HARVARD Kennedy School
MOSSAVAR-RAHMANI CENTER
for Business and Government

Does Betting on Currencies Make Them Riskier? The Carry Trade and Endogenous Risk

Honorable Mention, 2020 Dunlop Undergraduate Thesis Prize

Divya Arya

May 2020

M-RCBG Associate Working Paper Series | No. 145

Mossavar-Rahmani Center for Business & Government
Weil Hall | Harvard Kennedy School | www.hks.harvard.edu/mrcbg

Does Betting on Currencies Make Them Riskier?

The Carry Trade and Endogenous Risk

Divya Arya

Presented to the Department of Economics
in partial fulfillment of the requirements
for a Bachelor of Arts degree with Honors

Harvard College
Cambridge, Massachusetts
March 12, 2020

Does Betting on Currencies Make Them Riskier?

The Carry Trade and Endogenous Risk

Divya Arya

Presented to the Department of Economics
in partial fulfillment of the requirements
for a Bachelor of Arts degree with Honors

Harvard College
Cambridge, Massachusetts
March 12, 2020

Abstract

I study the role of arbitrage in creating non-fundamental foreign exchange movements. I focus on the carry trade, a dominant currency arbitrage strategy and a well-known violation of uncovered interest parity. I argue that if investor capital is exposed to systematic factors, the risk is propagated to the currencies they trade. I present a three-proposition model in which currencies inherit such arbitrage-driven risk only when carry trade activity is widespread, implying the endogeneity of the carry trade's observed return. Considering 15 advanced and 32 emerging market currencies, I find that the interest rate differential of a carry trade predicts a measure of risk due to shocks to investor funding, and controlling for liquidity magnifies the effect. My results strongly support the model in which the carry trade generates arbitrage-driven risk by inducing exchange rate movements. My findings imply that anomaly returns of the carry trade persist in part because the arbitrage strategy itself generates risk. My results indicate that currencies are vulnerable to more than just macroeconomic fundamentals. This suggests that some emerging markets may benefit from managing their exchange rates to constrain arbitrage-driven risk.

Acknowledgements

I would like to thank my advisor, Professor Jeremy Stein, for the support, direction, and invaluable feedback he has generously provided throughout this process. Professor Stein's insight and guidance have enabled me to develop and improve this project since our junior tutorial. It has been a privilege to work with him.

I would also like to thank Slavik Sheremirov and Rishab Guha for their ideas, suggestions, and detailed feedback. I am grateful to Professors Jeffrey Frankel and Ben Enke for their advice and help.

Lastly, I thank my wonderful family and friends for the constant support and encouragement. Your faith in me inspired me to create a piece of work of which I am truly proud. Thank you for believing in me.

Table of Contents

I. Introduction

Currency trading through the foreign exchange (FX) market encompasses all aspects of buying, selling, and exchanging currencies at current or predetermined prices. The FX market is accessible, decentralized, and global, making it the most liquid and largest financial market in the world by trading volume, followed by the credit and stock markets. With 6.6 trillion dollars traded per day in April 2019 (up from 5.1 trillion dollars in April 2016), the FX market is growing rapidly as regulation loosens. On top of this, emerging markets are gaining market share – from 5.2% in 2004 to 25% in 2019 – as they adopt floating exchange rates (BIS, 2019). Currency arbitrage strategies take advantage of under and overvalued currencies. They range from simple buy and hold trades to complex derivative contracts and sophisticated algorithms. I study the role of arbitrage in creating non-fundamental FX movements.

I focus on the currency carry trade, a dominant strategy for arbitrage in the FX market.[1] The carry trade consists of selling low interest rate currencies (called funding currencies) and investing in high interest rate currencies (called investment currencies). The investment currency appreciates more than the funding currency in a given time according to the difference in interest rates, yielding a profit when converted back to the funding currency. The carry trade is a well-known violation of uncovered interest parity (UIP), which holds that the difference in interest rates should be offset by a commensurate depreciation of the exchange rate. This would wipe out the carry trade's profitability.

[1] The total amount of capital invested in the currency carry trade is difficult to estimate due to the lack of reporting requirements. But during a recent carry trade activity peak in 2014, industry experts estimated that the total amount was in the multitrillion dollar range, with 2 trillion dollars invested in emerging markets alone (Dohmen, 2014; Kynge, 2014). To illustrate the magnitude of an individual trade, the total amount invested in the popular Japanese yen carry trade in 2007 was estimated at 250 billion dollars, or 5% of Japan's GDP at the time (Setser, 2007). Investors can unwind these positions over the course of days, inducing the exchange rate movements considered in my study.

Empirically, the opposite is true – the exchange rate actually appreciates a little on average (Fama, 1984), contributing to its large predictable excess returns. This anomaly is known as the "forward premium puzzle," and extensive research has asked why the carry trade's forward premium persists (Fama, 1984; Bansal & Dahlquist, 2000; Brunnermeier et al., 2008; Frankel & Poonawala, 2010; Farhi & Gabaix, 2016). My study takes the profitability of the carry trade as given. I treat the question, what do attempts to arbitrage the forward premium imply for the risk of foreign exchanges?

To answer this question, I follow in the spirit of Cho's (2019) "Turning Alphas into Betas," which considers risk of stock anomalies. For currencies, the traditional explanation of foreign exchange betas (or risk) relies on macroeconomic fundamentals like inflation, interest rates, political stability, and monetary policy. The explanation I explore is the act of arbitrage through the currency carry trade. I hypothesize that if investor capital is exposed to systematic factors, the risk is propagated to the currencies they trade. This is illustrated by the following example: the carry trade between two currencies with a high interest rate differential is perceived as profitable and draws investors. They invest capital in the strategy, and in response the exchange rate between the two currencies appreciates. Then the investors experience an external shock to their capital and are forced to unwind their positions. In response, the exchange rate depreciates. In this way, the carry trade causes a non-fundamental exchange rate movement. This risk of volatility that the exchange rate inherits from shocks to investor funding is called *arbitrage-driven risk*.

To understand if currencies take on arbitrage-driven risk through the carry trade and to quantify the impact, I test a model with three propositions. Since the currency carry trade became a dominant arbitrage strategy in the early-mid 2000s, I consider 2 periods:

when carry trade activity is low (called the pre-arbitrage period) and when carry trade activity is high (called the post-arbitrage period). Importantly, I theorize that more attractive trades (high interest rate differentials) take on greater arbitrage-driven risk due to capital inflow and exchange rate movements. In the pre-arbitrage period, this relationship should not exist as investors do not engage in the carry trade (Proposition 1). In the early years of carry trade activity, investors flood capital into the strategies perceived as attractive in the pre-arbitrage period, which subsequently take on more risk in the post-arbitrage period (Proposition 2). However, arbitrage-driven risk should only arise in times of financial constraint, when shocks to funding actually force investors to unwind positions (Proposition 3). I present a simplified depiction of the model in Figure 1.

Figure 1: A Simplified Depiction of Arbitrage-Driven Risk Model

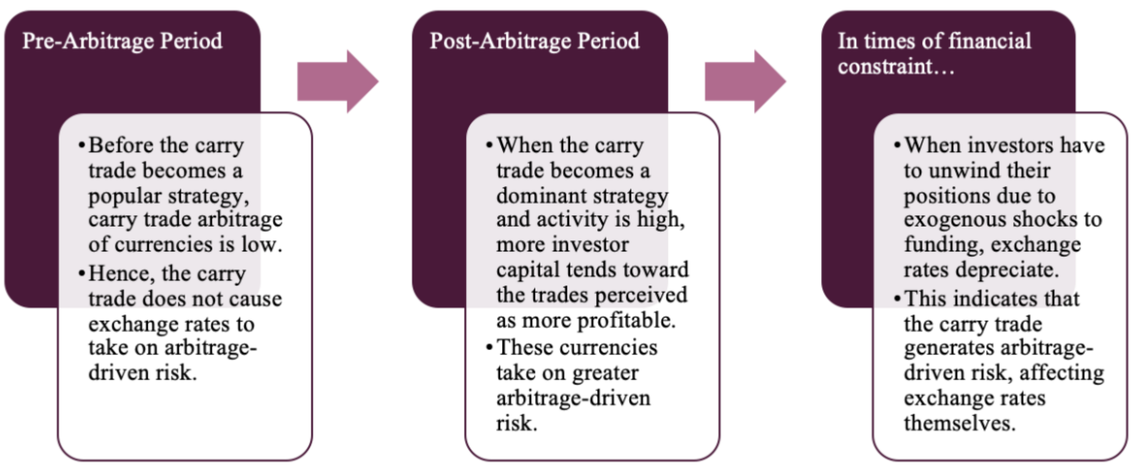


Figure 1 presents a simplified version of the model I outline and test. It explains how perceived return should predict funding risk only when carry trade activity is high, establishing the carry trade as the mechanism by which shocks to investor funding are inherited by the currencies they trade.

I find strong evidence that the carry trade generates arbitrage-driven risk for the currencies of 15 advanced and 32 emerging markets. First, I demonstrate that arbitrage-driven risk is proportionally inherited by more attractive trades when carry trade activity is high: interest rate differentials positively predict risk from shocks to investor funding in the post-arbitrage period (September 2004 – September 2019). In the pre-arbitrage period (September 1989 – August 2004), the relationship is insignificant because carry trade activity is low. This suggests that the carry trade causes currencies to inherit investor funding risk. I confirm that these results only occur in months where exchange rates are floating and can fluctuate with market forces; funding risk does not arise when exchange rates are managed by government policy and do not move in response to arbitrage. These results are robust to alternative arbitrage time periods as well as other definitions of carry trade attractiveness. Next, I show that pre-arbitrage interest rate differentials predict post-arbitrage funding risk in the early years of carry trade activity. This supports the intuition that the attractiveness of a trade determines the size of investor demand and exchange rate movement. Finally, I demonstrate that arbitrage-driven risk only arises in financially constrained times when investors are forced to unwind positions in response to funding shocks. This confirms that the identified funding risk is driven by investor arbitrage.

In summary, I offer a novel explanation of currency risk: investment in the carry trade causes non-fundamental exchange rate movements, resulting in currencies that fluctuate with shocks to investor funding. This, in part, explains why the carry trade continues to be profitable – the carry trade itself generates endogenous risk, which persists in the form of a forward premium. Specifically, more profitable carry trades take on greater risk, so "alphas" (profitability) are turned into "betas" (risk). This inverts traditional asset-pricing theory, which holds that betas determine alphas. The impact of the carry trade also has policy implications for governments with floating exchange rates. Though floating exchange rates allow countries to develop economically and institutionally, my results suggest that they are vulnerable to more than just macroeconomic fundamentals.

This paper is organized as follows: Section II describes the model. Section III reviews previous literature. Section IV describes data and methodology. Section V presents the results. Section VI discusses the results and concludes.

II. Model

Below, I present the model by which the carry trade generates arbitrage-driven risk. This follows in the spirit of Cho's (2019) research on equity anomalies.

