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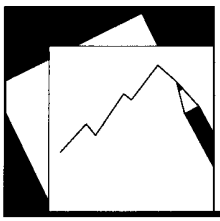

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The Behavior of Currencies during Risk-off Episodes

Reinout De Bock and Irineu de Carvalho Filho

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The Behavior of Currencies during Risk-off Episodes[1]

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Abstract

Episodes of increased global risk aversion, also known as risk-off episodes, have become more frequent and severe since 2007. During these episodes, currency markets exhibit recurrent patterns, as the Japanese yen, Swiss franc, and U.S. dollar appreciate against other G-10 and emerging market currencies. The pattern of these moves can be explained by a combination of fundamental factors, such as the nominal interest rate, the international investment position and measures of exchange rate misalignment, and market-liquidity factors, such as bid-offer spreads and restrictions on international capital flows. We also find that currency performance in a risk-off episode has become more related to a currency‟s yield and relationship to broader risks in recent years.

JEL Classification: F31

Keywords: Risk-off episodes, exchange rates, safe haven currencies

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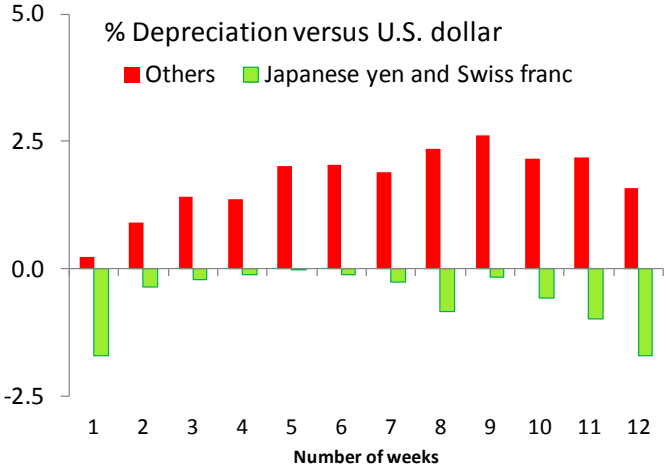
I. INTRODUCTION

What determines currency returns when investors across the world want to reduce their risk exposure at the same time? Most investors would agree that there are episodes – referred to in the financial press as risk-off episodes – when risky positions are cut across asset classes, as if there were a rise in risk aversion globally. As such, risk-off episodes undermine the benefits of diversification within and across asset classes.

In this paper, we identify risk-off episodes based on the VIX, a measure of U.S. equity market volatility that is widely-used as a proxy for global risk aversion.[2] The VIX has several desirable properties for our analysis. First, it can be measured at a high frequency and in real time, so tracking the index can help to identify the onset of risk-off episodes. Second, since the VIX is derived from options prices on the S&P 500, there is no immediate link with FX markets. Finally, risk-off episodes derived from this measure correspond to our priors about disruptive market events in the last two decades.

Using this gauge for risk-off events, we first note that currency markets exhibit recurrent patterns during risk-off episodes, as the Japanese yen, Swiss franc, and U.S. dollar (USD) tend to appreciate against other G-10 and emerging market currencies, be it 1-week or 12-weeks after the start of a risk-off episode (Figure 1).

Figure 1. FX Spot Returns at Different Horizons, Average of 8 Risk-off Episodes



Note: Others is the equally-weighted average USD return on the currencies of Argentina, Australia, Brazil, Canada, Chile, China, Colombia, Czech Republic, Denmark, Egypt, Euro area, Hungary, India, Indonesia, Israel, Republic of Korea, Malaysia, Morocco, Mexico, New Zealand, Norway, Peru, Philippines, Poland, Romania, Russian Federation, Singapore, South Africa, Sweden, Thailand, Turkey, Ukraine, United Kingdom and Venezuela. We define the start of a risk-off episode when the VIX moves 10 percentage points above its 60-day backward-looking moving average. Source: Bloomberg and authors" calculations

[2] The VIX is derived from options prices on the S&P 500 index, and informs us about volatility and risk pricing in the US equity market. The VIX is often given a broader interpretation, as it is highly correlated with broader measures of financial stress (such as the Financial Stress Index developed by the Federal Reserve Bank of St. Louis) and with bond market indicators, including spreads on sovereign bonds of emerging market countries.

In particular, returns of emerging markets (EM) currencies vis-à-vis the USD exhibit a high degree of correlation during and across these episodes. In this paper we show that these recurrent patterns of FX returns in risk-off episodes can be identified by simple correlations, as the cross section of spot returns against the USD is positively correlated across episodes, but also by Vector Auto Regressions (VARs).

We also find that the cross-section behavior of bilateral exchange rates with respect to the USD can be linked to information on policy interest rates and balance of payments dynamics available *prior* to the risk-off episode. The predictability of spot returns conditional on entering a risk-off episode suggests that two non-exclusive mechanisms may be at play. Investors may reassess the riskiness of each currency in light of a changing global environment (new information) or reprice risky assets in general (new price of risk).

Our research shows that lower policy rates, stronger current account balances, and stronger net foreign asset or reserve asset positions are factors related to smaller risk-off depreciations or larger appreciations. Deviations of actual exchange rates from measures of equilibrium levels also matter, as overvaluation in two of the three models of the IMF‟s Consultative Group on Exchange Rates (CGER) makes currencies more vulnerable in risk-off episodes. Market characteristics also help to explain FX performance during risk-off episodes, as less liquid currencies, as measured by bid-ask spreads and restrictions on international capital flows, tend to weaken during risk-off episodes.

In addition, market prices and positioning prior to the onset of risk-off episodes help predict currency behavior in a risk-off episode. Currencies whose returns have a higher beta with respect to the VIX tend to depreciate more at the outbreak of a risk-off episode. This might sound tautological but we want to stress that our betas are estimated from weekly currency returns in the 52 weeks *before* the episode. Currencies with a higher beta with the Japanese yen per Australian dollar (AUDJPY) are also prone to sell-offs. This beta gives a sense of how a given currency trades relative to the highly liquid AUDJPY pair that is popular with investors looking to implement G-10 carry trades. In addition, option prices are informative as well. Currencies are less resilient during risk-off episodes if at-the-money options are more expensive or investors are willing to pay more to insure against sharp currency swings.

Finally, we examine how responses to risk-off episodes have changed over time. Risk-off episodes have become more frequent and severe since the beginning of the Global Financial Crisis in the summer of 2007, after a few years of relatively calm markets. We find no substantial difference over time in the role of fundamentals associated with the balance of payments or international investment position. But a currency‟s yield and sensitivity to global risks have become better predictors of risk-off depreciations during more recent risk-off episodes.

This paper has a unique focus on currency behavior across risk-off episodes but our results are related to an extensive recent literature. Brunnermeier et al. (2008) link the crash risk of carry trade strategies to funding constraints of leveraged investors. Ranaldo and Söderlind

(2010) study the safe haven properties of the major advanced economies' currencies.[3] They find that the Japanese yen, and to a lesser extent, the Swiss franc display safe haven characteristics. These currencies tend to appreciate when global equity prices fall and FX volatility increases, and more so when those events are extreme. Grisse and Nitschka (2012) examine the safe haven characteristics of the Swiss franc. Habib and Stracca (2012) find that the net foreign asset position is a robust indicator of safe haven status.

The existence of recurrent patterns in the cross-section of currency returns suggests that certain fundamental-based currency strategies could generate extraordinary profits, as explored by Nozaki (2010) and Jordà and Taylor (2012). In a result analogous to the findings of this paper, Melvin and Taylor (2008) argue that conditioning the carry trade on a global financial stress index would have been a winning strategy during the Global Financial Crisis.

[3] Safe-haven currencies are defined as those that provide a hedge for a reference portfolio of risky assets, conditional on shocks to global risk aversion.

II. RISK-OFF EPISODES

A. Identifying Risk-off Episodes

Our work requires an operational, quantitative, real-time definition of risk-off episodes. We experimented with a variety of rules based on widely tracked gauges of risk aversion in currency markets, such as the VIX, the AUDJPY exchange rate, measures of option-implied volatility on major currency pairs, and the cross-sectional volatility of exchange rates. In our view, the VIX presents three advantages. First, risk-off episodes derived from the VIX conform to our priors about disruptive market events in the last two decades. Second, the VIX is available at high frequencies, so the index can be used to identify the onset of risk-off episodes quickly. Third, the VIX is derived from options prices on the S&P 500 so does not directly draw on information from currency markets.

In our view, the start of a risk-off episode can be best defined using a non-linear threshold. For the objective of this paper, we chose to define the start of a risk-off episode when the VIX is 10 percentage points higher than its 60-day backward-looking moving average (MA). Under this definition, there were 11 distinct risk-off episodes since 1992, as shown in Figure 2. The rectangular shades in grey indicate periods of 12 weeks since the beginning of risk-off episodes. The spike in the VIX in fall 2008 dwarfs the other ones, but more recent episodes still indicate substantial increases in volatility relative to the baseline. It is also noteworthy that risk-off events have happened more often since 2007.

The risk-off episodes based on our rule are easily identifiable from their start date (Table 1). For instance, episode #1 is related to fears over the impact of the Asian crisis on the global economy and episode #2 can be traced back to concerns on Russia"s economy that culminated into a devaluation and default on domestic bonds on 17 August 1998. Episode #3 is linked to wider macroeconomic concerns following the burst of the Dot Com bubble; #4 is the aftermath of the attack on the World Trade Center; and episode #5 is connected to fears of a slowing US economy. Episode #6 reflects increasing concerns on the valuation of subprime credit securities and asset-back commercial paper following the announcement by BNP Paribas that it could no longer value holdings of US subprime mortgage backed securities in some mutual funds. Episode #7 signals mounting disruptions in the USD money markets in the fall of 2007.[4] Episode #8 is the Lehman failure; #9 is the Greek crisis in May 2010; #10 is the aftermath of the Japan earthquake; and #11 is the bout of instability triggered by the confrontation over the US debt ceiling and a deterioration of the European crisis.[5]

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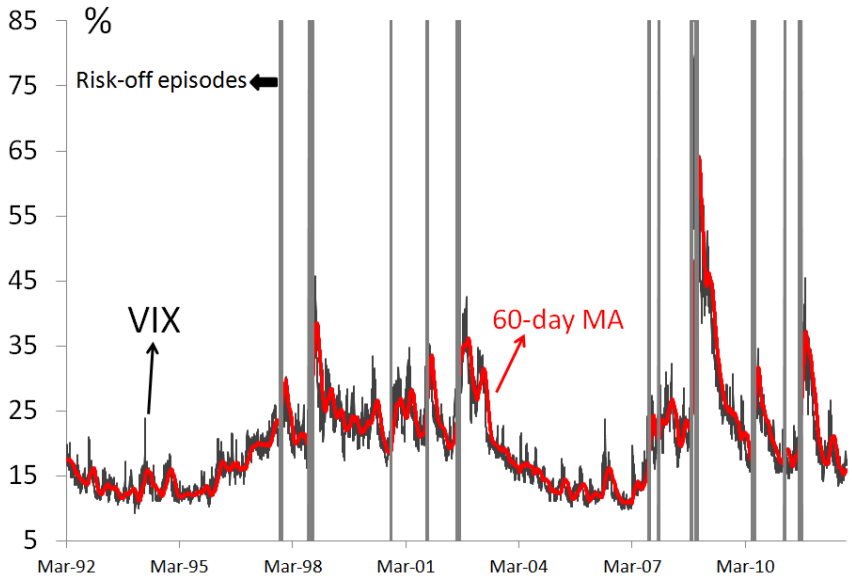
[4] We treat the two risk-off episodes in the second half of 2007 as a single risk-off episode, starting in August 2007. Both episodes are related to the U.S. subprime crisis and disruptions in the market for asset-backed commercial paper.

