing on expected depreciations given the default of member countries. We control for potential CDS quanto effects in our empirical analysis and we study the EUR in robustness checks. Tse and Wald (2013) find that using sovereign CDS spreads sheds some light on the forward premium puzzle but argue that CDS spreads have no explanatory power for carry trade returns.

[3] Other papers following this approach are, for instance, Barroso and Santa-Clara (2013), Burnside et al. (2011), Farhi et al. (2014), Lettau et al. (2014), Lustig et al. (2011, 2013), Menkhoff et al. (2012a,b), Verdelhan (2015), and Lustig et al. (2015).

default risk can naturally be seen as a source of currency crashes.

We also look beyond the first moment of the currency return distribution. The finding that sovereign risk relates contemporaneously to changes in implied volatilities of currency options as well as to option-implied measures of higher moments of the currency return distribution is consistent with the findings of Carr and Wu (2007a,b). The result that sovereign risk also forecasts returns to option strategies and instruments designed for trading FX volatility and skewness provides insights for higher moment risk premia in currency markets (see, e.g., Bakshi et al., 2008).

At a more general level, this paper contributes to the literature that studies how measures of country risk (typically proxied for by ratings) relate to return predictability. While previous research focuses on international equity markets (e.g., Erb et al., 1995, 1996; Avramov et al., 2012) or bond markets (e.g. Borri and Verdelhan, 2012), we show that sovereign risk forecasts excess returns to currency trading.

The remainder of the paper unfolds as follows: Section II describes a set of testable predictions on the link between sovereign risk and exchange rate changes. Section III describes our data, instruments, and trading strategies. Section IV reports results related to the contemporaneous link between sovereign risk and exchange rates. Section V reports results for return predictability and the link between sovereign risk and carry trades. Section VI provides additional results and robustness checks, and the last section concludes. The Appendix contains technical details, and an Internet Appendix presents additional analyses and robustness checks.

II. Testable Hypotheses

So far, research on how exchange rates and currency risk premia relate to sovereign risk is scant. To fill this gap, this paper empirically tests whether currencies of countries with high sovereign risk trade at a discount and offer higher expected returns compared to countries with low sovereign risk. Below, we describe the four main hypothesis that guide our empirical analysis.

Hypothesis 1: Exchange rate changes are negatively related to shocks to sovereign risk.

If shocks to sovereign risk are priced in currency markets, we should expect to see a negative link between changes in a country's sovereign CDS spread and changes in its exchange rate. Put differently, if sovereign risk is a priced state variable in currency markets, innovations to sovereign risk should be contemporaneously correlated with exchange rates such that the currency of a country depreciates when its sovereign risk increases. Furthermore, given that previous research documents a strong common component in sovereign CDS spreads (Longstaff et al., 2011), one should expect the link between sovereign risk and exchange rate changes to be dominated by global shocks.

Hypothesis 2: Higher moments of the exchange rate distribution (volatility, skewness, and kurtosis) are related to sovereign risk.

The earlier literature (e.g. Reinhart, 2002; Mano, 2013) shows that actual sovereign defaults have often been followed by currency crises, associated with severe currency depreciations (or devaluations), and heightened uncertainty about the exchange rate. Our second hypothesis is thus that default expectations embedded in sovereign CDS spreads convey information for the higher moments of the currency return distribution. To test this hypothesis, we examine whether premia for currency option strategies that provide insurance against volatility, crash risk (skewness), and extreme events (kurtosis) increase with sovereign risk.

Hypothesis 3: Exposure to sovereign risk should be related to fundamental measures of a country's financial vulnerability.

We would expect that exchange rates of countries with a more sustainable external position (more foreign wealth, less external debt, lower share of debt denominated in foreign currency) should be less sensitive to changes in global and local sovereign risk. Likewise, countries with a higher inflation rate should be more sensitive to CDS spread shocks as foreign creditors will demand a premium for inflation risk. For the same reason, countries that are more exposed to global sovereign risk shocks should also have higher interest rates. This hypothesis reflects our interpretation of sovereign risk (CDS spreads) as a market-based measure of the factors which determine a country's creditworthiness in international financial markets, including both international and country-specific economic conditions.

Hypothesis 4: The expected excess return to holding foreign currency (the currency risk premium) increases with the foreign country's sovereign risk.

If investors require compensation for bearing sovereign risk, sovereign CDS spreads should predict currency excess returns. Similarly, if investors care about adverse movements in the higher moments of the currency distribution, selling insurance against volatility, skewness, and kurtosis risk should yield positive excess returns.

III. Data, Descriptive Statistics, and FX Trading Strategies

In this section we describe the data, present some summary statistics, and discuss the trading strategies that we use in the empirical analysis to explore whether sovereign risk matters for currency returns.

A. Data and sample construction

In the empirical analysis, we use sovereign CDS spreads to measure sovereign risk. Sovereign CDS spreads represent timely market information and allow for a more accurate assessment of sovereign risk compared to sovereign credit ratings or sovereign bond yield spreads as sovereign CDS markets are typically more liquid than corresponding bond markets (see, e.g., Duffie et al., 2003; Pan and Singleton, 2008; Longstaff et al., 2011; Palladini and Portes, 2011; Augustin, 2013; Mano, 2013).[4]

The core analysis on the link between sovereign risk and exchange rates requires daily data on sovereign CDS spreads, spot and forward exchange rates, as well as currency options. From the merged sample, we eliminate countries with fixed or quasi-fixed exchange rate regimes as well as countries that impose restrictions to their capital account and thus limit the actual trading of their currencies.[5] Applying these filters and requiring at least

[4] Other advantages of using CDS data, also discussed in the literature on corporate CDS, include the comparability of CDS spreads across reference entities because of standardized CDS contract specifications (in terms maturities, cash flows, default definitions, etc.) as well as avoidance of bond-specific effects related to covenants, taxes, and liquidity. They also present other arguments that favor the use of sovereign CDS data over using sovereign credit ratings, for instance, the fact that ratings are only updated at low frequencies and often represent stale measures of credit risk for sovereign issuers.

[5] Specifically, we only keep observations of countries at times when their capital account openness index has a value greater than or equal to zero (Chinn and Ito, 2006) and the exchange rate regime according to the IMF coarse classification is 3 or 4. These regimes comprise currencies which are in a pre-announced

12 months of consecutive data results in a sample from January 2003 to November 2013 (limited by CDS data not being available earlier) that covers 20 developed and emerging countries and exchange rates against the US Dollar (USD): Australia (AUD), *Brazil* (BRL), Canada (CAD), *Chile* (CLP), *Colombia* (COP), *Czech Republic* (CZK), *Hungary* (HUF), *Indonesia* (IDR), *Israel* (ILS), Japan (JPY), *South Korea* (KRW), *Mexico* (MXN), New Zealand (NZD), Norway (NOK), *Poland* (PLN), *Singapore* (SGD), Sweden (SEK), Switzerland (CHF), *Turkey* (TRY), and the UK (GBP), where italic fonts indicate the 12 countries that we refer to as emerging economies. Below we describe the data on sovereign CDS spreads, exchange rates, and currency options. Other data that we use in supplementary empirical analysis and robustness checks are discussed *ibidem*.

Sovereign CDS data. CDS contracts provide insurance against the event that a reference entity, in our case a sovereign, defaults on its debt.[6] The buyer of a credit protection pays typically a semi-annual premium, the CDS spread, over the contract's tenor as long as no default occurs. In the event of a default, the protection seller compensates the protection buyer for the loss given default and the contract terminates. We refer to Pan and Singleton (2008) for a detailed discussion of the contractual provisions of sovereign CDS contracts such as events that trigger defaults, delivery and settlement upon default.

We collect data on sovereign CDS spreads from Markit. For most of the analysis, we use CDS contracts with a tenor of 5 years, "complete restructuring" clause (docclause CR), and USD as currency of denomination. This represents the most liquid segment of the sovereign CDS market. We also conduct various robustness checks, including the use of CDS contracts denominated in other currencies.

Exchange rate data. We obtain daily data on spot (S_t) and 1-month forward (F_t) exchange rates from BBI and WM/Reuters via Datastream. All exchange rates are relative to the USD and defined as units of USD per unit of foreign currency, i.e., we take the perspective of a US investor and a rising exchange rate represents a foreign currency

crawling band that is wider than or equal to $+/-2\%$, a *de facto* crawling band that is narrower than or equal to $+/-5\%$, a moving band that is narrower than or equal to $+/-2\%$, a managed float, or a free float.

[6]Depending on contract specifications, a credit event may also be restructuring or rescheduling of debt.

appreciation.

Currency option data. We use over-the-counter (OTC) one-month currency option data from JP Morgan. The OTC market for currency options is characterized by specific trading conventions in that options are quoted in terms of Garman and Kohlhagen (1983) implied volatility (IV) on baskets of plain vanilla options, at fixed deltas (δ), and with constant maturities. For a given maturity, quotes are typically available for five different option combinations: delta-neutral straddle, 10δ and 25δ risk-reversals, and 10δ and 25δ butterfly spreads.[7] The delta-neutral straddle is constructed from a long call and a long put option with the same absolute delta such that the total delta is zero (0δ) and the IV of this strategy equals the at-the-money (ATM) IV quoted in the market. In a risk reversal, the trader buys an out-of-the money (OTM) call and sells an OTM put with symmetric deltas (25δ or 10δ). The butterfly spread combines a long strangle (similar to a straddle but with δ-symmetric OTM options) with a short ATM-straddle, and is equivalent to the difference between the average IV of the OTM call and OTM put minus the IV of the straddle. From these data, one can recover the implied volatility smile ranging from a 10δ put to a 10δ call. Appendix A describes the procedure to convert deltas into strike prices and implied volatilities into option prices to obtain IVs and currency option prices for five plain-vanilla European call and put options for currency pairs vis-a-vis the USD.

Macro data. Turning to macroeconomic data, we obtain annual data series on foreign (or external) assets and liabilities from Lane and Milesi-Ferretti (2007), available on Philip Lane's website. Foreign assets are measured as the dollar value of assets a country owns abroad, while foreign liabilities refer to the dollar value of domestic assets owned by foreigners. We extend the dataset until the end of 2013 using the IMF's International Financial Statistics database. In addition, we also use quarterly data on the investor holdings of sovereign debt compiled by Arslanalp and Tsuda (2014a,b) and available on the IMF's website. Finally, we collect year-on-year monthly inflation data from Datastream.

[7]In line market conventions, a 10δ (25δ) call option is a call with a delta of 0.10 (0.25) and a 10δ (25δ) put option is a put with a delta equal to -0.10 (-0.25).

B. *Descriptive statistics*

Table I reports the time periods and descriptive statistics for CDS spreads, forward discounts, and ATM option IVs for each of the 20 countries covered in our sample, after applying the data filtering procedure described above. At first glance, emerging countries seem to have higher CDS spreads and forward discounts than developed countries (in the median) but dispersion is much lower for (median) option IVs. Taking a closer look reveals that the cross-country variation in CDS spreads, forward discounts, and option IVs is not perfectly correlated across instruments, neither within developed or emerging markets, nor across all countries.

For instance, comparing Mexico and Sweden over the full sample period shows that MXN has substantially higher CDS spreads (112bp vs 15bp) and forward discounts (32bp vs 7bp) but that its median option IV is lower (9.7% vs 11.3%). As another example, NOK has a lower CDS spread than JPY (14bp vs 19bp) but a substantially higher forward discount (11bp vs -9bp) and higher IV (11.3% vs 9.86%). This last example also illustrates how CDS spreads may convey different information for exchange rates compared to forward discounts, i.e., differences in aggregate interest rates, comprising a riskless plus a default risk component.

Table I about here

C. *FX trading strategies across moments*

Guided by the testable hypotheses formulated in Section II, we explore the empirical relation between sovereign risk and exchange rates in two steps. First, we analyze the contemporaneous link between sovereign CDS spread changes and currency depreciation as well as changes in the higher moments of the FX distribution (volatility, skewness, kurtosis). Second, we evaluate the predictive ability of sovereign risk for excess returns on currency investments across the first four moments of the FX distribution. Below we describe how we construct the relevant FX strategies from spot and forward exchange rates and currency option IVs.

Currency spot/forward strategies. Let $s_{i,t}$ and $f_{i,t}$ denote the logs of spot and 1-month forward exchange rates at time t, respectively, for the foreign currency i relative to the USD. The 1-month log exchange rate return from t to $t+1$ is given by $\Delta s_{i,t+1} = s_{i,t+1} - s_{i,t}$. We compute the excess return from buying a unit of foreign currency in the forward market at time t and selling the position in the spot market after one month as $rx_{i,t+1} = s_{i,t+1} - f_{i,t}$. Since covered interest rate parity typically holds even at fairly high frequencies (Akram et al., 2008), the 1-month forward discount $fd_{i,t} = s_{i,t} - f_{i,t}$ corresponds to the difference between the 1-month foreign ($i^{\star}_{t,1}$) and US ($i_{t,1}$) interest rates, and the excess return can be rewritten as $rx_{i,t+1} = \Delta s_{i,t+1} + i^{\star}_{t,1} - i_{t,1}$. Given these standard definitions of FX returns and excess returns, in Sections IV and V, we present empirical evidence strongly supporting our predictions that sovereign risk matters for *contemporaneous currency depreciations* and *future currency excess returns*.