Proposition 1*: Perceived return and capital inflow predict funding risk in the post-arbitrage period, but not in the pre-arbitrage period.*

Proposition 2*: Perceived return in the pre-arbitrage period predicts funding risk in the beginning of the post-arbitrage period.*

Proposition 3*: Funding risk is arbitrage-driven risk if it only arises when investors are constrained.*

These three propositions tell a compelling story. Investors perceive certain carry trades as profitable based on their high interest rate differentials. They flood capital into these strategies, causing exchange rates to appreciate. If investors experience a shock to their funding and are forced to unwind their positions, the exchange rates depreciate. This relationship can be demonstrated by showing that perceived return (interest rate differentials) and capital inflow predicts funding risk in the post-arbitrage period when carry trade activity is high, but they cannot in the pre-arbitrage period when carry trade activity is low. This shows that the carry trade drives exchange rate movement and funding risk. Proposition 1 contends that perceived return and capital inflow positively predict funding risk in the post-arbitrage period, but not in the pre-arbitrage period.

In the early years of the post-arbitrage period, investors tended toward trades that seemed more profitable in the pre-arbitrage period. As a result, the strategies with higher perceived return exhibited greater exchange rate movement in response to shocks to investor funding. Proposition 2 asserts that currencies' funding risk in the post-arbitrage period is predicted by their perceived return in the pre-arbitrage period. However, the identified funding risk in Propositions 1 and 2 should only arise in times of financial constraint. In unconstrained times, investors do not have to unwind positions in response to funding shocks as they find capital elsewhere. In constrained times, investors are forced to unwind positions and exchange rates move in response, reflecting arbitrage-driven risk. Proposition 3 contends that funding risk is indeed arbitrage-driven risk if it only arises in constrained times.

Figure 2 demonstrates the implications of this model. In the pre-arbitrage period, perceived return cannot predict arbitrage-driven risk because shocks to investor funding

Figure 2: Theoretical Relationship between Perceived Return and Funding Risk

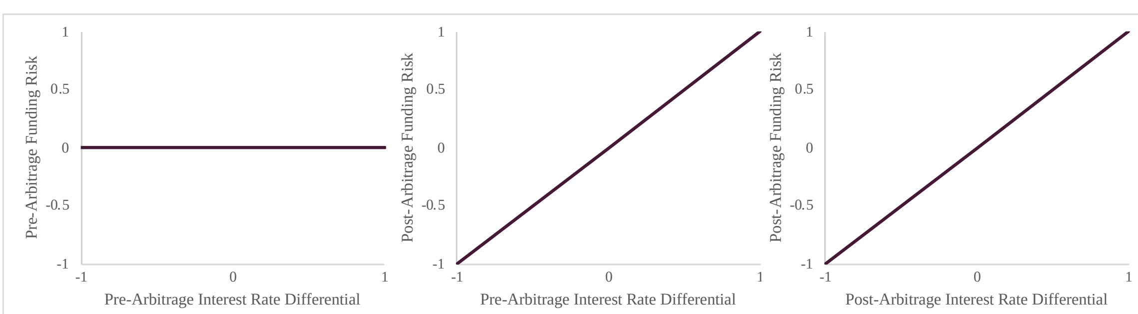


Figure 2 demonstrates the theoretical implications of the arbitrage-driven risk model. In the pre-arbitrage period, interest rate differential cannot predict funding risk (Graph 1). In the early years of carry trade activity, the interest rate differential in the pre-arbitrage period predicts funding risk in the post-arbitrage period (Graph 2). In the post-arbitrage period, the interest rate differential predicts funding risk (Graph 3). This figure is based on Cho (2019).

are not propagated to currencies. In the early years of the post-arbitrage period, strategies with high perceived return in the pre-arbitrage period take on greater arbitrage-driven risk. Finally, in the post-arbitrage period, perceived return positively predicts arbitrage-driven risk due to investors inducing exchange rate movements.

I test Propositions 1-3 with a variety of robustness checks. By examining the relationship between the interest rate differential and funding risk, I analyze how the carry trade induces non-fundamental exchange rate movement and makes currencies riskier. This implies the endogeneity of the carry trade's observed return.

III. Literature Review

My study unites the broader research movement on the effects of institutional arbitrage with the literature on the currency carry trade's forward premium.

Shleifer and Vishny (1997) conducted groundbreaking research on the effects of institutional arbitrage. They showed that arbitrageurs who manage outside capital are evaluated on past returns. As a result, when their investors withdraw capital, arbitrageurs can be forced out of positions prematurely. This process worsens overall mispricing across asset classes (Shleifer & Vishny, 1997). Drechsler and Drechsler (2014) build on Shleifer and Vishny's (1997) work by showing that investors demand a shorting premium for the risk that others are forced out of their positions. This is an endogenous risk that the investors help create (Drechsler & Drechsler, 2014). Cho (2019) extends this argument, suggesting that investors propagate this vulnerability of being forced out of their positions to all the strategies they hold. He shows that this arbitrage-driven risk is generated for 40 stock anomalies.

I hypothesize that arbitrage-driven risk can be used to help explain the currency carry trade anomaly. Fama (1984) was among the first to identify the carry trade violation of uncovered interest parity. He finds that high interest currencies tend to appreciate a little, so currencies with high interest rates feature positive predictable excess returns (Fama, 1984). This has come to be called the forward premium puzzle. Since then, extensive research has tried to explain why the carry trade defies uncovered interest parity, and most focus on exogenous shocks that induce carry trade profitability. For example, Farhi and Gabaix (2016) focus on the impact of rare global disasters. Notably, Brunnermeier et al. (2008) study endogenous risk, showing that shocks to investor funding are reflected in crashes in the exchange rate. The authors attribute this to investor capital being withdrawn, and argue that it is reflected dynamically over a 3-month time horizon due to slow-moving capital. To demonstrate this, they show that high interest rate differentials predict negative exchange rate skewness over lagged time periods (Brunnermeier et al., 2008). My research complements Brunnermeier et al.'s (2008) by establishing the theoretical ground of arbitrage-driven risk and measuring the risk of shocks to investor funding. The authors retrospectively quantify this risk through exchange rate crashes.

The literature on the carry trade focuses on advanced economies because their exchange rates follow a near random walk, allowing for larger profits (Meese & Rogoff, 1983). But trading emerging currencies is growing in market share as governments adopt floating exchange rates. The evidence for or against an emerging currency forward premium not statistically strong because research is substantially less extensive. Bansal and Dahlquist (2000) find that the forward premium is limited to advanced economies. Their empirical evidence from lower-income and emerging economies supports traditional uncovered interest parity. A decade later, Frankel and Poonawala (2010) uncover a small but significant forward premium for 14 emerging carry trades. Likewise, Burnside (2014) finds that a portfolio of 26 emerging carry trades is highly profitable, which is due to their persistently high interest rate differentials. But the author is unable to disentangle time varying premia from idiosyncratic risk premia, and finds that investor capital flow does not fully match the profitability of these trades (Burnside, 2014). This seems intuitive given that idiosyncratic risks, such as extreme inflation and financial instability, particularly affect emerging markets. This limited capital inflow matches emerging currencies' smaller FX market share, which was 25% in 2019 (BIS, 2019). But as their market share continues to grow, research on the impact of the carry trade on emerging market currencies is warranted. Though the emerging market forward premium is still a puzzle, I take emerging market carry trade activity as given to study its impact on currency risk.

In a literature review on emerging market carry trades, Alper et al. (2009) suggest that future research consider "structural breaks" for emerging markets that adopted floating exchange rates in recent years (Alper et al., 2009, p. 123). This is because the carry trade of a managed exchange rate differs from that of a floating exchange rate: rather than arbitrage the interest rate differential, traders bet that the peg will hold around the very small fluctuations of a managed exchange rate. My research has the advantage of several more years of data from emerging markets that adopted floating exchange rates recently, so I examine structural breaks between floating and managed exchange rates to shed light on non-fundamental FX movements.

IV. Data and Methodology

To test the three propositions of the model and uncover the mechanism of arbitrage-driven risk, I consider the interest rate differentials and funding risk of advanced and emerging markets with floating exchange rates. Specifically, I consider 15 advanced and 32 emerging carry trades to the USD from September 1989-August 2004 (pre-arbitrage period) and September 2004-September 2019 (post-arbitrage period).[2] In this section, I discuss each of these assumptions, detailed explanations of each variable, and my classifications of markets and exchange rates. Table 1 includes summary statistics for key variables in the pre- and post-arbitrage periods for 15 advanced carry trades to the USD. Appendix C includes the summary statistics for 32 emerging carry trades. Each of these variables is discussed in detail below.

I use these key variables to test the propositions of my model. Specifically, Equation 1 is the baseline test for Proposition 1: in the pre-arbitrage period, perceived return (the interest rate differential) should not be able to predict risk due to external funding shocks (funding beta). In the post-arbitrage period, a strategy's interest rate differential should positively predict funding risk. Satisfying both of these conditions suggests that investing in currencies through the carry trade increases exchange rate risk:

$$\beta_{it}^{\text{post}} = b_0 + b_1\, IRD_{it}^{\text{post}} + b_2\, \beta_{it}^{\text{pre}} + \epsilon_{it} \qquad (1)$$

where a carry trade's funding beta, or a measure of risk due to external shocks to investor capital, is denoted by β_{it} for country *i* and year *t*. A carry trade's interest rate differential (perceived return) is denoted by IRD_{it}. Funding beta and interest rate differential are

[2] According to the Bank of International Settlements (2019), the USD is on 88% of one side of all FX trades.

Table 1: Summary Statistics (Advanced Carry Trades)

Summary statistics of 15 advanced carry trades to the USD (data sources in Appendix B). The interest rate differential (IRD) captures perceived return and Funding Beta measures risk due to external shocks to funding. I define the pre-arbitrage period as September 1989-August 2004 and the post-arbitrage period as September 2004-September 2019. Interest rate differentials and futures position are mean values. See Appendix C for summary statistics for 32 emerging carry trades.

	Pre-Arbitrage				Post-Arbitrage			
	IRD	Futures Position	Funding Beta	Funding Beta SD	IRD	Futures Position	Funding Beta	Funding Beta SD
Australia	2.233	.106	.362	7.049	2.260	.154	-.212	3.143
Canada	1.081	.022	.079	6.035	.193	.030	.344	1.506
Czech Republic	1.881	…	-1.754	13.389	-.134	…	.872	1.526
Euro Area	.375	.087	-.344	8.684	-.421	-.018	.251	2.974
Iceland	5.222	…	.575	34.780	6.196	…	1.930	3.737
Israel	4.246	…	-2.436	17.156	.308	…	-.279	3.854
Japan	-2.939	-.036	-.225	6.728	-.927	-.110	.564	1.145
New Zealand	2.876	.462	.103	5.471	2.483	.219	-.806	1.925
Norway	2.316	…	-.646	7.537	.712	…	.552	3.212
Singapore	-1.900	…	-1.382	7.324	-.398	…	.479	3.593
South Korea	4.992	…	-1.069	8.833	1.360	…	.721	2.510
Sweden	2.066	…	.323	8.384	-.648	…	.446	3.202
Switzerland	-1.064	-.056	-.138	14.036	-1.340	-.114	.549	2.789
Taiwan	.397	…	-.699	15.177	-.748	…	.989	1.080
United Kingdom	2.512	-.026	-.160	8.318	.432	-.047	-.510	1.955
Total (Avg.)	**1.620**	**.080**	**-.494**	**11.260**	**.622**	**.016**	**.393**	**2.543**

analyzed in the pre- and post-arbitrage periods. These variables are explained in detail below. The error term is denoted by ϵ_{it} and parameters b_0, b_1, and b_2 are estimated using ordinary least squares (OLS). Standard errors are robust to heteroskedasticity and account for serial correlation through Newey-West with a lag of 15 years and clustering by year.