[5] The algorithm chooses September 17 2001 as the beginning of the 9/11 risk-off episode as US equity markets were closed for a few days and the VIX series was held at its 09/10 value until 9/16.

Figure 2. VIX and Risk-off Episodes, 1992-2012



Source: Bloomberg and authors‟ calculations

Table 1 Initial Dates of Risk-off Episodes

#	Date	Event
1	29 October 1997	Escalation of Asian crisis
2	4 August 1998	Concerns on Russian economy
3	12 October 2000	Fear of slowing US economy
4	17 September 2001	9/11 Attacks
5	10 July 2002	Fear of slowing US economy
6	10 August 2007	BNP Paribas halts withdrawals from three money market mutual funds
7	12 November 2007	Disruptions in USD money markets
8	17 September 2008	Lehman failure
9	6 May 2010	Greek crisis
10	16 March 2011	Uncertainty over impact of Japan‟s March 11 Earthquake
11	4 August 2011	Confrontation over US debt ceiling and deterioration of crisis in euro area

In what follows, we focus on the 12 weeks subsequent to the beginning of a risk-off episode. We do not try to determine the end of a risk-off episode. Episodes of high volatility may last from a few weeks to several months, and the transition from turmoil to more accommodating financial conditions is usually harder to pinpoint than the onset of a risk-off period. The VIX shows some degree of mean reversion over longer horizons but for the risk-off episodes we

study, there is little evidence of mean reversion. The average level of the VIX 12 weeks after the start of a risk-off episode is on average only 2.4 percentage points below the level that triggered the episode. This compares to a standard deviation of the change in the VIX of 9.8 percentage points for the same horizon of 12 weeks after the start of a risk-off episode.[6]

B. Why have risk-off episodes become more frequent?

The initial dates of our risk-off episodes suggest that latent risks in the G-3 economies are driving the higher frequency of risk-off episodes. In fact, with the exception of the Japanese earthquake in March 2011, recent risk-off episodes can be traced back to concerns on sovereign or private sector balance sheets in Europe and the United States. Since 2007 investors are increasingly more worried about tail risks to global financial stability emanating from the euro area and the United States. Some observers argue that we have entered a world with multiple equilibria, where adequate policy responses could lead to a virtuous cycle and vice versa (e.g., IMF, 2011b). Risk-off episodes bring tail risks to the forefront and put asset valuations in other developed and emerging markets under pressure.

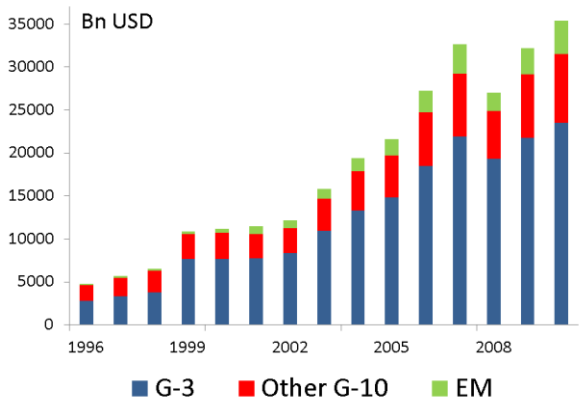
In addition, the increased integration of global financial markets could lead to a more rapid re-pricing of global risks across markets. Taylor (2012) notes that that the expansion of external balance sheets in the last two decades is unparalleled in economic history. The growth in cross-border financial flows reflects asset reallocation by Western investors, but also reserve accumulation, wealth creation and demographic developments in emerging economies. After some retrenchment in capital flows following Lehman‟s bankruptcy, the growth in international portfolio flows has resumed (Figure 3).[7]

[6] This is calculated over the 8 episodes reported in Table 2.

[7] Milesi-Ferretti and Tille (2012) discuss the factors behind the increase in home bias observed in 2008-09.

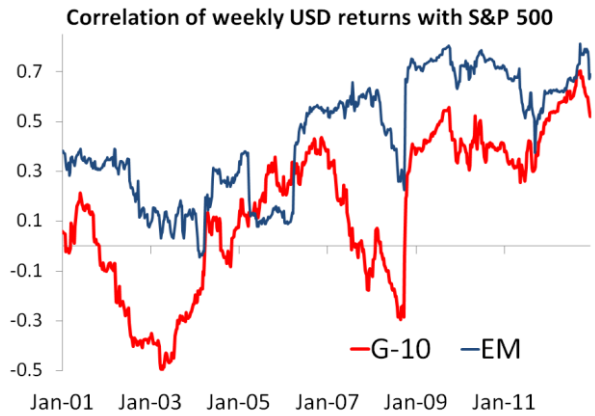
Figure 3. Increased Financial Integration and Correlations

(a) Stock of Portfolio Liabilities



Note: Data from a country's International Investment Position.

(b) FX Returns and S&P 500



Note: Chart shows correlation of weekly returns on the S&P 500 with weekly USD returns on G-10 (based on the "DXY" index) and EM currencies ("FXJPEMCI"). Sample size is past 52weeks.

Source: Bloomberg, IFS and authors' calculations

The larger stock of portfolio liabilities worldwide has important implications for currency markets. Sizable flows into local bond and equity markets have lead to a sharp increase in local currency exposure by foreign investors.[8] Even when there is no pullback of foreign flows in the wake of a risk-off event, hedging of local currency exposure can lead to FX weakness. In addition, periods of strong inflows tend to appreciate currencies, making undervaluations less evident. This might make investors less willing to stay long when a risk-off episode hits.

[8] Note that investors tend to hedge FX exposure related to fixed income versus equity holdings differently, and the composition of portfolio flows since 2008 may have had implications for currency markets as well.

III. WHAT HAPPENS TO EXCHANGE RATES DURING RISK-OFF EPISODES?

In this section, we establish recurring features of currency movements during risk-off episodes.[9] We present some simple correlations before turning to a VAR analysis. We do not include the risk-off episodes of October 1997 and August 1998 as data are not available for some of the variables studied in the next section.

A. Are Risk-off Episodes Alike?

There are recurrent patterns in the cross-sectional distribution of risk-off depreciations. In general, there is a positive correlation between USD spot returns of different currencies across episodes (Table 2).[10] For a short horizon of three weeks, exchange rate behavior in previous episodes helps to predict risk-off depreciations in subsequent ones. For the horizon of twelve weeks, the patterns are harder to discern and no risk-off episodes stand out.

Table 2. Correlation of Spot Returns Across Episodes

Horizon of 3 weeks	October 2000	September 2001	July 2002	August 2007	Lehman Failure	Greece May 2010	Japan March 2011	August 2011
October 2000	1.00	0.22	0.05	0.18	0.06	0.12	0.00	0.09
September 2001		1.00	0.21	0.36	0.31	0.16	-0.35	0.53
July 2002			1.00	0.31	0.34	0.03	-0.19	0.11
August 2007				1.00	0.30	0.27	-0.31	0.25
Lehman Failure					1.00	0.47	-0.70	0.42
Greece May 2010						1.00	-0.64	0.18
Japan March 2011							1.00	-0.36
August 2011								1.00

Horizon of 12 weeks	October 2000	September 2001	July 2002	August 2007	Lehman Failure	Greece May 2010	Japan March 2011	August 2011
October 2000	1.00	0.13	0.21	0.45	-0.24	0.43	0.53	-0.13
September 2001		1.00	-0.18	-0.03	0.00	-0.08	0.07	0.09
July 2002			1.00	-0.16	0.16	-0.16	-0.16	0.22
August 2007				1.00	-0.34	0.20	0.28	-0.21
Lehman Failure					1.00	0.05	-0.31	0.42
Greece May 2010						1.00	0.26	-0.02
Japan March 2011							1.00	-0.51
August 2011								1.00

Note: Matrices show correlations between USD spot returns at three and twelve weeks into different episodes. Blue/red shaded cells denote positive/negative statistically significant correlations at the 95 percent level.

[9] Previous research has found that in the aftermath of Lehman"s failure, currencies whose returns were more correlated to the AUDJPY, had higher interest rates, and were in an appreciation streak before the crisis tended to depreciate relatively to the U.S. dollar (e.g. De Bock and Englander, 2008). Currencies from countries running large current account deficits also depreciated more than others.

[10] In this paper, we focus on spot returns of local currencies against the USD during a risk-off episode. But it is worth noting that many FX transactions are against the euro in the case of some Central and Eastern European economies, whereas some countries have also pegged exchange rates at times. For instance, the Moroccan dirham is pegged to a disclosed basket with euro representing 80 percent and USD 20 percent.