Currency option trading strategies. In addition to trading in traditional instruments such as spot and forward contracts, investors also trade in the currency option market in order to hedge against or get exposure to currency volatility, skewness and kurtosis. More generally, investors do not only care about (excess) returns but also about higher moment risk in FX markets. Following Beber et al. (2010), we use option data to construct proxies for the (risk-neutral) higher moments of the exchange rate return distribution.[8]

In general, an investor buys a delta-neutral straddle to seek protection against volatility risk, sells a risk reversal to hedge against sharp foreign currency depreciations (skew or crash risk), and sells a butterfly spread to hedge against extreme exchange rate changes in either direction (kurtosis risk). Specifically, to quantify FX volatility, we use the ATM straddle (STD), which allows for such a volatility interpretation because it offers a symmetric payoff structure and is delta-neutral. Investors seeking protection against FX volatility enter a long position in STD. To measure FX skew, we use the 25δ risk reversal, which provides a proxy for the asymmetry of the IV smile by measuring the difference between OTM call and put IVs. A standard approach to obtain crash insurance against sharp foreign currency depreciations is to enter a long position in the OTM put and a short position in the OTM

[8] In our core analysis we use 25δ options with a maturity of one month but results are robust to using 10δ options as well as maturities up to five years.

call, i.e., to enter the opposite position in the risk reversal compared to its quotation in FX markets. We refer to this protection against skew risk as RR_{25}. Finally, we use the butterfly spread to assess the kurtosis of exchange rate changes. By combining a short ATM straddle with long positions in an OTM call and an OTM put, the butterfly spread (BF_{25}) provides a measure for the thickness of the exchange rate return distribution's tails and compensates investors for extreme FX returns in either direction. To summarize, our proxies for FX volatility, skewness, and kurtosis are given by

$$
\begin{aligned}
STD &= IV_{ATM}, \\
RR_{25} &= IV_{25P} - IV_{25C}, \\
BF_{25} &= (IV_{25C} + IV_{25P})/2 - IV_{ATM}.
\end{aligned}
$$

In our analysis of the *contemporaneous* link between sovereign risk and exchange rates, we expect all of these measures to increase with sovereign CDS spreads.

To complement our analysis of whether sovereign risk *forecasts* currency excess returns consistent with the notion of sovereign risk premia, we also compute the excess returns to trading FX volatility, FX skew, and FX kurtosis. If currency option investors care about sovereign risk, they should be willing to pay a premium (i.e., to accept negative excess returns) when entering the protection strategies STD, RR_{25}, and BF_{25}. In turn, selling insurance against higher moment risk should provide positive excess returns, and we empirically test this in Section V.[9]

IV. Sovereign CDS Spreads and Exchange Rates

In this Section, we document a strong *contemporaneous* relation between sovereign CDS spreads and exchange rates. Specifically, we find that an increase in the sovereign risk of a country is associated with a depreciation of its currency, an increase in exchange rate volatility, as well as a shift in currency skew reflecting increased costs of crash insurance. We

[9] We follow Burnside et al. (2011) to compute the excess returns of these option strategies and present details in Appendix B.

also show that this link is largely driven by global CDS shocks. These global shocks contain substantial information beyond that contained in the VIX, and countries' FX exposures to global CDS spread shocks are related to their external asset-liability positions, inflation, and interest rates.

A. *Sovereign risk and currency depreciation*

To assess the *contemporaneous* relation between exchange rate changes and sovereign CDS spreads (*Hypothesis 1* formulated in Section II), we first run pooled regressions of log exchange rate changes ($\Delta s_{i,t}$) on changes in the foreign country's 5-year CDS spread ($\Delta C^{\star}_{i,t}$), using all 20 countries (indexed by i) over the full sample period:

$$\Delta s_{i,t} = a + b\Delta C^{\star}_{i,t} + e_{i,t}. \tag{1}$$

Here, and throughout the paper, we employ two-way clustered standard errors (clustered by currency and time) to test for statistical significance in all pooled regressions. Panel A of Table II reports the estimation results of this regression. At the monthly frequency, we find a significantly negative slope coefficient of -7.41 (t-stat -8.33) and an R^2 of 26.40%. This seems impressive given that the correlation between exchange rate changes and other economic variables is typically very low. Moreover, these results also indicate a high degree of economic significance, as a coefficient estimate of -7.41 suggests that, on average, an increase in a country's CDS spread by 50 basis points is accompanied by a sizeable depreciation of its currency of about 3.7%.

Table II about here

These results remain qualitatively unchanged when using higher frequencies, CDS country differentials, changing the currency of CDS denomination, and considering subsample periods. More specifically, Panel A shows that coefficient estimates are also significantly negative when running the regression on weekly and daily data with R^2s of 14% and 9.52%. The results are very similar when using the differential between foreign country and US sovereign CDS spread changes, $\Delta(C^{\star}_{i,t} - C_t)$, and when using CDS spreads denominated in local currencies of the respective countries ($\Delta \widehat{C}^{\star}_{i,t}$).[10] The small differences in these estimates compared to our benchmark regressions are mainly a result of the samples being smaller in these regressions because the US CDS spread is only available from late 2003. Likewise, there are fewer observations for CDS spreads in local currencies as compared to USD-denominated CDS spreads. When restricting the sample such that all data are available, we find very similar slope coefficients and R^2s from all regression specifications. The subsample results show that exchange rate returns are closely related to CDS spread changes prior to the crisis (January 2003 to June 2007, Panel B) and during the crisis (July 2007 to November 2013, Panel C). In the pre-crisis sample the R^2s are lower but the highly significant slope estimate of -5.17 (monthly frequency) suggests that the relation between sovereign risk and exchange rate changes is economically significant over that period as well.[11] Panel C shows that all results are most pronounced during the recent financial crisis period.[12]

Finally, we re-estimate the regressions using changes in interest rate differentials, $\Delta(i^{\star}_{t,k} - i_{t,k})$ as independent variable. Interest rates are the most commonly used fundamental in the exchange rate literature and, conceptually, they comprise a riskfree as well as a default risk component (see, e.g., Duffie et al., 2003). We consider short-term rates ($k = 1$ month, consistent with the recent carry trade literature) and longer-term rates ($k = 60$ months, computed from swap rates, to match the maturity of CDS contracts). The results in Table II show that coefficients are typically not significant and that R^2s never exceed 1%. This is an order of magnitude lower compared to the CDS spread regressions but consistent with the very low explanatory power of fundamentals for exchange rate changes documented in the literature (e.g., Verdelhan, 2015). By contrast, market prices of sovereign default

[10] The results based on local currency CDS spreads show that our findings are not driven by CDS-quanto effects; see e.g. Mano (2013).

[11] This finding also relates to a potential confounding of sovereign and counterparty risk. During the crisis both sovereign and (interbank) counterparty risk increased. However, since our results also extend to the pre-crisis period, it seems unlikely that interbank counterparty risk explains our results.

[12] A related concern might be that the negative link between sovereign risk and exchange rate changes is driven purely by periods of time when the USD appreciates due to safe haven effects, i.e. there is a bad global shock, sovereign risk goes up and the USD appreciates on average against all other countries. We test for this by splitting the sample into two subsamples based on the average exchange rate change of all countries against the USD. We find a significantly negative link between CDS spread changes and exchange rate changes for both subsamples, i.e. for periods of time when the USD appreciates and periods of time when the USD depreciates against all other currencies.

insurance appear to reflect currency-relevant information about the state of the economy, uncertainty, and risk aversion at a high frequency.

Overall, we find that fluctuations in exchange rates are strongly related to changes in sovereign risk, as stated in *Hypothesis 1.* Moreover, exchange rate changes appear much more closely related to changes in sovereign risk than to changes in interest rates.

Individual currencies. To investigate cross-country patterns in the link between sovereign risk and exchange rates, we run regressions for individual countries:

$$\Delta s_{i,t} = a_i + b_i \Delta C^{\star}_{i,t} + e_{i,t}, \tag{2}$$

and report the results in Table III. At the monthly frequency, we find negative and statistically significant slope coefficients as well as large R^2s ranging from 10% to 64%, for all currencies but the JPY. The link between sovereign risk and exchange rates seems more pronounced for emerging market currencies but we also find a strong link for other currencies, e.g. typical carry targets such as GBP and AUD. We provide evidence on the determinants of a country's exchange rate sensitivity to CDS spread changes in Section IV.C, and specifically discuss the link between sovereign risk and carry trades in Section V. The weekly and daily results support the negative link between exchange rates and sovereign risk as well, but for subsequent individual country results we focus on the monthly frequency to conserve space.

Table III about here

B. Higher moments of exchange rate changes implied by option IVs

If investors care about currency risk, they may want to obtain insurance against exchange rate changes in FX option markets. More specifically, in our context they should be willing to pay more for the insurance strategies described in Section III.C when the foreign country's sovereign risk increases. We evaluate this prediction in Section II by relating changes in the IVs of volatility protection (STD), crash insurance (RR_{25}), and the butterfly spread (BF_{25}).

Table IV about here

The regression results in Table IV show that changes in sovereign risk are highly correlated with movements in higher FX moments at all frequencies. Consistent with economic intuition, an increase in sovereign risk is related to: (i) higher exchange rate volatility, (ii) more (negative) skewness and higher cost of crash insurance (i.e., OTM puts more expensive than OTM calls), and (iii) higher butterfly spread, suggesting that market participants are concerned about extreme events (i.e., OTM options more expensive than ATM options). The regression coefficients are highly significant across moments and across frequencies, and associated with sizeable regression R^2s, thereby strongly supporting a link between sovereign risk and higher FX moments as well (see *Hypothesis 2* in Section II). By contrast, but similar to the evidence for currency depreciation rates, the relation between interest rates and currency options appears much weaker.

C. Global versus local sovereign risk and exchange rates

To better understand the relation between sovereign CDS spreads and exchange rates, we explore whether it is driven solely by a link between "local" sovereign risk and exchange rates or whether shocks to *global* sovereign risk matter for currencies. We do so by running regressions of bilateral exchange rate changes on a simple measure of global shocks,

$$\Delta s_{i,t} = a_i + b_i^{glob} \Delta \overline{C_t^{\star}} + e_{i,t}, \tag{3}$$

where we compute global shocks ($\Delta \overline{C_t^{\star}}$) as the change in the equally-weighted average of CDS spreads across all countries except country i.[13] The results in the left panel ("Global shocks") of Table V are comparable to those in Tables II and III. The slope coefficients

[13] This procedure follows Verdelhan (2015) and serves to rule out potential mechanical effects resulting from country i affecting the global CDS spread. For example, in a regression of AUD exchange rate changes on the global sovereign risk factor, we compute the global sovereign risk factor as the average innovation in CDS spreads of all countries except Australia. Empirical results are qualitatively identical and quantitatively very similar when including country i in the computation of the global CDS spread. It should also be noted that we have a "dollar effect" as in Verdelhan (2015), in the sense that all the exchange rates in the sample are against the USD. Hence, if global sovereign risk is correlated with broad USD movements, our regressions will pick up this dollar effect. In our robustness checks, we show that our conclusions remain unchanged when we choose a different base currency.

are significantly negative and the R^2s are high for all countries with the single exception of Japan. In the country regressions, the adjusted R^2 ranges from 15% to 63% (excluding JPY) and in the pooled regression the R^2 is about 27%. Thus, our findings suggest that most of the exchange rate-related information in sovereign CDS spread changes is global in nature. This is in line with Longstaff et al. (2011) who find that sovereign risk of individual countries is mainly driven by global systematic factors, and Verdelhan (2015) who shows that global risk matters for a large share of variation in bilateral exchange rates. Finally, it seems noteworthy that we also find a significantly negative estimate for Switzerland, suggesting that the relation between sovereign risk and exchange rate changes is not just capturing "flight-to-safety" episodes (e.g. Ranaldo and Söderlind, 2010), typically characterized by CHF appreciations.

TABLE V ABOUT HERE

While global sovereign risk shocks play a major role across countries, it is interesting to note differences in R^2s compared to the individual country CDS spread regressions reported in Table III. To shed light on these differences, we augment Equation (3) by adding a purely local component (local sovereign CDS spread changes orthogonalized with respect to global CDS spread changes, $\Delta C^{\star loc}_{i,t}$):

$$\Delta s_{i,t} = a_i + b_i^{loc} \Delta C^{\star loc}_{i,t} + b_i^{glob} \Delta \overline{C^{\star}_t} + e_{i,t}. \tag{4}$$

We report results in the right part of Table V ("Local and global shocks") and find significant local slope coefficient estimates for 12 out of the 20 currencies. In the pooled regression, the local coefficient is significant, and adding a local component increases the R^2 from 27.39% to 32.70%. These results suggest that CDS spread changes unrelated to global CDS shocks matter for many countries, apparently for most emerging markets but also for currencies such as GBP and SEK, i.e., there is no clear developed versus emerging country pattern. Overall, this analysis suggests that most of the variation in bilateral exchange rates is related to the global component but that sovereign-specific risk also plays a minor role.

Global CDS shocks and the VIX. A recent literature argues that the VIX (a volatility index computed from options on the S&P500) can be interpreted as a global measure of risk aversion and uncertainty (see, e.g., Bekaert et al., 2013) and captures global financial cycles (Miranda-Agrippino and Rey, 2014). Hence, it seems natural to ask whether movements in the VIX subsume the information in (global) CDS spreads. We explore the extent to which changes in the VIX are contemporaneously related to exchange rate changes and (global) CDS spread changes. First, we repeat the global regressions using VIX (log) changes instead of global CDS spread changes. Specification (i) in Panel A of Table VI presents pooled regression evidence that exchange rate changes significantly relate to VIX changes; however, the R^2 of 13.78% is much lower than the pooled-R^2 (27.39%) of global CDS changes in Table V. As a result, adding a local CDS component (orthogonalized to VIX changes) in specification (ii) more than doubles the R^2 and the coefficient is highly significant, suggesting that the VIX does not capture as much common variation across countries as global CDS spread shocks do. Similarly, we show in specification (iii) of Panel B that adding the global CDS component (orthogonalized to VIX changes) doubles the R^2 as compared to the VIX to 28.78% and it further increases in specification (iv) with a significant local component (orthogonalized to VIX and global CDS) to 33.82%. Accordingly, Panel C shows that global shocks (orthogonalized to VIX) and local shocks (orthogonalized to VIX and global CDS changes) capture 20% of the variation in exchange rate changes. In contrast, the VIX orthogonalized to global CDS changes is not significant and has a very low R^2 of 1.38%. Overall, global CDS spread changes appear to be related to changes in the VIX to some extent but they contain substantial currency-relevant information beyond the VIX.

