The Chilean peso exchange-rate carry trade and turbulence

Paulo Cox and José Gabriel Carreño

Abstract

In this study we provide evidence regarding the relationship between the Chilean peso carry trade and currency crashes of the peso against other currencies. Using a rich dataset containing information from the local Chilean forward market, we show that speculation aimed at taking advantage of the recently large interest rate differentials between the peso and developed-country currencies has led to several episodes of abnormal turbulence, as measured by the exchange-rate distribution's skewness coefficient. In line with the interpretative framework linking turbulence to changes in the forward positions of speculators, we find that turbulence is higher in periods during which measures of global uncertainty have been particularly high.

Keywords

Currency carry trade, Chile, exchange rates, currency instability, foreign-exchange markets, speculation

JEL classification

E31, F41, G15, E24

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I. Introduction

Between 15 and 23 September 2011, the Chilean peso depreciated against the United States dollar by about 8.2% (see figure 1). The magnitude of this depreciation was several times greater than the average daily volatility of the exchange rate for these currencies between 2002 and 2012.[1] No events that would affect any fundamental factor that influences the price relationship between these currencies seems to have occurred that would trigger this large and abrupt adjustment. This change occurred during a period of great global uncertainty in the context of the debate over the United States' debt ceiling that raged during the months of August, September and October of 2011, which was magnified by the Federal Reserve's announcement confirming that it expected to see a highly uncertain scenario for the United States economy in the week of 20 September.[2]

Before the debate about the debt ceiling had sparked increased global uncertainty and the sharp depreciation, there had been a moderate but sustained appreciation of the Chilean peso throughout August 2011. This gradual but steady appreciation, followed by a sudden and large depreciation, gave rise to relatively large skewness or asymmetry coefficients in the distribution of the daily variations in the exchange rate. In fact, the skewness coefficient for the Chilean peso/United States dollar exchange rate was 1.89 during the third quarter of 2011, when this event occurred.[3] Simultaneously, and most importantly, sudden movements in the forward positions held by non-resident traders (FPNRs) in the local currency market —primarily based on non-deliverable forward contracts (NDFs)— towards buyer positions[4] had reversed their trend during the preceding weeks and had begun to move towards seller positions (see figure 1), while interest rate differentials between the Chilean peso and the United States dollar were at record highs.[5] Indeed, comparing 16 Friday to 23 Friday of the following week, FPNRs had exhibited an accumulated drop of about US$ 2.3 billion, with an average daily drop of about US$ 570 million. This decrease represents almost twice the standard deviation of daily changes in net FPNRs for 2011.[6]

As is documented in work by Brunnermeier, Nagel and Pedersen (2008), changes in these positions can be associated with investors that use forward contracts in the currency market for speculative purposes, a popular strategy known as "carry trade".[7] Currency carry trades such as the

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1 The standard deviation of the daily variation in the exchange rate is 0.79 in the sample (2000-2012). The average daily depreciation during this episode was approximately 2.05%, which corresponds to more than 2.5 standard deviations.

2 The Economic Policy Uncertainty (EPU) Index for the United States built by Baker, Bloom and Davis (2015) reached a record high during August and September of 2011, substantially exceeding, for example, the level reached during the terrorist attack of 11 September 2001. For further details, see figure A1.1 in the annex or consult www.policyuncertainty.com/us_daily.html.

3 This figure represents the second-highest record in the sample (2002-2012). During the first quarter of 2011, the skewness of the daily variation in the exchange rate was 3.04. The monthly skewness coefficient for September 2011 was 1.02, the fourth-highest skewness coefficient in the entire sample.

4 This is from the point of view of local banks. A buyer carry-trade position, as seen from the point of view of a local bank, corresponds to a seller position from an investor's point of view.

5 The average interest rate differential was 5.1% in 2011 and 5.4% in the third quarter of that year. For the 2002-2012 sample as a whole, the average interest rate differential between the Chilean peso and the United States dollar was 2%. Figure A1.3 in the annex plots the relationship between the three-month interest rate differential and the level of exchange-rate volatility for the entire period.

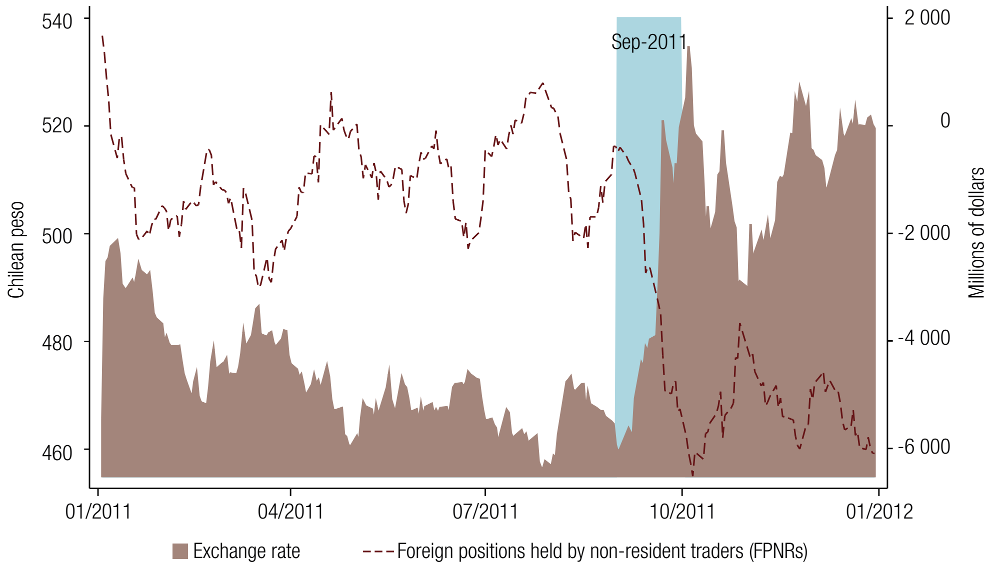
6 Note that 2011 was a particularly volatile year in terms of FPNRs.

7 A carry trader is an investor who borrows in a low-interest-rate currency and invests in a high-interest-rate currency. Since this type of investment is not undertaken for hedging purposes, it is associated with speculation. Carry trade and greater foreign participation in local currency markets are recent phenomena that have exhibited significant growth (see Alfaro and Kanczuk (2013)). Of course, there are also mechanisms other than trades in the non-deliverable forward contract (NDF) market that can be used to conduct carry trade investments. (We thank José de Gregorio for drawing our attention to this point.) And, of course, not only foreign investors are implementing these strategies: domestic traders speculate as well. We believe, however, that FPNRs provide a better approximation of the correlations that we want to study here. In addition, the different types of investors are easier to identify, especially in the Chilean case, by examining trades in the NDF market.

ones that are of interest to us here are an investment strategy whereby speculators exploit the interest rate differentials between two currencies by taking short positions (debt) in a low-interest-rate currency (the "funding currency") in order to invest ("go long") in a higher-interest-rate currency (the "investment currency"). Because this strategy is not used to cover exchange-rate depreciation nor employed for hedging trading positions, the carry trade is associated with speculative behavior. As is the case with any form of speculation, the carry trade is a double-edged sword. On the one hand, it provides liquidity to the foreign-exchange market and potentially leads prices towards their fundamental level, thereby improving the performance of trade and financial activities. On the other hand, speculation in the exchange rate can create risks that would not be present in situations in which these strategies could not be applied. These risk scenarios and their implications for monetary policy are heavily influenced by the institutional framework and the economic factors that are specific to each economy.[8]

Figure 1

Chilean peso/United States dollar exchange rates and forward positions of non-resident traders in non-deliverable forward contracts, 2011



Source: Prepared by the authors, on the basis of information from the Central Bank of Chile.

Like many other emerging economies, the Chilean economy is not free of these risks. To assess the potential risks (or lack of them) in the Chilean case, one of the many factors to be determined is whether the persistently large interest rate differentials existing between Chile and other advanced economies in recent years have given rise to a greater use of carry trade and, if so, whether this has sparked greater turbulence in the exchange rate or not.

Closely following work by Brunnermeier, Nagel and Pedersen (2008), the present study offers evidence on carry trade between the Chilean peso and the main currencies of advanced economies (particularly the United States dollar) that are traded in the local formal exchange market, and their effect on the skewness of daily changes in the exchange rate (our measure for turbulence). Based on a unique database of on-shore currency derivative transactions in the Chilean market, we study the behaviour of the forward positions of foreign investors and plot the relationships between those positions, on the

[8] Recent developments in such strategies have attracted a great deal of attention in the aftermath of the global financial crisis of 2008 and have fuelled concerns about the effect that low interest rates in developed economies could have on currency stability and the effectiveness of monetary policy in emerging countries. For an exploration of the implications of this recent development for the conduct of monetary policy, see Plantin and Shin (2011).

one hand, and interest rates differentials and the skewness of daily changes in the peso/dollar and peso/euro exchange rates, on the other.[9] The main results of these comparisons are of substantial interest and have not been fully documented before now.

First, we provide evidence that the Chilean peso has been exposed to crash risk: positive interest rate differentials are correlated with a positive conditional skewness of changes in exchange-rate movements. Second, there is a correlation that suggests a causal relationship between movements in the forward net position of foreign investors and the asymmetry coefficient (see figure 1). Finally, we show that an increase in global risk or risk aversion[10] coincides with reductions in the net forward positions of foreign investors, as suggested by the interpretation presented in Brunnermeier, Nagel and Pedersen (2008) and Brunnermeier and Pedersen (2009).[11] Crash risk discourages speculators from taking positions that are large enough to reverse interest rate parity and move it towards its equilibrium, which in turn explains the forward premium puzzle.

The rest of this article is organized as follows. In section II, we briefly review the relationship between the forward premium puzzle and carry trade and look at how this relationship has been addressed in the literature. In section III, we describe the data and present preliminary evidence on the relationship between carry trade, FPNR movements and the exchange rate. Section IV presents our results and section V concludes.