The risk-off episode related to the Japan earthquake in March 2011 is an exception to the rule and significantly negatively correlated with the other episodes. Looking closer at the episode explains why. Higher yielding currencies sold off right after the earthquake struck on March 11 but currency weakness was reversed after the coordinated currency intervention of March 18 (for details, see Neely 2011). Although this might argue for excluding the Japan earthquake episode from our analysis, we choose to not let any ex-post knowledge guide our sample selection, so we include this episode.[11]

B. Evidence from VARs

We look at impulse response functions to measure the impact of a risk-off episode on a currency. We estimate a VAR model for each country on weekly data, starting in the first week of 2000 till June 2012. The variables included in the VAR are:

$$Z_t = \left[risk - off_t, \ln(s_t) \right]', \tag{1}$$

where *risk-off* is a dummy indicating the beginning of a risk-off episode and *s* the weekly average of the bilateral nominal exchange rate relative to the U.S. dollar (from the IMF/GDS database). We estimate the VAR with 12 lags. We also include a linear and a quadratic trend as control variables to capture longer-term structural changes (e.g. some countries have reduced inflation rates during the sample period). The reduced-form VAR is then:

$$Z_t = c + control_t + \sum_{j=1}^{12} B_j Z_{t-j} + u_t, E(u_t u_t') = V. \tag{2}$$

The variable c is a constant. The inverse of the Choleski factor of the variance-covariance matrix *V* can be used to identify structural shocks that are orthogonal to each other. Given the ordering of our variables, this implies that the beginning of a risk-off episode may have an immediate effect on exchange rates, but there is no feedback from exchange rates to the dummy in the first week of a risk-off episode. We also restrict the coefficients in the reduced form so that no lagged variable has an effect on the risk-off dummy.

We find significant immediate and cumulative effects of risk-off episodes on currency performance (Table 3, also see Figure 5 at the end of the paper for the individual country impulse response functions). The Japanese yen and the Swiss franc appreciate relatively to the U.S. dollar at the beginning of a risk-off episode.[12] The appreciation of the Swiss franc tends to be reverted between the first and the third week of the risk-off episode, while the appreciation of the Japanese yen appears to be more persistent. After 24 weeks, the cumulative risk-off appreciation of the Japanese yen is 2.8 percent.

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[11] Note that in the regression analysis discussed later in this paper, we will include a separate dummy for each risk-off episode.

[12] On a multilateral basis, the U.S. dollar also appreciates during risk-off episodes, so our convention of measuring all exchange rates relative to the U.S. dollar tends to somewhat understate the extent to which the Japanese yen and Swiss franc exhibit safe haven behavior.

On the other side of the spectrum, the Australian and New Zealand dollars, Brazilian real, Colombian, Mexican and Philippine pesos, Indian rupee, Korean won, Malaysian ringgit, and South African rand depreciate either on impact or in the week immediately after the risk-off episode starts. One week after the start of the risk-off episode, the Brazilian real and South African rand depreciate on average by more than 2 percent. The Australian dollar depreciates by 1.9 percent.

Other currencies tend to depreciate three to six weeks into the risk-off episode, namely the Canadian and Singaporean dollars, Chilean peso, Indonesian rupiah, Peruvian sol, Swedish krona, Turkish lira, and United Kingdom pound are found to depreciate over a horizon of 3 to 6 weeks into the risk-off episode. The inclusion of the Swedish krona in this sample is remarkable given its strong appreciation versus the euro in May-July 2012, when euro area concerns flared up. Market participants note that the krona has traded more like a safe haven during these months. The Ukrainian hryvnia tends to depreciate 12 weeks into the episode. After 12 weeks, the cumulative risk-off depreciation of the Brazilian real, Korean won, South African rand, and Ukrainian hryvnia is more than 5 percent.

While some currencies do not show a statistically significant response to risk-off episodes here, it is worth pointing out that we lump risk-off episodes together in the VAR. The lack of significance may reflect wide changes in a currency‟s sensitivity to a risk-off conditions over time (that is, across the episodes we study). For example, the Russian ruble weakened substantially in the fall of 2008 but did not underperform when we pool episodes since 2000. We could also not find any significant effect for the currencies of Argentina, China, Czech Republic, Denmark, Egypt, euro area, Israel, Morocco, Romania, Thailand, and Venezuela.

Interestingly, there is quite a bit of heterogeneity among the currencies that depreciate in a risk-off episode. The impulse response function for the currencies of advanced economies, such as Australia, New Zealand and Sweden show mean reversion as weeks go by. On the other hand, weakness of EM currencies is more persistent, as the risk-off depreciations of Brazil, Chile, Mexico, Philippines, and South Africa show little tendency towards mean reversion, at least in the two quarters following the on-set of the risk-off event.

Table 3. Impulse Response Functions, Effect of Risk-off Episodes on Exchange Rates Versus the U.S. Dollar.

	Number of weeks since the beginning of the risk-off episode					
	0	1	3	6	12	24
Argentina	-0.15 [0.54]	-0.25 [0.80]	-0.72 [1.17]	-0.96 [2.18]	-0.91 [4.19]	-1.27 [6.42]
Australia	-0.53 [0.50]	-1.94 [0.81]	-4.85 [1.24]	-4.60 [1.73]	-1.84 [2.60]	-1.33 [2.78]
Brazil	-1.52 [0.60]	-2.62 [0.95]	-6.51 [1.47]	-5.69 [2.08]	-7.27 [3.24]	-6.84 [3.50]
Canada	-0.57 [0.37]	-0.78 [0.58]	-2.66 [0.83]	-3.07 [1.10]	-3.02 [1.60]	-2.90 [1.65]
Chile	-0.56 [0.45]	-1.10 [0.73]	-2.64 [1.12]	-3.74 [1.57]	-4.80 [2.43]	-4.52 [2.49]
China,P.R.: Mainland	0.01 [0.04]	0.01 [0.07]	0.04 [0.11]	0.08 [0.16]	0.19 [0.26]	0.31 [0.39]
Colombia	-0.66 [0.46]	-1.23 [0.72]	-2.62 [1.12]	-2.37 [1.62]	-3.21 [2.43]	-3.11 [2.46]
Czech Republic	0.37 [0.50]	0.61 [0.82]	-0.76 [1.28]	-1.95 [1.80]	0.93 [2.54]	1.29 [2.59]
Denmark	0.25 [0.41]	0.58 [0.66]	-0.61 [1.01]	-1.92 [1.41]	1.32 [2.00]	1.57 [2.07]
Egypt	0.08 [0.24]	0.12 [0.39]	0.19 [0.65]	0.13 [0.95]	-0.21 [1.45]	-0.63 [1.65]
Euro Area	0.24 [0.41]	0.50 [0.66]	-0.63 [1.01]	-1.94 [1.42]	1.39 [2.01]	1.64 [2.08]
Hungary	-0.63 [0.61]	-0.39 [0.96]	-1.92 [1.46]	-4.02 [2.04]	-1.27 [2.87]	-1.07 [2.87]
India	-0.63 [0.24]	-0.98 [0.40]	-2.16 [0.63]	-2.32 [0.91]	-2.07 [1.36]	-1.57 [1.29]
Indonesia	-0.40 [0.45]	-0.67 [0.74]	-2.53 [1.22]	-4.18 [1.79]	-4.86 [2.47]	-4.24 [2.53]
Israel	-0.20 [0.31]	0.21 [0.50]	-0.14 [0.78]	-0.42 [1.12]	-0.38 [1.59]	-0.26 [1.68]
Japan	0.75 [0.37]	1.72 [0.59]	1.61 [0.90]	2.26 [1.21]	2.84 [1.71]	2.78 [1.62]
Korea	-0.53 [0.42]	-1.45 [0.68]	-4.27 [1.04]	-5.30 [1.40]	-6.98 [2.02]	-6.67 [1.95]
Malaysia	-0.31 [0.17]	-0.32 [0.29]	-0.98 [0.44]	-1.13 [0.61]	-1.11 [0.86]	-1.11 [0.89]
Mexico	-1.01 [0.40]	-1.33 [0.62]	-3.65 [0.95]	-3.29 [1.33]	-4.88 [1.99]	-4.69 [1.94]
Morocco	0.21 [0.32]	0.42 [0.52]	-0.49 [0.80]	-1.45 [1.13]	0.94 [1.62]	1.25 [1.70]
New Zealand	-0.09 [0.53]	-1.58 [0.86]	-3.94 [1.31]	-3.56 [1.80]	-1.77 [2.65]	-1.57 [3.02]
Norway	-0.26 [0.47]	-0.26 [0.74]	-2.09 [1.11]	-3.05 [1.55]	-1.44 [2.34]	-1.09 [2.61]
Pakistan	-0.09 [0.18]	-0.13 [0.29]	-1.16 [0.44]	-0.82 [0.64]	0.25 [1.07]	0.84 [1.43]
Peru	-0.22 [0.19]	-0.15 [0.29]	-0.69 [0.44]	-1.07 [0.62]	-0.69 [0.90]	-0.66 [0.90]
Philippines	-0.33 [0.26]	-0.88 [0.40]	-2.62 [0.62]	-2.73 [0.86]	-2.51 [1.25]	-2.49 [1.36]
Poland	-0.49 [0.57]	-0.33 [0.90]	-2.11 [1.41]	-3.41 [2.04]	-0.08 [2.96]	0.49 [3.17]
Romania	-0.08 [0.45]	-0.17 [0.71]	-1.71 [1.07]	-2.42 [1.54]	-1.52 [2.23]	-1.19 [2.28]
Russian Federation	-0.40 [0.31]	-0.79 [0.50]	-1.35 [0.86]	-1.92 [1.32]	-1.62 [2.05]	-1.19 [2.39]
Singapore	-0.17 [0.19]	0.05 [0.32]	-0.98 [0.51]	-1.43 [0.69]	-1.33 [0.97]	-1.28 [0.97]
South Africa	-1.06 [0.69]	-2.31 [1.07]	-4.39 [1.63]	-7.47 [2.28]	-7.45 [3.27]	-7.35 [3.29]
Sweden	-0.56 [0.48]	-0.85 [0.77]	-2.36 [1.16]	-3.28 [1.61]	-0.98 [2.35]	-0.82 [2.53]
Switzerland	1.01 [0.42]	2.17 [0.69]	-0.13 [1.07]	-1.13 [1.47]	1.29 [2.04]	1.34 [2.08]
Thailand	0.01 [0.23]	0.20 [0.37]	-0.85 [0.57]	-1.14 [0.82]	-1.61 [1.25]	-1.72 [1.41]
Turkey	-0.47 [0.70]	-1.75 [1.11]	-3.29 [1.74]	-4.19 [2.56]	-0.15 [3.74]	0.16 [3.58]
Ukraine	-0.02 [0.16]	-0.07 [0.36]	-0.21 [0.63]	-1.70 [1.11]	-5.70 [2.00]	-7.64 [2.54]
United Kingdom	0.35 [0.37]	0.41 [0.60]	-0.25 [0.90]	-2.18 [1.25]	-0.89 [1.87]	-0.61 [2.12]
Venezuela	0.44 [1.11]	0.79 [1.64]	1.07 [2.42]	1.48 [3.28]	2.51 [4.53]	2.41 [4.32]

The impulse response functions were derived from a bivariate VAR with the bilateral exchange rate with respect to the U.S. dollar and a dummy for the start of risk-off periods, using weekly data, with 12 lags. The shock to the risk-off variable was normalized to one. Standard errors are recorded inside square brackets. The specification for the risk-off dummy constrained all coefficients to zero. A linear and a quadratic trend were included as exogenous variables. Numbers with a color background are statistically significant at the 10 percent level (two-sided test) and green shades denote appreciation in a risk-off episode while orange background denote risk-off depreciation.