IV.A Interest Rate Differential (IRD)

In its simplest form, the carry trade consists selling a low interest currency and buying a high interest currency and allowing it to appreciate until the end of the trade period (buy and hold strategy). The interest rate differential captures the perceived return of that carry trade. Investors have higher demand for strategies with greater perceived return (high interest rate differentials). My model predicts that this demand distortion drives arbitrage-driven risk in that investors flood more capital into strategies with higher perceived return, causing a larger exchange rate appreciation in response. The exchange rate movement reflects the risk of shocks to investor funding, which would cause them to unwind positions and depreciate the exchange rate. Proposition 1 tests this theory: interest rate differentials should positively predict funding risk when carry trade activity is high (the post-arbitrage period). They should not exist when carry trade activity is low (pre-arbitrage period).

To calculate interest rate differentials, I use monthly data on 3-month interbank interest rates when available and interest rates on treasury bills otherwise (Datastream), in line with the literature on the forward premium. I consider the interest rate differentials of 15 advanced and 32 emerging countries (listed in Appendix B) to the US from September 1989-September 2019:

$$z_{t+1} = i_t^* - i_t \qquad (2)$$

where z_{t+1} is the interest rate differential (perceived return), i_t^* is foreign interest rate, and i_t is domestic interest rate in month *t*.

Because the interest rate differential measures perceived return and hence investor demand, I explore two alternative proxies for investor demand. First, I consider CAPM alpha. In his research on arbitrage-driven risk in stock anomalies, Cho (2019) considers a strategy's alpha, or excess return to the market. While CAPM alpha is a similar measure of investor demand, it captures returns *ex post*. For stock anomalies, there is no equivalent in-the-moment measure of investor demand like the interest rate differentials of carry trades. Cho uses CAPM alpha as a proxy for investor demand distortion. So, while IRDs more accurately capture demand distortion, I confirm that my results are robust to Cho's methodology by testing carry trades' CAPM alpha. In line with the literature, I calculate CAPM alpha by regressing monthly interest rate differentials on monthly US market premium (Ken French data library).

Second, I consider realized return. While CAPM alpha captures excess return of the interest rate differential to the market, realized return considers the effect of exchange rates. In the time of the trade period where investors buy a high interest currency and convert back to the low interest currency, exchange rates change. If exchange rates depreciate too much, the profits of the high interest appreciation are wiped out. But the literature on the carry trade's profitability shows that exchange rates actually appreciate a little on average (Fama, 1984). The literature on the carry trade's forward premium uses realized return to demonstrate that uncovered interest parity does not hold for the carry trade anomaly.

In my analysis, I take the profitability of the carry trade as given to assess the impact of carry trade activity on exchange rate risk. To this end, it is more appropriate to use perceived return rather than realized return, which is less reflective of investor in-the-moment demand. But to confirm that my results are robust to realized return, I use Brunnermeier et al.'s (2008) methodology:

$$z_{t+1} = (i_t^* - i_t) - \Delta s_{t+1} \qquad (3)$$

where z_{t+1} is realized return, i_t^* is log foreign interest rate, i_t is log domestic interest rate, and s_{t+1} is log nominal exchange rate to the USD in month *t* (~January 1971-September 2019 from FRED and Datastream). The log functions are required to scale the data as exchange rate fluctuations can be orders of magnitude larger than interest rate differentials.

IV.B Funding Beta (ß)

I theorize that currencies traded in the carry trade inherit the risk of shocks to investor funding. When an investor bets on a carry trade, the exchange rate appreciates. When they experience an external shock to their capital, investors are forced to unwind their positions, and the exchange rate depreciates. Funding beta (also called funding risk) measures the risk generated from external shocks to investor funding. These shocks are exogenous in that they affect currencies and exchange rates through causing investors to unwind positions, not endogenous shocks that directly affect interest rates.

I base my definition of funding beta on Cho's (2019) research on equity anomalies. He utilizes the "leverage factor" created by Adrian, Etula, and Muir (2014). The leverage factor measures the leverage of the entire financial intermediaries sector. It captures the balance sheet capacity of financial intermediaries, such as prime brokers and banks who provide funding to hedge funds. When funding constraints tighten, balance sheet capacity falls and intermediaries are forced to deleverage by pulling their lending. As a result, hedge fund funding falls, and they are forced to unwind their positions in strategies like the carry trade. When funding constraints loosen and the leverage factor increases, balance sheet capacity increases and intermediaries can lever up by extending loans. With increased capital, hedge funds can invest in strategic vehicles. In this way, the leverage factor represents funding constraints. Cho (2019) calculates the funding beta of 40 stock anomalies by regressing strategy returns (CAPM alpha) on the leverage factor.

The Federal Reserve Board flow of funds data used to calculate the leverage factor is quarterly, which works for calculating the funding beta of stock anomalies because they maintain relatively consistent profitability over time. By contrast, interest rate differentials are much more variable, so the profitability of a carry trade varies even within one quarter. Quarterly interest rate differentials do not capture much of this variation. To mitigate this issue, I use Frazzini and Pedersen's (2014) monthly Betting Against Beta (BAB) factor, which captures funding constraints robust to the leverage factor. The BAB factor measures the return of a portfolio that longs low-beta stocks and shorts high-beta stocks. Frazzini and Pedersen (2014) find that when funding constraints tighten, investors turn to risky, high-beta stocks as a substitute for leverage. As they shift their positions away from safe, low-beta stocks toward risky, high-beta stocks, they push up the prices of high-beta stocks, and "betting against beta" becomes a less profitable strategy. Thus, the BAB factor falls when funding constraints tighten. Adrian et al. (2014) find that their leverage factor correlates well with the BAB portfolio and explains the cross-section of returns. Ma (2017) directly replicates Cho's findings with changes in the BAB factor, demonstrating that it captures funding constraints robust to the leverage factor at the monthly level.[3]

To calculate funding beta (by currency by year), I use the BAB factor (data from AQR Capital Management) from September 1989-September 2019. I regress the monthly interest rate differential on changes in the BAB factor.

IV.C Futures Position

To test if the carry trade generates funding risk, I use the interest rate differential as the determinant of investors' perceived return and demand. Thus, testing capital flow into the carry trade complements my analysis as close approximation of demand distortion. Capital invested is intrinsically determined by the perceived return of a trade, which is why its

[3] Ma (2017) replicates Cho's findings in a working paper published by Harvard University in 2017 (see References). The results in Cho's published article in 2019 follow the 2017 version closely.

results should mirror those of the interest rate differential. Equation 4 demonstrates the test of Proposition 1 using capital invested (Futures):

$$\beta_{it}^{\text{post}} = b_0 + b_1 \, Futures_{it}^{\text{post}} + b_2 \, \beta_{it}^{\text{pre}} + \epsilon_{it} \qquad (4)$$

To measure capital invested, I use futures position data from the Commodity Futures Trading Commission (CFTC) for seven advanced currencies (Canadian dollar, Euro, Swiss franc, British pound, Japanese yen, Australian dollar, and New Zealand dollar) and three emerging currencies (Mexican peso, Brazilian real, and Russian ruble) from ~January 1986-September 2019. A frequently cited measure of carry trade activity (Brunnermeier et al., 2008; Curcuru et al., 2010; Heath et al., 2007), futures position is the net position of non-commercial (speculative) traders in exchange rate futures on the Chicago Mercantile Exchange, as collected and reported by the CFTC. I calculate futures position as follows: net (long-minus-short) futures positions of noncommercial traders in a foreign currency as a fraction of total open interest of all traders. Futures position captures the size of investor demand for the carry trade to the USD.

By volume, the Chicago Mercantile Exchange is the largest market for currency futures in the world. But this data on futures position as a measure of carry trade activity has qualifications. Speculative traders use the exchange's futures contracts for many purposes other than the carry trade. Moreover, hedge funds, which are prominent carry traders, trade more in forward markets, which are not subject to the same CFTC reporting requirements. The Chicago Mercantile Exchange only captures a small proportion of the liquidity in FX market. Despite these limitations, futures position is the best publicly available data on carry trade activity and at least gives a sense of the direction of trade for investors. Visual representation of futures position for each currency is in Appendix D.

IV.D Arbitrage Periods

My model for arbitrage-driven risk relies on two periods: (1) the pre-arbitrage period, when carry trade activity is low so shocks to investor funding are not propagated to currencies, and (2) the post-arbitrage period, when carry trade activity is high so shocks to investor funding are propagated to currencies. My use of the term "arbitrage" in this context focuses on the currency carry trade specifically, a dominant investment strategy in FX markets.[4] While historically we cannot pinpoint when investors discovered the carry trade, the early 2000s are generally considered the "advent" of widespread currency carry trade activity. In this section, I consider the history of currency carry trade activity and evaluate data on futures position to identify a structural break between the pre- and post-arbitrage periods.

History of Currency Carry Trade Activity

Tracking carry trade activity precisely is difficult due to the liquidity of the market, the lack of data on institutional positions, and the complexity of some carry trade strategies. Carry trade strategies can range from a simple buy and hold to more complex derivative contracts, including foreign exchange futures, forwards and interest rate swaps, and high-speed algorithms. To mitigate these issues, studies on currency carry trade activity feature several datasets (Curcuru et al., 2010; Heath et al., 2007). Motivated by the sudden rise in carry trade activity in the early 2000s, Heath et al. (2007) study the Bank of International Settlement's (BIS) data on the currency breakdown of bank's international assets and liabilities as well as the Chicago Mercantile Exchange's data on futures position and over-

[4] Currencies have been arbitraged using different strategies since their modern invention (Knoll, 2008). I focus specifically on the carry trade, an anomaly violation of uncovered interest parity that has puzzled economists for decades.

the-counter transactions from the CFTC. With a few more years of data, Curcuru et al. (2010) also study the BIS and CFTC datasets and complement their analysis with ETFs, realized return, and exchange rate appreciation. Taken together, these datasets provide a comprehensive picture of carry trade activity.

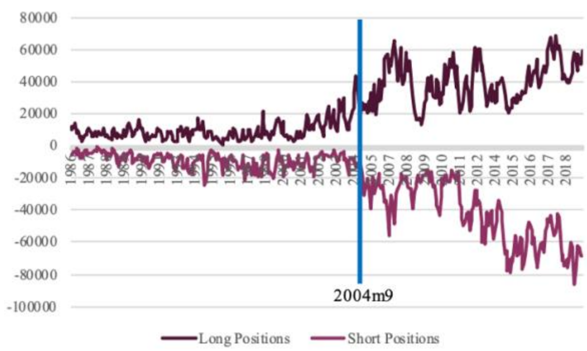
The results of these studies paint a fairly consistent picture. Curcuru et al. (2010) identify early 2006 as the start of widespread currency carry trade activity, driven by yen-denominated borrowing due to Japan's low interest rates.[5] Heath et al. (2007) demonstrate that "the carry trade has been important since 2004" (p. 39), driven by a surge in interbank lending among G7 countries at the end of 2003. They reference a report written in 2004 by Bank of International Settlement scholars, titled "Why Has FX Trading Surged? Explaining the 2004 Triennial Survey" (Galati & Melvin, 2004). The authors note that average daily turnover in the FX market rose to 1.9 trillion dollars in April 2004, a dramatic 57% increase since its April 2001 survey. This is compared to an average 2% triennial growth pre-2004 and an average 30% triennial growth post-2004 (BIS, 2019). To explain the surge, they point to the "so-called carry trade, a strategy that fed back into prices and supported the persistence of trends in exchange rates" (p. 68). While the carry trade has been an investment vehicle for decades, its rise as a popular currency arbitrage strategy in the early-mid 2000s could have been driven by trends of appreciation and the rise of hedge funds and commercial trading advisors.