II. Related literature: the forward premium puzzle

One of the best-known empirical puzzles in the macroeconomic and financial literature is the forward premium puzzle,[12] which represents a violation of uncovered interest rate (UIP) parity. According to economic theory, when applied to the particular case of the foreign-exchange market, speculators in frictionless markets will arbitrage away any profit opportunity for exploiting interest rate differentials between two currencies. According to this principle, the currencies of economies with high interest rates (investment currencies) should tend to depreciate relative to the currencies of economies with lower interest rates (funding currencies). This hypothesis has been disproven empirically, however: on average, investment currencies tend to appreciate relative to funding currencies.[13]

In the seminal work by Engel (1996), which discusses this puzzle, the author concludes that traditional friction-free economic models are unable to solve this puzzle and suggests that new models which take into account other phenomena, such as the peso problem,[14] transaction costs or crash risk, among several other alternative hypotheses, should be seriously considered.

Thus far, several authors have attempted to explain the puzzle by following Engel's recommendation. Bacchetta and Van Wincoop (2010) and Mitchell, Pedersen and Pulvino (2007) point to market frictions that can block capital arbitrage. The first of these studies concluded that the excess return from carry trade is due to the infrequent review of investment decisions by investors, while the second study finds that financial constraints on speculators' investments create situations in

[9] Our study thus complements studies based on data from off-shore operations. This is particularly the case with regard to the study carried out by Brunnermeier, Nagel and Pedersen (2008).

[10] We use the Volatility Index (VIX), the spread between the London Interbank Offered Rate (LIBOR) and the Overnight Indexed Swap (OIS) rate (known as LOIS) and the Economic Policy Uncertainty (EPU) Index built by Baker, Bloom and Davis (2015) as proxies for uncertainty (2013).

[11] According to this interpretation, the impact of the event of September 2011 that was described above is not an isolated one.

[12] For a review and discussion of this literature, see Hodrick (1987) and Engel (1996).

[13] The hypothesis is shown to be false by, for example, Bekaert and Hodrick (1992). See the discussion of this subject in the seminal work of Fama (1984) or, more recently, in Burnside and others (2010).

[14] That is, the effects of inference of low-probability events that are not observed in the sample.

which price gaps remain in place for long periods of time. Burnside and others (2010) argue that the positive average pay-off on an unhedged carry trade reflects its "peso event" risk.[15]

Following an alternative argument, some authors suggest that carry trade returns reflect a form of compensation for the crash risk present in these strategies (Gyntelberg and Remolona (2007), Lustig, Roussanov and Verdelhan (2008), Gromb and Vayanos (2010) and Jurek (2014)). For instance, Jurek (2014) finds that the crash risk premium accounts for at least one third of the excess return on currency carry trades. In line with this approach, Brunnermeier, Nagel and Pedersen (2008) study carry trades and currency crashes involving the United States dollar and apply the more general theoretical framework proposed in Brunnermeier and Pedersen (2009) in order to explain general liquidity problems. In this study, we test the hypothesis suggested in Brunnermeier, Nagel and Pedersen (2008) and in Brunnermeier and Pedersen (2009). This hypothesis says that sudden and abrupt exchange-rate depreciations which cannot be tied to news events concerning fundamentals are caused by the unwinding of carry trades when speculators approach the thresholds of their funding constraints. According to this hypothesis, large interest rate differentials encourage speculators to take positions which, in the absence of frictions, would bring profitable opportunities to an end. However, the crash risk discourages the same investors from taking positions that would completely close that profit window.

III. Data and preliminary evidence

In the following section, which deals with the results of our research, we will focus on the Chilean peso exchange rate *vis-à-vis* the most commonly traded foreign currencies in the Chilean local market: the United States dollar and the euro.[16] In this section, however, we will also look at other currencies for which data are available,[17] in addition to the dollar and the euro. We collect daily nominal exchange rates against the Chilean peso and three-month interest rates for the following currencies:[18] the United States dollar, the euro, the British pound, the Brazilian real and the Australian dollar. These are the most commonly traded currencies in the Chilean on-shore market.[19] We consider the period running from the first quarter of 2002 to January 2012.

1. The variables

We define the following variables:

Logarithm of the nominal exchange rate (s_t): the exchange rate corresponds to the number of Chilean pesos that are equivalent to one unit of foreign currency. The log of the nominal exchange rate is then defined as:

$$s_t = log(nominal\ exchange\ rate)$$

[15] The term "peso event" refers to an event that is unlikely to occur but that would involve a large change if it were to happen.

[16] These two currencies comprise approximately 99% of all transactions involving foreign investors in the local market.

[17] This allows us to analyse whether currencies with significant interest rate differentials with respect to the Chilean peso are used as investment or funding currencies in carry trade investment strategies. According to the hypothesis advanced by Brunnermeier and Pedersen (2009), we should not observe their use for this purpose when the incentive for undertaking this type of investment strategy is low.

[18] To build the three-month interest rate differentials with respect to the Chilean peso, we use the 90-day prime rate cap and the 90-days British Bankers' Association (BBA) London Interbank Offered Rate (LIBOR) for the United States dollar, the British pound, the euro and the Australian dollar. Exchange rates are obtained from Bloomberg terminals.

[19] In an earlier version of this study, we also included the Peruvian sol, the Colombian peso, the New Zealand dollar, the Norwegian krone, the Mexican peso, the Japanese yen and the Canadian dollar. The results discussed in this section are consistent with the inclusion of these currencies.

Carry (interest rate differential) $\left(i_t^* - i_t\right)$: the difference between i_t^*, which denotes the logarithm of the domestic rate in period t (the foreign interest rate from the point of view of a foreign investor), and i_t^*, which denotes the logarithm of the foreign (investor's) economy's interest rate (associated with the currency being exchanged).

Carry trade return (z_t): The *ex post* return on investment denominated in a foreign currency that is financed with domestic debt (in pesos), where:

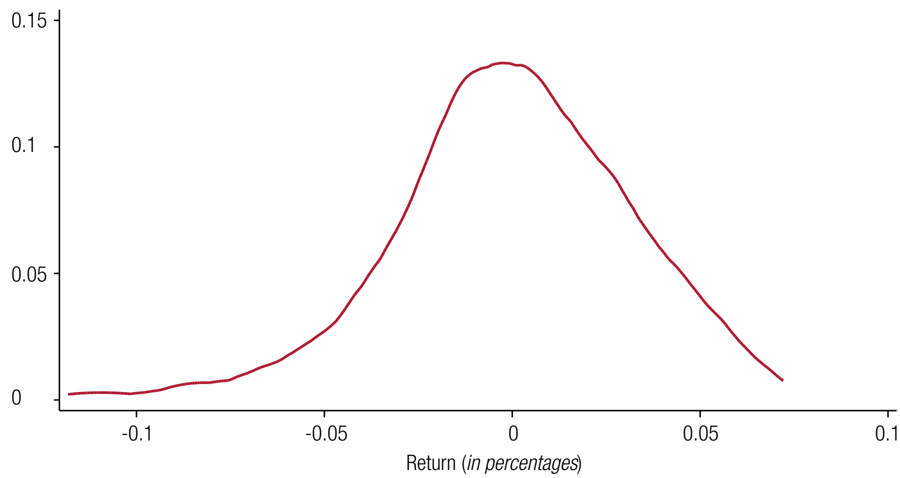
$$z_{t+1} = i_t^* - i_t - \Delta s_{t+1}$$

where:

$\Delta s_{t+1} = s_{t+1} - s_t$. The return is calculated from the perspective of a non-resident trader who invests in Chilean pesos and finances his/her positions in a foreign currency. Thus, the final return from this strategy is computed in units of foreign currency.

Asymmetry or skewness coefficient ($Skew_t$): the skewness coefficient (third moment of the distribution) of the daily change in the exchange rate, expressed on a quarterly basis. A negative skewness indicates that the tail on the left side of the probability distribution is longer than the one on the right side and that the bulk of the values lie to the right of the variable's mean (see figure 2). A positive skewness, conversely, indicates that the tail on the right-hand side of the probability distribution is longer than the tail on the left-hand side and that the bulk of the values lie on the left-hand side of the distribution. A zero value indicates that the values are equally distributed on both sides of the mean.

Figure 2
Distribution with negative skewness



Source: Prepared by the authors, on the basis of information from the Central Bank of Chile.

Foreign investors' non-deliverable forward net positions ($FPNR_t$): the net positions of non-residents in currency derivatives between the foreign currencies and the Chilean peso using NDFs.[20] For this variable, we have relevant information only for transactions based on the exchange rates between the Chilean peso and the United States dollar and between the Chilean peso and the euro.

[20] In 2013, the Bank for International Settlements Triennial Central Bank Survey showed that NDFs constitute only a fifth of the global foreign-exchange market in outright forwards and a tiny fraction of overall foreign exchange trading. In the case of the Chilean peso, NDF transactions represent almost 90% of the transactions in the forward market (Salinas and Villena (2014)).

Throughout this study, FPNRs are analysed from the perspective of local banks. Accordingly, non-residents' buyer positions represent trades in which these investors are buying Chilean pesos or selling dollars (Chilean banks, on the other hand, are buying dollars or selling Chilean pesos). Positive values for this variable indicate that the foreign currency (dollar) is being used as a "funding currency" and the domestic currency (the peso) as an "investment currency."