IV. EXPLAINING THE CROSS-SECTIONAL VARIATION

In this section we show that a number of factors are associated with FX performance during risk-off episodes. We want to emphasize that all our variables are available *prior* to the risk-off episode and we do not include later data points in the analysis. Interestingly, our results suggest that investors purposefully re-evaluate currency risk during risk-off episodes without necessarily updating their information set.

Economic theory and previous work dictate our choice of explanatory variables, while we also add variables on option prices and liquidity. Table A1 (in the appendix) calculates the volatility and correlations between the variables. Though some of the variables are highly correlated, it is worth to consider the cross-sectional patterns of depreciation associated to each variable in isolation before we move to multivariate regressions.

A. Policy Interest Rates

- *Policy interest rate before the episode.* High interest rate currencies tend to be on the receiving end of carry trade and portfolio flows. Market conditions that cause a pullback or slowdown in these flows would weaken high interest rate currencies.[13] It is worth noting that policy interest rates are often set in response to developments in the domestic economy. As such, policy rates are highly correlated with inflation rates.[14]

B. External Sector

- *Lagged current account balance.* The availability of financing of current account deficits may become more restrictive in risk-off episodes, so we expect larger depreciations in countries with larger deficits during such episodes.
- *Net foreign asset position.* A country with a large positive net foreign asset position (or reserves) is less likely to run into problems servicing its external debt or face liquidity shortages that lead to currency sell-offs.[15] In particular, a larger stock of reserves relative to short-term liabilities can help to defend the exchange rate level during risk-off episodes. McCauley (2012) shows that many EM sold substantial amounts of foreign exchange reserves and U.S. dollars forward in 2008 to defend their currencies. In

[13] Policy interest rates are from IMF/GDS, extended by the IFS series „short rate" for Indonesia, Malaysia and Mexico.

[14] In Table A1, we calculate a correlation of 80% between inflation and policy rates prior at the onset of a risk-off episode. If purchasing power parity holds, a higher rate of inflation would also imply a higher rate of depreciation.

[15] Habib and Stracca (2012) find that the net foreign asset position is a robust determinant of safe haven currency status.

addition, repatriation flows could very well strengthen the currency. This seems to be the case in Switzerland (de Carvalho Filho, 2012).

- *Recent foreign portfolio inflows (4 quarters MA, percent of GDP).* This variable captures a country‟s higher vulnerability to FX weakness following a sharp increase in debt or equity flows.[16] Often such inflows lead to appreciations, potentially making a currency all the more vulnerable in a risk-off episode. Even if there are no outflows during the risk-off episodes, currencies could still depreciate as investors hedge the local currency exposure on their bond holdings.¨

C. Exchange Rate Misalignment

- *Measures of exchange rate misalignments.* Risk-off episodes may trigger exchange rate adjustments that close the gap between actual real exchange rates and measures of equilibrium exchange rates. We use three measures of exchange rate misalignments estimated by the IMF‟s Consultative Group on Exchange Rates (CGER). The **Macroeconomic Balance** (MB) approach compares deviations from current account balances from current account norms. The **Equilibrium Real Exchange Rate** (ERER) approach evaluates deviations from real effective exchange rates from the levels implied by a panel cointegration regression. Finally, the **External Sustainability** (ES) approach focuses on consistency between current account balances and a stable ratio of net foreign assets to GDP.[17]

D. Currency Behavior Prior to the Risk-off Episode

- *Beta with respect to VIX.* Some currencies are more sensitive to fluctuations in global risk appetite.[18] To measure a currency‟s sensitivity, we estimate its beta with the VIX prior to the risk-off episode, using a sample of 52 weekly observations of spot and VIX returns. A more positive beta implies that a currency depreciates more during the weeks when the VIX increases.
- *Beta with respect to AUDJPY.* Many FX investors track the highly liquid Japanese yen per Australian dollar (AUDJPY) to evaluate broad risk positioning on FX markets. To get an indication of how investors position a currency across the currency universe, we calculate the beta of a currency with the AUDJPY in the 52 weeks prior to the episode.[19] A positive beta means that a currency tends to depreciate when AUDJPY is weaker.

[16] In addition, the stock of portfolio flows is available for very few countries on a quarterly basis.

[17] Lee at al. (2008) describe these exchange rate assessment models in greater detail.

[18] Lustig et al. (2011) show that FX carry returns are correlated to the VIX.

[19] De Bock and Englander (2008) find that this beta was significantly correlated with FX performance in 2008.

E. Cost of Buying an Option and Tail Risk Insurance

- *Implied volatility of at-the-money options with a 3-month maturity*. This implied volatility is a forward-looking measure of the cost investors are willing to pay to hedge against USD moves from current market levels over the next 3 months.[20] Measures of implied volatility also tend to be correlated with realized volatility.
- *Risk reversals versus U.S. dollar.* Risk reversals track the premium investors are willing to pay for insuring against sharp currency swings. This insurance cost gives an indication of market concerns on tail risk scenarios. To calculate the risk reversals of a given currency, we subtract the implied volatility of an out-of-the-money (25 delta) USD put option at the 3-month maturity from the implied volatility of an equivalent out-of-the-money USD call option.[21] In this case, a *higher* value of a risk reversal implies that investors are willing to pay *more* to insure against weakness vis-à-vis the USD in a risk-off episode. We expect risk reversals to be positively correlated with currency weakness during a risk-off episode.

F. Liquidity Conditions

- *Bid-ask spread.* The bid-ask spread captures the ease at which investors can unwind or build positions in a currency. The effect of bid-ask spreads on a currency‟s exposure to risk-off episodes is an empirical question. It is plausible that currencies that are more efficiently traded are the first ones that investors would sell off during a risk-off episode. But low bid-ask spreads may also indicate deeper markets. This could allow investors to unwind positions with more muted effects on prices. The measure we use is based on the median bid-ask spread in the month before the episode, from Datastream.
- *Capital liberalization and controls.* A country‟s exposure to global risk aversion shocks can also depend on the rules governing transactions between residents and non-residents. Countries that are more open to cross-border capital movement could be more exposed to shocks in global financial markets. We used the *de jure* measures of capital account and financial account openness by Chinn and Ito (2006, 2008). These measures are based on the IMF‟s Annual Report on Exchange Arrangements and Exchange Restrictions

[20] The implied volatility is effectively the market price of an option when we know the strike of the option, the current spot/forward level of an exchange rate, interest rates and time to maturity.

[21] The “smile” refers to the observation that implied volatilities of out-of-the-money calls and puts are different from options struck at-the-money.

(AREAER), updated to 2010.[22] We code the variable such that a more positive value means freer movements of capital flows.

G. Simple regressions

The rows of Table 4 present the coefficients in a regression of depreciation against the USD since the beginning of the risk-off episode on one of the country-specific variables X_i described above. The regression also includes a constant α and a separate dummy variable *risk-off* for each one of the risk-off episodes. We pool the set of risk-off episodes T and then estimate the following regressions:

$$s_{i,t+k} - s_t = \alpha_k + X_{it} \cdot \beta_k + risk\text{-}off_t \cdot \gamma_k + \varepsilon_{itk} \quad \text{for } k = 1, 2 \ldots 12; \text{ and } t \in \mathrm{T} \qquad (3)$$

where ε_{itk} is the error term. We focus on four different horizons *k* (one, 3-, 6- and 12-weeks). We only include risk-off episodes since 2000 due to data limitations. The sample of currencies is determined by data availability and includes advanced and emerging markets.[23]

First, EM currencies (row 1 in Table 4) do not differ from advanced economies at the onset of the risk-off episode, but as we lengthen the horizon to twelve weeks, their currencies tend to weaken significantly. This result is consistent with the impulse response functions in section III. Currencies of advanced economies such as the Australian and New Zealand dollars tend to depreciate on impact but also rebound sharply. In contrast, EM currencies such as the Brazilian real or the Mexican peso face more persistent depreciations on impact.

We find that high yielding currencies (row 2) tend to depreciate more in the six weeks following the onset of a risk-off episode, which is likely related to disruptions in carry trade. positioning by global investors.

Balance of payments determinants are also correlated with risk-off currency movements. Higher current account balances (3) and stronger net foreign asset positions (4) are correlated with appreciation over all horizons. On the other hand, countries that have seen stronger foreign portfolio inflows (5) in the run-up to a risk-off episode are more vulnerable to FX weakness for horizon of 6 weeks or longer (but this result is not statistically significant for the 12 weeks horizon).

In a smaller sample we find that measures indicating overvaluation are also related to FX weakness during risk-off episodes.[24] The CGER variables based on the Macroeconomic

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[22] The Chinn-Ito database was downloaded from http://web.pdx.edu/~ito/Chinn-Ito_website.htm. The series for the Euro area was filled with the values for Germany.

[23] Our sample includes Argentina, Australia, Brazil, Canada, Chile, Colombia, Czech Republic, Denmark, Euro Area, Hungary, India, Israel, Japan, Republic of Korea, Malaysia, Mexico, New Zealand, Norway, Peru, Philippines, Poland, Russian Federation, Singapore, South Africa, Sweden, Switzerland, Thailand, Turkey, and United Kingdom.

Balance MB (7) and External Sustainability ES (9) framework show a link between overvaluation and risk-off depreciations, unlike the Equilibrium Real Exchange Rate (8) approach. It is worth adding that the MB and ES approaches signal overvaluation when current account balances are weaker than a current account norm. We previously found that current account balances are unconditionally correlated with risk-off appreciations (4). Our results suggest that the dynamics of current account are driving the results for the MB and ES approaches. In fact, simple correlations between these variables at the onset of risk-off episodes (Table A1) are in line with this observation. The MB and ES measures have a correlation coefficient of 85%, and a strong negative correlation with the current account balance.