Table VI about here

D. *Currency exposures to sovereign risk and country fundamentals*

In order to better understand the economic drivers of our results, we examine the link between countries' FX exposure to sovereign risk and a number of key economic fundamentals. The results are reported graphically in Figure 2. First, we plot countries' FX exposures to global sovereign risk as measured by the slope coefficients of Equation (3) against (i) the average ratio of foreign total assets to liabilities, which represents a proxy for the countries' vulnerability to external shocks, (ii) the average ratio of foreign debt assets to liabilities, and (iii) the average ratio of foreign holdings to total holdings of government debt.[14] Recalling that the relation between a country's FX exposure and sovereign risk is negative, the patterns documented in Figure 2 appear intuitive: Countries with a worse external position are more sensitive (in absolute terms) to global CDS spread shocks. This holds for both total assets (i) as well as for debt instruments only (ii). Similarly, countries with a larger share of government debt held by foreign investors have a higher FX sensitivity to global CDS spread shocks (iii). Likewise, we find that currencies of countries with higher inflation rates are also more exposed to global sovereign risk shocks (iv). All these findings support *Hypothesis 3* formulated in Section II. Moreover, none of the fundamentals suggests different tales for developed versus emerging markets (marked by blue bullets and red crosses, respectively).

Figure 2 about here

While it is not the purpose of this paper to explicitly identify the mechanism that drives these relations, our results clearly support an economic link between exchange rate exposure and macro fundamentals. One interpretation of these results may be that net-creditor countries, countries with a lower share of foreign debt, and countries with lower inflation have lower exposures to global shocks because they are less vulnerable to credit events and less dependent on foreign debt financing. Such a reasoning is consistent with the notion that external asset positions can serve as collateral and thereby reduce foreign investors' loss in the event of a default.[15]

Finally, we provide evidence that interest rates capture country-differentials in currency exposures to global sovereign risk shocks. Panels (v) and (vi) in Figure 2 show that higher

[14] We standardize CDS spread changes in the exposure regressions by their sample means and standard deviations to facilitate easier comparability and interpretation.

[15] For example, Bussiere and Fratzscher (2006) examine a set of 20 open emerging markets and show that a high current account deficit and decelerating growth make a country more vulnerable to crises. Greenlaw et al. (2013) study 20 advanced economies and find that the average nominal yield on long-term government debt is sensitive to both lagged debt and the current-account deficit. They suggest that a country will start paying a premium to foreign debt-holders as compensation for default or inflation risk when the government is not able to run a sufficiently high primary surplus.

one-month and five-year interest rates coincide with a more negative relation between exchange rates and sovereign risk, which suggests carry trade returns may be linked to sovereign risk as well.

V. Sovereign Risk and Currency Return Predictability

The findings above reveal a strong link between contemporaneous changes in sovereign CDS spreads and exchange rates. To test whether sovereign risk is priced in exchange rates, we now examine the predictive relation between sovereign risk and currency excess returns. Consistent with the hypotheses formulated in Section II, we find that currency portfolios sorted by sovereign risk forecast excess returns to trading currencies, FX volatility, and FX skewness. Moreover, we find that the link between sovereign risk and currency risk premia also matters for the performance of benchmark trading strategies: carry and momentum strategies generate high returns across countries with high sovereign risk but significantly lower returns across countries with low sovereign CDS spreads.

A. Sovereign risk portfolios

If sovereign risk is priced in exchange rates, the currencies of high risk countries should earn returns in excess of low risk currencies. To empirically test this prediction, we form currency portfolios based on two alternative measures of sovereign risk. Below, we discuss the construction of currency portfolios and present their performance, which shows that sovereign risk forecasts the first three moments of the exchange rate distribution.

Ex-ante measures of sovereign risk Our results above suggest that the link between exchange rates and sovereign risk is dominated by global CDS changes. In our analysis of risk premia in the cross-sections of currencies, we should therefore find that countries with high (low) exposures of their sovereign risk to global shocks earn high (low) currency excess returns. To measure country i's global CDS exposure conditional on time-t information, we regress past changes in its CDS spread on past changes in the global CDS spread,

$$\Delta C^{\star}_{i,t-1y;t} = \alpha_i + \beta_{i,t} \Delta \overline{C^{\star}_{t-1y;t}} + \varepsilon_{t-1y;t},$$

over a rolling window of one year ($[t-1y;t]$), which we estimate at a weekly frequency. By re-estimating this regression every month, we obtain real-time estimates of countries' systematic sovereign risk ($\beta_{i,t}$) that allow us to explore the performance of $\beta_{i,t}$-ranked portfolios in an out-of-sample setting.[16]

As a second measure of sovereign risk, we use countries' time-t CDS spreads ($C^{\star}_{i,t}$) to form currency portfolios. An advantage of using the time-t CDS spreads is that we do not need to lose data for estimating the (initial) exposures, which allows us to explore portfolio returns over a longer period.

Portfolio construction To reduce the potential impact of outliers in our portfolio results, we use rank weights as in Asness et al. (2013) to compute the portfolio weight of currency i for the period from t to $t+1$ as

$$w_{i,t+1} = c_t(\text{rank}(K_{i,t}) - \sum_i \text{rank}(K_{i,t})/N_t), \tag{5}$$

where $K_{i,t}$ denotes the conditioning variable used to determine portfolio weights. N_t denotes the number of currencies available at time t. The scaling factor c_t is chosen such that the portfolio is one dollar long and one dollar short at the time of portfolio construction. Thus, the portfolio is dollar-neutral. The excess return to this rank portfolio is then given by $r_{t+1} = \sum_i w_{i,t+1} rx_{i,t+1}$ and we update the portfolio weights at the end of each month. Using these portfolio weights, we evaluate the portfolio excess returns of the currency trading strategies described in Section III.C: currency investments based on spot and forward exchange rates (RX), selling protection against FX volatility using delta-neutral straddles (STD), selling crash insurance using risk reversals (RR_{25}), and selling protection against kurtosis risk using butterfly spreads (BF_{25}). For all trading strategies, we evaluate the performance of portfolios based on using CDS-betas ($\beta_{i,t}$) and based on using CDS spreads ($C^{\star}_{i,t}$) as conditioning variable $K_{i,t}$.

[16]By only relying on CDS data in the estimation $\beta_{i,t}$, we obtain a pure measure of countries' systematic sovereign risk exposure without using exchange rate data. We therefore have a single measure of a country's exposure to global CDS changes that we can use as a signal for all trading strategies (i.e. across all four moments of currency returns: forward-, volatility-, skewness-, and kurtosis-trading strategies).

Returns to sovereign risk portfolios Table VII reports the results for sovereign risk portfolios sorted by global CDS exposures in Panel B and for portfolios sorted by CDS spreads in Panel B, respectively.

For the CDS-beta portfolios, we find that trading the first three moments of exchange rate changes (RX, STD, RR_{25}) yields significantly positive excess returns and high Sharpe ratios. Investors earn 7.46% *p.a.* for buying high and selling low sovereign risk currencies and the corresponding Sharpe ratio is 1.12. Trading volatility risk generates excess returns of 3.85% (STD) with a Sharpe ratio of 0.85, and selling crash insurance of high against low risk sovereigns yields 5.28% (RR_{25}) with a Sharpe ratio of 1.43. There is no significant excess return to trading kurtosis (BF_{25}), which suggests that the predictive ability of sovereign risk is more pronounced for the left tail of the distribution, i.e., for currency depreciations as compared to appreciations. Overall, these results suggest that sovereign risk is priced in currency markets, consistent with *Hypothesis 4*: currencies of countries with a higher (lower) exposure to global sovereign risk shocks command higher (lower) risk premia. Our results also provide further support for *Hypothesis 2* in that returns to trading volatility and skewness are significantly positive.

TABLE VII ABOUT HERE

The results for the currency portfolios sorted by sovereign CDS spread levels (Panel B) are very similar and allow for the same conclusions: sovereign risk forecasts the excess returns to trading currencies, FX volatility, and FX skewness. In general, the returns and Sharpe ratios are somewhat higher compared to the CDS-beta portfolios, with the excess return of buying high and selling low sovereign CDS currencies being 9.05% *p.a.* with a Sharpe ratio of 1.35. The difference in performance compared to the exposure-sorted portfolios mostly results from the longer sample period (as discussed above, we do not need to reserve any data for exposure estimation); comparing the returns of exposure- and CDS-sorted portfolios over the period for which both conditioning variables are available, we find that the correlation across trading strategies is in the range of 0.88 to 0.92 (last row in Panel B). Hence, CDS spread levels appear to capture systematic sovereign risk that matters for currency risk premia consistent with the predictions formulated in *Hypothesis 4* (related to currency excess returns) and in *Hypothesis 2* (related to higher FX moments).

Having documented that sovereign risk matters for currency risk permia, we now explore how the information in sovereign CDS spreads relates to the performance of carry trades and momentum in currency markets.[17]

B. Sovereign risk, carry, and momentum

We start our analysis of the link between carry, momentum, and sovereign risk in currency markets by comparing the cumulative excess returns of rank portfolios in Figure 3.[18] While the sovereign risk portfolio appears to exhibit some commonalities with the carry or the momentum portfolio over certain periods, the plots show that the carry strategy performs for forward trades (RX) and skewness trades (RR_{25}), whereas momentum performs best for volatility trades (STD). None of the three strategies generates significant returns for kurtosis trades.

Figure 3 about here

To understand how sovereign risk relates to carry and momentum returns, we conduct sequential portfolio sorts. Every month, we sort currencies by their sovereign risk in the first step and by carry or momentum in the second step. More specifically, we assign currencies to the high or low CDS portfolio based on their CDS spread being above or below the cross-country median CDS spread at time t. Within the high CDS and the low CDS portfolios, we then form portfolios of high and low carry currencies and portfolios of high and low momentum currencies. Thus, we have four portfolios double-sorted on sovereign risk and carry and four portfolios double-sorted on sovereign risk and momentum.

Table VIII presents the results for these double sorted portfolios. We find that both carry and momentum strategies are significantly more profitable when implemented among currencies of high sovereign risk countries compared to low CDS countries. A carry strategy among currencies with high CDS spreads generates an average excess return of 9.6% *p.a.* (significant) with a Sharpe ratio of 1.09, whereas the carry trade among low CDS currencies

[17]Given that the performance of exposure- and CDS spread-sorted currency portfolios is very similar, we subsequently use the latter to allow for a longer sample period.

[18]Carry is based on lagged 1-month forward discounts and momentum is based on lagged 1-month returns, which is the most profitable momentum strategy in Menkhoff et al. (2012b).

only generates 2.3% *p.a.* (not significant) with a Sharpe ratio of 0.34. Likewise, momentum yields an excess return of 8.8% *p.a.* (significant) and a Sharpe ratio of 1.10 in high sovereign risk currencies compared to 1.1% *p.a.* (not significant) and a Sharpe ratio of 0.18 in low CDS currencies.[19] Moreover, we find that buying high CDS and selling low CDS currencies generates an excess return of around 10.5% to 10.7% *p.a.* (significant) among high carry and high momentum currencies with Sharpe ratios of around 1.3, whereas the high minus low CDS returns are only 3% to 3.2% (marginally significant) with Sharpe ratios slightly above 0.5 among low carry and low momentum currencies.

These results provide further evidence that sovereign risk matters for currency excess returns. More specifically, sovereign CDS spreads appear to convey information that is relevant for the profitability of benchmark FX strategies such as carry trades and momentum.

VI. Additional results and robustness checks

We present additional evidence that (i) sovereign risk matters for speculator activity in FX derivative markets and that (ii) there is a link between sovereign risk and the Euro as well. While we discuss these findings in the paper, we delegate the tables with empirical results to the Internet Appendix to conserve space. Furthermore, extensive robustness checks suggest that our conclusions remain unchanged across different sample periods and base currencies, after accounting for transaction costs, and for other FX instruments such as volatility risk premia generated by volatility swaps. We briefly summarize these results at the end of the section but refer to the Internet Appendix for a detailed discussion.

[19] The results are qualitatively the same for other double sort specifications, in that carry and momentum strategies have significantly higher excess returns and Sharpe ratios among countries with high CDS spreads compared to countries with low CDS spreads. When we sequentially sort portfolios that first condition on carry or momentum and subsequently on sovereign risk, we find that carry (momentum) returns are 13.3% (7.3%) for high CDS countries and 2.8% (-0.3%) for low CDS countries. When we conduct unconditional double sorts, i.e. we independently sort countries into high and low sovereign risk, carry, and momentum portfolios, we find that carry (momentum) returns are 10.9% (4.9%) for high CDS countries and 1.9% (0.6%) for low CDS countries.

A. *FX speculator positions*

If currency investors indeed care about sovereign risk, we should find that shocks to sovereign risk lead to portfolio adjustments. As an empirical proxy for such portfolio adjustments, we compute net speculator positions in currency futures and options markets based on commitment of traders data provided by the CFTC. Following the literature (see, e.g., Moskowitz et al., 2012), we compute net speculator positions as the difference of long and short positions by non-commercial traders, scaled by open interest. For the sample of countries used in this paper, data is available for AUD, CAD, CHF, GBP, JPY, MXN, and NZD (all against USD) at a weekly frequency. We run a sequence of pooled regressions of changes in net speculator positions on changes in CDS spreads for forecast horizons of $k = 0, 1, 2, 3, 4$ weeks, using

$$\Delta p_{i,t+k} = \alpha_k + \beta_k \Delta C^*_{i,t} + \gamma_{1,k} \Delta s_{i,t} + \gamma_{2,k} \Delta s_{i,t-1} + \varepsilon_{i,t+k},$$

where $\Delta p_{i,t+k}$ denotes the k-week change in net speculator positions and where we include lagged exchange rate changes ($\Delta s_{i,t}, \Delta s_{i,t-1}$) as controls to rule out simple momentum trading explanations.[20] The results in Table IA.1 show that the relation between changes in net positions and CDS spreads is significantly negative contemporaneously ($k = 0$) as well as for a forecast horizon of one week ($k = 1$). This finding is consistent with speculators reducing their FX derivative positions in currencies of countries that experience an increase in their sovereign risk and lends support to the view that CDS spreads contain information that is not subsumed by exchange rate changes themselves.