[5] Though Curcuru et al. (2010) identify 2006 as the year when carry trade activity purportedly became widespread, their analyses of different datasets do not all confirm this hypothesis. To mitigate this issue, I test several years in the early-mid 2000s as the break between the arbitrage periods.

Identifying Arbitrage-Period Structural Break

To determine the periods with low and high carry trade activity, I conduct a structural break test using the futures position data from the CFTC (Figure 3). Despite its weaknesses (see Section IV.C), futures position is among the best publicly available data and is frequently used to measure carry trade activity (Brunnermeier et al., 2008; Curcuru et al., 2010; Heath et al., 2007). My results identify September 2004 as the month in which total futures positions (|long positions| + |short positions|) statistically diverge from 0. This result is consistent with the literature on carry trade activity described above.

Figure 3: Determining Arbitrage Periods



Test for a structural break: Unknown break date	
Observations	406
Trimmed sample	1991m2 – 2014m10
Estimated break date	**September 2004*** **
H_0: No structural break	
Stat: 382.62	p-value: 0.000

Figure 3 is a visual and statistical representation of the break between the arbitrage periods (September 2004). It uses long and short futures positions in currency contracts from CFTC data.

This statistically significant structural break sets up a quasi-natural experiment by which I can test the propositions of my model. Accordingly, I use September 2004 as the break between the arbitrage periods. However, my results should not be reliant on this exact 2004 cutoff. I test the robustness of my assumption by considering alternative structural break years in the early-mid 2000s to ensure that my results hold. Additionally, I test arbitrage periods of equal length in years: I define the pre-arbitrage period from September 1989-August 2004 and the post-arbitrage period as September 2004-September 2019. I test the robustness of this assumption by considering shorter period lengths to ensure that carry trade activity was too low to propagate funding risk to the currencies.

For emerging markets, some governments did not adopt a *de jure* floating exchange rate policy until after September 2004 (see Appendix B). For those countries, the pre-arbitrage period is considered until the adoption of a floating exchange rate. A managed currency constrains any exchange rate movements, such as those induced by the carry trade. A floating exchange rate allows currencies to take on arbitrage-driven risk.

IV.E Constrained and Unconstrained Periods

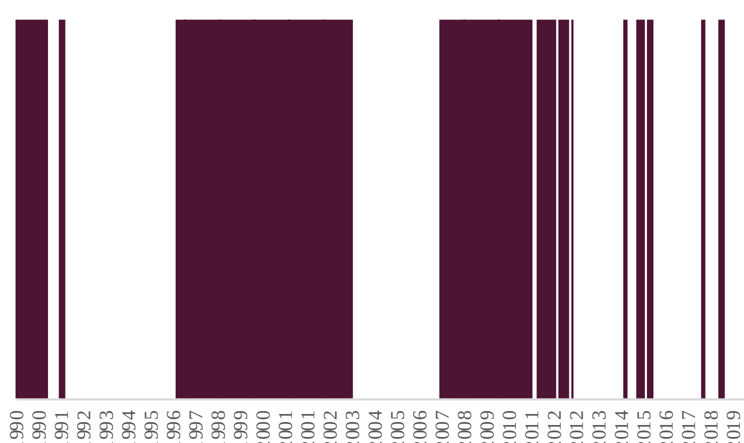
Propositions 1 and 2 examine whether the interest rate differential predicts the risk of shocks to investor funding (funding beta). In order to demonstrate that funding beta is in fact arbitrage-driven risk, it must only arise in times when investors are constrained (Proposition 3). When liquidity is low and funding is tight, shocks to investor capital force investors to unwind their positions and induce exchange rate movements. When liquidity is high and funding is readily available, shocks to investor capital do not force them to unwind their positions as they find capital elsewhere, so arbitrage-driven risk is not generated. Thus, if funding betas only arise in constrained times and do not arise in unconstrained times, they reflect arbitrage-driven risk.

If the inverse were true, the identified funding betas could be understood as mechanical wealth portfolio betas. In this case, even if the investor was too small to affect exchange rate movements, just holding a profitable carry trade strategy would cause the currency to take on the investors' funding risk factors. A shock to investor funding would impact a carry trade because they are part of investors' portfolios. Because they receive greater capital inflow, profitable strategies would be affected more. If investors are unconstrained by liquidity and can hold more profitable strategies, funding beta strengthens. If investors are constrained and have to unwind positions, funding beta weakens as the strategies become a smaller portion of the portfolio. Therefore, to understand whether the identified funding risk is an arbitrage-driven beta or mechanical wealth portfolio beta, Proposition 3 tests whether funding betas strengthen or weaken in constrained times (Equation 5).

$$\beta_{it}^{\text{post,constrained}} = b_0 + b_1\, IRD_{it}^{\text{post,constrained}} + b_2\, \beta_{it}^{\text{pre}} + \epsilon_{it} \qquad (5)$$

To identify funding constrained periods, I consider the VIX, which Nagel (2012) demonstrates captures the risk premium from providing liquidity. The VIX itself does not necessarily drive liquidity provision, but it proxies for the underlying variables such as the severity of funding constraints. I follow Nagel's (2012) definition of constrained times: months in which the moving average VIX is above the sample median (using daily data from CBOE). Figure 4 depicts months implied constrained by this definition.

Figure 4: Months Implied Constrained by the VIX



Constrained times are defined as months in which the moving average of the VIX is above the median of the period, in accordance with the literature.

IV.F Market and Exchange Rate Classifications

I sort currency carry trades based on two classifications: (1) floating versus pegged exchange rate and (2) advanced versus emerging market. First, my analysis is limited to floating exchange rates because they can fluctuate with carry trade induced movements. This is not to say that pegged or otherwise controlled exchange rates do not exhibit a forward premium when traded (Frankel & Poonawala, 2010). Investors bet that either the peg is abandoned (resulting in massive change in exchange rate) or that the peg will hold around very small fluctuations in the exchange rate. But the mechanism of arbitrage-driven risk is limited by managed exchange rate's inability to fluctuate with market forces. To identify floating exchange rates, I follow the IMF's *Annual Report on Exchange Arrangements and Exchange Restrictions* (2018). Second, to identify advanced and emerging markets, I follow the IMF's *World Economic Outlook* (2019) classification. These classifications are frequently cited in emerging market carry trade literature (Alper et al., 2009; Frankel & Poonawala, 2010). Figure 5 depicts the classifications on a map (see Appendix A for more details).

Figure 5: Map of IMF Exchange Rate and Market Classifications

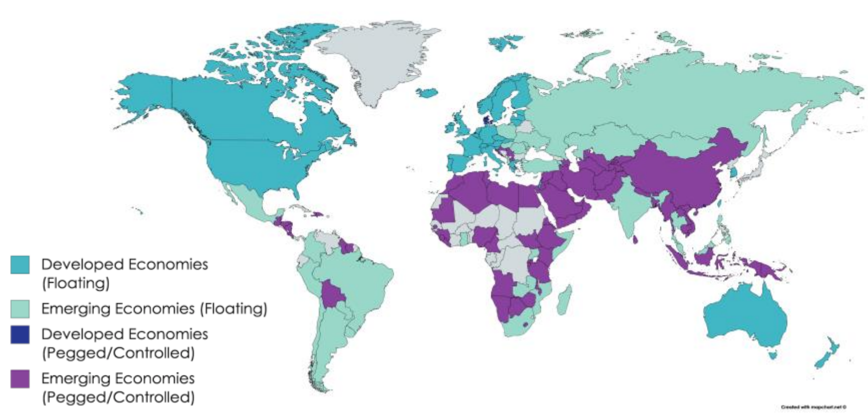


Figure 5 is a geographic representation of the market and exchange rate classifications outlined in Appendix A. It is based on the IMF's *World Economic Outlook* (2019) and AREAER (2018).

To check the robustness of the IMF's (2018) exchange rate classification, I use the Ilzetzki et al. (2017) classification, which rates currencies based on the degree of central bank management, regardless of official government policy. They consider 194 countries over seven decades (1946-2016), covering my full sample except Taiwan and three years of data (2017-2019). The motivation behind this alternative classification is that "*de jure* descriptions of exchange rate regimes…routinely depart from actual practices and can be downright misleading" (Ilzetzki et al., 2017, p. 3). Because the IMF's AREAER (2018) follows official government policy, I use the Ilzetzki et al. (2017) classification to compare months in which exchange rates were *de facto* floating to months in which they were *de facto* managed. The carry trade does not induce exchange rate movements if exchange rates are managed, so arbitrage-driven risk should only arise under floating exchange rates. Appendix B details the differences between the Ilzetzki et al. (2017) and IMF (2018) exchange rate classifications and provides data sources.

V. Results

In summary, my results demonstrate that investing in the carry trade causes currencies to take on arbitrage-driven risk. To demonstrate this, I test the three propositions of the model. First, I demonstrate that in the post-arbitrage period, the interest rate differential and futures position positively predict funding risk, while they do not in the pre-arbitrage period (Proposition 1). I conduct a variety of robustness checks to ensure that these results hold. The relationship is only significant under floating exchange rates using the Ilzetzki et al. (2017) classification. I also demonstrate the robustness of alternative structural break years, pre-arbitrage period lengths, and proxies for investor demand. Second, I confirm that near the beginning of the post-arbitrage period, pre-arbitrage interest rate differentials predict post-arbitrage funding risk (Proposition 2). This is because investors flood capital into the strategies that seemed most profitable in the pre-arbitrage period, generating larger risk in the post-arbitrage period. Lastly, I verify that funding risk only arises when investors are constrained and shocks to their funding force them to unwind their positions (Proposition 3). This confirms that funding risk is indeed reflective of arbitrage-driven risk. In this section, I first demonstrate these results for 15 advanced carry trades and then for 32 emerging carry trades.

Figure 6 demonstrates my empirical results for advanced carry trades. The data mirrors the theoretical representation in Figure 2 – in the pre-arbitrage period, the interest rate differential does not predict funding risk as carry trade activity is low. In the early years of carry trade activity, pre-arbitrage interest rate differential can positively predict funding risk. In the post-arbitrage period, interest rate differential can positively predict funding risk, demonstrating that the carry trade generates currency risk.