Sensitivity to global risks, measured by the betas with respect to the VIX index, has a strong unconditional correlation with risk-off depreciations on impact (9). It is worth repeating that we calculate the betas of currency returns with the VIX *prior* to the risk-off episode. Likewise, the currency beta with AUDJPY (10) is positively correlated with risk-off depreciations at all horizons.

Option prices also turn up significant in the regressions. Both implied volatility (11) and risk reversals (12) are positively correlated with risk-off depreciations. This is reassuring, as these variables track how costly it is for investors to insure against currency moves from current levels. We would expect dealers to charge higher prices for options on currencies that are more sensitive to sell-offs during a risk-off episode. In contrast, it is worth pointing out that option prices are not a good predictor of currency moves in tranquil times and some analysts argue that implied volatilities underprice tail risks.[25]

Market-liquidity factors matter as well. Bid-ask spreads (13) are not associated with risk-off depreciations on impact, but tend to be positively correlated with risk-off depreciations over 12 weeks. In addition, currencies from countries where capital flows are less restricted- as indicated by the Chinn-Ito index of capital liberalization- are less prone to FX weakness during risk-off episodes. We also examined if the depth of the domestic bond market in EM (measured by data on trading volumes from the Emerging Markets Trade Association) helps to explain FX performance in risk-off episodes but found no significant effects.[26]

Table 4. Simple regressions of depreciation since the beginning of the risk-off episode

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[24] CGER estimates are available for 27 currencies in our sample, starting in the second semester of 2006.

[25] For example, Englander (2012) argues that EURUSD risk reversals can look relatively cheap compared to indicators for euro area sovereign risks.

[26] A higher trading volume could lead to more bond sales and FX weakness in risk-off episodes if it is less costly for portfolio managers to liquidate positions in currencies with deeper bond markets such as Brazil or Mexico. Alternatively, monetary authorities may have "fear of floating". Through market based interventions or moral suasion it may be easier to stabilize nominal exchange rates for currencies with shallower domestic bond markets.

Dependent variable: **Depreciation since the beginning of the risk-off episode**		Mean [St. Dev]	Number of weeks since the episode started				N. Obs.
			1	**3**	**6**	**12**	
(1)	Emerging market dummy	0.70	0.284	0.388	0.441	2.130	269
		[0.458]	[0.435]	[0.568]	[0.541]	[0.596]	
	Policy Rate						
(2)	Interest rate before the episode	6.61	0.061	0.089	0.077	0.101	269
		[7.799]	[0.025]	[0.026]	[0.039]	[0.046]	
	External sector						
(3)	Current account balance (% GDP)	0.02	-5.696	-9.972	-10.668	-10.475	261
		[0.065]	[2.215]	[2.664]	[2.832]	[3.865]	
(4)	Net foreign assets (% GDP)	-0.11	-0.765	-1.004	-1.082	-1.427	242
		[0.557]	[0.319]	[0.378]	[0.353]	[0.397]	
(5)	Foreign portfolio inflows (% GDP), 4 quarters MA	0.10	0.437	-0.758	0.640	-1.879	236
		[0.146]	[0.928]	[1.472]	[1.096]	[1.431]	
	Measures of exchange rate misalignment						
(6)	MB misalignment	-1.04	0.031	0.063	0.107	0.075	125
		[11.838]	[0.011]	[0.013]	[0.021]	[0.024]	
(7)	ERER misalignment	-1.46	0.011	0.029	0.035	0.015	125
		[14.711]	[0.013]	[0.023]	[0.03]	[0.035]	
(8)	ES misalignment	-3.31	0.033	0.052	0.095	0.068	125
		[13.324]	[0.009]	[0.015]	[0.022]	[0.023]	
	Sensitivity to global and FX-specific risks						
(9)	Beta with the VIX	0.07	5.729	6.260	6.182	2.699	269
		[0.114]	[1.835]	[2.3]	[3.124]	[3.494]	
(10)	Beta with AUD/JPY exchange rate	0.16	2.477	3.640	4.196	1.943	269
		[0.219]	[0.676]	[0.877]	[0.864]	[1.707]	
	Option prices						
(11)	Implied volatility of at-the-money option	11.29	0.060	0.126	0.122	0.100	237
		[5.946]	[0.021]	[0.032]	[0.056]	[0.054]	
(12)	Risk reversal versus USD (tail risk insurance)	1.15	0.348	0.504	0.644	0.507	165
		[1.845]	[0.102]	[0.211]	[0.364]	[0.419]	
	Liquidity measures and financial openness						
(13)	Bid-ask spread, in bps	12.43	0.024	0.022	0.028	0.046	253
		[16.002]	[0.014]	[0.013]	[0.014]	[0.015]	
(14)	Chinn-Ito measure of capital liberalization	0.95	-0.209	-0.232	-0.211	-0.652	261
		[1.495]	[0.108]	[0.152]	[0.186]	[0.209]	

Note: This table displays estimates of equation (3) of section IV(a). Standard errors are robust with clustering at the currency level. Shaded numbers are statistically significant at the 95% level (two-sided test). Green shade denotes variables associated with an appreciation during a risk-off episode, orange background denotes a risk-off depreciation. The sample includes Argentina, Australia, Brazil, Canada, Chile, China, P.R.: Mainland, Colombia, Czech Republic, Denmark, Euro Area, Hungary, India, Indonesia, Israel, Japan, Republic of Korea, Malaysia, Mexico, New Zealand, Norway, Peru, Philippines, Poland, Romania, Russian Federation, Singapore, South Africa, Sweden, Switzerland, Taiwan, Thailand, Turkey, Ukraine, and United Kingdom.

H. Multivariate Analysis

Next we distill the essential variables from Table 4 using multivariate regressions. We focus on two different horizons (one- and 12-week), and include a dummy for each one of the episodes as in the previous subsection. We exclude the CGER exchange rate misalignments due to data limitations. We split the factors into those representing macroeconomic/ balance of payments variables and those representing market prices. This distinction is relevant because market prices tend to aggregate macroeconomic and other information and inclusion of market prices may drive down the economic and statistical significance of macroeconomic factors and give an erroneous impression that those do not matter.

We start with a specification with seven explanatory variables, which we chose based on the fit of the regressions estimated above while excluding collinear variables.[27] For each horizon we present three specifications (i) a regression with macroeconomic variables and market prices, (ii) only macroeconomic variables, and (iii) only market price variables. Each specification includes the emerging market dummy and the episode-specific dummies.

For the immediate effect of the risk-off episode (1-week horizon), high-yield currencies and those with larger implied volatility tend to depreciate the most (Table 5), while we find no difference between EM and advanced economies if we control for macroeconomic and market pricing variables. Currencies of countries running large current account surpluses appear to depreciate less, but this effect is not statistically significant.

Extending the point of view to a 12-week horizon, we see an increasing explanatory power of the empirical specification (the adjusted R-squared rises from about 0.4 to about 0.6). For the longer horizon, interest rates appear to matter less while market pricing variables such as the beta with the AUDJPY exchange rate and implied volatility gain in relative importance. We do not find a coefficient significantly different from zero on the beta VIX in the multivariate regression.

[27] We also used the R package BMS (Zeugner, 2010) to estimate Bayesian model averaging of linear specifications with the 14 variables in Table 4 and a range of other variables. We include balance of payments and international investment position variables as well as financial development measures from Beck and Demirgüç-Kunt (2009), such as financial system deposits (% GDP) and stock market turnover ratio. The sign of the posterior means of the coefficients are in line with those reported in Table 5. One week into the episode, the currency beta with respect to the VIX is the most robust variable. But the policy interest also has a large posterior inclusion probability (PIP). In week three, the currency beta with the AUDJPY and the VIX have the largest PIPs, but the sign on the currency beta with the VIX switches to negative. In the twelfth week, currency betas still have the highest PIPs, and the emerging market dummy, the option implied volatility before the episode, and the trading volume of the domestic bond market have PIPs over 1/3. Those results are available upon request.

Table 5. Multivariate regressions of depreciation since the beginning of risk-off episodes

Dependent variable: **Depreciation since the beginning of the risk-off episode**	Number of weeks since the episode started					
	1			12		
Emerging market dummy	0.028	0.047	0.294	2.702	2.353	2.654
	[0.448]	[0.539]	[0.289]	[0.82]	[0.81]	[0.65]
Macroeconomic variables						
Interest rate before the episode	0.056	0.068		0.035	0.051	
	[0.018]	[0.03]		[0.056]	[0.045]	
Current account balance (% GDP)	-4.389	-7.043		-4.698	-6.948	
	[2.93]	[3.78]		[5.89]	[5.55]	
Foreign portfolio inflows (% GDP), 4 quarters MA	0.511	0.986		2.331	2.321	
	[1.288]	[1.404]		[1.75]	[1.725]	
Market prices						
Beta with the AUDJPY exchange rate	1.125		1.482	2.983		3.554
	[0.829]		[0.875]	[2.13]		[2.01]
Beta with the VIX	2.849		3.294	-5.291		-4.877
	[2.073]		[2.518]	[4.238]		[4.299]
Implied volatility	0.006		0.047	0.053		0.076
	[0.031]		[0.014]	[0.098]		[0.065]
Number of observations	209	209	209	209	209	209
R-squared	0.46	0.43	0.43	0.63	0.63	0.63
Adjusted R-squared	0.42	0.39	0.40	0.61	0.61	0.61
RMSE	1.84	1.89	1.88	5.26	5.24	5.24

Note: Regression constant and dummies for each one of the episodes not shown. Standard errors are robust with clustering at the currency level. Numbers in green shade are statistically significant at the 95 percent level (two-sided test) and denote risk-off appreciation, orange background denotes risk-off depreciation. The sample coverage includes Argentina, Australia, Brazil, Canada, Chile, China, P.R.: Mainland, Colombia, Czech Republic, Denmark, Euro Area, Hungary, India, Indonesia, Israel, Japan, Republic of Korea, Malaysia, Mexico, New Zealand, Norway, Peru, Philippines, Poland, Romania, Russian Federation, Singapore, South Africa, Sweden, Switzerland, Thailand, Turkey, Ukraine, and United Kingdom.

V. HAVE CURRENCY RISK FACTORS CHANGED SINCE 2007?

This section examines if currency risk factors have changed in response to the evolving global economic environment. It is plausible that low interest rates in core advanced economies and recurring fears about global financial stability have changed the behavior of currencies during risk-off episodes since 2007. We run two regressions, one with currency risk factors representing macroeconomic and balance of payments variables and a second regression with factors more closely associated with market pricing.