B. *Sovereign risk and the Euro*

We do not include the Eurozone in the core analysis above for the reason that it consists of multiple countries with individual sovereign risk (and CDS contracts) but a common currency. Since there is no CDS contract for the Eurozone as such, we use the itraxx Western Europe SovX index as a (admittedly imperfect) proxy for the sovereign risk in

[20]Including further lags of CDS spread changes or exchange rates does not change the conclusions from these regressions.

the Eurozone. This index starts in 2009 and averages many countries from the Eurozone (Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain) but also some European countries which are not Eurozone members (Denmark, Norway, Sweden, United Kingdom); from 2012, Cyprus and Greece are excluded. We generate a series that synthetically replicates the SovX from 2003 onwards and use the generic SovX series as soon as it becomes available. Despite the SovX clearly being an imperfect proxy, we find that linking the EUR exchange rate to the SovX confirms our main results. Table IA.2 reports results for contemporaneous regressions of exchange rate changes, changes in ATM straddle, risk reversal, and butterfly spread IVs, confirming that increases in the SovX are associated with EUR depreciations as well as increases in EUR volatility and EUR crash risk.

C. *Discussion of further robustness checks*

This subsection contains a brief overview of some additional robustness checks that corroborate our findings. While we present these results in detail in the Internet Appendix, the findings can be summarized as follows. Tables IA.3 to IA.5 present country results of regressing changes in option-implied FX moments on sovereign CDS spread changes which confirm the pooled regression evidence that increases in sovereign risk are associated with increases in the volatility, skewness, and kurtosis of exchange rate changes. Table IA.6 shows that the returns of CDS-sorted portfolios (presented in Table VII above) are not wiped out by transaction costs. Additionally, we consider volatility swaps as an alternative instrument for trading higher-moment risk and show that FX volatility risk premia are predicted by sovereign CDS spreads but not by interest rates (Table IA.7). Furthermore, we also discuss the factor structure of sovereign risk portfolio returns (Table IA.8) and robustness to choosing a different base currency (Table IA.9). Finally, we present time-series predictability results to show that lagged CDS spread innovations Granger-cause exchange rate changes (Figure IA.1).

VII. Conclusion

Using data on credit default swaps (CDS) for a broad set of countries, we show that sovereign risk is priced in currency markets. Sovereign risk matters for exchange rate changes as well as for the higher moments of the exchange rate distribution such as volatility and skewness. More specifically, our findings suggest that the information embedded in sovereign CDS spreads is powerful in capturing the time-series behavior of bilateral exchange rates and for understanding risk premia in the cross-section of currencies. Exchange rate changes strongly comove with changes in sovereign risk at a daily to monthly frequency, and the variation in CDS spreads across countries forecasts currency excess returns to trading on the first three moments of returns. Sovereign risk also matters for currency risk premia captured by carry and momentum trades; both strategies generate significantly higher excess returns when trading the currencies of high CDS countries compared to low CDS countries.

We also find that the relation between exchange rates and sovereign CDS spreads is mostly driven by countries' exposures to global sovereign risk, whereas purely local sovereign risk matters much less. While shocks to global sovereign risk are related to changes in the VIX (often used as a measure of global uncertainty), exchange rates changes are much more closely related to innovations in global sovereign risk than to VIX changes. The extent to which currencies are exposed to shocks to global sovereign risk is related to measures of countries' financial vulnerability such as their external position.

Overall, sovereign risk seems to be an important, but so far neglected, source of risk in currency markets. While these findings withstand extensive robustness checks and are intuitively clear, our understanding of the relation between sovereign credit risk and currency markets requires further work. Given the evidence reported in this paper, a formal theoretical model that links (the term structure of) sovereign risk to the distribution of exchange rate returns seems to be an important avenue for future macro-finance research.

Appendix

A. Extracting Strike Prices from FX Option IVs

To compute currency option prices and returns (see Appendix B), we first need to extract the options' strike prices from the delta-based IV market quotes of straddles, risk reversals, and butterfly spreads (see Section III.A). We work with at-the-money (ATM), 25δ call and put, and 10δ call and put options. According to market convention, options on developed currencies (i.e., AUD, CAD, CHF, DKK, EUR, GBP, JPY, NOK, NZD, and SEK) up to a 1-year maturity are quoted using the spot delta whereas the forward delta is used for all other currency-maturity combinations. We use 25δ options to illustrate the concepts. Denote by IV_{ATM}, IV_{25C}, and IV_{25P} the time-t implied volatility of ATM, 25δ call, and 25δ put options with maturity τ, respectively.[21] To keep the notation simple, we omit the currency subscript i. When options are quoted using spot deltas, the strike price (X) of ATM, 25δ call and put options are computed, respectively, as

$$X_{ATM,t} = F_{t,\tau} \cdot \exp\left[\frac{\tau}{2} \cdot IV_{ATM}^2\right], \tag{A.1}$$

$$X_{25C,t} = F_{t,\tau} \cdot \exp\left[\frac{\tau}{2} \cdot IV_{25C}^2 - N^{-1}(0.25 \cdot \exp(i_{t,\tau}^{\star} \cdot \tau)) \cdot IV_{25C} \cdot \sqrt{\tau}\right], \tag{A.2}$$

$$X_{25P,t} = F_{t,\tau} \cdot \exp\left[\frac{\tau}{2} \cdot IV_{25P}^2 + N^{-1}(0.25 \cdot \exp(i_{t,\tau}^{\star} \cdot \tau)) \cdot IV_{25P} \cdot \sqrt{\tau}\right]. \tag{A.3}$$

For forward delta options, the strike price of ATM, 25δ call and put options are given by

$$X_{ATM,t} = F_{t,\tau} \cdot \exp\left[\frac{\tau}{2} \cdot IV_{ATM}^2\right], \tag{A.4}$$

$$X_{25C,t} = F_{t,\tau} \cdot \exp\left[\frac{\tau}{2} \cdot IV_{25C}^2 - N^{-1}(0.25) \cdot IV_{25C} \cdot \sqrt{\tau}\right], \tag{A.5}$$

$$X_{25P,t} = F_{t,\tau} \cdot \exp\left[\frac{\tau}{2} \cdot IV_{25P}^2 + N^{-1}(0.25) \cdot IV_{25P} \cdot \sqrt{\tau}\right]. \tag{A.6}$$

Results for 10δ options follow naturally (i.e., replace 0.25 with 0.10).

[21] The formulas reported in this Appendix refer to options on exchange rates defined as units of US dollar per units of foreign currency, i.e., when the dollar is both the pricing currency for the underlying exchange rate and the premium currency for the option.

B. Excess Returns of FX Option Strategies

We provide details on the computation of excess returns for option-based strategies aimed at trading the volatility, skewness, and kurtosis of exchange rate changes that we introduce in Section III.C: straddles (STD), 25δ risk reversals (RR_{25}), and 25δ butterfly spreads (BF_{25}).

To compute excess returns from options strategies, we first extract strike prices from IV quotes as described in Appendix A, and then compute option prices following Garman and Kohlhagen (1983). We denote by $C_{\delta,t}$ and $P_{\delta,t}$ the prices of one-month European call and put options with $\delta \in \{ATM, 25, 10\}$; to keep the notation simple, we drop currency subscript i. We follow Burnside et al. (2011) and compute returns on long and short positions in call options (LC and SC) and put options (LP and SP) as

$$rx^{LC}_{\delta,t+1} = \frac{\max(S_{t+1} - X, 0) - C_{\delta,t}(1 + i_{t,1})}{F_t}, \tag{B.1}$$

$$rx^{LP}_{\delta,t+1} = \frac{\max(X - S_{t+1}, 0) - P_{\delta,t}(1 + i_{t,1})}{F_t}, \tag{B.2}$$

$$rx^{SC}_{\delta,t+1} = \frac{\min(X - S_{t+1}, 0) + C_{\delta,t}(1 + i_{t,1})}{F_t}, \tag{B.3}$$

$$rx^{SP}_{\delta,t+1} = \frac{\min(S_{t+1} - X, 0) + P_{\delta,t}(1 + i_{t,1})}{F_t}. \tag{B.4}$$

We scale the net option payoffs by the forward rate so that all positions are fully collateralized, i.e., we assume no leverage. We then compute excess return on the three trading strategies according to their construction described in III: STD as long ATM call plus long ATM put, RR_{25} as a long 25δ put plus a short 25δ call, and BF_{25} as short positions in ATM call and ATM put plus long positions in 25δ call and 25δ put:

$$rx^{STD}_{t+1} = rx^{LC}_{ATM,t+1} + rx^{LP}_{ATM,t+1}, \tag{B.5}$$

$$rx^{RR_{25}}_{t+1} = rx^{LP}_{25P,t+1} + rx^{SC}_{25C,t+1}, \tag{B.6}$$

$$rx^{BF_{25}}_{t+1} = rx^{SP}_{ATM,t+1} + rx^{SC}_{ATM,t+1} + rx^{LC}_{25C,t+1} + rx^{LP}_{25P,t+1}. \tag{B.7}$$

In our empirical analysis, we investigate whether sovereign risk-motivated selling of insurance against volatility, skew, and kurtosis risk, i.e., being short the above strategies, generates positive excess returns.

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Table I: Descriptive statistics

This table shows descriptive statistics and sample coverage for all 20 countries in our data set. We report the median (*med*), minimum (*min*), and maximum (*max*) of 5-year sovereign CDS spreads, one-month forward discounts defined as difference between the log spot and the log one-month forward exchange rate (equivalent to the foreign country minus US interest rate), and one-month at-the-money (ATM) option-implied volatility (IV). Note that IVs are quoted in percentage per annum.

	Sample		CDS Spread (bp)			Forward Discount (%)			ATM IV (% *p.a.*)		
	start	*end*	*min*	*med*	*max*	*min*	*med*	*max*	*min*	*med*	*max*
AUD	30/04/2003	19/08/2010	1.60	3.42	196.66	-0.52	0.23	1.03	5.95	11.23	46.00
BRL	03/01/2005	31/12/2010	61.14	132.72	594.54	-0.02	0.68	1.59	6.00	14.30	69.00
CAD	11/09/2003	29/11/2013	1.60	24.61	133.50	-0.22	0.04	0.48	4.49	8.80	27.00
CHF	05/06/2007	29/11/2013	1.44	46.00	176.49	-0.32	-0.03	0.90	5.12	10.80	23.85
CLP	29/03/2004	29/11/2013	12.53	66.87	315.95	-0.46	0.06	0.82	4.94	10.70	45.00
COP	02/01/2008	31/12/2008	114.56	184.00	600.25	0.36	0.62	0.89	9.50	18.00	35.00
CZK	02/01/2003	29/11/2013	4.69	37.61	350.14	-0.80	0.02	0.21	5.96	11.26	39.07
GBP	20/03/2006	29/11/2013	1.20	52.23	164.63	-0.45	0.02	0.52	4.52	8.81	30.50
HUF	03/01/2012	29/11/2013	241.64	318.69	736.35	0.17	0.39	0.52	9.83	13.56	24.20
IDR	25/09/2003	31/12/2010	91.82	220.00	1246.75	-10.05	0.73	15.99	3.69	8.89	67.34
ILS	29/03/2004	29/11/2013	16.92	109.79	285.00	-0.19	0.06	0.29	3.43	7.62	20.69
JPY	02/01/2003	29/11/2013	2.45	19.11	159.31	-0.84	-0.09	0.72	5.80	9.86	38.00
KRW	02/01/2008	29/11/2013	46.80	103.21	708.64	-1.40	0.15	0.25	4.28	11.47	73.56
MXN	02/01/2003	29/11/2013	28.51	112.01	587.88	0.11	0.32	1.35	4.80	9.70	95.00
NOK	24/10/2003	29/11/2013	1.17	14.34	63.63	-1.58	0.11	1.14	6.40	11.30	33.45
NZD	31/07/2003	19/08/2010	1.92	11.50	247.72	-1.49	0.23	0.64	8.30	13.00	40.00
PLN	02/01/2003	29/11/2013	7.53	58.50	418.56	-0.37	0.25	0.50	7.14	12.73	51.38
SEK	02/01/2003	29/11/2013	1.31	15.14	158.44	-1.73	0.07	1.28	6.45	11.30	32.70
SGD	18/07/2003	26/03/2012	2.00	11.00	103.50	-0.93	-0.04	0.19	2.90	5.51	15.92
TRY	02/01/2008	29/11/2013	110.37	201.52	820.55	0.27	0.57	1.56	4.47	12.27	52.09

Table II: CDS spread changes and currency depreciation: Pooled regressions

This table reports results from contemporaneous pooled regressions of exchange rate changes on CDS spread changes and interest rate differentials. $C_t^\star$ (C_t) denotes the 5-year foreign (US) sovereign CDS spread in US dollar, $\widehat{C}_t^\star$ ($\widehat{C}_t$) denotes the 5-year foreign (US) sovereign CDS spread in foreign currency, $i_{t,1}^\star$ ($i_{t,1}$) is the 1-month foreign (US) interest rate, $i_{t,60}^\star$ ($i_{t,60}$) is the 5-year foreign (US) interest rate, and Δ indicates the change of a variable (one unit of time). *Panel A* shows results for the full sample period whereas *Panel B* (*Panel C*) reports results for the pre-crisis (crisis) subsample. We report estimates of the slope coefficients (b), t-statistics (t_b) based on clustered (by currency and time) standard errors, and R^2 for regressions conducted on a daily, weekly, and monthly data frequency. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively.