Figure 6: Empirical Relationship between Interest Rate Differentials and Arbitrage-Driven Risk

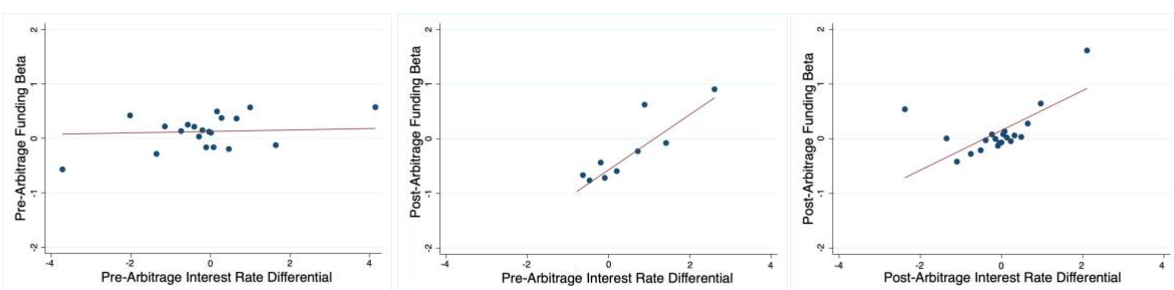


Figure 6 is a binscatter representation of the main results for 15 advanced carry trades, mirroring the theoretical representation in Figure 2. The first graph demonstrates the lack of relationship between the interest rate differential (perceived return) and funding risk in the pre-arbitrage period. The second graph demonstrates that in the early years of carry trade activity (2004-2006), the interest rate differential in the pre-arbitrage period predicts funding risk in the post-arbitrage period. The third graph demonstrates that interest rate differential positively predicts funding risk in the post-arbitrage period. Graphs are scaled to same axes values.

V.A Advanced Currency Carry Trades

Proposition 1: Explaining Funding Risk with Interest Rate Differentials

To test my central hypothesis that carry trade activity generates arbitrage-driven risk, I consider the relationship between the interest rate differential (capturing perceived return and investor demand) and funding risk. The intuition behind this is that investors bet more on strategies with high interest rate differentials, causing exchange rates to appreciate. When investors unwind their positions due to an external shock to their capital, exchange rates depreciate. Thus, currencies with high interest rate differentials vary more with the external shocks to investor funding. Proposition 1 contends that in the post-arbitrage period, the interest rate differential should positively predict risk due to shocks to funding. In the pre-arbitrage period, this relationship should be insignificant as carry trade activity is minimal. Satisfying these two conditions suggests that investment in the carry trade generates funding risk.

My results support Proposition 1 for 15 advanced carry trades (Table 2). I find that in the post-arbitrage period, the interest rate differential positively and significantly predicts funding risk, controlling for pre-arbitrage funding risk (Columns 1-2). The coefficients are economically significant: with time fixed effects, a 1 percentage point increase in the annualized interest rate differential yields a 0.296 increase in funding beta. Compared to an average funding beta standard deviation of 2.543 (Table 1), a 1 percentage point increase in IRD leads to 0.116 standard deviation increase in funding beta on average. In other words, a currency's exposure to shocks to investor funding increases with its interest rate differential to the funding currency (USD). I support this finding by considering futures position, a more direct measure of investor demand that is intrinsically

Table 2: Explaining Funding Betas with Interest Rate Differentials

This table confirms Proposition 1 of the model for 15 advanced carry trades from 2004-2019 under the IMF classification of floating exchange rates (Appendix B). The results show that interest rate differential and futures position positively predict funding risk in the post-arbitrage period (Columns 1-3), controlling for pre-arbitrage funding risk. This relationship is insignificant in the pre-arbitrage period (Columns 5-6). The coefficient of futures position with time fixed effects is insignificant likely due to the noisiness of the measure (Column 4). The interest rate differential (IRD) captures perceived return and Funding Beta measures risk due to external shocks to funding. I define the pre-arbitrage period as September 1989-August 2004 and the post-arbitrage period as September 2004-September 2019. In parentheses are standard errors that are robust to heteroskedasticity and account for serial correlation through Newey-West with a lag of 15 years and clustering by year.

$$\text{Baseline: } \beta_{it}^{\text{post}} = b_0 + b_1\, IRD_{it}^{\text{post}} + b_2\, \beta_{it}^{\text{pre}} + \epsilon_{it}$$

	Post-2004 Funding Beta				Pre-2004 Funding Beta	
	(1)	(2)	(3)	(4)	(5)	(6)
Post-2004 IRD	0.240***	0.296**				
	(0.034)	(0.133)				
Post-2004 Futures Position			1.874**	0.726		
			(0.771)	(0.952)		
Pre-2004 Funding Beta	0.142	0.093	-0.920	-0.430		
	(0.314)	(0.215)	(0.912)	(0.475)		
Pre-2004 IRD					0.232	
					(0.334)	
Pre-2004 Futures Position						-1.118
						(3.141)
Constant	0.499	-1.049**	0.374	-0.762***	7.439*	-0.088
	(0.526)	(0.109)	(0.246)	(0.198)	(4.142)	(1.410)
Year FE	No	Yes	No	Yes	Yes	Yes
Observations	222	222	110	110	210	96
R_2	0.189	0.299	0.067	0.431	0.488	0.456

Note: *** p<0.01, ** p<0.05, * p<0.1

determined by the interest rate differential (Columns 3-4). Without time fixed effects, coefficient is statistically significant: a 1 point increase in futures position (long-minus-short positions/total open interest) yields a 1.874 increase in funding beta on average (Column 3). I find that the relationship is insignificant when considering time fixed effects, likely due to noisiness of the measure (Column 4). Finally, I confirm that interest rate differential and futures position do not predict funding beta in the pre-arbitrage period (Columns 5-6). Because carry trade activity is low, funding risk is not propagated to currencies. Thus, the coefficients are insignificant as the model predicts.

Floating Versus Managed Exchange Rates

Interest rate differentials should only predict funding risk when exchange rates can fluctuate freely in response to carry trade activity. If they are managed by government policy, exchange rate movement is constrained, including those induced by the carry trade. I test whether interest rate differentials only predict funding risk under floating exchange rates. To do so, I utilize the Ilzetzki et al. (2017) classification described in Section IV.F. This system identifies months in which exchange rates were *de facto* floating, considering official and unofficial caps, floors, and other management policies. As a result, the number of observations falls from 222 to 162 under floating exchange rates and to 96 under managed exchange rates.

My findings support the intuition of the model: the interest rate differential predicts funding risk under floating exchange rates, but not under managed exchange rates (Table 3). Under floating exchange rates, interest rate differentials significantly and positively predict funding risk, controlling for pre-arbitrage funding risk. With time fixed effects, the coefficient indicates that a 1 percentage point increase in annualized interest rate differential yields a 0.375 increase in funding beta (Column 2). This is a 27% increase compared to the full sample (Table 2), as controlling for months in which the exchange rate is floating amplifies the impact of the carry trade on exchange rate movements. By

Table 3: Funding Betas and Interest Rate Differentials Under Floating Versus Managed Exchange Rates

This table compares months in which exchange rates were floating versus managed under the Ilzetzki et al. (2017) classification of exchange rate regimes (Appendix B). The results confirm that the interest rate differential and futures position positively predict funding risk when exchange rates are floating (Columns 1-3), controlling for pre-arbitrage funding risk. This relationship is insignificant when exchange rates are managed (Columns 5-6). The coefficient of futures position with time fixed effects is insignificant likely due to the noisiness of the measure (Column 4). This confirms that the carry trade induces non-fundamental exchange rate movements for 15 advanced carry trades from 2004-2019. The interest rate differential (IRD) captures perceived return and Funding Beta measures risk due to external shocks to funding. I define the pre-arbitrage period as September 1989-August 2004 and the post-arbitrage period as September 2004-September 2019. In parentheses are standard errors that are robust to heteroskedasticity and account for serial correlation through Newey-West with a lag of 15 years and clustering by year. Under managed exchange rates, futures position was not considered for lack of data (fewer than 20 observations).

Baseline: $\beta_{it}^{\text{post,floating}} = b_0 + b_1\, IRD_{it}^{\text{post,floating}} + b_2\, \beta_{it}^{\text{pre}} + \epsilon_{it}$

	Post-2004 Floating ER Funding Beta				Post-2004 Managed ER Funding Beta	
	(1)	(2)	(3)	(4)	(5)	(6)
Post-2004 IRD	0.270***	0.375***			-0.397	-0.475
	(0.068)	(0.119)			(0.247)	(0.363)
Post-2004 Futures Position			1.850**	0.893		
			(0.792)	(1.043)		
Pre-2004 Funding Beta	0.278	0.336	-0.468	-0.008	-0.360	-0.090
	(0.191)	(0.206)	(0.730)	(0.837)	(0.354)	(0.238)
Constant	0.754**	-1.152***	0.620***	-0.776***	-0.674	-0.827
	(0.300)	(0.142)	(0.155)	(0.238)	(0.475)	(0.362)
Year FE	No	Yes	No	Yes	No	Yes
Observations	162	162	88	88	96	96
R_2	0.278	0.649	0.131	0.455	0.043	0.359

Note: *** p<0.01, ** p<0.05, * p<0.1

limiting the sample to months in which exchange rates fully absorb the impact of the carry trade, the interest rate differential has an explanatory power of 64.9% for the variation in funding risk (Column 2). Likewise, futures position significantly predicts funding risk without time fixed effects (Column 3). As in the full sample, the coefficient loses its significance with time fixed effects (Column 4), likely due to the noisiness of the measure. Finally, I confirm that under managed exchange rates, the interest rate differential does not predict funding risk (Columns 5-6). Managed exchange rates cannot fully fluctuate in response to investors' changing positions, so the impact of the carry trade is constrained.

Examining Structural Break Year

To test the robustness of my Proposition 1 results, I consider alternative structural break years. Based on my analysis of futures position data in Section IV.D, I define the arbitrage periods around September 2004. However, my results should not be reliant on this exact cutoff. The relationship between the interest rate differential and funding risk should be positive and significant in the general period after the carry trade became widespread (~2000s-2010s); in this period, greater investment would cause more profitable strategies to take on greater arbitrage-driven risk. The relationship should be insignificant in the general period when carry trade activity was low (~1980s-1990s).