This variable is the most important one in our study and is used as a proxy for carry trade activity. To construct this variable, we use information reported to the Central Bank of Chile on a daily basis[21] by commercial banks operating in the formal exchange market.[22] Chile requires all currency derivative transactions (mostly NDFs) to be reported to the central bank by the entities authorized to conduct such operations in the formal exchange market. Those reports must detail the counterparts' identities, the notional amounts, the type of compensation scheme, the expiration date and the price. Thus, the opacity that usually characterizes information in over-the-counter markets is not a factor here thanks to the nature of foreign exchange regulations in Chile.[23]

2. Carry trade and the asymmetry of changes in the exchange rate: preliminary evidence

Table 1 shows summary statistics for the main variables in our study for the five major currencies traded in the local currency derivative market. We note that there is a positive cross-section correlation between the average interest rate differential $i_t^* - i_t$ and the average excess return z_t, which implies a violation of the uncovered interest parity (UIP) condition. The largest average excess return (in United States dollars), for example, had the highest average interest rate differential in the sample.

An investor taking a long carry-trade position in Chilean pesos, financed with debt in United States dollars, would have earned the quarterly average of the interest rate differential —of 0.004 (i.e. an annualized return of 1.61%)— plus a quarterly excess return on the exchange rate of about 0.003 (1.21% per year) during the period covered in our sample. However, at the same time, the investor would have been exposed to a positive skewness of 0.049.[24]

In the last row of table 1, we report FPNRs. A negative position means that, in the aggregate, speculators hold a net selling position in dollars; conversely, positive positions imply that this group of investors constitute a net buyer. If the positions were predominately composed of carry trade, net FPNRs would be positive, on average. This is not what we observe in table 1. Thus, there are transactions other than speculative ones, such as hedging, for instance, which overshadow the carry trade transactions. However, as mentioned above, what interests us here is not the level of FPNRs, but the change in these positions from one period to another and the relationship between these changes, on the one hand, and the interest rate differentials and the skewness coefficient, on the other.

[21] The central bank collects information on spot transactions and derivative contracts that are concluded by banking firms and other institutions belonging to the formal exchange market in both the local and off-shore markets. This information is collected in accordance with the Compendium of Foreign Exchange Regulations Manual. For more details about the depth, liquidity and size of the formal exchange market and its recent development, see Ahumada and Selaive (2007) and Salinas and Villena (2014).

[22] The positions at the end of every month are published by the Central Bank of Chile.

[23] Throughout most of the period considered in our study, aggregate FPNRs were negative, which indicates that, in aggregate terms, the FPNR variable does not reflect the implementation of carry trade strategies. However, it is the *change* in these positions which interests us here.

[24] We also note from the table that the bulk of "speculative" (that is, involving foreign investors) transactions are between the Chilean peso and the United States dollar, with a smaller volume of transactions involving the Chilean peso and the euro. Other currencies will not be discussed in the remaining sections of this study because the transactions involving these currencies are so sporadic.

Table 1
Descriptive statistics (means): quarterly data for the period 2002Q1-2012Q1

	USD	EUR	GBP	BRL	AUD
Δs_t	-0.003	0.001	-0.003	0.001	0.005
z_t	0.007	0.002	0.004	-0.01	-0.006
$i^*_{t-1} - i_{t-1}$	0.004	0.002	0.001	-0.01	-0.001
Skewness	0.0049	0.113	0.076	-0.023	-0.081
FPNR	-2 290	-49	...	...	...

Source: Prepared by the authors, on the basis of information from the Central Bank of Chile.
Note: USD: United States dollars; EUR: Euros; GBP: British pounds; BRL: Brazilian reais; AUD: Australian dollar. Δs_t is the change in the logarithm of the exchange rate (Chilean pesos per unit of foreign currency). z_t, when the three-month interest rate differential is positive, is the return on investment in a long position in the local currency financed by a loan in foreign currency. When the difference is negative, it is the reverse. FPNRs are the net (long-short) forward positions of non-residents, in billions of pesos, considering NDF contracts only; FPNR data are for United States dollars since 2003Q1. Data for euros are for the period beginning in 2006Q2. A positive net FPNR implies that non-residents are, in the aggregate, making commitments to buy Chilean pesos in order to engage in carry trade.

Using information from table 1, in figure 3 we show the relationship between the carry trade, its return (panel 3A) and the skewness coefficient (panel 3B).[25] In line with the uncovered interest parity condition, the average return must be zero. However, there is a positive correlation between the average interest rate differentials and the excess return, which violates that condition (panel 3A). This relationship is in line with work done by Jurek (2014), who, using a sample of the Group of Ten (G10) currencies, finds that currency carry trade delivers significant excess returns, with annualized Sharpe ratios equal to or greater than those of equity markets (1900-2012). The evidence shown in both table 1 and figure 3 (panel 3B) also suggests that there is a positive relationship between skewness and average interest rate differentials. This positive correlation implies that the carry trade is subject to a positive skewness (crash risk) i.e. the Chilean peso is exposed to a sharp depreciation against the United States dollar and other currencies. We also note in table 1 that the skewness coefficient is negative for those currencies for which the interest rate differential is negative, such as the Brazilian real and the Australian dollar. This is consistent with the interpretation presented by Brunnermeier and Pedersen (2009).

Another way of obtaining evidence on excess returns and their correlation with the asymmetry coefficient is by analysing the distribution of the excess return z_t conditional on the interest rate differentials $i^*_{t-1} - i_{t-1}$ (figure 4), with the observations grouped according to the following ranges of differentials: $i^*_{t-1} - i_{t-1} \leq$-0.0035; -0.0035 $\leq i^*_{t-1} - i_{t-1} \leq$-0.0035; and $i^*_{t-1} - i_{t-1} \geq$-0.0035.

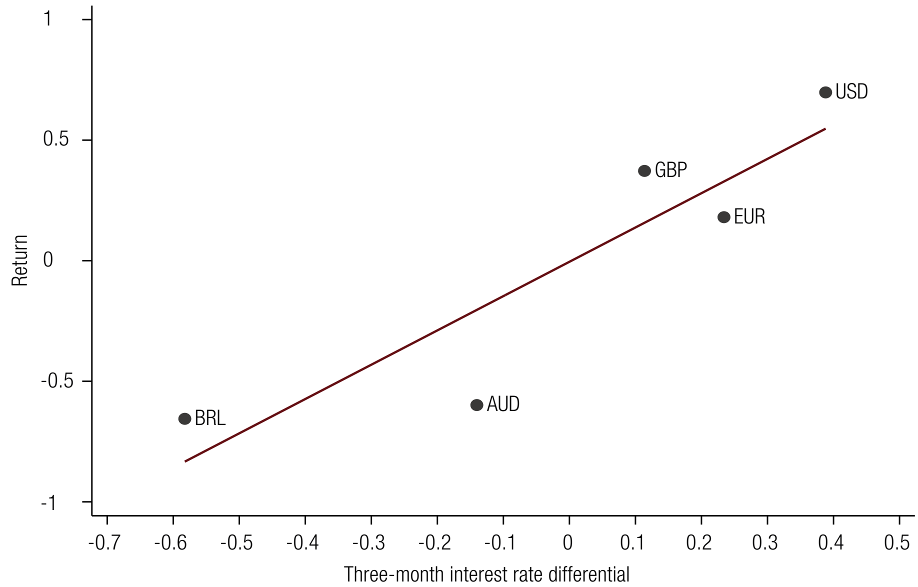
We note from figure 4 that, in the case of significant interest rate differentials (blue dashed line),[26] the distribution of the excess return is, on average, positive and exhibits a long tail on the left-hand side, evincing the asymmetry of the change in the exchange rate (skewness). Conversely, when interest rate differentials are negative, we do not observe skewness in the return's distribution, since, for these currencies, the incentive to conduct carry trade with the Chilean peso is weaker, as is the case with the Brazilian real, as well. With respect to interest rate differentials around zero, we see that the distribution is centered at zero and symmetrical. All this confirms the existence of crash risk in carry trade transactions.

[25] For more details on all the values observed, by currency and quarter, see figures A1.1 and A1.2 in the annex.

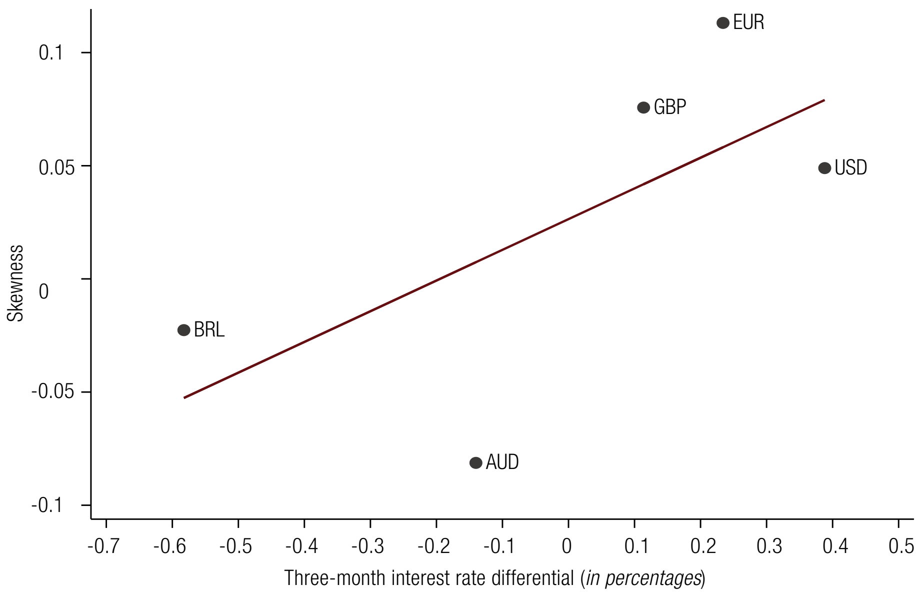
[26] Both the United States dollar and the euro belong to this group.