We then compare the impact of macroeconomic variables and market prices before and after 2007 by introducing interaction terms for each one of the variables with a dummy for the episodes since 2007. The pre-2007 period includes 3 risk-off episodes (October 2000, September 2001 and July 2002), and the post-2007 period includes 5 risk-off episodes (the August 2007 subprime crisis, Lehman‟s bankruptcy, the Greek crisis in May 2010, Japan‟s March 2011 earthquake and the confrontation over the U.S. debt ceiling), for a total of 8 risk-off episodes.

Table 6. Risk-off Depreciations, Before and After the Global Financial Crisis

Dependent variable: **Depreciation since the beginning of the risk-off episode**

Panel A. Regression with macroeconomic variables	Number of weeks since the episode started			
	1	**3**	**6**	**12**
Emerging market dummy	-0.384	0.126	0.533	3.604
	[0.696]	[0.836]	[0.863]	[1.372]
X After 2007	0.290	-0.790	-0.902	-3.084
	[0.532]	[0.91]	[1.067]	[1.667]
Interest rate before the episode	0.056	0.066	0.054	0.010
	[0.031]	[0.017]	[0.038]	[0.029]
X After 2007	0.128	0.193	0.346	0.474
	[0.036]	[0.113]	[0.135]	[0.165]
Current account balance (% GDP)	-14.270	-7.861	1.450	9.402
	[6.672]	[8.196]	[6.329]	[10.14]
X After 2007	11.070	-0.946	-7.501	-15.160
	[5.147]	[8.657]	[8.988]	[12.46]
Foreign portfolio inflows (% GDP), 4 quarters MA	0.165	0.225	5.231	4.286
	[2.302]	[3.164]	[2.907]	[3.161]
X After 2007	1.115	-0.943	-4.567	-2.919
	[1.778]	[2.792]	[3.391]	[4.062]
Number of observations	209	209	209	209
R-squared	0.44	0.39	0.63	0.63
Adjusted R-squared	0.40	0.34	0.60	0.60
RMSE	1.88	3.12	3.99	5.17

Panel B. Regression with market pricing variables	Number of weeks since the episode started			
	1	**3**	**6**	**12**
Emerging market dummy	-0.125	-0.128	-0.405	2.264
	[0.389]	[0.562]	[0.961]	[1.459]
X After 2007	0.544	1.016	1.906	0.484
	[0.389]	[0.554]	[1.016]	[1.702]
Beta with the AUDJPY exchange rate	1.618	-0.121	-0.596	-2.107
	[1.027]	[1.38]	[1.571]	[2.808]
X After 2007	0.330	8.564	9.979	13.940
	[1.253]	[1.766]	[2.478]	[6.205]
Beta with the VIX	11.080	12.970	12.920	7.239
	[3.483]	[3.41]	[6.939]	[5.526]
X After 2007	-10.520	-23.270	-25.650	-24.850
	[4.16]	[5.011]	[6.807]	[9.871]
Implied volatility	0.063	0.111	0.072	0.068
	[0.013]	[0.019]	[0.042]	[0.061]
X After 2007	-0.019	-0.023	0.144	-0.078
	[0.08]	[0.143]	[0.135]	[0.175]
Number of observations	209	209	209	209
R-squared	0.46	0.44	0.64	0.63
Adjusted R-squared	0.42	0.40	0.62	0.60
RMSE	1.84	2.99	3.89	5.15

Note: Regression constant and dummies for each one of the episodes not shown. Standard errors are robust with clustering at the currency level. Numbers in green shade are statistically significant at the 95 percent level (two-sided test) and higher levels of the variable support currency in risk-off episode. Orange background denotes risk-off depreciation. Sample coverage includes Argentina, Australia, Brazil, Canada, Chile, China, P.R.: Mainland, Colombia, Czech Republic, Denmark, Euro Area, Hungary, India, Indonesia, Israel, Japan, Republic of Korea, Malaysia, Mexico, New Zealand, Norway, Peru, Philippines, Poland, Romania, Russian Federation, Singapore, South Africa, Sweden, Switzerland, Thailand, Turkey, Ukraine, and United Kingdom.

In the specification with only macroeconomic and balance of payments variables, we find that for the 1, 3, 6, and 12 weeks horizons, the effect of the interest rate before the episode became substantially larger after 2007 (Table 6, panel A). Since the global financial crisis, high-yield currencies have depreciated more sharply during risk-off episodes. Moreover, the effect is larger the longer the horizon under consideration. We also find that macroeconomic variables explain an increasing proportion of risk-off depreciations when we lengthen the horizon of the risk-off episode. The adjusted R-squared on the regression increases from 0.40 in the first week of the risk-off episodes to 0.60 at the 12-week horizon!

Since the global financial crisis, cuts in G-3 policy rates have prompted many investors to increase their exposure to high-yield currencies. The increased importance of the policy rate in recent risk-off episodes could reflect investors‟ decisions to hedge or scale back positions when the VIX spikes. In addition, there were widespread losses on leveraged carry trades in high-yielding currencies in 2008, and investors are probably tracking more closely the extent to which a currency trades as a carry play.[28] The latter trend could be measured by a currency return‟s beta with the AUDJPY currency cross.

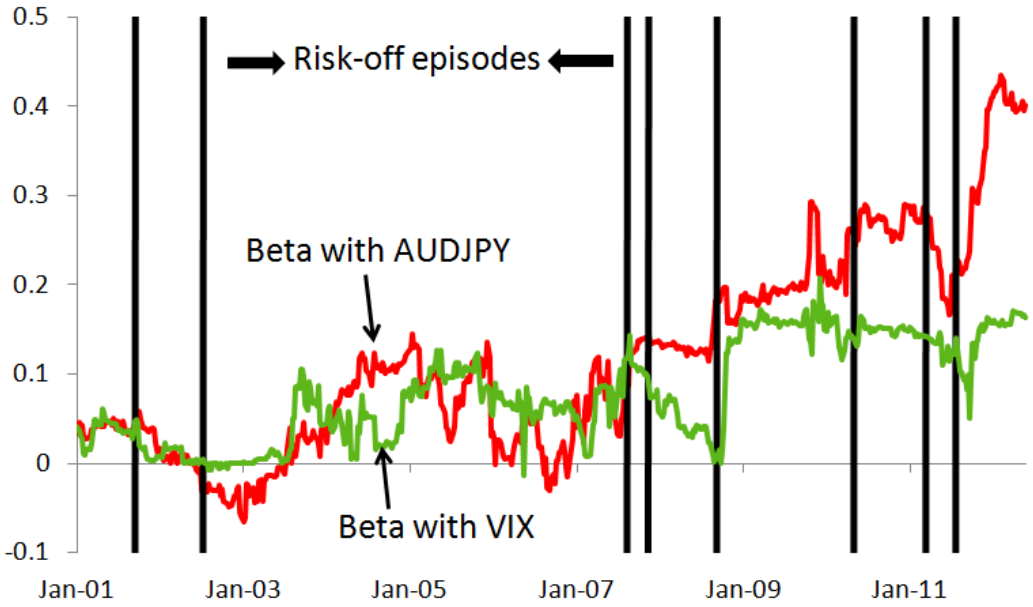
In fact, we find significant differences in the role of market prices in risk-off depreciations since 2007 (Table 6, panel B). The beta with the AUDJPY exchange rate is *only* significant in the post-2007 sample and predicts larger risk-off depreciations the longer the horizon. The adjusted R-squared on this regression also increases with time, from 0.42 in the first week to 0.60 for the 12-week sample. Similarly to the effect of the policy interest rate, the increasing importance of the beta with the AUDJPY may reflect the growing importance of the carry trade as a factor driving currency behavior during risk-off episodes. Figure 4 shows that the AUDJPY betas in our sample of EM countries have increased in recent years.

We also find a change in the signal of the beta with VIX post 2007. Prior to 2007, currencies with a higher beta with the VIX tended to depreciate relative to the USD during risk-off episodes, other things equal. Since 2007, however, the sign has flipped and currencies with higher VIX betas have in fact strengthened as the risk-off episode progresses. This indicates potentially large positive expected returns from investing in currencies with large VIX betas early on in a risk-off episode. This is consistent with the shape of the impulse response functions of some risk sensitive currencies in section III, showing that the Australian and New Zealand dollar that tend to suffer transitory depreciations during risk-off episodes.

The currency betas with the AUDJPY and VIX are positively correlated (Table A1 in the appendix). However, the median beta with the AUDJPY among emerging markets has trended up, but not the median beta with the VIX (Figure 4). A closer look at the betas of liquid EM currencies confirms this trend (Figure 5). Spot returns on select currencies have been behaving more like returns on the AUDJPY currency pair rather than returns on the VIX.

[28] Haldane (2011) argues that the financial crash of 2008 has left risk-takers psychologically scarred and has made them more willing to use simple heuristics such as risk-on/risk-off. This could increase contagion in financial markets.

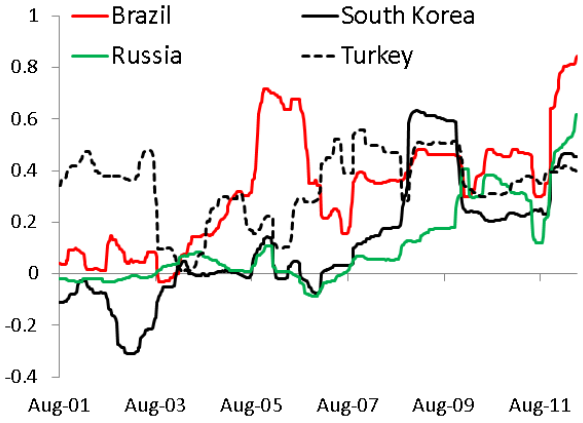
Figure 4. Median of EM Currency Return Betas with VIX and AUDJPY



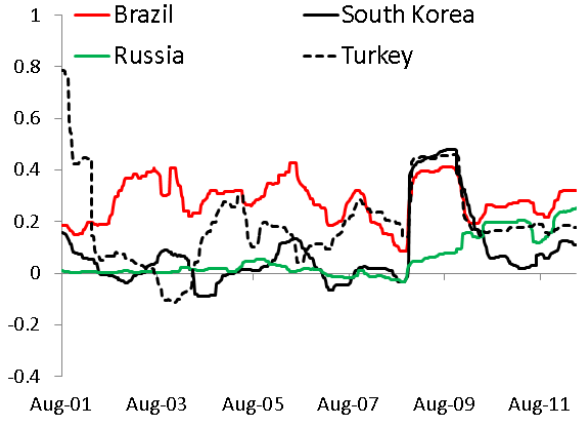
Note: Betas are the estimated coefficients in a regression of a currency"s weekly USD returns on the weekly return to the VIX or AUDJPY exchange rate using a sample of 52 weekly observations.
Source: Bloomberg and authors" calculations.