Panel A: Full Sample (01/2003 - 11/2013)

	monthly			weekly			daily		
	b	t_b	R^2	b	t_b	R^2	b	t_b	R^2
$\Delta C_t^\star$	-7.41^{***}	-8.33	26.40	-3.41^{***}	-3.08	14.00	-3.80^{***}	-3.63	9.52
$\Delta(C_t^\star - C_t)$	-7.49^{***}	-7.47	23.59	-3.16^{***}	-3.04	11.75	-3.40^{***}	-3.84	8.15
$\Delta\widehat{C}_t^\star$	-6.82^{***}	-7.47	32.20	-2.93^{***}	-3.00	17.72	-2.59^{***}	-4.12	9.52
$\Delta(\widehat{C}_t^\star - \widehat{C}_t)$	-7.00^{***}	-6.58	29.26	-2.81^{***}	-2.95	15.55	-2.44^{***}	-4.16	8.56
$\Delta(i_{t,1}^\star - i_{t,1})$	0.29	0.31	0.11	0.07	0.17	-0.00	0.13	1.39	0.05
$\Delta(i_{t,60}^\star - i_{t,60})$	-0.22	-0.31	0.01	-0.48	-0.88	0.31	-0.50^{*}	-1.75	0.61

Panel B: Pre-Crisis Subsample (01/2003 - 06/2007)

	monthly			weekly			daily		
	b	t_b	R^2	b	t_b	R^2	b	t_b	R^2
$\Delta C_t^\star$	-5.17^{***}	-7.03	7.32	-5.20^{***}	-9.28	5.18	-3.79^{***}	-2.74	2.53
$\Delta(C_t^\star - C_t)$	-5.18^{***}	-6.99	8.19	-5.33^{***}	-9.45	5.71	-4.03^{***}	-2.79	2.97
$\Delta\widehat{C}_t^\star$	-6.33^{**}	-2.37	12.43	-8.12^{***}	-4.88	8.73	-8.35^{***}	-4.78	8.59
$\Delta(\widehat{C}_t^\star - \widehat{C}_t)$	-6.23^{**}	-2.34	12.67	-8.31^{***}	-4.96	9.93	-8.66^{***}	-4.95	9.82
$\Delta(i_{t,1}^\star - i_{t,1})$	0.18	0.31	-0.12	0.26	1.26	0.04	0.08	0.63	0.01
$\Delta(i_{t,60}^\star - i_{t,60})$	-0.74	-1.18	1.21	-0.21	-0.53	0.08	-0.13	-0.69	0.09

Panel C: Crisis Subsample (07/2007 - 11/2013)

	monthly			weekly			daily		
	b	t_b	R^2	b	t_b	R^2	b	t_b	R^2
$\Delta C_t^\star$	-7.63^{***}	-8.89	30.46	-3.35^{***}	-3.00	16.04	-3.79^{***}	-3.63	11.06
$\Delta(C_t^\star - C_t)$	-7.74^{***}	-7.92	26.41	-3.10^{***}	-2.96	13.06	-3.37^{***}	-3.85	9.15
$\Delta\widehat{C}_t^\star$	-6.83^{***}	-7.59	33.40	-2.91^{***}	-2.99	18.43	-2.56^{***}	-4.09	9.84
$\Delta(\widehat{C}_t^\star - \widehat{C}_t)$	-7.03^{***}	-6.65	30.21	-2.79^{***}	-2.95	16.06	-2.41^{***}	-4.13	8.78
$\Delta(i_{t,1}^\star - i_{t,1})$	0.37	0.35	0.19	0.06	0.12	-0.01	0.14	1.28	0.06
$\Delta(i_{t,60}^\star - i_{t,60})$	0.06	0.07	-0.08	-0.60	-0.90	0.39	-0.76^{**}	-2.52	1.00

Table III: CDS spread changes and currency depreciation: Country regressions

This table presents estimates from contemporaneous regressions of exchange rate changes on foreign country sovereign CDS spread changes. The exchange rates are defined as units of US dollars per unit of foreign currency. The CDS contracts are denominated in US dollar and have a 5-year maturity. We report estimates of the slope coefficients (b) and R^2 from regressions conducted on a daily, weekly, and monthly data frequency. Standard errors for individual country estimates are based on Newey and West (1987) with Andrews (1991) lag selection. The last row reports results for a pooled regression for comparison where we employ clustered (by currency and time) standard errors. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample period is from January 2003 to November 2013.

	monthly		weekly		daily	
	b	R^2	b	R^2	b	R^2
AUD	-16.41^{***}	20.13	-12.77^{***}	14.69	-8.41^{***}	3.92
BRL	-7.03^{***}	38.88	-5.40^{***}	50.15	-5.81^{***}	30.50
CAD	-18.07^{***}	10.10	-5.25^{***}	0.74	-2.59^{**}	0.24
CHF	-13.05^{***}	15.65	-3.51	1.33	-1.12	0.08
CLP	-10.86^{***}	28.54	-6.32^{***}	20.38	-5.93^{***}	11.50
COP	-9.06^{***}	44.61	-1.94^{***}	14.94	-2.35^{***}	13.52
CZK	-8.98^{***}	20.39	-7.08^{***}	14.82	-7.52^{***}	10.97
GBP	-13.40^{***}	25.90	-9.13^{***}	13.81	-7.60^{***}	6.81
HUF	-6.21^{***}	64.06	-5.18^{***}	34.45	-5.47^{***}	30.56
IDR	-4.09^{***}	49.62	-0.44	2.71	-0.87^{***}	6.75
ILS	-5.34^{***}	15.21	-4.46^{***}	10.09	-3.23^{***}	4.20
JPY	0.05	-0.78	5.61^{**}	3.28	2.68^{***}	0.73
KRW	-7.73^{***}	48.12	-3.75^{***}	43.89	-4.94^{***}	27.86
MXN	-7.53^{***}	49.82	-4.36^{***}	41.62	-4.52^{***}	24.61
NOK	-33.64^{***}	17.66	-18.96^{***}	5.81	-12.61^{***}	2.91
NZD	-10.16^{***}	11.00	-7.50^{***}	7.78	-4.54^{***}	2.52
PLN	-11.49^{***}	42.07	-8.96^{***}	34.26	-9.04^{***}	24.30
SEK	-18.25^{***}	27.30	-14.48^{***}	17.19	-11.54^{***}	5.34
SGD	-9.78^{***}	20.40	-5.29^{**}	6.56	-2.36^{**}	1.09
TRY	-8.09^{***}	62.31	-4.51^{***}	60.69	-4.78^{***}	44.02
pooled	-7.41^{***}	26.40	-3.41^{***}	14.00	-3.80^{***}	9.52

Table IV: CDS spread changes and implied volatilities: Pooled regressions

This table displays results from contemporaneous pooled regressions of changes in the one-month implied volatility of delta-neutral straddles (Panel A), 25δ risk reversals (Panel B), and 25δ butterfly spreads (Panel C) on CDS spread changes. $C_t^\star$ (C_t) denotes the 5-year foreign (US) sovereign CDS spread in US dollar, $i_{t,1}^\star$ ($i_{t,1}$) is the 1-month foreign (US) interest rate, $i_{t,60}^\star$ ($i_{t,60}$) is the 5-year foreign (US) interest rate, and Δ indicates the change of a variable (one unit of time). We report estimates of the slope coefficients (b), t-statistics (t_b) based on clustered standard errors (clustered by currency and time), and R^2 for regressions conducted on a daily, weekly, and monthly data frequency. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample period is from January 2003 to November 2013.

Panel A: Delta-neutral Straddles

	monthly			weekly			daily		
	b	t_b	R^2	b	t_b	R^2	b	t_b	R^2
$\Delta C_t^\star$	7.18***	3.68	32.34	4.78***	3.08	20.61	4.35***	3.90	14.14
$\Delta(C_t^\star - C_t)$	7.96***	4.07	34.02	4.79***	2.98	19.74	4.01***	3.97	12.63
$\Delta(i_{t,1}^\star - i_{t,1})$	0.96	0.65	2.20	0.27	0.41	0.08	−0.03	−0.28	−0.00
$\Delta(i_{t,60}^\star - i_{t,60})$	1.15**	2.30	2.26	1.48**	2.16	2.26	0.60**	2.17	1.00

Panel B: Risk Reversals

	monthly			weekly			daily		
	b	t_b	R^2	b	t_b	R^2	b	t_b	R^2
$\Delta C_t^\star$	2.85***	3.22	29.74	1.25***	5.24	14.60	1.11***	3.27	6.67
$\Delta(C_t^\star - C_t)$	3.10***	3.31	30.23	1.22***	5.09	13.91	1.01***	3.25	6.07
$\Delta(i_{t,1}^\star - i_{t,1})$	0.31	0.66	1.33	0.08	0.55	0.07	−0.02	−0.99	0.01
$\Delta(i_{t,60}^\star - i_{t,60})$	0.40	1.35	1.55	0.30*	1.73	0.96	0.12**	2.12	0.28

Panel C: Butterfly Spreads

	monthly			weekly			daily		
	b	t_b	R^2	b	t_b	R^2	b	t_b	R^2
$\Delta C_t^\star$	0.26***	3.00	22.93	0.07***	3.13	3.84	0.06***	5.26	1.06
$\Delta(C_t^\star - C_t)$	0.28***	2.85	21.79	0.07***	2.96	3.54	0.06***	5.04	0.98
$\Delta(i_{t,1}^\star - i_{t,1})$	0.05	1.05	3.84	0.01	0.48	0.02	0.00	0.00	−0.00
$\Delta(i_{t,60}^\star - i_{t,60})$	0.03	1.49	0.99	0.01	1.28	0.08	0.01***	1.97	0.03

Table V: Bilateral exchange rates and global sovereign risk

On the left side this table reports results for regressions of bilateral exchange rate changes (all against the USD as base currency) on changes in the global CDS spread (an equally-weighted average of all other countries' CDS spreads). The right side of the panel shows results for regressions of exchange rate changes on global as well as local CDS spread changes (where local CDS spread changes are obtained by orthogonalizing a countries' CDS spread changes with respect to global CDS spread changes). We report estimates of the slope coefficients (b) and R^2 from regressions conducted on a daily, weekly, and monthly data frequency. Standard errors for individual country estimates are based on Newey and West (1987) with Andrews (1991) lag selection. The last row reports results for a pooled regression for comparison where we employ clustered (by currency and time) standard errors. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample period is monthly from January 2003 to November 2013.

	Global shocks		Local and global shocks			
	b	R^2	b_{loc}	b_{glob}	R^2	R^2_{loc}
AUD	−12.33***	40.45	−1.08	−12.33***	39.75	−1.19
BRL	−11.95***	29.32	−6.06***	−11.95***	38.38	8.50
CAD	−10.64***	49.36	−4.24	−10.64***	49.32	−0.59
CHF	−8.84***	25.94	−2.37	−8.84***	24.82	−1.58
CLP	−9.91***	26.45	−7.35*	−9.91***	28.77	2.07
COP	−12.59***	28.48	−13.03***	−12.59***	40.68	8.13
CZK	−7.00***	14.82	−7.02***	−7.00***	20.82	5.84
GBP	−6.77***	26.78	−7.53**	−6.77***	30.20	3.07
HUF	−23.21***	41.44	−5.26***	−23.21***	63.78	19.15
IDR	−10.90***	39.15	−3.26***	−10.90***	50.24	10.50
ILS	−5.54***	17.03	−2.34	−5.54***	17.44	0.26
JPY	0.89	−0.25	−1.51	0.89	−0.79	−0.53
KRW	−13.69***	43.05	−6.36***	−13.69***	47.64	3.89
MXN	−9.27***	40.05	−6.89***	−9.27***	49.53	9.09
NOK	−9.36***	29.83	−7.41	−9.36***	29.71	−0.37
NZD	−11.57***	29.72	6.20	−11.57***	30.41	0.20
PLN	−12.65***	35.03	−8.21***	−12.65***	44.52	9.14
SEK	−8.92***	31.69	−10.10***	−8.92***	36.64	4.64
SGD	−5.10***	34.56	−0.97	−5.10***	33.88	−1.08
TRY	−14.64***	62.86	−4.07**	−14.64***	65.24	1.42
pooled	−8.94***	27.39	−4.36***	−8.94***	32.70	5.29

Table VI: Global sovereign risk and the VIX

The table reports results for pooled regressions of exchange rate changes on changes in the VIX, changes in global CDS spreads, and local CDS spreads. In the regression specifications (i) - (v), we orthogonalize global and local CDS spread changes with respect to VIX changes (and orthogonalize local CDS spread changes with respect to global CDS spread changes if both are included jointly). In specification (vi) we orthogonalize VIX changes with respect to CDS spread changes. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively, based on clustered standard errors (clustered by currency and time). The sample period is monthly from January 2003 to November 2013.

	Local CDS		Global CDS		VIX		
	b_{loc}	t_b	b_{glob}	t_b	b_{vix}	t_b	R^2
Panel A. VIX changes as global shocks							
(i)					-0.07^{***}	-4.46	13.78
(ii)	-6.30^{***}	-8.66			-0.07^{***}	-5.69	30.26
Panel B. VIX changes and global CDS shocks							
(iii)			-7.71^{***}	-6.45	-0.07^{***}	-5.46	28.78
(iv)	-4.25^{***}	-5.44	-7.71^{***}	-7.71	-0.07^{***}	-5.91	33.82
Panel C. Incremental information exclusively in CDS shocks or VIX changes							
(v)	-4.25^{***}	-5.04	-7.71^{***}	-5.71			20.01
(vi)					-0.02	-1.57	1.38

Table VII: Sovereign risk portfolios

This table reports excess returns for rank portfolios based on (lagged) rolling CDS exposures (exposure of country CDS changes to global CDS changes) in Panel A and for rank portfolios based on (lagged) CDS spread levels in Panel B. We report results for currency portfolios investing in forwards (RX), straddles (STD), 25δ risk reversals (RR_{25}), and 25δ butterfly spreads (BF_{25}). For each portfolio, we report annualized mean returns, t-statistics, and annualized Sharpe Ratios (SR). t-statistics are based on standard errors following Newey and West (1987) and Andrews (1991). The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample period runs from January 2004 to November 2013.