I demonstrate that my results are robust to a variety of years around 2004 (Table 4). Considering alternative years 2001-2007 as the structural break, the interest rate differential predicts funding risk in the post-arbitrage period (Columns 1-5), but does not in the pre-arbitrage period (Columns 8-12). The coefficients in Columns 1-5 are statistically significant and remain in the same range of magnitude as the main test. To complement this analysis, I tested 1996 as the upper limit of the pre-arbitrage period and 2012 as the lower limit of the post-arbitrage period. This removes any immediate impact of the transition period when carry trade activity began to increase. As expected, the interest rate differential does not predict funding risk pre-1996 as carry trade activity was low

Table 4: Examining Alternative Structural Break Years

This table confirms that results are robust to alternative structural break years. The results demonstrate that alternative structural breaks are robust to September 2004, which is used in the main tests. Considering 2001-2007, the interest rate differential predicts funding risk in the post-arbitrage period (Columns 1-5), controlling for pre-arbitrage funding risk. This relationship is insignificant in the pre-arbitrage period (Columns 8-12). It also considers post-2012 and pre-1996 (Columns 6-7), which confirm that excluding the transition period (late 1990s-early 2000s) does not affect results. Structural breaks listed are in September of the year for consistency. Arbitrage period lengths are kept at 15 years except for post-2005, post-2006, post-2007, and post-2012 due to 2019 data upper limit. Number of observations varies in the pre-arbitrage period based on data sources (Appendix B). All tests were run with year fixed effects. This table considers 15 advanced carry trades from 2004-2019 under the IMF classification of floating exchange rates (Appendix B). Interest rate differential (IRD) captures perceived return and Funding Beta measures risk due to external shocks to funding. I define the pre-arbitrage period as September 1989-August 2004 and the post-arbitrage period as September 2004-September 2019. In parentheses are standard errors that are robust to heteroskedasticity and account for serial correlation through Newey-West with a lag of 15 years.

$$\text{Baseline: } \beta_{it}^{\text{post}} = b_0 + b_1\, IRD_{it}^{\text{post}} + b_2\, \beta_{it}^{\text{pre}} + \epsilon_{it}$$

	Post-Arbitrage Funding Beta						Pre-Arbitrage Funding Beta					
Structural Break	*2001*	*2002*	*2003*	*2005*	*2006*	*2012*	*1996*	*2001*	*2002*	*2003*	*2005*	*2006*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Post-Arbitrage IRD	0.188**	0.184*	0.213**	0.303**	0.339*	0.132**						
	(0.091)	(0.100)	(0.104)	(0.148)	(0.187)	(0.057)						
Pre-Arbitrage Funding Beta	0.516	0.438	0.391	0.074	0.115	0.277						
	(0.371)	(0.403)	(0.381)	(0.223)	(0.283)	(0.110)						
Pre-Arbitrage IRD							-0.224	0.169	0.169	0.232	-0.236	-0.114
							(0.219)	(0.201)	(0.189)	(0.334)	(0.175)	(0.203)
Constant	0.146	-0.588**	-2.998***	-0.390**	5.488***	1.937***	23.98***	-7.384	-0.108	7.439*	-3.114*	-3.763
	(0.192)	(0.246)	(0.189)	(0.118)	(0.274)	(0.105)	(2.200)	(4.840)	(1.799)	(4.142)	(1.804)	(1.800)
Observations	222	222	222	208	194	110	151	200	205	209	210	210
R^2	0.271	0.279	0.293	0.298	0.303	0.381	0.498	0.448	0.494	0.488	0.464	0.175

Note: *** p<0.01, ** p<0.05, * p<0.1

(Column 8). Likewise, the interest rate differential positively and significantly predicts funding risk post-2012 as carry trade activity is high (Column 7). However, the magnitude of the coefficient falls as interest rate differentials tighten and capital inflow decreases. These results demonstrate that my analysis is robust to a variety of structural break points, supporting the model's theory. The following tests in this paper use September 2004 as the structural break for consistency.

Examining Pre-Arbitrage Period Length

Next, I consider alternative pre-arbitrage period lengths for the robustness of my Proposition 1 results. To check the robustness of my 15-year assumption, which maintains periods of equal lengths, I consider these pre-arbitrage period lengths: 5 years, 10 years, and all years (Table 5). My results show that under any of these definitions, the interest rate differential does not predict funding risk in that all of the coefficients are insignificant (Columns 1-4). During these periods, there was not enough carry trade activity for shocks to investor funding to be inherited by currencies. This indicates that results are robust to alternative definitions of pre-arbitrage period length. The following tests in this paper maintain September 1989-August 2004 as the pre-arbitrage period for consistency.

Examining Alternative Proxies for Investor Demand

To test the robustness of my Proposition 1 results, I consider two alternative proxies for investor demand: CAPM alpha and realized return. In the main tests, I use the interest rate differential as a measure of perceived return, which captures investor in-the-moment demand for a particular carry trade strategy. Demand drives capital flow, which induces

Table 5: Examining Pre-Arbitrage Period Length

This table confirms that results are not reliant on length of the pre-arbitrage period. Considering 5-years, 10-years, 15-years, and all years, the interest rate differential does not predict funding risk when carry trade activity is low (Columns 1-4). This table considers 15 advanced carry trades from 2004-2019 under the IMF classification of floating exchange rates (Appendix B). The interest rate differential (IRD) captures perceived return and Funding Beta measures risk due to external shocks to funding. All tests include year fixed effects. I define the pre-arbitrage period in September of the year listed in the table and the post-arbitrage period as September 2004-September 2019. In parentheses are standard errors that are robust to heteroskedasticity and account for serial correlation through Newey-West with a lag of 15 years and clustering by year.

$$\text{Baseline: } \beta_{it}^{\text{pre}} = b_0 + b_1\, IRD_{it}^{\text{pre}} + \epsilon_{it}$$

	Pre-2004 Funding Beta			
	(1)	(2)	(3)	(4)
1999-2004 IRD	-0.118			
	(0.156)			
1994-2004 IRD		-0.244		
		(0.185)		
1989-2004 IRD [1]			0.232	
			(0.334)	
~1971-2004 IRD [2]				0.266
				(0.171)
Constant	1.804**	0.591	7.439*	1.500***
	(0.738)	(0.843)	(4.142)	(0.056)
Observations	70	140	210	305
R^2	0.234	0.182	0.488	0.510

Note: *** p<0.01, ** p<0.05, * p<0.1

[1]Reproduction of results from Table 2 Column 5.
[2]All Years IRD refers to no restriction on start of pre-arbitrage date. The interest rate differentials of each carry trade start according to the available interest rate data (listed in Appendix B).

exchange rate movement. To test this assumption, I first consider CAPM alpha, which measures the excess return of a carry trade to the market. Cho (2019) uses the CAPM alpha of stock anomalies, which lack a closer approximation of contemporary investor demand. Second, I consider realized return, which subtracts the month-over-month change in the exchange rate. By considering changes in the exchange rate, realized return captures investor return *ex post*, rather than investor demand *ex ante*. The literature on the forward

Table 6: Examining Alternative Proxies for Investor Demand

This table shows that results are robust to two alternative proxies for investor demand. CAPM Alpha reflects excess strategy return to the market and was calculated by regressing the interest rate differential on the US monthly market premium. Realized Return subtracts month-over-month change in the exchange rate from the interest rate differential (scaled using logarithms). Both positively and significantly predict funding risk in the post-arbitrage period (Columns 1-2), but not in the pre-arbitrage period (Columns 3-4). Funding Beta measures risk due to external shocks to funding. All tests include year fixed effects. This table considers 15 advanced carry trades from 2004-2019 under the IMF classification of floating exchange rates (Appendix B). I define the pre-arbitrage period as September 1989-August 2004 and the post-arbitrage period as September 2004-September 2019. In parentheses are standard errors that are robust to heteroskedasticity and account for serial correlation through Newey-West with a lag of 15 years and clustering by year.

$$\text{Baseline: } \beta_{it}^{\text{post}} = b_0 + b_1\,\alpha_{it}^{\text{post}} + b_2\,\beta_{it}^{\text{pre}} + \epsilon_{it}$$

	Post-2004 Funding Beta		Pre-2004 Funding Beta	
	(1)	(2)	(3)	(4)
Post-2004 CAPM Alpha	69.92***			
	(16.38)			
Post-2004 Realized Return		25.02***		
		(5.376)		
Pre-2004 Funding Beta	0.0577	-1.157		
	(0.125)	(1.383)		
Pre-2004 CAPM Alpha			-21.57	
			(13.97)	
Pre-2004 Realized Return				7.121
				(12.12)
Constant	2.000***	0.242**	33.87***	0.195***
	(0.663)	(0.094)	(1.121)	(0.036)
Observations	222	206	210	214
R^2	0.632	0.402	0.454	0.302

Note: *** p<0.01, ** p<0.05, * p<0.1

premium uses this definition to measure anomaly returns.

I find that CAPM alpha and realized return are robust to perceived return in reflecting investor demand (Table 6). Both significantly and positively predict funding risk in the post-arbitrage period, controlling for pre-arbitrage risk (Columns 1-2). While the sizes of the coefficients differ dramatically from those of perceived return (Table 2), the impact in terms of funding risk standard deviation is in the same order of magnitude. Considering CAPM alpha, a 1 percentage point increase yields a 0.275 standard deviation increase in funding risk; considering realized return, a 1 percentage point increase yields a 0.264 standard deviation increase in funding risk. Intuitively, these definitions measure larger funding betas by taking into account market and exchange rate movements *ex post*. If investors could predict these future factors as they made their investment decisions, their positions would reflect these funding risk levels. So, while realized return and CAPM alpha are statistically appropriate proxies, perceived return (interest rate differentials) best captures *ex ante* demand.

Proposition 2: Post-Arbitrage Funding Risk with Pre-Arbitrage Interest Rate Differentials

Thus far, my results support Proposition 1 in that interest rate differentials predict funding risk when carry trade activity is widespread (post-arbitrage period), but not when it is minimal (pre-arbitrage period). Next, I test Proposition 2, which contends that the pre-arbitrage interest rate differential predicts post-arbitrage funding risk in the early years of the post-arbitrage period. The intuition behind this is that as carry trade activity spreads, investors flood capital into the strategies perceived as more profitable before carry trading was a popular arbitrage strategy. This causes the strategies with higher perceived return (interest rate differential) in the pre-arbitrage period to experience larger exchange rate movements, reflecting larger funding risk in the post-arbitrage period.

My results support Proposition 2 (Table 7). I consider funding risk in 2004 as well as years just after 2004 to see how long the effect was maintained. I also consider months in which exchange rates were floating according to the Ilzetzki et al. (2017) classification

Table 7: Explaining Post-Arbitrage Funding Risk with Pre-Arbitrage Interest Rate Differentials

This table confirms Proposition 2 that in the early years of carry trade activity (~2004), the interest rate differential in the pre-arbitrage period predicts funding risk in the post-arbitrage period. While statistical power is low due to limited years, this relationship is confirmed in 2004 and 2004-2006 in months where exchange rates were floating (Columns 2 and 4), according to the Ilzetzki et al. (2017) classification. It loses significance by 2008, as interest rates shift, profitability changes, and investors bet on different carry trades (Columns 5-6). Considering all post-arbitrage years, the relationship is insignificant with low explanatory power (Columns 7-8). This table considers 15 advanced carry trades from 2004-2019 under the IMF classification of floating exchange rates (Appendix B). The interest rate differential (IRD) captures perceived return and Funding Beta measures risk due to external shocks to funding. I define the pre-arbitrage period as September 1989-August 2004 and the post-arbitrage period as September 2004-September 2019. In parentheses are standard errors that are robust to heteroskedasticity and account for serial correlation through Newey-West with a lag of 15 years and clustering by year.

$$\text{Baseline: } \beta_{it}^{\text{post}} = b_0 + b_1\, IRD_{it}^{\text{pre}} + \epsilon_{it}$$

	2004 Funding Beta		2004-2006 Funding Beta		2004-2008 Funding Beta		2004-2019 Funding Beta	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Pre-2004 IRD	0.144		0.792		0.585		0.127	
(No Controls)	(0.143)		(0.750)		(0.365)		(0.190)	
Pre-2004 IRD		0.145*		0.692**		0.504		0.231
(Floating ER)		(0.087)		(0.351)		(0.345)		(0.154)
Constant	-0.631**	-0.627**	1.516*	1.171	1.938***	1.540***	0.602**	0.615**
	(0.263)	(0.296)	(0.827)	0.778	(0.538)	(0.531)	(0.247)	(0.244)
Observations	14	12	42	36	70	61	222	162
R^2	0.416	0.602	0.165	0.195	0.187	0.118	0.036	0.095

Note: *** p<0.01, ** p<0.05, * p<0.1

to highlight when the impact of the carry trade could have been incorporated as exchange rate movements. I find that pre-arbitrage return has a positive relationship with funding risk in 2004 (Columns 1-2). The statistical power is low due to the limited sample size (one year), but the coefficient is significant at the 10% level when controlling for floating exchange rates (Column 2). Explanatory power is relatively large as pre-arbitrage interest rate differential explains 60.2% of the variation in 2004 funding risk. The relationship is maintained in 2004-2006 as interest rates continue to reflect pre-arbitrage levels (Columns

3-4). The magnitude of the coefficient under floating exchange rates is statistically significant and large, where a 1 percentage point increase in annualized interest rate differentials yields a 0.692 increase in funding beta (Column 4). This is more than double the magnitude of the full sample coefficient (Table 2), as I consider a smaller sample size and large interest rate differentials.