Figure 5. Currency Return Betas for Select EM

(a) Betas with AUDJPY



(b) Betas with VIX



Note: Betas are median values of past 3 months.
Source: Bloomberg and authors" calculations.

VI. CONCLUSION AND POLICY IMPLICATIONS

The cross-sectional behavior of exchange rates during risk-off episodes displays some recurring patterns. In this paper, we take a descriptive approach and document the behavior of exchange rates after spikes in the VIX, the option-implied volatility of equity prices, what we call risk-off episodes.

While there is heterogeneity in the cross-sectional behavior of exchange rates across risk-off events, the following patterns stand out. Right after the onset of the risk-off episode, high yield currencies and those whose returns have a higher beta with respect to the VIX or the AUDJPY exchange rate tend to have larger depreciations relative to the U.S. dollar. Stronger current account balances and net foreign asset positions are factors related to smaller risk-off depreciations or larger appreciations. Overvaluation in two out of three CGER models is a factor related to larger risk-off depreciations. While the increased frequency of risk-off episodes indicates that global factors have become more important, we would emphasize that country-specific factors remain essential in determining currency movements within a risk-off episode.

Looking at individual currencies, the Swiss franc and the Japanese yen tend to appreciate relative to the U.S. dollar during risk-off episodes. Because most other currencies depreciate relative to the U.S. dollar during risk-off episodes, the Swiss franc and the Japanese yen appreciate even more on a trade-weighted basis. On the other hand, a wide range of currencies, including those of Australia, Brazil, Canada, Chile, Colombia, India, Indonesia, Korea, Malaysia, Mexico, New Zealand, Peru, Philippines, Singapore, South Africa, Sweden, Turkey, Ukraine, and United Kingdom, tend to depreciate during risk-off episodes, for at least some horizon window.

Our findings could be helpful to policymakers. Knowing which currencies are most likely to appreciate or depreciate in future risk-off episodes is useful information for policymakers interested in the consequences of risk-off episodes for monetary policy and asset management. In countries with safe-haven currencies, risk-off episodes bring on challenges related to rapid currency appreciation, such as loss of export competitiveness and deflation risks (for the Swiss case, see de Carvalho Filho, 2012). In countries whose currencies are perceived as relatively risky, risk-off episodes may cause FX weakness, with possible consequences for inflation, and may be disruptive in some situations, if there is a high degree of “dollarization” of liabilities.

Figure 6. Impulse Response Functions, Effect of Risk-off Episode on Bilateral Exchange Rates Against the U.S. Dollar

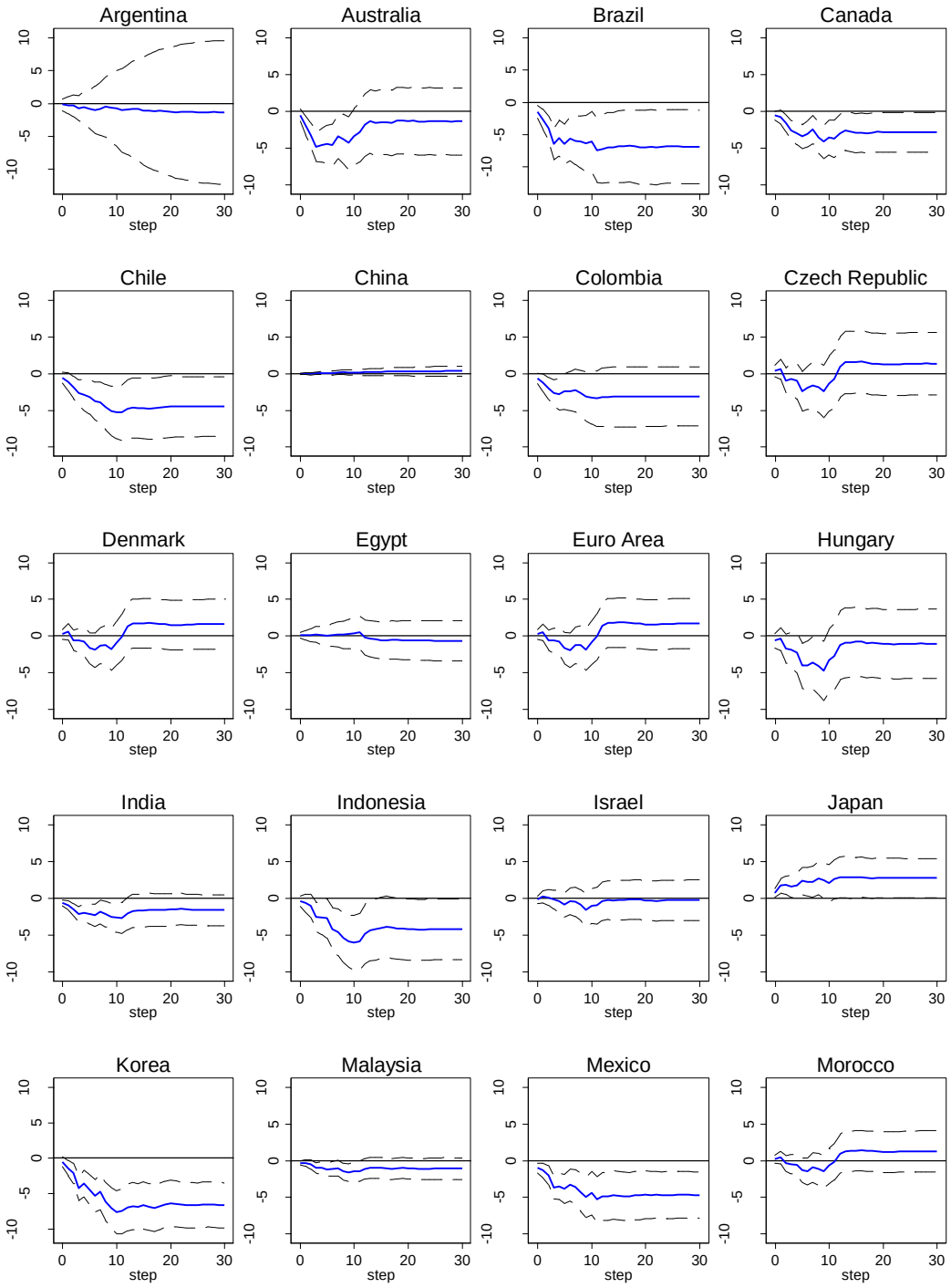
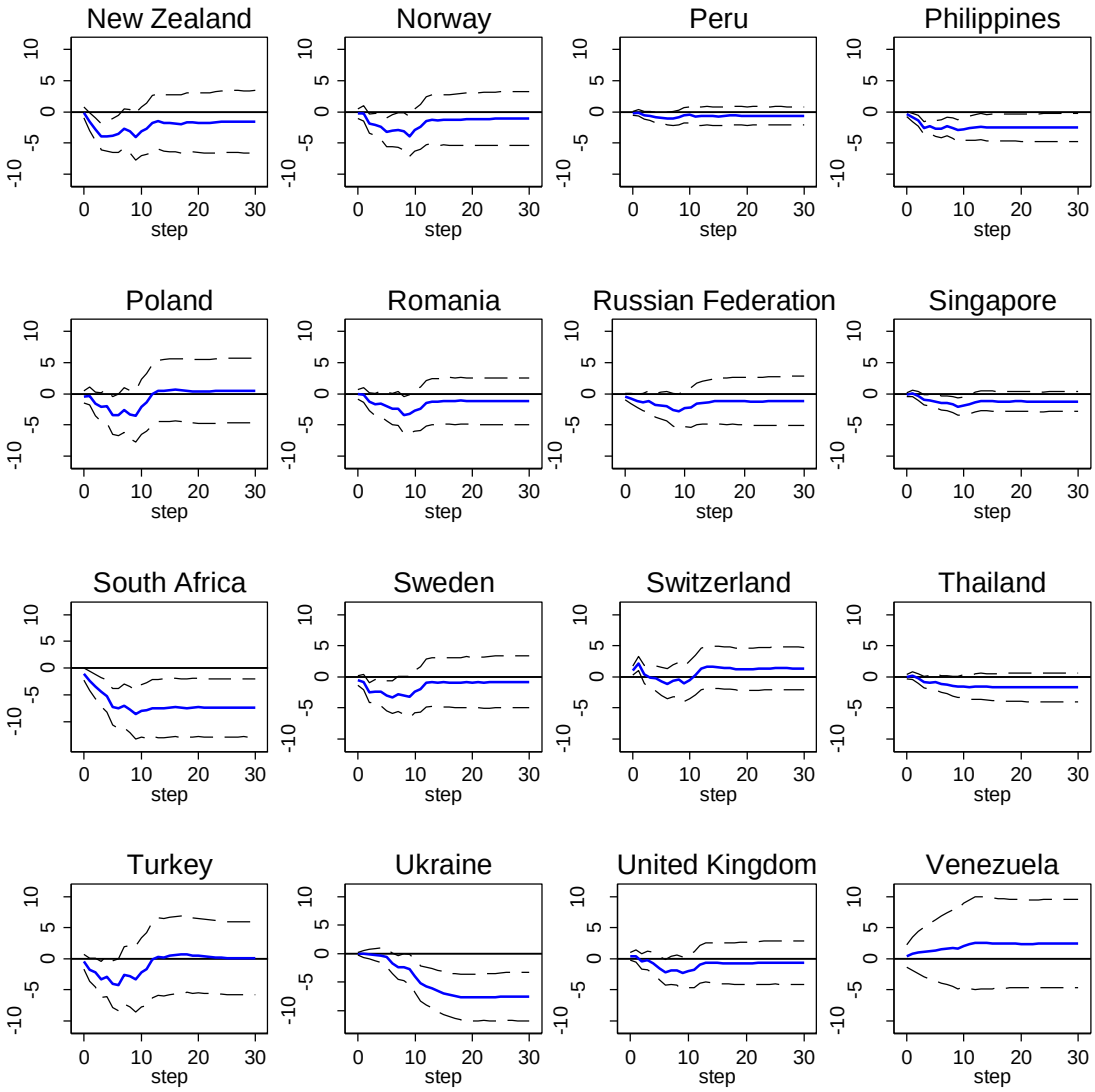