Figure 3
Cross-section empirical return, skewness and three-month interest rate differentials, quarterly data for the period 2002Q1-2012Q1

A. Returns
(In percentages)

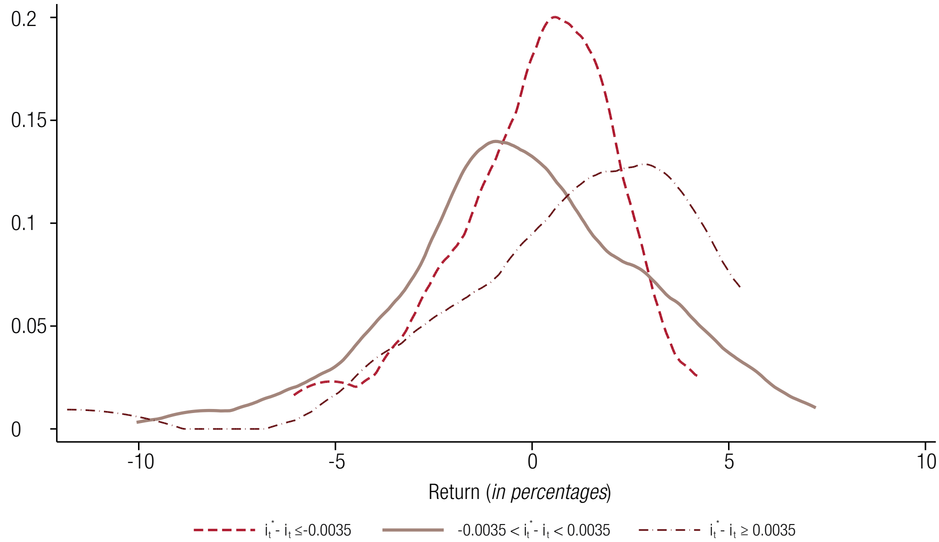


B. Skewness



Source: Prepared by the authors, on the basis of information from the Central Bank of Chile.
Note: USD: United States dollars; EUR: Euros; GBP: British pounds; BRL: Brazilian reais; AUD: Australian dollar.

Figure 4
Kernel distribution of the return z_t as a function of interest rate differentials (after removing fixed effects) for the period 2002Q1-2012Q1



Source: Prepared by the authors, on the basis of information from the Central Bank of Chile.
Note: Data are for the United States dollar, euro, British pound, Australian dollar, Brazilian real, Peruvian sol, Colombian peso, New Zealand dollar, Norwegian krone, Mexican peso, Japanese yen and Canadian dollar.

To sum up, the evidence provided here, for a cross-section of currencies, points to a positive relationship between interest rate differentials and the risk of currency crashes. However, these results correspond to correlations between variables that may or may not be systematically related. The following analysis will exploit the time series, adding information on speculators' transactions, with the object of testing empirically the hypothesis put forward by Brunnermeier and Pedersen (2009).

IV. Results

1. The relationship between the currency carry trade and turbulence in the exchange rate

We begin by studying the predictors of large corrections in the exchange rate. In particular, we focus on interest rate differentials and carry trade activity. As a proxy for crash risk, we use the skewness coefficient ($Skew_t$), the dependent variable. Using simple linear regressions, we test whether the FPNR coefficient and lags of the dependent variable are significant predictors of crash risk in relation to the exchange rate. An increase in interest rate differentials affects crash risk positively. We thus expect a positive sign for its coefficient. A buyer FPNR position (carry trade activity with the Chilean peso), moreover, increases this risk, and we therefore expect a positive sign in this coefficient as well. Finally, we expect a positive sign in the lagged dependent variable's coefficient, as a higher level of risk in the past should discourage very aggressive short positions in the present.

Specifically, we consider the following panel regressions:

$$Skew_{jt+1} = \beta_1 Skew_{jt} + \beta_2 \left(i_{jt}^* - i_{jt} \right) + \beta_3 FPNR_{jt} + \beta_4 X_{jt} + \alpha_j + \varepsilon_{jt} \qquad (1)$$

where j is a given country and t a given quarter. X_{jt} is a vector of controls that, depending on the specification, may include: z_{jt}, the carry trade's return; $BCCH_t$, which is a dummy that takes a value of 1 if, in the corresponding quarter, the central bank either announced a currency intervention or intervened in the exchange market, and 0 if not; $log(Copper)$, the log of the price of copper (cents of United States dollars/pound) reported in the London Metal Stock Exchange; $log(Oil)$ the log of the nominal price of oil reported in the New York Mercantile Exchange (NYMEX); the Emerging Markets Bond Index (EMBI), which is the weighted average of sovereign spreads for a large group of emerging-market economies and is intended to control for country risk changes; and, finally, α_j and ε_{jt}, which correspond to the currency's fixed effect and the disturbance term, respectively. The results are shown in table 2.[27] The first three columns show that the carry trade $(i_t^* - i_t)$ is a strong predictor of future skewness. We also find that the lag of the $Skew$ variable has a negative coefficient, which suggests a reversion to the mean in this variable. We also find that the FPNR coefficient is positively correlated with future skewness.

Table 2
Currency crash predictors

	$Skew_{t+1}$	$Skew_{t+1}$	$Skew_{t+1}$	$Risk\ Reversal_t$
$i_{t-1}^* - i_{t-1}$	57.34***	57.07***	53.31***	113.9***
	(13.22)	(12.82)	(0.501)	(9.182)
$FPNR_t$	0.0373***	0.0304***	0.128***	-0.257***
	(0.00153)	(0.00924)	(0.0443)	(0.0148)
$Skew_t$	-0.148***	-0.151***	-0.186***	-0.461***
	(0.0248)	(0.0154)	(0.0415)	(0.0688)
$BCCH_t$	0.848***	0.831***	0.765***	-0.618***
	(0.0609)	(0.0369)	(0.0745)	(0.0334)
z_t		2.651	1.631	-14.57***
		(3.016)	(1.092)	(2.545)
$\log(Copper)$			0.338***	-0.560
			(0.119)	(0.836)
$\log(Oil)$			-0.108	1.842***
			(0.119)	(0.448)
EMBI			-0.176	1.258***
			(0.427)	(0.130)
Observations	62	62	62	51
R^2	0.240	0.254	0.304	0.531

Source: Prepared by the authors, on the basis of information from the Central Bank of Chile and data from Bloomberg.
Note: Panel regressions with country fixed effects and quarterly data for 20032Q1-2012Q1. FPNR data include NDF contracts only, in billions of dollars. Risk reversals are the implied volatility difference between one-month foreign currency call and put options. Panel data are for United States dollars starting from the first quarter of 2002 and for euros starting from the second quarter of 2006. Risk reversal data are for United States dollars starting from the first quarter of 2005 and for euros starting from the third quarter of 2006. Clustered standard errors are shown in parentheses: *** p<0.01; ** p<0.05; * p<0.1.

We have included a dummy variable in all specifications for the central bank's intervention, which is positive and significant. Announcements or interventions by the central bank have been shown to increase the risk of currency collapse. To the extent that increases in $Skew_{t+1}$ arising from

[27] To facilitate the reading and interpretation of the FPNR coefficients in this table, we have expressed this variable in billions of dollars. In the rest of the article, this variable is expressed in millions of dollars.

these announcements result in a lower degree of speculation, this result is useful for the control of exchange-rate turbulence, but must be analysed further.

We emphasize that all these results are consistent with evidence discussed in the previous sections. The second column shows that the currency return, z_t, has the expected sign (positive carry trade returns prompt investors to take positions), although the coefficient is not significant, possibly because the FPNR coefficient is strongly correlated with the return.

Note that the relationship between the FPNR coefficient and the skewness coefficient (Skew) is robust to the inclusion of fundamentals that are traditionally included in long-term models for the Chilean peso/United States dollar exchange rate, such as the price of copper, the price of oil and EMBI. Of these three variables, the price of copper is the only control variable that is statistically significant when regressed on the exchange rate's skewness.[28]

As another robustness check, we include the risk reversal variable (in the last column in table 2) as an alternative dependent variable for crash risk. The risk reversal is a measure of the implied volatility in the difference between a one-month foreign currency call option and a one-month foreign currency put option.[29] The price, then, reflects the cost of insurance coverage for changes in the exchange rate. The higher the crash risk, the higher its price will be. As expected, both the carry and the lagged skewness variable are significant and have the expected signs. The FPNR coefficient is negative and significant. It thus has the opposite sign to the theoretical one, possibly because the effect of a higher carry on this variable at time period t is already captured by the interest rate differential. These results are similar to those reported by Hutchison and Sushko (2013), who find a close link between risk reversals and speculative futures positions in the Japanese yen. Something similar occurs with return z_t.

Having established the empirical relationships among the carry trade, the skewness and FPNRs, in the following section we study the dynamic relationship among these three variables in detail using an autoregressive vector analysis.

2. Autoregressive vector analysis: the case of the Chilean peso-United States dollar carry trade

In this section we estimate a second-order autoregressive vector analysis focusing exclusively on transactions involving the United States dollar. This analysis allows us to study the systematic and dynamic relationship between the interest rate differential, the carry trade return, the positions of speculators (FPNR) and the skewness coefficient in the context of the carry trade between the Chilean peso and the United States dollar. We use monthly data for the period 2002m1-2012m1. The shocks underlying the impulse response function are based on a Choleski decomposition based on the following order: $i_t^* - i_t$, z, $Skewness$ and FPNR.[30] All variables are filtered using the Hodrick-Prescott method for decomposition of the cyclical component of the series.

[28] The fact that the Chilean peso has the status of a commodity currency suggests that the trend of this fundamental must be taken into account in the episode described in the introduction. Indeed, the price of copper, which is the main factor behind trends in the Chilean peso/United States dollar exchange rate, both in the short and long run, depreciated by about 12% during this episode (see the introduction). However, it should not be forgotten that this price is also affected by global uncertainty. It seems implausible, in fact, that uncertainty in the United States was caused by news concerning the price of copper during this episode. Evidence regarding the role of copper in recent misalignments of the exchange rate can be found in Wu (2013), where the author identifies several recent episodes in which fundamentals, in particular the price of copper, fail to explain distortions in short-term changes in the exchange rate. The evidence reported in this study backs up those findings, since it indicates that the identified exchange-rate misalignments have been caused by turbulence induced by the United States dollar/Chilean peso carry trade.