As years pass and interest rates shift, the relationship loses its significance. I find that this had happened by 2008 (Columns 5-6). Because carry trade strategies depend on the interest rate differential, and interest rates shift according to government policy, there is no consistently dominant currency carry trade pair. As a result, when considering all years post-2004, the relationship has no significance and explanatory power falls (Columns 7-8). In 2019, the interest rate differential of a strategy in the pre-arbitrage period is irrelevant to the decisions of investors as interest rates have changed. Proposition 2 is limited to the years around the structural break.

Proposition 3: Funding Betas in Constrained Versus Unconstrained Times

Thus far, my results suggest that the carry trade leads to greater funding risk, and strategies with higher interest rate differentials take on more risk (Propositions 1 and 2). But how can we confirm that this identified funding risk actually works by the carry trade inducing non-fundamental exchange rate movements? Proposition 3 presents a solution.

If funding betas reflect arbitrage-driven risk, they arise only in constrained times. When liquidity is high (unconstrained times), shocks to funding do not force investors to unwind positions as they find capital elsewhere. When liquidity is low (constrained times), shocks to investor capital force investors to unwind positions – in response, exchange rates depreciate. If funding risk only arises in constrained times and not in unconstrained times, we know it is in fact arbitrage-driven risk through exchange rate movements.

The inverse would be true if funding risk actually proxied for investor wealth portfolio, where investors propagate funding shocks to currencies simply because they hold them in their portfolio. In this case, funding risk would strengthen when investors are unconstrained and can hold more of the profitable carry trades. A strategy with a large interest rate differential would mechanically have a large funding beta as it has a greater share of the portfolio. Funding beta would weaken in constrained times when investors can hold less of the strategy.

I find that funding betas only arise in constrained times, and not in unconstrained times, so funding risk does reflect arbitrage-driven risk (Table 8). The interest rate differential positively and significantly predicts funding risk in constrained times, controlling for pre-arbitrage risk (Columns 1-2). With time fixed effects, a 1 percentage point increase in annualized interest rate differential yields a 0.216 increase in funding beta (Column 2). This coefficient is similar in magnitude to that of the full sample (Table 2). I confirm this using futures position, which significantly and positively predicts funding risk in constrained times (Columns 3-4). The coefficients are significant at a higher level than those of the full sample, likely because limiting the sample to constrained times captures when investors are actually forced to withdraw capital. Finally, I find that interest rate differential and futures position do not predict funding risk in unconstrained times (Columns 5-8). These results demonstrate that funding betas arise only in constrained times, and thus reflect arbitrage-driven risk.

Table 8: Funding Betas Arise Only in Constrained Times

This table confirms that funding betas arise in constrained times (Columns 1-4) and do not in unconstrained times (Columns 5-8). According to Proposition 3, this suggests that funding betas reflect arbitrage-driven risk. Constrained times are defined as months in which the moving average of the VIX is above the median of the period. This table considers 15 advanced carry trades from 2004-2019 under the IMF classification of floating exchange rates (Appendix B). The interest rate differential (IRD) captures perceived return and Funding Beta measures risk due to external shocks to funding I define the pre-arbitrage period as September 1989-August 2004 and the post-arbitrage period as September 2004-September 2019. In parentheses are standard errors that are robust to heteroskedasticity and account for serial correlation through Newey-West with a lag of 15 years and clustering by year.

$$\text{Baseline: } \beta_{it}^{\text{post,constrained}} = b_0 + b_1\, IRD_{it}^{\text{post,constrained}} + b_2\, \beta_{it}^{\text{pre}} + \epsilon_{it}$$

	Post-2004 Constrained Funding Beta				Post-2004 Unconstrained Funding Beta			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post-2004 IRD	0.281*	0.216***			-0.034	-0.209		
	(0.150)	(0.062)			(0.221)	(0.207)		
Post-2004 Futures Position			2.337**	2.422***			3.184	-0.270
			(1.179)	(0.582)			(2.123)	(1.285)
Pre-2004 Funding Beta	0.214	0.270	0.703	0.830	0.002	0.129	-3.348*	-2.017
	(0.380)	(0.330)	(0.881)	(0.519)	(0.687)	(0.587)	(1.809)	(1.545)
Constant	0.099	3.501***	0.719*	2.274***	0.953	-0.313	0.985**	-0.646**
	(0.699)	(0.135)	(0.394)	(0.121)	(0.773)	(0.386)	(0.451)	(0.314)
Year FE	No	Yes	No	Yes	No	Yes	No	Yes
Observations	140	140	70	70	180	180	90	90
R^2	0.068	0.357	0.039	0.250	0.025	0.194	0.164	0.553

Note: *** p<0.01, ** p<0.05, * p<0.1

V.B Emerging Currency Carry Trades

My results for advanced economies suggest that investing in the currency carry trade generates arbitrage-driven risk, which is intuitive given the substantial carry trade volume of advanced currencies in FX markets. The following sections explore arbitrage-driven risk among emerging currencies, which account for 25% of total FX market share in 2019, but have received substantially less research (BIS, 2019). I test Propositions 1-3 for 32 emerging carry trades to the USD under floating exchange rates (listed in Appendix B), excluding futures position (data unavailable in the pre-arbitrage period, see Appendix D).

The tests maintain the September 2004 structural break, except for countries that adopted a floating exchange later (adoption date is used instead). This is to ensure I am capturing the impact of the carry trade on exchange rate movement, which cannot happen under managed exchange rates. In Appendix E, I consider the effect of political regime and state fragility on the generation of arbitrage-driven risk for emerging carry trades.

Proposition 1: Explaining Funding Risk with Interest Rate Differentials

I test Proposition 1 that interest rate differentials predict funding risk in the post-arbitrage period, but not in the pre-arbitrage period. Satisfying these conditions indicates that the carry trade is the underlying driver of emerging market currencies taking on risk due to shocks to investor funding.

My findings support Proposition 1 for emerging economies (Table 9). In the post-arbitrage period, interest rate differentials significantly and positively predict funding risk, controlling for pre-arbitrage funding risk (Columns 1-2). With time fixed effects, the magnitude of the coefficient is slightly larger than that of advanced carry trades: a 1 percentage point increase in the interest rate differential yields a 0.319 increase in funding risk. This could be driven by emerging economies' higher interest rate differentials than those of advanced economies on average (5.722 vs. 0.622, see Summary Statistics). However, their smaller FX market share indicates that higher interest rate differentials are not matched by higher capital inflow. Rather, emerging economies also have higher idiosyncratic risk and experience larger interest rate fluctuations. The emerging currency funding beta standard deviation is 11.14 on average (Appendix C), so the economic impact of a 1 percentage point increase in IRD is only 0.0286 standard deviations. Carry trade

Table 9: Explaining Funding Betas with Interest Rate Differentials

(Emerging Carry Trades)

These results confirm Proposition 1 of the model for 32 emerging carry trades from 2004-2019 under the IMF classification of floating exchange rates (Appendix B). Interest rate differentials positively predict funding risk in the post-arbitrage period (Columns 1-2), controlling for pre-arbitrage funding risk. This relationship is insignificant in the pre-arbitrage period (Columns 3-4). The interest rate differential (IRD) captures perceived return and Funding Beta measures risk due to external shocks to funding. I define the pre-arbitrage period as September 1989-August 2004 and the post-arbitrage period as September 2004-September 2019. For countries that adopted a floating exchange rate after September 2004, the adoption date is used as the structural break. Futures position was excluded for lack of pre-arbitrage data (Appendix D). In parentheses are standard errors that are robust to heteroskedasticity and account for serial correlation through Newey-West with a lag of 15 years and clustering by year.

$$\text{Baseline: } \beta_{it}^{\text{post}} = b_0 + b_1\, IRD_{it}^{\text{post}} + b_2\, \beta_{it}^{\text{pre}} + \epsilon_{it}$$

	Post-Arbitrage Funding Beta		Pre-Arbitrage Funding Beta	
	(1)	(2)	(3)	(4)
Post-Arbitrage IRD	0.435**	0.319**		
	(0.176)	(0.146)		
Pre-Arbitrage Funding Beta	-0.101	-0.044		
	(0.122)	(0.114)		
Pre-Arbitrage IRD			0.127	0.111
			(0.307)	(0.324)
Constant	1.442	0.761	-3.452	3.895***
	(2.173)	(1.262)	(3.907)	(0.551)
Year FE	No	Yes	No	Yes
Observations	428	428	317	317
R_2	0.021	0.295	0.002	0.085

Note: *** p<0.01, ** p<0.05, * p<0.1

induced funding risk is only a small proportion of total currency risk. The intuition that the carry trade induces funding risk is confirmed by the inability of interest rate differentials to predict funding risk in the pre-arbitrage period, when carry trade activity is low (Columns 3-4).

Floating Versus Managed Exchange Rates

In the post-arbitrage period, the demonstrated relationship between the interest rate differential and funding risk should only arise when exchange rates are floating. If exchange rates are managed by government policy or currency board, they do not move in response to investors' positions in the carry trade. So, funding risk is not generated under managed exchange rates. By controlling for the Ilzetzki et al. (2017) classification of *de facto* floating exchange rates, I compare funding risk under floating versus managed exchange rates. Intuitively, the number of observations falls from 428 to 301 under floating exchange rates and 176 under managed exchange rates.

I find that the interest rate differential can only predict funding risk under floating exchange rates, and not under managed exchange rates (Table 10). Interest rate differentials can positively and significantly predict funding risk under floating exchange rates, controlling for pre-arbitrage funding risk (Columns 1-2). Considering time fixed effects, a 1 percentage point increase in the interest rate differential yields a 0.492 increase in funding risk. This is a 54% increase compared to the full sample as controlling for floating exchange rates limits the sample to months in which exchange rates fully move. Under managed exchange rates, interest rate differentials do not predict funding risk (Columns 3-4). This confirms that when exchange rates are being managed, non-fundamental movements are constrained and the carry trade does not generate funding risk.