Figure 6 (continued). Impulse response functions, from risk-off to bilateral exchange rates against the U.S. dollar



step: weeks

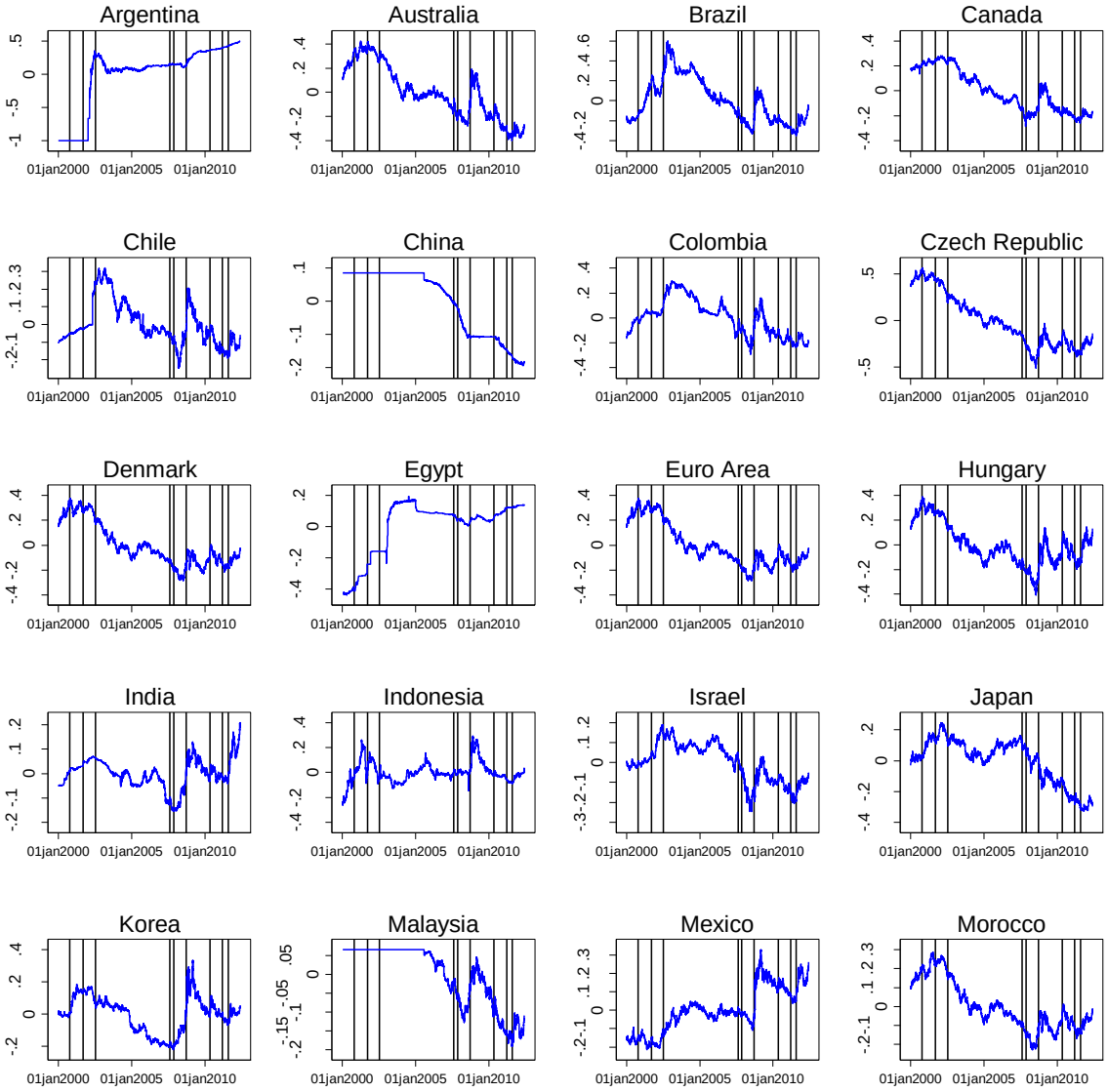
Appendix

Table A1: Volatility and Correlations of Key Variables

	EM	Inflation and Rates		External Sector			FX Misalignment			Sensitivity to Global Risks		Option Prices		Liquidity measures	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	EM dummy	Inflation	Policy rate	CA	NFA	Portfolio inflows	MB	ERER	ES	Beta VIX	Beta AUDJPY	Implied vol	Risk reversal	Bid-ask spread	Chinn-Ito
(1) Emerging market dummy	[0.46]														
(2) Inflation rate	**0.30**	[5.44]													
(3) Policy rate before the episode	**0.28**	**0.81**	[7.8]												
(4) Current account balance (% GDP)	-0.08	-0.09	-0.17	[0.06]											
(5) Net foreign assets (% GDP)	**-0.18**	**-0.13**	**-0.19**	**0.76**	[0.56]										
(6) Foreign portfolio inflows (% GDP), 4 q MA	**-0.44**	-0.18	**-0.23**	-0.08	0.05	[0.15]									
(7) MB misalignment	-0.06	0.05	**0.19**	**-0.63**	**-0.38**	0.13	[11.84]								
(8) ERER misalignment	-0.10	-0.11	0.04	**-0.36**	**-0.20**	**-0.02**	0.47	[14.71]							
(9) ES misalignment	-0.01	0.14	**0.24**	**-0.69**	**-0.41**	**0.22**	**0.85**	**0.45**	[13.32]						
(10) Beta with the VIX	0.10	0.10	0.04	**-0.23**	**-0.30**	0.07	**0.34**	0.14	**0.32**	[0.11]					
(11) Beta with AUDJPY exchange rate	-0.11	0.06	-0.04	**-0.29**	**-0.35**	**0.25**	**0.40**	**0.25**	**0.46**	**0.65**	[0.22]				
(12) Implied volatility of at-the-money option	0.00	**0.34**	**0.54**	**-0.26**	**-0.26**	**-0.14**	**0.55**	**0.21**	**0.49**	**0.14**	**0.13**	[5.95]			
(13) Risk reversal versus USD	0.09	**0.36**	**0.35**	**-0.38**	**-0.41**	0.09	**0.49**	0.12	**0.48**	**0.47**	**0.56**	**0.49**	[1.85]		
(14) Bid-ask spread, in bps	**0.30**	**0.35**	**0.41**	**-0.16**	**-0.22**	**-0.14**	0.06	0.08	0.15	**0.13**	0.00	**0.21**	**0.16**	[16]	
(15) Chinn-Ito measure of capital liberalization	**-0.61**	**-0.42**	**-0.42**	0.10	0.15	**0.24**	0.12	**0.26**	-0.04	0.11	-0.01	-0.19	**-0.26**	**-0.62**	[1.49]

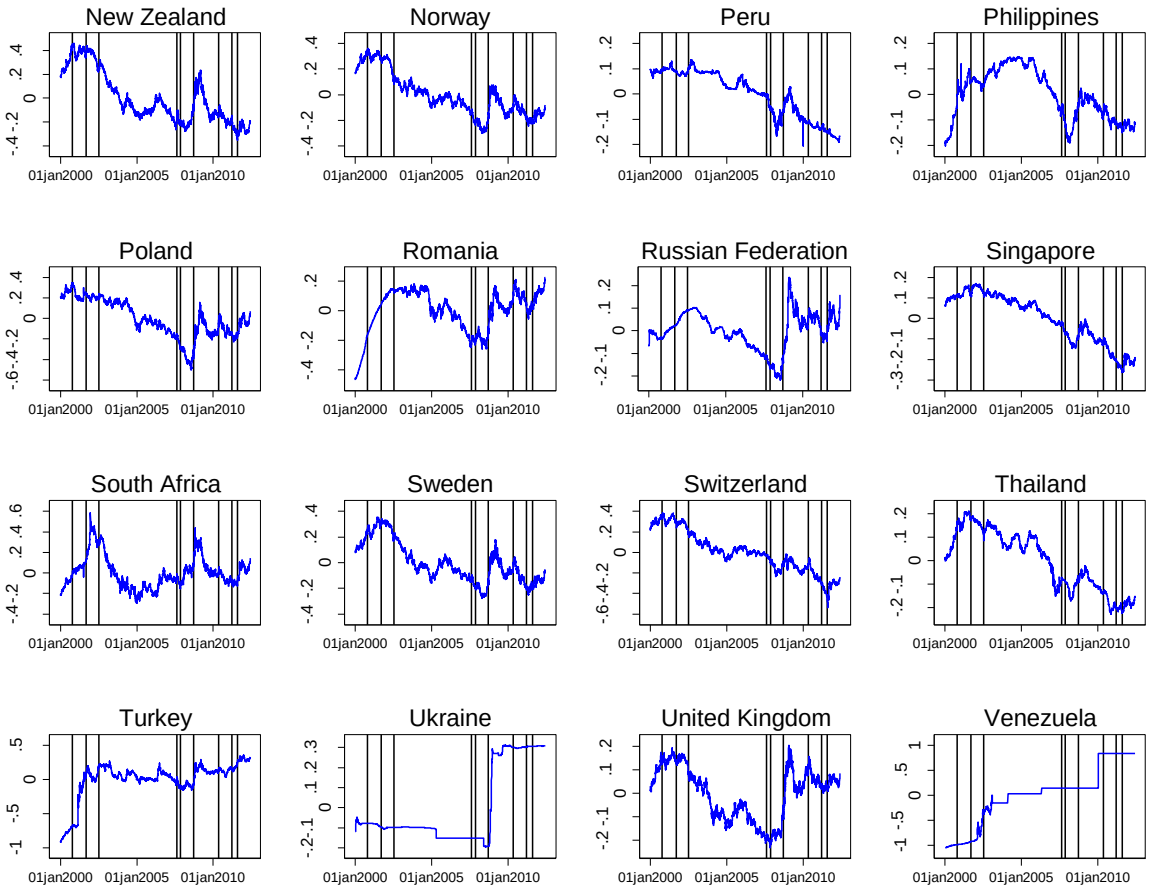
Note: Standard deviations are reported on the diagonal. Cells in bold denote that a t-test rejects the null hypothesis that a single correlation coefficient is equal to zero at the 95 percent level of confidence.

Appendix Figure A1. Exchange rates against the U.S. dollar and risk-off episodes



Notes: Exchange rates are expressed as log deviations from their average for 01Jan2000 to 04Jun2012.

Appendix Figure A1 (continued). Bilateral exchange rates against the U.S. dollar and risk-off episodes



Notes: Exchange rates are expressed as log deviations from their average for January 1, 2000 to June 4, 2012.

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