[29] The table shows a smaller number of observations for the specification using risk reversal as the dependent variable. This is due to data availability.

[30] This order is consistent with the theory on which our main workhorse hypothesis is based, i.e., that of Brunnermeier and Pedersen (2009).

Figure 5 reports the impulse response of a one-standard-deviation shock on the interest rate differential, using 95% confidence intervals. Panel 5C in figure 5 shows that the FPNR coefficient is closely related to the interest rate differential (panel 5A). Large spreads induce higher carry trade activity, triggered by an increase in the expected return for investors who use the Chilean peso as an investment currency and the United States dollar as a funding currency.

An increase in carry trade transactions has two effects on skewness ($Skew_t$). On the one hand, it generates an appreciation of the exchange rate; on the other, this appreciation incubates crash risk. The latter is reflected in the increased likelihood of abrupt adjustments in the exchange rate (an increase in positive skewness). Indeed, the bulk of the distribution of changes in the exchange rate shifts towards appreciation events, while the tail on the right-hand side of the distribution thickens due to the increase in crash risk events having a lower frequency but larger magnitude. This larger skewness effect is caused by a withdrawal (unwinding) of speculative positions, which in turn induces a "spiral loss." This increase in the risk of collapse leads investors to unwind positions or to not continue investing as much as they did before the shock. Panel 5D in the figure shows that, as the volume of carry trade transactions grows bigger (panel 5C), we first observe an increase in the skewness coefficient, followed by a gradual decline which converges towards pre-shock levels as the positions of the speculators recoil towards their initial level.

When interpreting the results of the autoregressive vector analysis, it is important to bear in mind that the impact of carry trade on the exchange rate would probably be much larger if we conditioned it on periods that exhibited greater carry trade activity (periods, for instance, during which interest rate differentials were particularly large). Indeed, for much of the relevant period, i.e. between 2002 and mid-2007, currency derivatives were not being used to any significant degree, probably because they were not, at that time, an attractive investment. Throughout the period, this effect tends to reduce the impact captured by an unconditional autoregressive vector analysis on the sample as a whole.

Figure 5

Impulse response functions from an autogressive vector analysis (2) for a one-standard-deviation shock to interest rate differentials for the period 2002m1-2012m1

A. Impulse

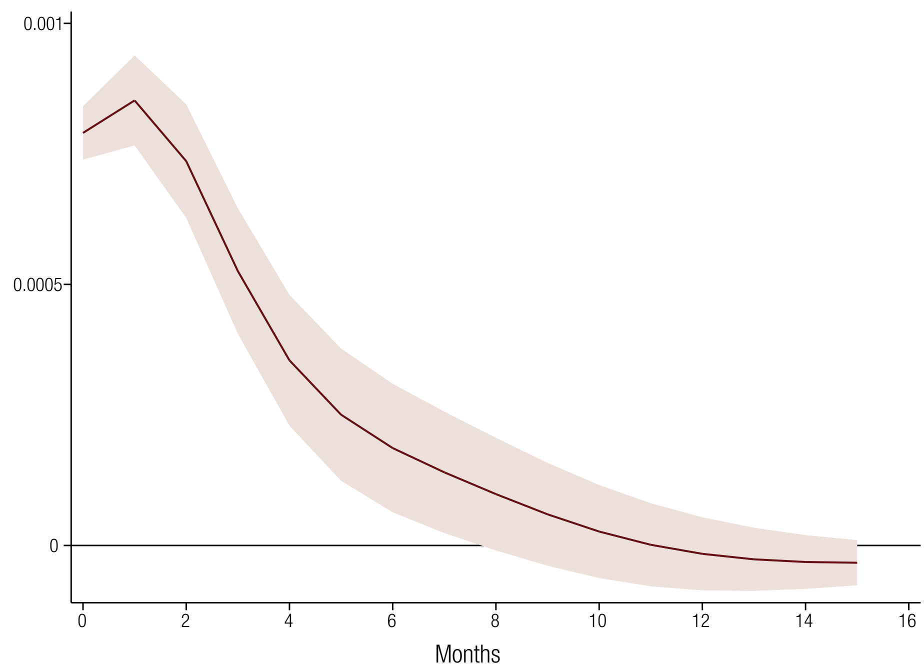
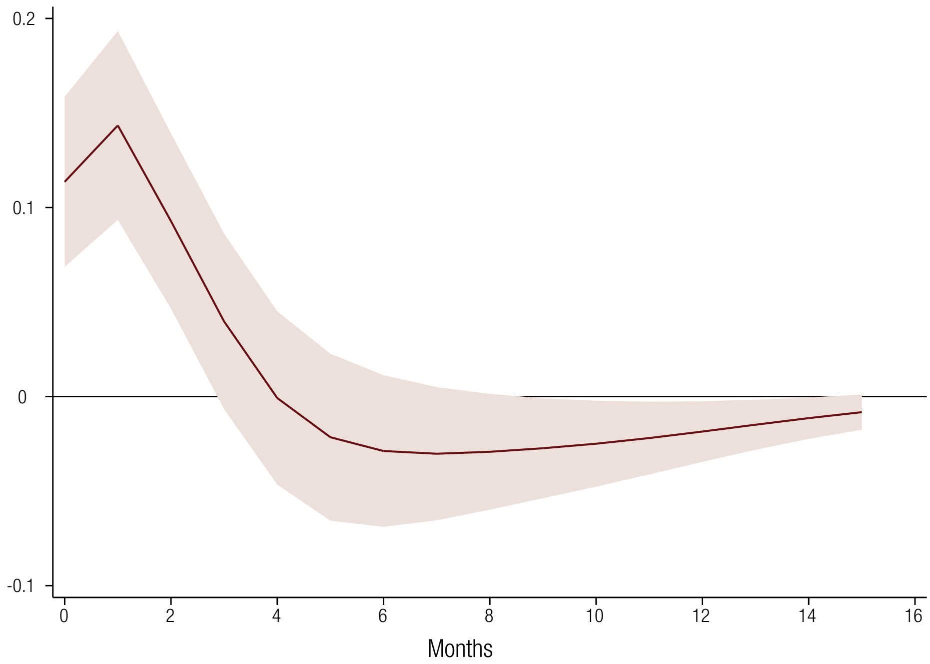


Figure 5 (continued)

B. Return on carry trade



C. Forward positions held by non-residents

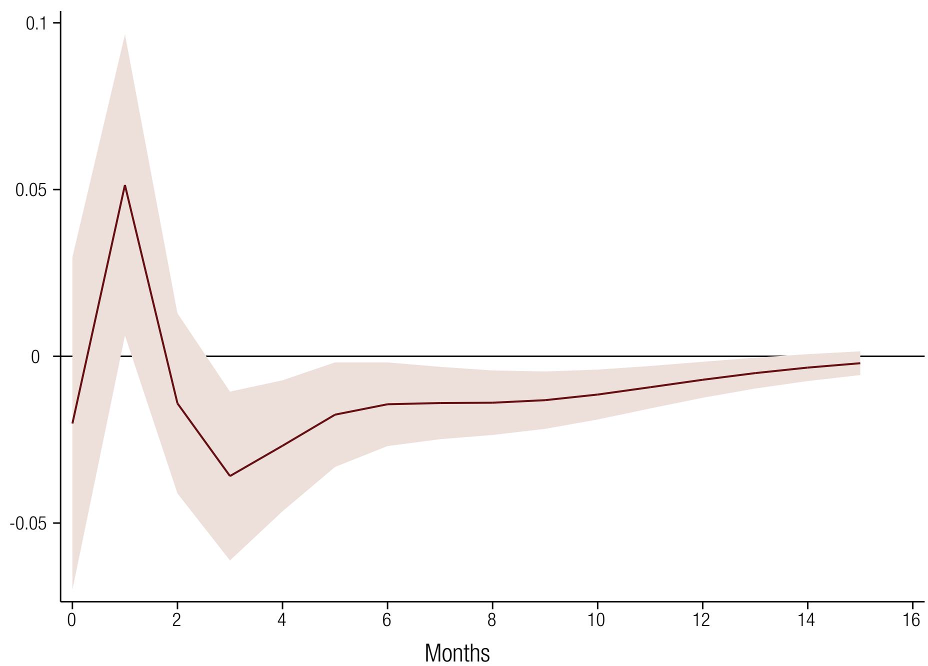
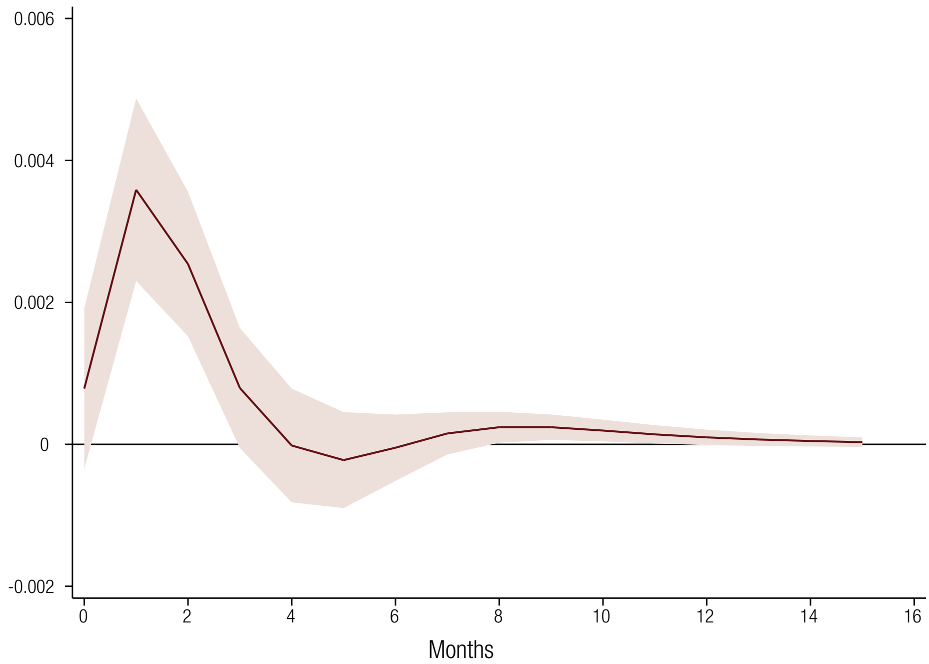


Figure 5 (concluded)

D. Skewness



Source: Prepared by the authors, on the basis of information from the Central Bank of Chile.