	RX	STD	RR25	BF25
Panel A: Portfolios based on rolling CDS exposures				
Mean	7.46***	3.85***	5.28***	−0.12
t	[3.21]	[2.38]	[3.64]	[−0.17]
SR	1.12	0.85	1.43	−0.07
Panel B: Portfolios based on CDS spread levels				
Mean	9.05***	4.32**	7.08***	0.24
t	[3.79]	[2.17]	[4.08]	[0.36]
SR	1.35	0.85	1.67	0.13
Correlation	0.91	0.90	0.88	0.92

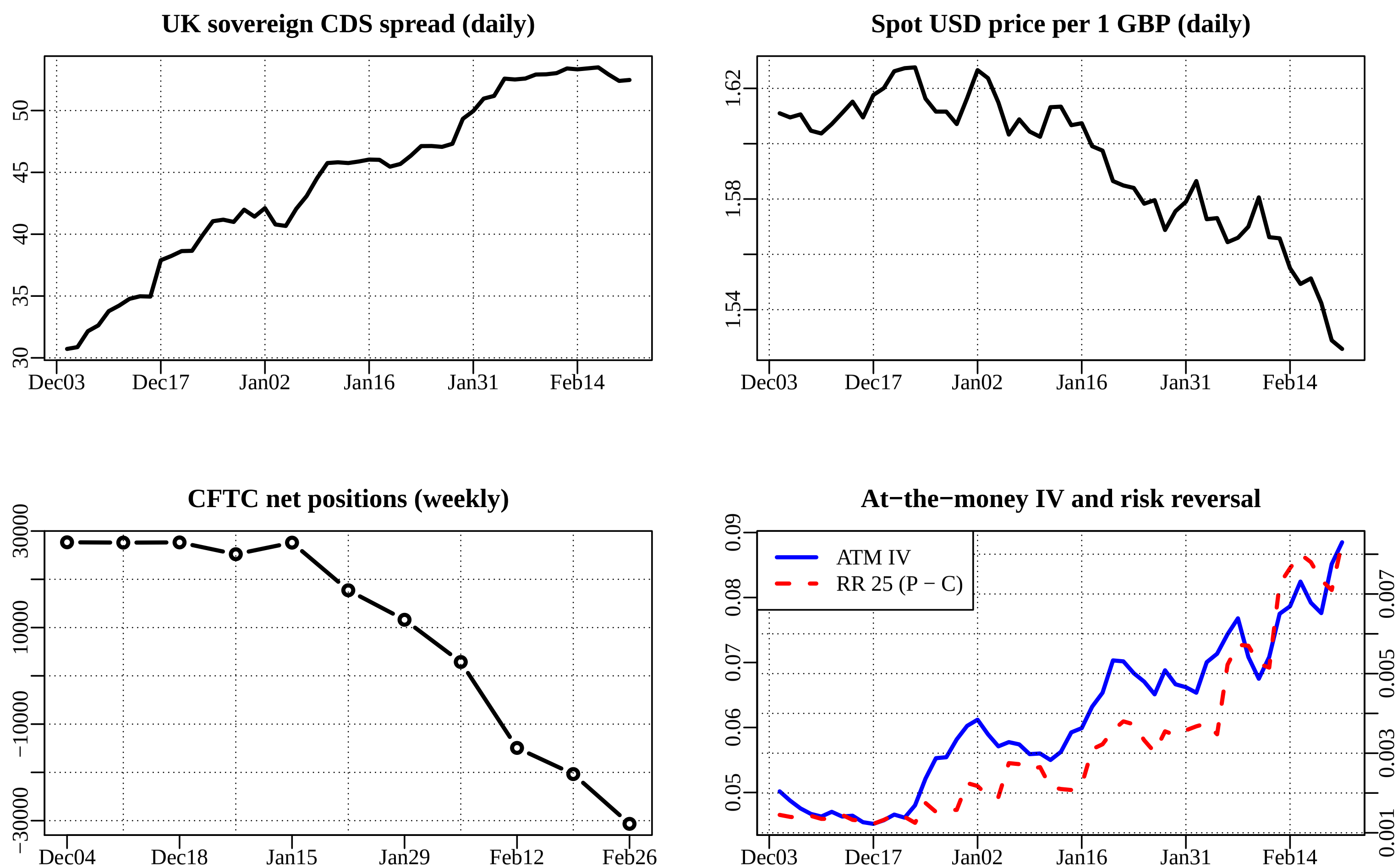
Table VIII: Sovereign risk, carry, and momentum

This table reports currency excess returns for two-by-two sequential portfolio sorts that condition on sovereign risk in the first step and on carry (Panel A) or momentum (Panel B) in the second step. Portfolios are updated every month; within portfolios all currencies are equally-weighted. We report annualized average excess returns, along with t-statistics based on standard errors following Newey and West (1987) and Andrews (1991), and Sharpe Ratios (SR). Rows labeled by "HML Carry" ("HML Momentum") present results of buying high and selling low carry (momentum) currencies among high CDS and low CDS countries. Likewise, "HML CDS" reports results of buying high and selling low CDS currencies among high and low carry (momentum) countries in Panel A (Panel B). The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample period is monthly from January 2003 to November 2013.

Panel A: CDS spreads and carry				
		High CDS	Low CDS	HML CDS
High Carry	Mean	13.00***	2.47	10.53***
	t	[2.70]	[0.59]	[3.23]
	SR	1.09	0.22	1.28
Low Carry	Mean	3.37	0.14	3.23*
	t	[0.95]	[0.05]	[1.93]
	SR	0.35	0.02	0.53
HML Carry	Mean	9.63***	2.32	
	t	[2.89]	[0.92]	
	SR	1.09	0.34	

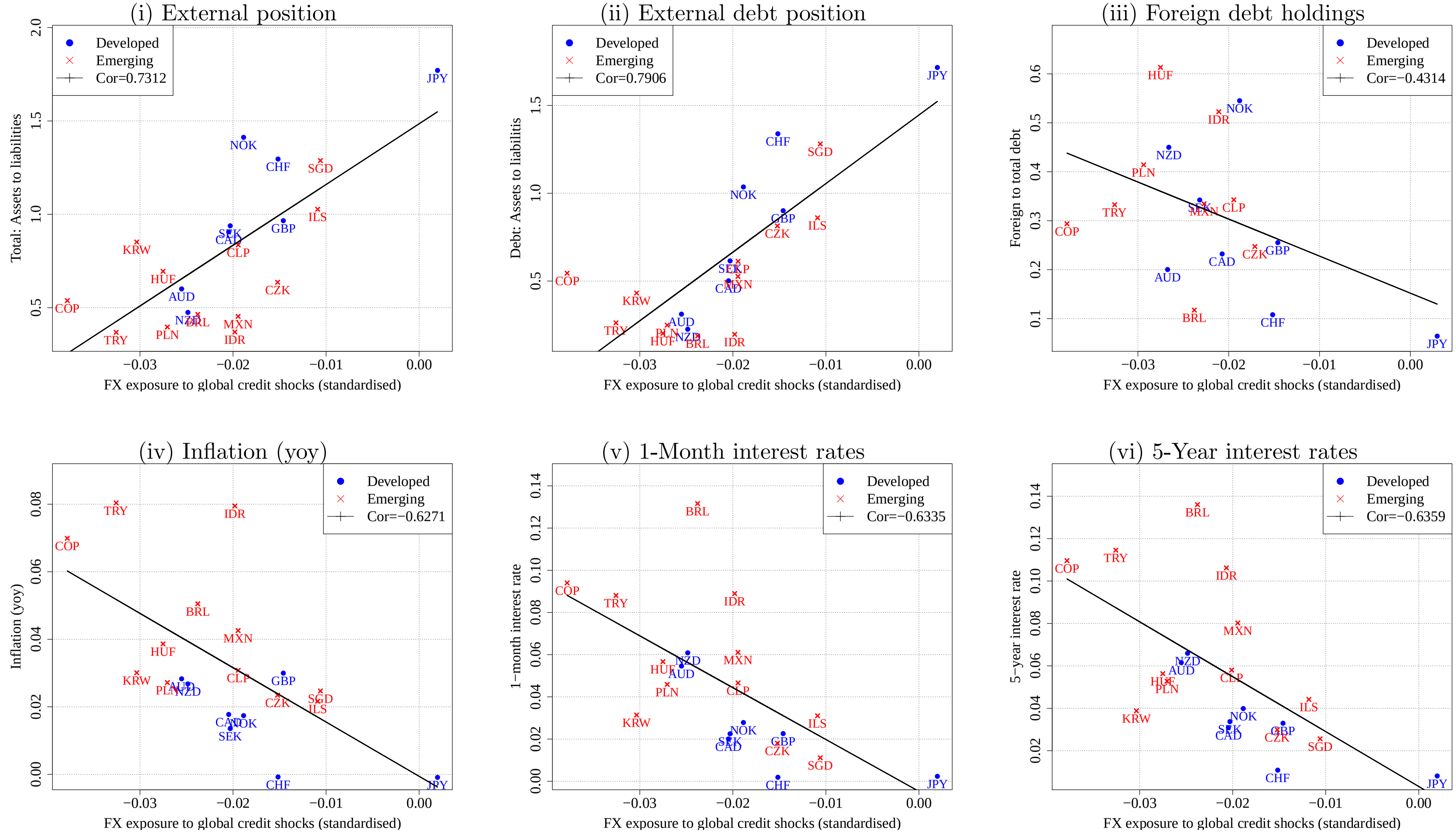
Panel B: CDS spreads and momentum				
		High CDS	Low CDS	HML CDS
High Mom	Mean	12.58***	1.86	10.73***
	t	[2.78]	[0.69]	[3.12]
	SR	1.18	0.21	1.31
Low Mom	Mean	3.78	0.78	3.00*
	t	[1.04]	[0.20]	[1.75]
	SR	0.36	0.08	0.51
HML Mom	Mean	8.80***	1.07	
	t	[3.10]	[0.48]	
	SR	1.10	0.18	

Figure 1: Sovereign CDS spreads and foreign exchange markets around the UK downgrade in February 2013



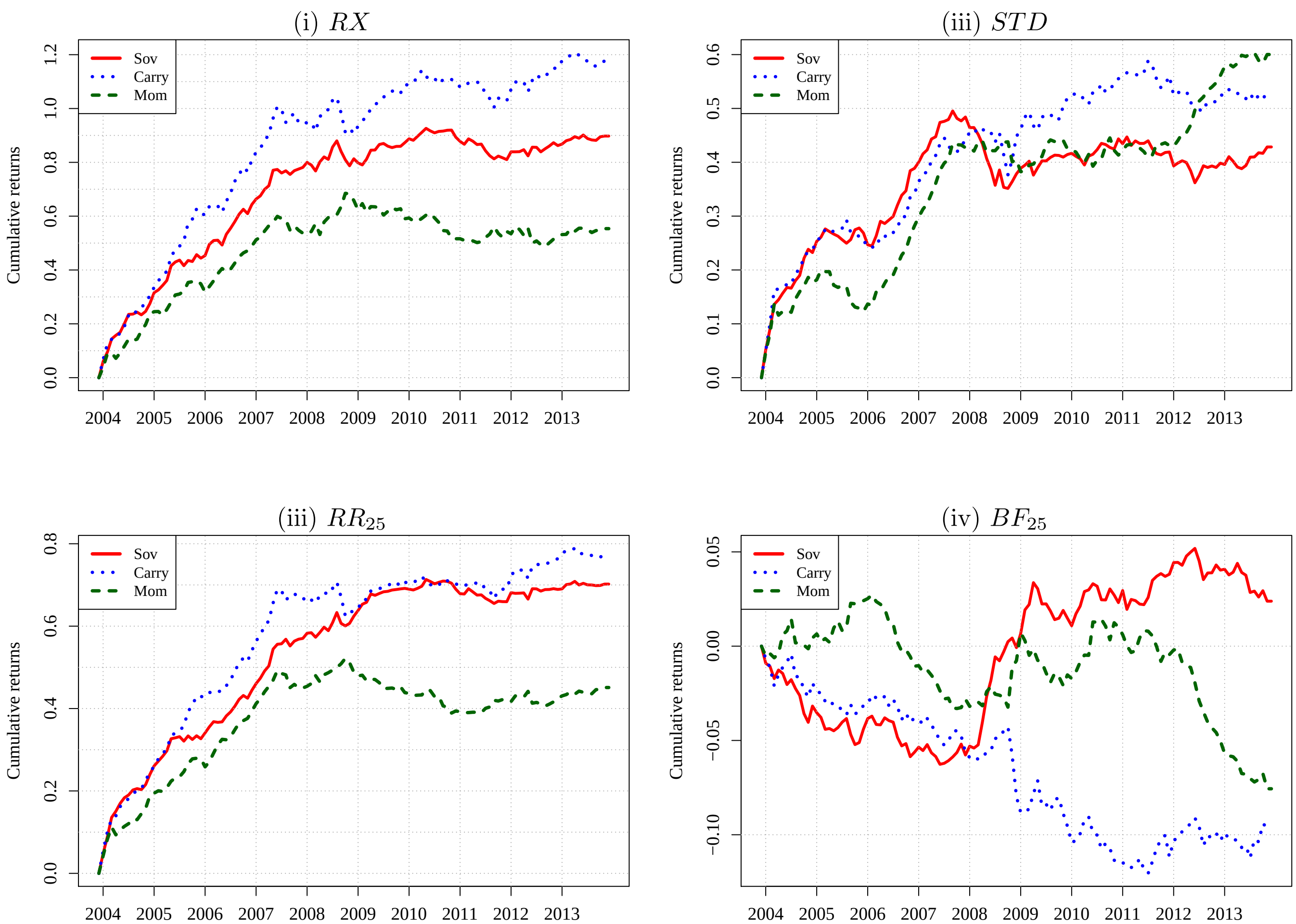
This figure summarizes data on sovereign CDS spreads and currency markets for the three months prior to the UK sovereign credit rating downgrade on 22 February 2013. The top panel plots the evolution of the 5-year UK sovereign CDS spread (left) and the USD/GBP spot exchange rate (right, quoted as USD price per one GBP). The lower left panel presents the net positions (long minus short) taken by non-commercial traders in USD/GBP currency futures and options markets as reported by the US Commodity Futures Trading Commission (CFTC) on a weekly basis. The lower right panel plots the at-the-money (ATM) implied volatility (IV) of USD/GBP options (solid line in blue, left y-axis) and the difference between 25δ out-of-the-money IVs for put and call options, i.e., the negative of the 25δ risk reversal (dashed line in red, right y-axis).

Figure 2: FX exposures to global default risk shocks



This figure plots the slope coefficient from regressing exchange rate changes on global CDS spread changes against the average (i) ratio between foreign assets and liabilities, (ii) ratio between foreign debt assets and liabilities, (iii) ratio between foreign holdings of the government debt and total holdings of government debt, (iv) inflation rate, and foreign interest rates with maturities of one month (v) and 5 years (vi). The sample runs from 2003 to 2013 (depending on data availability). Blue bullets and red crosses indicated developed and emerging markets, respectively.