3. Liquidity risk and the unwinding of carry trades

In this section, we will take a closer look at speculators' behaviour. Specifically, we will study the factors that lead speculators to unwind their positions, such as sudden losses in their positions, an increase in funding margins or a reduction in their tolerance to risk. To this end, we use two measures for aggregate uncertainty that are normally associated with funding illiquidity and investors' risk aversion: (i) the volatility index of the Chicago Board Options Exchange (CBOE VIX), and (ii) the Economic Policy Uncertainty (EPU) Index built by Baker, Bloom and Davis (2015). Both measures of uncertainty are used as observable proxies that should be correlated with the factors mentioned above (see, for example, Anzuini and Fornari (2011) for the macroeconomic determinants of carry trade activity). We report results using the EPU Index only.[31] We consider the following panel regressions:

$$\Delta PFNR_{jt} = \beta_1 \Delta EPU_t \times sign\left(i^*_{jt-1} - i_{t-1}\right) + \beta_2 EPU_t + \beta_3 FPNR_{jt-1} + \beta_4 BCCH_t + \alpha_j + \varepsilon_{jt} \quad (2)$$

and

$$\Delta z_{jt} = \beta_1 \Delta EPU_t \times sign\left(i^*_{jt-1} - i_{t-1}\right) + \beta_2 EPU_t + \beta_3 BCCH_t + \alpha_j + \varepsilon_{jt} \quad (3)$$

where j is the country, t is time, α_j represents the country's (or currency) fixed effect, and ε_{jt} is the disturbance term. The expected sign for the coefficient of the interaction variable obtained from multiplying EPU and carry trade, under the hypothesis that the unwinding of positions is taking place and affecting crash risk, is negative in both regressions. Until now, we have ignored the direction of carry trade, given that interest rate differentials and other variables change sign when the direction of

[31] Results using VIX are reported in the annex in table A1.1 and are consistent with those discussed here.

carry trade changes. Certainly this is not the case with VIX or EPU, and therefore we interact these two variables with the sign of interest rate differentials,[32] $sign(i^*_{t-1} - i_{t-1})$.

We estimate specifications in equations (2) and (3) using the fixed effects estimator. Table 3 presents the results for the EPU Index. The first two columns show that the impact of increased global uncertainty on contemporary changes in FPNRs (same month) is positive. This is reversed in the following month, as is to be expected in a context where an increase in global uncertainty causes an unwinding of carry trade positions. This implies that greater global uncertainty scenarios can lead to crash risk, but with a lag. The fact that the contemporaneous effect upon FPNRs is positive (column 1 in table 3) is not consistent with the hypothesis of Brunnermeier and Pedersen (2009). Our explanation for this seemingly puzzling result is the following. Shocks to uncertainty lead non-speculating investors to take positions in order to hedge their fundamentals-driven investments against higher volatility in the exchange rate. Readers will recall that FPNRs are predominantly used by these investors, who buy dollars. Subsequently, as long as persistent uncertainty shocks are narrowing funding margins in global financial markets, the changes observed in FPNRs will increasingly be accounted for by speculators who are unwinding their positions. This explains both the contemporaneous positive effect and the subsequent negative effect.

We also note from the table that increases in $FPNR_{t\text{-}1}$ predict a smaller change in $FPNR_t$, which could be explained by the presence of a larger crash risk.

Table 3

Monthly sensitivity of positions and carry trade returns to changes in the economic policy uncertainty index

	$\Delta FPNR_t$	$\Delta FPNR_{t+1}$	Z_t	Z_{t+1}
$\Delta EPU_t \times sign(i^*_{t-1} - i_{t-1})$	0.987***	-1.325***	5.25e-05***	-0.000170***
	(0.0433)	(0.153)	(1.74e-05)	(6.43e-05)
$\Delta FPNR_{t\text{-}1}$	-0.207***	-0.0686***		
	(0.00250)	(0.00494)		
$\Delta log(Copper)_{t\text{-}1}$	0.445*	-0.809***		
	(0.244)	(0.229)		
$BCCH_t$	-25.00***	47.55***	-0.00364***	-0.000604
	(5.678)	(15.00)	(8.36e-05)	(0.00311)
Observations	179	175	183	179
R^2	0.041	0.014	0.007	0.033

Source: Prepared by the authors, on the basis of information from the Central Bank of Chile and data from Bloomberg and Economic Policy Uncertain Index [online] www.policyuncertain.com.

Note: Panel with country fixed effects and monthly data, 2002M3-2012M1 for United States dollars and 2006M8-2012M3 for euros. FPNR data include NDF contracts only. Monthly interest rate at the beginning of period t. Clustered standard errors are shown in parentheses: *** p<0.01; ** p<0.05; * p<0.1.

In the third and fourth columns, we indicate the relationship between uncertainty and expected returns. Global uncertainty is positively correlated with the return on investment in the second month following a change in uncertainty, which discourages carry trade. Considering all these results, taken together, we can draw the following conclusion: when risk tolerance declines, traders unwind their positions, inducing a reduction in FPNRs and in return z_t. The inclusion of the $BCCH_t$ dummy shows it to be an important explanatory factor for both the return on carry trade and changes in the FPNR variable, although its impact is short-lived.

[32] Of course, this is only meaningful when the carry sign changes. Although the frequency of the occurrence of this event is low in the sample, there are quarters for which the direction of the carry between the Chilean peso and the United States dollar and between the peso and the euro actually does change from positive to negative and vice versa.

The inclusion of a fundamental variable, such as the price of copper, is relevant, but is not robust to the inclusion of other controls.[33] Given the strong contemporary relationship between the EPU Index and the carry trade excess return, we analyse to what extent indices for global uncertainty are able to predict future returns and to approximate changes in risk premiums (the foundation for the carry trade return). We consider the following econometric panel specification:

$$z_{jt+1} = \beta_1\left(i^*_{jt} - i_t\right) + \beta_2\left(\Theta_t \times sign\left(i^*_{jt-1} - i_{t-1}\right)\right) + \alpha_j + \varepsilon_{jt} \tag{3}$$

where j is the country, t time, αj represents the country's (or currency's) fixed effects and ε_{jt} is the disturbance term. Θ_t is the indicator of global uncertainty or liquidity. In addition to the global uncertainty measures (the Economic Policy Uncertainty (EPU) Index and the volatility index (VIX)), we consider the measure of liquidity provided by the spread between the London Interbank Offered Rate (LIBOR) and the Overnight Indexed Swap (OIS) rate (known as LOIS). Results from fixed effects estimations are shown in table 4.

Table 4

Exchange-rate return z_t regressed on carry trade $i^*_t - i_t$ and its interaction with the volatility index, the spread between the London Interbank Offered Rate and the Overnight Indexed Swap rate, and the economic policy uncertainty index

Excess return on	z_{t+1}	z_{t+2}	z_{t+3}	z_{t+1}	z_{t+2}	z_{t+3}	z_{t+1}	z_{t+2}	z_{t+3}
$i^*_t - i_t$	1.073***	0.924***	0.724***	1.077***	0.882***	0.694***	1.121***	0.974***	0.721***
	(0.297)	(0.244)	(0.122)	(0.293)	(0.258)	(0.110)	(0.275)	(0.209)	(0.141)
$\Delta VIX_t \times sign\,(i^*_t - i_t)$	-0.000991	-0.000326***	-0.000398						
	(0.000753)	(0.000124)	(0.000376)						
$\Delta LOIS_t \times sign\,(i^*_t - i_t)$				-0.0147**	-0.0222***	-0.0100***			
				(0.00739)	(0.00798)	(0.00140)			
$\Delta EPU_t \times sign\,(i^*_t - i_t)$							-0.000116***	-0.000154	-1.15e-05
							(2.23e-05)	(0.000163)	(9.92e-05)
Observations	236	234	232	236	234	232	236	234	232
R^2	0.147	0.052	0.042	0.091	0.116	0.043	0.073	0.066	0.028

Source: Prepared by the authors, on the basis of information from the Central Bank of Chile and data from Bloomberg and Economic Policy Uncertain Index [online] www.policyuncertain.com.

Note: Panel regressions with country fixed effects and monthly data are for 2002M3-2012M1. The data are for United States dollars and euros. The Volatility Index (VIX) measures "appetite" for risk. The spread between LIBOR and the Overnight Indexed Swap (OIS) rate (LOIS) is a measure for international liquidity, while the Economic Policy Uncertainty (EPU) Index is a measure of economic and political uncertainty. VIX, LOIS and EPU correspond to the final observation for each quarter. Clustered standard errors are shown in parentheses: *** p<0.01; ** p<0.05; * p<0.1.

One notable result is that the effect of uncertainty on returns is confirmed, and this is robust across the different measures for global uncertainty.[34] The effect is also shown to be persistent over time. An increase in uncertainty in negatively impacts the return in the same quarter and in the following two quarters, although the impact eventually becomes non-significant over time. Overall uncertainty, therefore, is an important predictor of returns, while these effects are relevant in the short term. Evidence is consistent, then, with the hypothesis of Brunnermeier and Pedersen (2009).

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[33] For example, when including the lag of carry trade $(i^*_{t-1} - i_{t-1})$ in the regression, the price of copper is not significant, while the other estimated coefficients keep their signs and significance.

[34] Table A1.1 in the annex shows the results using VIX instead of EPU as an indicator for uncertainty.

4. Where is carry trade activity more concentrated: in short- or long-duration contracts?

One of the advantages of the data sources used in this study is that they allow us to obtain detailed information about NDF contracts that is usually not available in other economies or markets. In particular, we are able to classify trading transactions (the notional amounts of NDFs) according to their duration. In this section, we use this information to identify the duration of the contracts for which the carry trade is most active in the NDF exchange market.

Table 5 depicts the differing carry trade effect on NDF transactions subscribed by non-resident agents according to their duration. A carry trade investment strategy should entail the adoption of longer positions by speculators following an increase in interest rate differentials. As shown in table 5, for short-term (<1 month) operations, the relationship between the carry trade and FPNRs (the dependent variable) is not statistically significant. In the medium run (i.e. for contracts ranging from one month to one year), however, we note that carry trade is significantly correlated to FPNRs, which is consistent with the evidence and analysis presented here and elsewhere (Ichiue and Koyama (2011)). We also notice that the sign accompanying the carry trade coefficient is reversed for longer durations, confirming that speculative activity is concentrated in medium-duration contracts.

Table 5

Forward positions held by non-resident traders, by term of the underlying non-deliverable forward contracts, regressed on carry $i^*_{t-1} - i_{t-1}$

	Forward positions held by non-residents, disaggregated by the term of the contract				
	7 days	8-30 days	31-180 days	181-365 days	>365 days
$i^*_{t-1} - i_{t-1}$	1.837	-2.381	90.495**	72.365***	-50.315*
	(1.495)	(10.656)	(44.102)	(24.934)	(27.207)
Observations	333	119	40	40	40
R^2	0.005	0.0006	0.11	0.21	0.04

Source: Prepared by the authors, on the basis of information from the Central Bank of Chile.

Note: Ordinary least squares (OLS) regressions are for United States dollars for the period 2002M1-2012M1. Data for seven-day contracts are available from 2005 on. Forward positions of non-residents are expressed in billions of United States dollars. Interest rate differentials are for 7, 30, 180 and 360 days, respectively (weekly, monthly and quarterly data), with the latter being derived from 180-day rates. Interest rate differentials shown in the first and second columns are for the beginning of the week/month. In third and fifth columns, the interest rate differentials correspond to the beginning of the quarter. For contracts of more than one year in duration, the interest rate differentials are based on one-year interest rates. For Chilean pesos, the prime cap rate is used, while for United States dollars, LIBOR is used. Robust standard errors are shown in parentheses: *** p<0.01; ** p<0.05, * p<0.1.

V. Conclusions

In this paper we have documented evidence on the use by foreign investors of currency carry trade investment strategies involving the Chilean peso and other developed-economy currencies; the use of this strategy has been encouraged by the large interest rate differentials between these currencies observed in recent years. This has had a significant impact, especially during periods of great global uncertainty, on the nominal exchange rate, which has gone through numerous episodes of turbulence. By using several econometric specifications, we show that a significant and robust explanatory factor in the distribution of daily changes in the exchange rate is the forward position of non-resident traders in the local market. Consistent with the interpretation of the relationship between the distribution's asymmetry coefficient and the futures positions of such investors, we also find that the risk of a currency collapse (crash risk) discourages investors from taking positions that would lead to the restoration of parity rates. We also have shown that an increase in the overall risk or the level of risk aversion, measured by indices such as VIX, LOIS or EPU, coincides with reductions in FPNRs and lower carry trade returns (risk premium).

Evidence from this study also suggests that FPNRs should be added to the analysis when assessing the factors that destabilize the exchange rate in the short run. The FPNR variable is a plausible candidate for explaining recent strong misalignments in the exchange rate, as identified by Wu (2013). We also recommend considering the asymmetry coefficient (skewness) as an indicator of turbulence in the exchange rate. This variable provides relevant information that is not captured by other commonly used indicators, such as the standard deviation.

From the point of view of monetary policy, the recent rapid development of the carry trade in the case of the Chilean peso is a factor that, in conjunction with other events and economic scenarios, can lead to a situation in which policymakers are faced with a trade-off between inflation control and the incubation of currency risks in the real sector's balance sheets. In this context, hikes in the policy rate intended to curb inflation could spur the carry trade, thereby generating more inflationary pressure. This is a risk that policymakers should take into consideration during periods marked by large interest rate differentials between the Chilean peso and other currencies.

Bibliography

Ahumada, A. and J. Selaive (2007), "Desarrollo del mercado de derivados cambiarios en Chile", *Revista de Análisis Económico*, vol. 22, No. 1.

Alfaro, L. and F. Kanczuk (2013), "Carry trade, reserve accumulation, and exchange-rate regimes", *NBER Working Paper Series*, No. 19098, Cambridge, Massachusetts, National Bureau of Economic Research.

Anzuini, A. and F. Fornari (2011), "Macroeconomics determinants of carry trade activity", *Economic Working Papers*, No. 817, Bank of Italy.

Bacchetta, P. and E. van Wincoop (2010), "Infrequent portfolio decisions: a solution to the forward discount puzzle", *American Economic Review*, vol. 100, No. 3, Nashville, Tennessee, American Economic Association.

Baker, S., N. Bloom and S. Davis (2015), "Measuring economic policy uncertainty'", *NBER Working Paper Series*, No. 21633, Cambridge, Massachusetts, National Bureau of Economic Research [online] www.policyuncertainty.com/media/BakerBloomDavis.pdf.

Bekaert, G. and R.J. Hodrick (1992), "Characterizing predictable components in excess return on equity and foreign exchange markets", *Journal of Finance*, vol. 47, No. 2, Wiley.

BIS (Bank for International Settlements) (2013), *Statistical Release. OTC Derivatives Statistics at End-June 2013* [online] http://www.bis.org/publ/otc_hy1311.pdf.

Brunnermeier, M.K. and L.H. Pedersen (2009), "Market liquidity and funding liquidity", *Review of Financial Studies*, vol. 22, No. 6, Oxford University Press.

Brunnermeier, M.K., S. Nagel and L.H. Pedersen (2008), "Carry trades and currency crashes", *NBER Macroeconomics Annual 2008*, vol. 23, Cambridge, Massachusetts, National Bureau of Economic Research.

Burnside, C. and others (2010), "Do peso problems explain the returns to the carry trade?", *The Review of Financial Studies*, vol. 24, No. 3, Oxford University Press.

Central Bank of Chile (n/d), "Manual de procedimientos y formularios de información del Compendio de Normas de Cambios Internacionales" [online] http://www.bcentral.cl/es/faces/pfinanciera/manualprocedimientos?_afrLoop=1343102542531642&_afrWindowMode=0&_afrWindowId=null#!%40%40%3F_afrWindowId%3Dnull%26_afrLoop%3D1343102542531642%26_afrWindowMode%3D0%26_adf.ctrl-state%3D1bb09id9aa_4.

Engel, C. (1996), "The forward discount anomaly and the risk premium: a survey of recent evidence", *Journal of Empirical Finance*, vol. 3, No. 2, Amsterdam, Elsevier.

Fama, E. (1984), "Forward and spot exchange rates", *Journal of Monetary Economics*, vol. 14, No. 3, Amsterdam, Elsevier.

Gromb, D. and D. Vayanos (2010), "Limits of arbitrage", *Annual Review of Financial Economics*, vol. 2, No. 1.

Gyntelberg, J. and E. Remolona (2007), "Risk in carry trades: a look at target currencies in Asia and the Pacific", *BIS Quarterly Review*, Bank for International Settlements, December.

Hodrick, R.J. (1987), *The Empirical Evidence on the Efficiency of Forward and Futures Foreign Exchange Markets*, Harwood Academic Publishers.

Hutchison, M. and V. Sushko (2013), "Impact of macro-economic surprises on carry trade activity", *Journal of Banking and Finance,* vol. 37, No. 4, Amsterdam, Elsevier.

Ichiue, H. and K. Koyama (2011), "Regime switches in exchange rate volatility and uncovered interest parity", *Journal of International Money and Finance*, vol. 30, No. 7, Amsterdam, Elsevier.

Jurek, J. (2014), "Crash-neutral currency carry trades", *Journal of Financial Economics*, vol. 113, No. 3, Amsterdam, Elsevier.

Lustig, H., N. Roussanov and A. Verdelhan (2008), "Common risk factors in currency markets", *NBER Working Paper Series,* No. 14082, Cambridge, Massachusetts, National Bureau of Economic Research.

Mitchell, M., L. Pedersen and T. Pulvino (2007), "Slow moving capital", *American Economic Review*, vol. 97, No. 2, Nashville, Tennessee, American Economic Association.