Figure 3: Cumulative excess returns



This figure shows cumulative portfolio excess returns of rank-weighted portfolios sorted by sovereign CDS spreads ("Sov"), forward discounts ("Carry"), and past currency returns ("Mom"). We evaluate the returns on trading in forwards (RX), straddles (STD), (risk reversals (RR_{25}), and butterfly spreads (BF_{25}). Portfolios are rebalanced monthly and the sample period is from January 2004 to November 2013.

Internet Appendix for

Exchange Rates and Sovereign Risk

(not for publication)

IA.A. Higher FX moment regressions for individual countries

We repeat the empirical analysis from Section IV.B on the individual country level by regressing changes in option-implied higher FX moments on sovereign CDS spread changes. The results reported in Tables IA.3 to IA.5 confirm the pooled regression evidence that increases in sovereign risk are associated with increases in the volatility, skewness, and kurtosis of exchange rate changes.

IA.B. Transaction costs

We show that our results for excess returns to sovereign risk portfolios are robust to accounting for transaction costs. We obtain data on quoted bid-ask spreads, which are typically much higher than effective spreads due to the fact that dealers usually quote conservative numbers and since actual trades take place at the lowest quoted spread and not at the average. Gilmore and Hayashi (2011) show that actual spreads in FX markets are of the order of 25% of quoted spreads. To be conservative, we use 50% of the quoted spread in the computation of excess returns and present portfolio returns net of bid ask spreads in Table IA.6.[22] The average return to buying high and selling low sovereign risk currencies (RX) is 6.10% per annum with a Sharpe ratio of 0.88. In general, the results exhibit patterns similar to those in Table VII in the main text. A notable difference is that straddle returns become statistically insignificant but remain positive and generate a reasonably high Sharpe Ratio (0.58) such that the performance still seems economically

[22] We adjust long and short positions separately for transaction costs. For long positions, we go long at the ask and sell the position after one month at the bid; for short positions, we go short at the bid and close the position at the ask after one month (see, e.g. Lustig et al., 2011). Bid and ask prices for options are computed from bid and ask option IVs.

significant.

IA.C. Volatility risk premia

To provide further evidence that higher FX moments are related to sovereign risk, we compute volatility risk premia generated by currency volatility swaps.[23] A long position in a volatility swap contract pays out the difference between the volatility realized over the contract's maturity (floating leg) and the ex-ante implied volatility (fixed leg); see, e.g. Carr and Wu (2009). The fixed leg of a one-month contract (SV_t^1) is given by the risk-neutral expectation of future realized volatility and can be computed model-free based on a portfolio of OTM put and OTM call options.[24] Realized volatility ($RV_{t,t+1}$) is computed from daily log exchange rate changes during time t and $t+1$. The excess return from trading a volatility swap is given by

$$rx_{t,t+1}^{VS} = \frac{RV_{t,t+1} - SV_t^1}{RV_t^1}, \tag{IA.C.1}$$

showing that it depends on the extent to which the exchange rate path exhibits volatility.[25]

In line with the other derivative strategies, we compute the returns of selling volatility insurance by forming currency portfolios on the basis of CDS spreads.[26] Table IA.7, shows

[23]Academic research on risk premia associated with the second moment of returns typically focuses on variance swaps. In currency markets, however, there is an active market for volatility swaps whereas the market for variance swaps is far less liquid. Both, conceptually as well as empirically, it makes no difference whether we use the former or the latter.

[24]The fixed leg equals the risk-neutral expectation of the return volatility, $SV_t^1 = E_t^{\mathbb{Q}}\left[RV_{t,t+1}\right]$, and can be computed from prices of OTM options that expire at $t+1$ as shown, e.g., in Britten-Jones and Neuberger (2000) and Jiang and Tian (2005). We use a cubic spline around the available IV points to obtain a smooth IV smile between the maximum and minimum available strikes, beyond which we extrapolate implied volatility by assuming it is constant (this procedure follows Jiang and Tian, 2005; Carr and Wu, 2009). We then compute the option values using the Garman and Kohlhagen (1983) valuation formula and use trapezoidal integration.

[25]The properties of the volatility swap are therefore different from those of the straddle. The straddle is viewed as a volatility trade as it provides a non-directional symmetric payoff that depends on the exchange rate having moved significantly up or down until expiry, but it does not depend on the volatility of the exchange rate path itself.

[26]Volatility risk premia generally have standard deviations exceeding unity. To make the returns of this strategy comparable to those of the other currency investments discussed in the paper, we scale the excess returns of volatility swaps by their lagged rolling standard deviation. Our scaling procedure is inspired by Moskowitz et al. (2012) and does not change the quality of results compared to using unscaled returns because, essentially, we only allow for a deleveraging of the strategy.

that the sovereign risk portfolios capture significant volatility risk premia amounting to 9.72% per year. This finding suggests that sovereign CDS spreads contain information relevant for FX volatility risk premia.

IA.D. The factor structure of CDS-sorted portfolio returns

As noted in the discussion of Figure 3, we find that returns to rank portfolios trading on the four moments of exchange rates are less than perfectly correlated. We report correlation coefficients of all four portfolios' excess returns in Panel A of Table IA.8. As expected, there is a high correlation between RX and RR_{25} but the other portfolio returns have a low or even negative correlation (e.g., STD and RR_{25}). Panel B reports results of a principal components analysis which shows that the first principal component only explains about one half of the overall variance. Hence, there are significant gains from diversification across moments of the exchange rate distribution.

IA.E. Changing the base currency

The majority of sovereign CDS contracts is denominated in USD. For the 20 foreign countries covered in our sample, the Markit database coverage of 5-year CDS contracts with restructuring clause CR up to November 2013 (with different starting dates) comprises 52,213 daily observations. For the other sample currencies, we find the second highest coverage when using the JPY as base currency with 24,524 daily observations for Japan and 11 foreign countries. We use this data to repeat the empirical analysis on the contemporaneous link between sovereign risk and exchange rate changes as well as higher moments of the FX distribution from the perspective of a JPY investor.

Using JPY exchange rates and foreign country CDS spreads, we find that our results do not depend on the choice of base currency. The results in Table IA.9 show that an increase in sovereign risk is associated with currencies depreciation, higher FX volatility, and more expensive crash risk insurance. At the monthly frequency, the estimated slope coefficients are highly significant and the associated R^2s are sizeable with values of 33%, 23%, and 16% for exchange rate changes and changes in ATM IV and skewness, respectively. The results are less pronounced or not significant for the butterfly spread and higher frequencies, with the comparably less liquid market for JPY-denominated CDS contracts being a potential reason for the latter finding.

IA.F. Predictive regressions: Further results

Our results in Section IV establish a strong contemporaneous link between CDS spread innovations and exchange rate returns and our findings in Section V show that sovereign CDS spreads *predict* exchange rate changes. This Section provides evidence that CDS spread innovations Granger-cause exchange rate changes whereas there is no evidence that exchange rate changes forecast changes in CDS spreads. Below, we present results for predictive regressions and vector autoregressive models (VARs) for exchange rate changes and CDS spread changes estimated on daily data.

The upper two panels of Figure IA.1 directly show the cumulative change in the exchange rate as predicted by lagged changes in the CDS spread and the predicted change in the CDS spread due to lagged changes in exchange rate changes. More specifically, we run (pooled) predictive regressions of the form

$$\Delta x_{i,t+1;t+k} = \alpha_k + \beta_{1,k}\Delta C^{\star}_{i,t} + \beta_{2,k}\Delta C^{\star}_{i,t-1} + \gamma_{1,k}\Delta s_{i,t} + \gamma_{2,k}\Delta s_{i,t-1} + \varepsilon_{i,t+k},$$

where $\Delta x_{i,t;t+k}$ is either the cumulative CDS spread change or currency return from $t+1$ to $t+k$ and where we let k range from 1 to 15 trading days. Confidence intervals (95%) are based on a block bootstrap with blocks of 20 trading days (roughly one month). The left panel of Figure IA.1 shows that changes in CDS spreads forecast currency returns up to one week (5 trading days) which is in line with our evidence for speculator positions above. The right panel shows that an appreciation of the foreign currency has not immediate forecast power for CDS spread changes but that sovereign risk eventually declines somewhat after about two weeks. Overall, this finding suggests that sovereign risk Granger-causes exchange rates in a way that is consistent with our finding for quantities above.

Finally, We also run the same experiment with a conventional (pooled) VAR (2 lags) and cumulative impulse-response functions are shown in the two lower panel of Figure IA.1 and corroborate our findings based on predictive regressions discussed above. A 100 basis point rise in CDS spread changes forecasts a cumulative change in the exchange rate of about -1.25% whereas we find basically no evidence of sovereign risk predictability by means of lagged exchange rate changes.

Table IA.1: Sovereign risk and net speculator positions

This table reports results for pooled regressions of changes in net speculator positions p (net position of non-commercial traders scaled by open interest from the CME's commitment of traders) on changes in CDS spread changes ($\Delta C_t^{\star}$) and exchange rates (Δs)

$$\Delta p_{t+k} = \alpha_k + \beta_k \Delta C_t^{\star} + \gamma_{1,k} \Delta s_t + \gamma_{2,k} \Delta s_{t-1} + \varepsilon_{t+k}.$$

The sample of currencies is AUD, CAD, CHF, GBP, JPY, MXN, and NZD (all against USD). We report results for contemporaneous regressions ($k = 0$) and for predictive regressions where we lag the CDS spread change relative to the change in the net speculator position by one to four weeks. Numbers in brackets are t-statistics based on Newey and West (1987) and Andrews (1991). The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample is weekly from January 2004 to November 2013.

	Forecast horizon				
	0	1	2	3	4
β_k	-9.33^{***}	-9.71^{***}	-0.94	3.01	-1.63
	[-2.72]	[-4.25]	[-0.49]	[1.59]	[-0.84]
$\gamma_{1,k}$	0.83^{***}	0.44^{***}	-0.05	-0.13	-0.25^{**}
	[6.08]	[4.39]	[-0.46]	[-1.45]	[-2.29]
$\gamma_{2,k}$	0.03	-0.07^{***}	-0.07^{***}	-0.06^{**}	-0.05^{**}
	[0.99]	[-2.77]	[-2.81]	[-2.36]	[-2.13]
R^2%	3.18	1.50	0.38	0.47	0.53

Table IA.2: Sovereign risk and the Euro

This table reports estimates of the slope coefficients (b), t-statistics (t_b) based on Newey and West (1987) and Andrews (1991), and R^2 for regressions of USD/EUR exchange rate changes (Panel A), changes in the 1-month implied volatility of delta-neutral straddles (Panel B), 25δ risk reversals (Panel C), and 25δ butterfly spreads (Panel D) on changes in a Eurozone sovereign risk index (itraxx Western Europe SovX). The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. We report results for the daily, weekly, and monthly frequency from January 2003 to November 2013.

Panel A. Spot Returns

	monthly			weekly			daily		
	b	t_b	R^2	b	t_b	R^2	b	t_b	R^2
$\Delta C_t^\star$	-6.77^{***}	-4.41	18.02	-3.35^{***}	-3.47	7.11	-3.20^{***}	-4.31	5.16
$\Delta(C_t^\star - C_t)$	-6.66^{***}	-3.93	16.93	-2.88^{***}	-2.97	5.12	-2.60^{***}	-4.42	4.08

Panel B. Delta-neutral Straddles

	monthly			weekly			daily		
	b	t_b	R^2	b	t_b	R^2	b	t_b	R^2
$\Delta C_t^\star$	3.44^{***}	6.08	12.35	2.48^{***}	3.12	8.25	2.33^{***}	4.55	5.95
$\Delta(C_t^\star - C_t)$	3.41^{***}	6.12	11.03	2.30^{***}	2.88	6.36	1.80^{***}	4.03	4.01

Panel C. Risk Reversals

	monthly			weekly			daily		
	b	t_b	R^2	b	t_b	R^2	b	t_b	R^2
$\Delta C_t^\star$	0.77^{***}	3.43	8.57	0.90^{***}	3.57	11.02	0.65^{***}	5.15	5.47
$\Delta(C_t^\star - C_t)$	0.89^{***}	3.32	10.97	0.81^{***}	3.24	8.09	0.50^{***}	4.62	3.80

Panel D. Butterfly Spreads

	monthly			weekly			daily		
	b	t_b	R^2	b	t_b	R^2	b	t_b	R^2
$\Delta C_t^\star$	0.11^{**}	2.37	9.63	0.06^{**}	2.50	5.73	0.03^{**}	2.31	1.07
$\Delta(C_t^\star - C_t)$	0.11^{**}	2.36	8.18	0.05^{**}	2.12	3.30	0.02^{*}	1.71	0.54

Table IA.3: CDS spread changes and changes in currency option IVs: Country regressions

This table reports results from regressions of changes in currency option IVs on changes in CDS spreads. The table shows estimates of the slope coefficients (b), t-statistics (in brackets) based on HAC standard errors following Newey and West (1987) and Andrews (1991), and R^2 for regressions conducted on a daily, weekly, and monthly data frequency. The sample period is monthly from January 2003 to November 2013. Standard errors for individual country estimates are based on Newey and West (1987) with Andrews (1991) lag selection. The last row reports results for a pooled regression for comparison where we employ clustered (by currency and time) standard errors. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively.