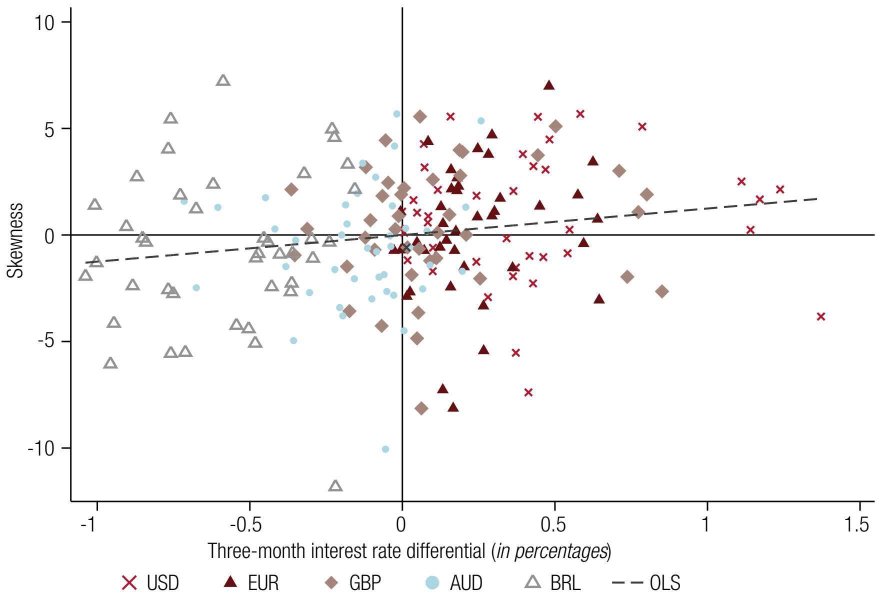
Plantin, G. and H.S. Shin (2011), "Carry trades, monetary policy and speculative dynamics", *CEPR Discussion Papers*, No. 8224.

Salinas, J. and J. Villena (2014), "Mercado cambiario chileno, una comparación internacional: 1998 a 2013", *Estudios Económicos Estadísticos*, No. 106, Santiago, Central Bank of Chile.

Wu, Y. (2013), "What explains movements in the peso/dollar exchange rate?", *IMF Working Paper*, No. WP/13/171, Washington, D.C., International Monetary Fund.

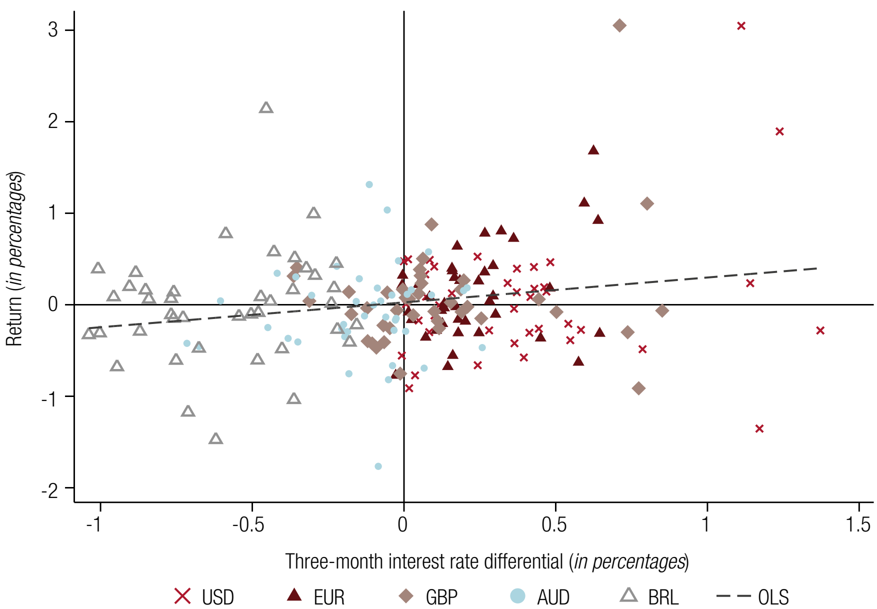
Annex A1

Figure A1.1
Cross-section of empirical skewness and three-month interest rate differentials for the period 2002Q1-2012Q1



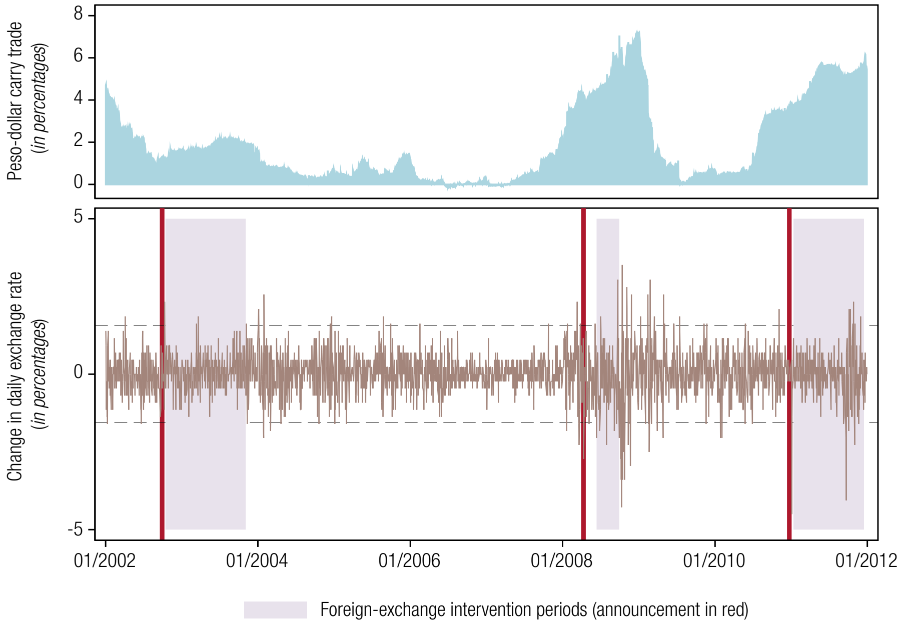
Source: Prepared by the authors, on the basis of information from the Central Bank of Chile.
Note: USD: United States dollars; EUR: Euros; GBP: British pounds; AUD: Australian dollar; BRL: Brazilian reais; OLS: Ordinary least squares.

Figure A1.2
Cross-section of empirical return and three-month interest rate differentials for the period 2002Q1-2012Q1



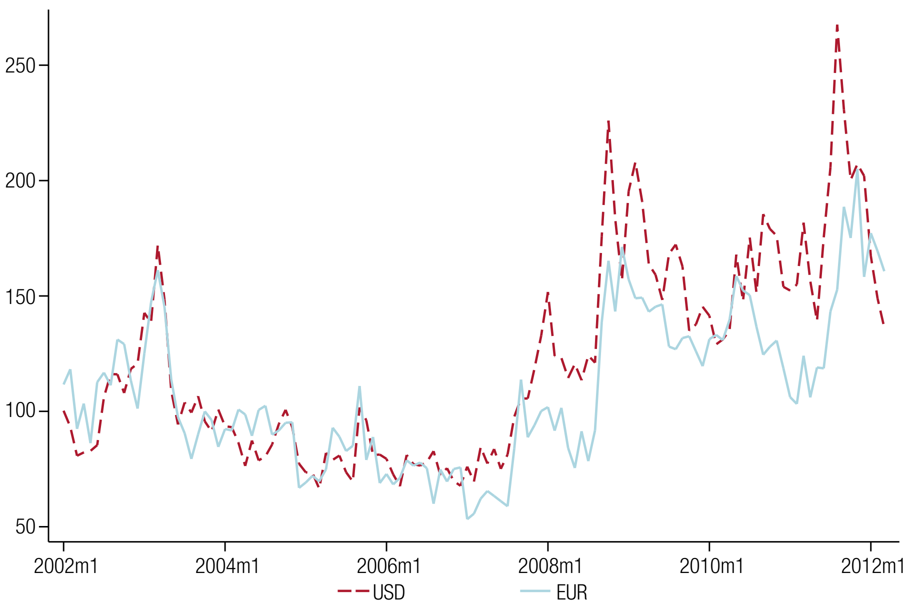
Source: Prepared by the authors, on the basis of information from the Central Bank of Chile.
Note: USD: United States dollars; EUR: Euros; GBP: British pounds; AUD: Australian dollar; BRL: Brazilian reais; OLS: Ordinary least squares.

Figure A1.3
Three-month interest rate differentials (carry trade) and Chilean peso-United States dollar exchange-rate volatility



Source: Prepared by the authors, on the basis of information from the Central Bank of Chile.
Note: The red lines represent announcements by the central bank that it would be intervening in the foreign-exchange market. The shaded areas mark the periods during which those interventions were implemented. The dashed lines in the lower graph correspond to two standard deviation bands (2002-2012 sample).

Figure A1.4
Economic policy uncertainty index, 2002M1-2012M1



Source: S. Baker, N. Bloom and S. Davis, "Measuring economic policy uncertainty'", *NBER Working Paper Series*, No. 21633, Cambridge, Massachusetts, National Bureau of Economic Research, 2015 [online] www.policyuncertainty.com/media/BakerBloomDavis.pdf.
Note: USD: United States dollars; EUR: Euros.

Table A1.1
Monthly sensitivity of carry trade positions and returns to changes in the volatility index

	(1) $\Delta FPNR_t$	(2) $\Delta FPNR_{t+1}$	(3) z_t	(4) z_{t+1}
$\Delta VIX_t \times sign\,(i^*_{t-1} - i_{t-1})$	-12.48	-1.203	-6.46e-06	-0.00106
	(11.82)	(1.396)	(0.000143)	(0.000806)
$\Delta FPNR_{t-1}$	-0.190***	-0.0718***		
	(0.0106)	(0.00567)		
$\Delta log(Copper)_{t-1}$	0.311***	-0.824***		
	(0.0614)	(0.256)		
$BCCH_t$	-64.62	54.48***	-0.00408***	-0.00223
	(45.83)	(9.703)	(0.000141)	(0.00721)
Observations	179	175	183	179
R^2	0.060	0.011	0.004	0.120

Source: Prepared by the authors, on the basis of information from the Central Bank of Chile and data from Bloomberg.
Note: The panel shows country fixed effects and monthly data for the period 2002M3-2012M1 for United States dollars and for the period 2006M8-2012M3 for the euro. The data on forward positions held by non-residents include non-deliverable forward contracts only. Monthly interest rates are shown for the beginning of period *t*. Clustered standard errors are shown in parentheses: *** p<0.01; ** p<0.05; * p<0.1.