	monthly		weekly		daily	
	b	R^2	b	R^2	b	R^2
AUD	7.55	5.08	7.97*	7.23	7.18***	4.49
BRL	4.44**	15.18	9.54***	57.94	7.48***	32.31
CAD	10.41***	7.30	4.78***	1.71	2.32***	0.51
CHF	4.93**	7.93	5.17*	8.30	2.28**	1.56
CLP	12.06***	50.08	3.63***	10.12	4.59***	9.76
COP	8.62***	34.74	0.43	−0.59	0.65	1.21
CZK	9.23***	57.44	4.30***	16.72	4.38***	11.40
GBP	5.80***	8.20	5.62**	8.75	6.01***	8.07
HUF	2.57*	32.33	2.23***	25.72	1.94***	21.34
IDR	9.58***	61.71	1.81***	9.00	1.98	8.36
ILS	1.53*	5.47	1.28**	3.58	1.32***	2.89
JPY	2.34	0.64	10.16**	13.39	6.68***	5.55
KRW	8.87***	44.02	4.38***	23.02	6.19***	24.99
MXN	6.12**	32.70	12.86***	48.20	10.17***	39.62
NOK	13.64	6.76	9.52	4.11	3.54	0.72
NZD	6.81	9.39	4.43	3.14	3.50***	2.21
PLN	7.42***	42.27	6.16***	32.99	4.11***	12.41
SEK	6.68**	9.07	3.15	2.24	4.47***	2.63
SGD	5.65	11.71	2.48	1.44	2.16*	1.36
TRY	6.18***	44.87	4.69***	65.06	4.25***	35.92
pooled	7.18***	32.34	4.78***	20.61	4.35***	14.14

Table IA.4: CDS spread changes and changes in risk reversal IVs: Country regressions

This table reports results from regressions of changes in risk reversal IVs ($\Delta = 25$) on changes in CDS spreads. The table shows estimates of the slope coefficients (b), t-statistics (in brackets), and R^2 for regressions conducted on a daily, weekly, and monthly data frequency. The sample period is monthly from January 2003 to November 2013. Standard errors for individual country estimates are based on Newey and West (1987) with Andrews (1991) lag selection. The last row reports results for a pooled regression for comparison where we employ clustered (by currency and time) standard errors. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively.

	monthly		weekly		daily	
	b	R^2	b	R^2	b	R^2
AUD	0.63	−0.66	1.89	5.74	2.03***	4.33
BRL	2.37*	15.50	2.30***	36.10	1.71***	17.64
CAD	3.20**	8.45	1.42***	1.63	0.66***	0.50
CHF	1.04	2.07	1.40**	5.32	0.31	0.22
CLP	4.16***	33.30	0.47	1.00	0.77*	1.52
COP	2.27***	33.02	−0.16	−0.08	0.05	−0.31
CZK	1.84***	26.86	1.35***	12.97	1.06***	5.84
GBP	1.92***	13.01	1.93***	15.69	1.63***	10.09
HUF	0.89**	45.37	0.86***	28.52	0.55***	13.56
IDR	4.43***	54.65	0.81***	12.55	0.40	1.93
ILS	0.81***	18.47	0.54***	7.41	0.33***	1.77
JPY	−0.11	−0.76	−2.79**	6.52	−1.80***	3.16
KRW	3.62***	38.32	2.44***	26.02	3.38***	19.39
MXN	3.09**	28.47	1.82***	30.77	1.59***	15.88
NOK	4.53***	12.21	3.01*	3.97	1.49***	1.42
NZD	0.85	0.16	1.86**	8.32	1.16**	2.76
PLN	2.39***	35.89	1.61***	18.43	1.22***	7.54
SEK	1.16***	4.15	1.94***	8.52	1.56***	3.33
SGD	2.07	10.25	1.38	3.03	0.31	0.11
TRY	2.41***	60.25	0.99***	37.65	1.09***	26.41
pooled	2.85***	29.74	1.25***	14.60	1.11***	6.67

Table IA.5: CDS spread changes and changes in butterfly spread IVs: Country regressions

This table reports results from regressions of changes in butterfly spread IVs ($\Delta = 25$) on changes in CDS spreads. The table shows estimates of the slope coefficients (b), t-statistics (in brackets), and R^2 for regressions conducted on a daily, weekly, and monthly data frequency. The sample period is monthly from January 2003 to November 2013. Standard errors for individual country estimates are based on Newey and West (1987) with Andrews (1991) lag selection. The last row reports results for a pooled regression for comparison where we employ clustered (by currency and time) standard errors. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively.

	monthly		weekly		daily	
	b	R^2	b	R^2	b	R^2
AUD	0.15	2.16	0.26*	10.51	0.15**	2.56
BRL	0.22	7.30	0.09***	3.41	0.08***	0.93
CAD	0.26*	3.74	0.07	0.14	0.04	0.05
CHF	0.04	−1.49	0.11**	4.36	0.01	−0.04
CLP	0.32**	16.28	0.01	−0.19	0.12*	1.08
COP	0.19*	47.80	−0.02**	0.92	0.02	0.76
CZK	0.25***	17.60	0.05	0.74	0.01	−0.02
GBP	0.35**	17.11	0.11	4.93	0.05**	0.98
HUF	0.02***	7.76	0.02**	−0.33	−0.01	−0.21
IDR	0.37***	47.60	0.09***	16.30	0.06**	3.40
ILS	0.03	0.14	−0.03	0.18	0.01	−0.03
JPY	0.05	−0.33	0.27*	7.58	0.22**	4.83
KRW	0.43***	48.41	0.09***	4.51	0.14***	4.58
MXN	0.32***	35.79	0.06***	5.61	0.08***	3.58
NOK	0.75**	17.25	0.20	1.74	0.05*	0.07
NZD	0.13	2.52	0.18	7.46	0.06**	0.95
PLN	0.21*	22.39	0.02	0.03	0.03	0.10
SEK	0.30*	16.10	0.13*	4.34	0.07**	0.01
SGD	0.16	3.79	0.28	7.82	0.02	−0.02
TRY	0.17***	28.73	0.04	3.75	0.03***	1.03
pooled	0.26***	22.93	0.07***	3.84	0.06***	1.06

Table IA.6: Sovereign risk portfolios: Transaction costs

This table is similar to Table VII but here we report average annualized returns, t-statistics, and Sharpe Ratios for returns after adjusting for transaction costs. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample period is January 2004 to November 2013.

	RX	STD	RR_{25}	BF_{25}
Mean	6.71^{**}	2.41	5.74^{***}	-1.69^{**}
t	[2.56]	[1.23]	[2.60]	[−2.05]
SR	1.01	0.45	1.28	−0.83

Table IA.7: Sovereign risk and FX volatility risk premia

This table reports annualized volatility risk premia from a rank-weighted portfolio based on sovereign CDS spreads. t-statistics are based on standard errors following Newey and West (1987) with Andrews (1991) lag selection. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. Std denotes the standard deviation of volatility risk premia. The sample period is monthly from January 2004 to November 2013.

Panel A. CDS spread portfolio			Panel B. Carry rank portfolio	
Mean	9.72***		Mean	4.48
t	[2.84]		t	[1.33]
Std	8.47		Std	8.30

Table IA.8: Return factor structure

This table reports return correlations (Panel A) for currency portfolios based on CDS spreads where we consider investing in forwards (RX), straddles (STD), $\Delta 25$ risk reversals (RR_{25}), and $\Delta 25$ butterfly spreads (BF_{25}). Panel B shows results for a principal components analysis where the last row reports the cumulative R^2. The sample period is monthly from January 2004 to November 2013.

Panel A. Return correlations				
	RX	STD	RR_{25}	BF_{25}
RX	1.000	-0.117	0.850	0.022
STD	-0.117	1.000	-0.297	-0.747
RR_{25}	0.850	-0.297	1.000	0.069
BF_{25}	0.022	-0.747	0.069	1.000

Panel B. Principal components				
	1	2	3	4
RX	0.521	-0.481	0.388	0.588
STD	-0.492	-0.497	0.610	-0.373
RR_{25}	0.577	-0.398	-0.265	-0.662
BF_{25}	0.392	0.602	0.639	-0.276
Cum %	0.517	0.905	0.973	1.000

Table IA.9: Using the JPY as base currency

This table reports estimates of the slope coefficients (b), t-statistics (t_b), and R^2 for regressions of JPY exchange rate changes (Panel A), changes in ATM IV (Panel B), changes in $\Delta 25$ risk reversals (Panel C), and changes in $\Delta 25$ butterfly spreads (Panel D) on changes in foreign sovereign CDS spreads (ΔC_t^*) and changes in differentials of foreign minus Japanese CDS spreads ($\Delta(C_t^* - C_t)$). We report results for the daily, weekly, and monthly frequency. Standard errors for individual country estimates are based on Newey and West (1987) with Andrews (1991) lag selection. The last row reports results for a pooled regression for comparison where we employ clustered (by currency and time) standard errors. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively.

Panel A. Spot Returns

	monthly			weekly			daily		
	b	t_b	R^2	b	t_b	R^2	b	t_b	R^2
ΔC_t^*	-7.98^{***}	-6.60	33.37	-8.12^{***}	-3.04	18.08	-4.51	-1.07	1.42
$\Delta(C_t^* - C_t)$	-8.98^{***}	-6.90	32.92	-8.42^{***}	-3.33	23.88	-1.94	-0.66	0.46

Panel B. Changes in 1-Month Delta-neutral Straddles

	monthly			weekly			daily		
	b	t_b	R^2	b	t_b	R^2	b	t_b	R^2
ΔC_t^*	6.19^{***}	4.82	22.58	2.14	0.78	1.29	3.06	0.75	0.57
$\Delta(C_t^* - C_t)$	6.75^{***}	4.50	20.89	0.62	0.24	-0.12	0.42	0.11	-0.10

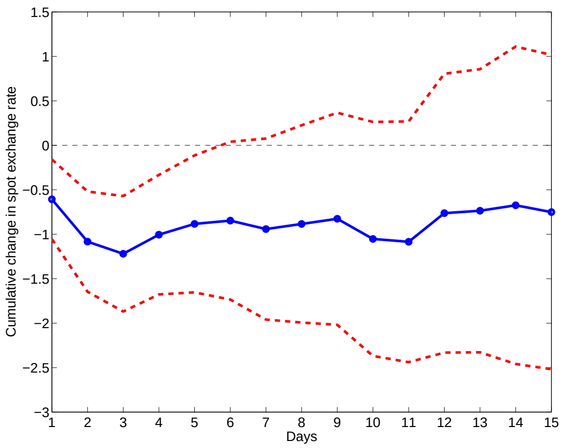
Panel C. Changes in 1-Month $\Delta 25$ Risk Reversals

	monthly			weekly			daily		
	b	t_b	R^2	b	t_b	R^2	b	t_b	R^2
ΔC_t^*	4.26^{**}	2.30	16.10	3.96^{**}	2.45	6.07	1.29	0.36	0.01
$\Delta(C_t^* - C_t)$	5.21^{***}	3.05	18.78	5.32^{***}	2.81	13.69	1.31	0.41	0.15

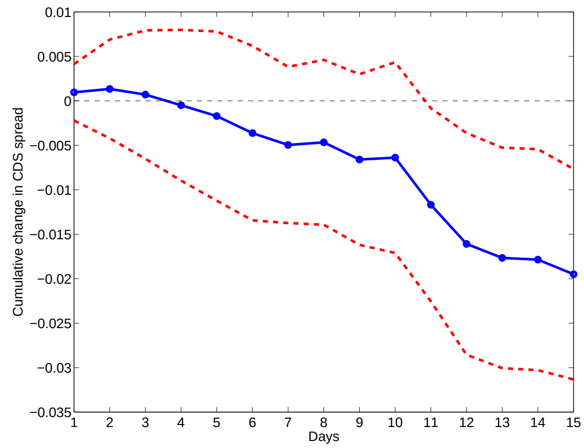
Panel D. Changes in 1-Month $\Delta 25$ Butterfly Spreads

	monthly			weekly			daily		
	b	t_b	R^2	b	t_b	R^2	b	t_b	R^2
ΔC_t^*	-0.86	-0.87	0.91	-2.83	-1.61	3.57	-0.31	-0.08	-0.12
$\Delta(C_t^* - C_t)$	-1.31^{*}	-1.77	1.72	-4.15^{**}	-2.21	9.82	-0.91	-0.27	0.01

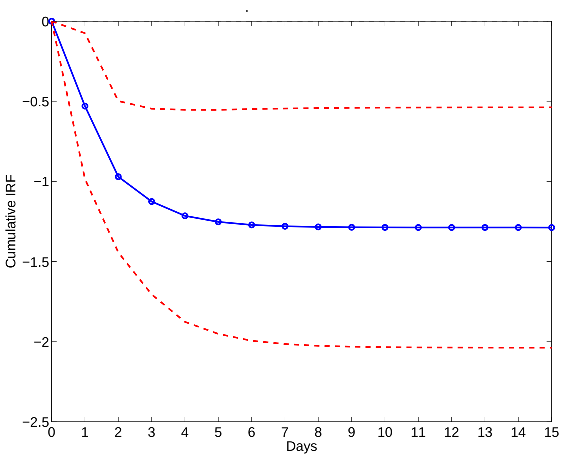
Figure IA.1: CDS changes and exchange rates in a predictive setting



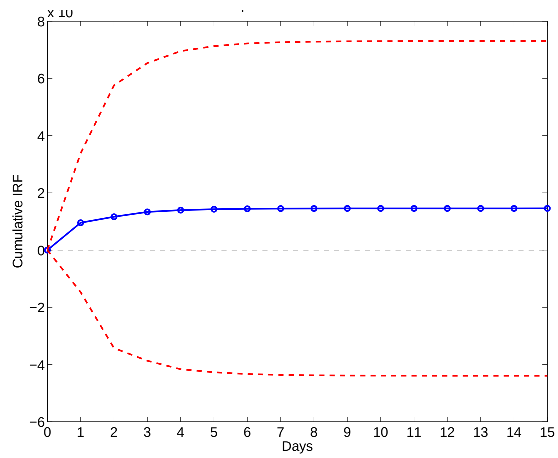
(a) Predictive regression of Δs on ΔCDS



(b) Predictive regression of ΔCDS on Δs



(c) VAR IRF: Response of Δs to ΔCDS



(d) VAR IRF: Response of ΔCDS to Δs

This figure shows responses of log exchange rate changes and CDS spread changes to lagged log exchange rate changes or CDS spread changes. Panels (a) and (b) are based on predictive regressions with cumulative log exchaneg rate changes (Panel a) or CDS spread changes (Panel b) as dependent variables and lagged log exchange rate changes and lagged CDS spread changes as predictors for forecast horizons of up to 15 days. Panels (c) and (d) are based on a pooled VAR with two lags. 95% confidence intervals are based on a block bootstrap (20 day blocks) with 5,000 repetitions.