Proposition 2: Post-Arbitrage Funding Risk and Pre-Arbitrage Interest Rate Differentials

Proposition 2 contends that in the early years of carry trade activity, the interest rate differential in the pre-arbitrage period should predict funding risk in the post-arbitrage

Table 10: Funding Betas and Interest Rate Differentials Under Floating Versus Managed Exchange Rates

(Emerging Carry Trades)

This table compares months in which exchange rates were floating versus managed according to the Ilzetzki et al. (2017) classification *de facto* classification for 32 emerging carry trades from 2004-2019 (Appendix B). The results confirm that the interest rate differential positively predicts funding risk when exchange rates are floating (Columns 1-2), controlling for pre-arbitrage funding risk. This relationship is insignificant when exchange rates are managed (Columns 3-4). This confirms the carry trade distorts exchange rates by inducing non-fundamental movements. The interest rate differential (IRD) captures perceived return and Funding Beta measures risk due to external shocks to funding. I define the pre-arbitrage period as September 1989-August 2004 and the post-arbitrage period as September 2004-September 2019. In parentheses are standard errors that are robust to heteroskedasticity and account for serial correlation through Newey-West with a lag of 15 years and clustering by year.

Baseline: $\beta_{it}^{\text{post,floating}} = b_0 + b_1\, IRD_{it}^{\text{post,floating}} + b_2\, \beta_{it}^{\text{pre}} + \epsilon_{it}$

	Post-Arbitrage Floating ER Funding Beta		Post-Arbitrage Managed ER Funding Beta	
	(1)	(2)	(3)	(4)
Post-Arbitrage IRD	0.474**	0.492**	-0.315	-0.242
	(0.232)	(0.206)	0.196	(0.153)
Pre-Arbitrage Funding Beta	-0.347	-0.306	-0.105	-0.053
	(0.295)	(0.281)	(0.168)	(0.154)
Constant	-1.242	-3.184	-0.085	-2.916**
	(1.691)	(2.018)	(2.332)	(1.221)
Year FE	No	Yes	No	Yes
Observations	301	301	176	176
R_2	0.088	0.292	0.020	0.115

Note: *** p<0.01, ** p<0.05, * p<0.1

period. This is based on the intuition that investors flood capital into more profitable strategies, causing larger exchange rate movements and generating funding risk. This requires that interest rate differentials in the first years post-arbitrage maintain pre-arbitrage levels, such that investor decisions remain consistent. According to my results (Table 7), this is true for advanced economies.

Figure 7 demonstrates why this does not hold for emerging economies. It depicts the correlation between pre-arbitrage interest rate differential and annualized post-arbitrage interest rate differential for advanced and emerging economies. For advanced economies, the correlation is strong especially near the structural break. However, the correlation weakens as years pass and interest rates shift according to government policy. For emerging economies, pre-arbitrage interest rate differentials remain consistent for just one year (2004). After this, the correlation drops, indicating little interest rate differential consistency. This makes intuitive sense given the large fluctuations in emerging interest rates year-over-year according to government and central bank interest rate policy. This is compounded by the imprecise structural break for emerging carry trades, which were only 5% of the FX market in 2004 and many emerging markets adopted a floating exchange rate after 2004 (Appendix B). The structural break was clearer for advanced carry trade activity,

Figure 7: Correlating Pre-Arbitrage and Annual Post-Arbitrage Interest Rate Differentials

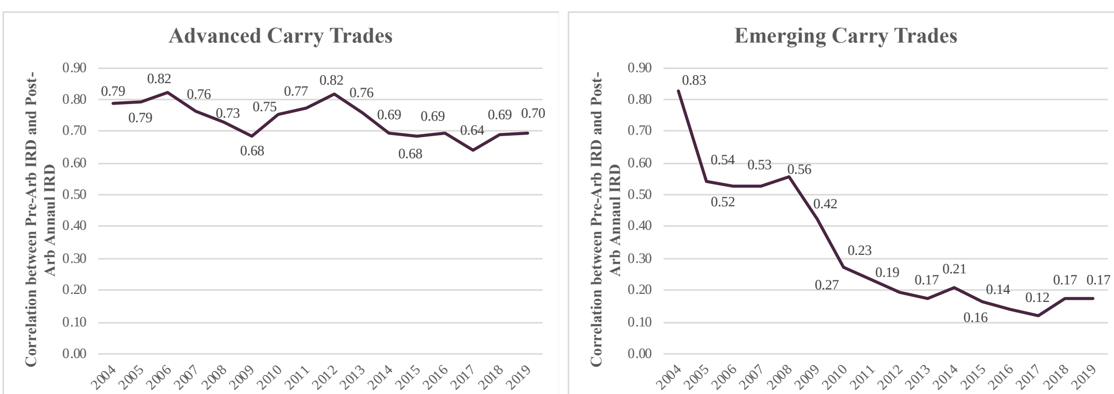


Figure 7 depicts the correlation between pre-arbitrage and annualized post-arbitrage interest rate differentials for advanced and emerging carry trades. Advanced interest rate differentials exhibit a strong positive correlation, especially near the structural break (Graph 1). For emerging interest rate differentials, the correlation is strong for one year, and then weakens substantially as interest rate differentials shift (Graph 2). As a result, pre-arbitrage interest rate differentials do not predict post-arbitrage funding risk for emerging carry trades (Proposition 2).

as it was identified in literature, reports, and data at the time (Galati & Melvin, 2004). The increase in emerging carry trades has occurred more gradually over the last 15 years. As a result, Proposition 2 – that the pre-arbitrage interest rate differential predicts post-arbitrage funding risk – does not hold for emerging carry trades.

Proposition 3: Funding Betas in Constrained Versus Unconstrained Times

Thus far, my emerging market results support Proposition 1 that interest rate differentials predict funding risk in the post-arbitrage period, but not in the pre-arbitrage period. To demonstrate that funding risk reflects arbitrage-driven risk, Proposition 3 contends that funding betas should only arise in constrained times. When investors are constrained, shocks to their funding force them to unwind their positions and exchange rates depreciate. When investors are unconstrained, funding shocks do not cause them to unwind positions as they access capital elsewhere. If funding risk strengthens in unconstrained times, it could reflect investor wealth portfolio risk. In this case, strategies with higher interest rate differentials mechanically have a higher funding risk as they make up a greater share of the investors' portfolios. Proposition 3 tests whether funding betas strengthen in constrained or unconstrained times.

I find that funding betas of emerging carry trades only arise in constrained times, so they reflect arbitrage-driven risk (Table 11). The interest rate differential positively and significantly predicts funding risk in the post-arbitrage period, controlling for pre-arbitrage funding risk (Columns 1-2). With time fixed effects, a 1 percentage point increase in the interest rate differential yields a 0.594 increase in funding risk. This coefficient is 86% larger than that of the full sample, reflecting how the impact of the carry trade is amplified

Table 11: Funding Betas Arise Only in Constrained Times

(Emerging Carry Trades)

This table confirms that funding betas arise in constrained times (Columns 1-2) and do not in unconstrained times (Columns 3-4). According to Proposition 3, this suggests that funding betas reflect arbitrage-driven risk. Constrained times are defined as months in which the moving average of the VIX is above the median of the period. This table considers 32 emerging carry trades from 2004-2019 under the IMF classification of floating exchange rates (Appendix B). The interest rate differential (IRD) captures perceived return and Funding Beta measures risk due to external shocks to funding. I define the pre-arbitrage period as September 1989-August 2004 and the post-arbitrage period as September 2004-September 2019. In parentheses are standard errors that are robust to heteroskedasticity and account for serial correlation through Newey-West with a lag of 15 years and clustering by year.

Baseline: $\beta_{it}^{\text{post,constrained}} = b_0 + b_1\, IRD_{it}^{\text{post,constrained}} + b_2\, \beta_{it}^{\text{pre}} + \epsilon_{it}$

	Post-Arbitrage Constrained Time Funding Beta		Post-Arbitrage Unconstrained Time Funding Beta	
	(1)	(2)	(3)	(4)
Post-Arbitrage IRD	0.698***	0.594***	-0.190	-0.160
	(0.107)	(0.129)	(0.192)	(0.188)
Pre-Arbitrage Funding Beta	0.607	0.658	-0.415	-0.404
	(0.377)	(0.399)	(0.254)	(0.250)
Constant	6.237***	4.288***	0.436	0.719
	(2.191)	(1.111)	(1.259)	(1.330)
Year FE	No	Yes	No	Yes
Observations	191	191	349	349
R^2	0.042	0.271	0.027	0.117

Note: *** p<0.01, ** p<0.05, * p<0.1

when shocks to investor funding actually induce capital withdrawals. In unconstrained times, interest rate differentials do not predict funding betas (Columns 3-4). These results suggest that for emerging carry trades, the funding risk generated is arbitrage-driven.

VI. Discussion and Conclusion

My empirical results support Propositions 1-3 of the model for 15 advanced and 32 emerging carry trades, demonstrating that the carry trade generates arbitrage-driven risk through non-fundamental exchange rate movements. This is illustrated by the following story: an investor bets on a carry trade with a high interest rate differential (perceived return). This causes the exchange rate to appreciate proportional to the investor's demand for the foreign currency. If the investor is hit by an exogenous shock to their funding, they are forced to unwind their position. In response, the exchange rate depreciates. Through the investor's bet on the carry trade, the currencies vary with shocks to investor funding and take on arbitrage-driven risk. My results suggest that this story holds for both advanced and emerging currencies with floating exchange rates.

Comparing the results by market, emerging carry trades take on slightly more funding risk than advanced carry trades. On average, emerging economies have higher interest rate differentials to the US than advanced economies, so according to the theory, investors should flood more capital into the more profitable strategies. In reality, emerging currencies have greater idiosyncratic risk than advanced currencies, and this is reflected in large interest rate differential fluctuations and the inconsistency of profitable emerging carry trade strategies over time. As a result, investors flood less capital into these strategies, reflected in their smaller FX market share. The arbitrage-driven risk that emerging market currencies inherit from the carry trade is only a small fraction of their total risk. This explains why the coefficient translates to only a small economic impact in terms of funding risk standard deviation. As emerging economies continue to develop, their interest rate differentials may fluctuate less and become more attractive to foreign investors. The impact of arbitrage in inducing exchange rate movements will likely increase as investors bet more capital on these strategies. These results will continue to evolve as emerging carry trades' share of the FX market grows.

My results have important implications for both countries with floating exchange rates and economic theory itself. Economists have long encouraged governments to adopt floating exchange rates for the benefits of automatic stabilization, flexibility, monetary policy independence, and importantly, integration with global markets (Friedman, 1953). In 2019, most advanced economies and increasingly emerging economies have adopted floating exchange rates in order to develop economically and institutionally. I demonstrate that floating exchange rates experience non-fundamental exchange rate movements through the carry trade, suggesting that currencies are vulnerable to more than just macroeconomic fundamentals. For emerging economies considering the adoption of floating exchange rates, the risk of exchange rate appreciation due to arbitrage could impact the benefits of low-cost imports. This implies that emerging economies may benefit from constraining arbitrage-driven risk by managing their exchange rates.

In terms of economic theory, my findings contribute to two interesting discussions. First, I suggest that uncovered interest parity does not fully hold for floating exchange rates that are open to arbitrage. Specifically, as exchange rates experience fluctuations due to shocks to investor funding, they cannot entirely offset interest rate differentials. Exchange rates that inherit arbitrage-driven risk violate uncovered interest parity. Second, my results contribute to the literature on the forward premium by suggesting an endogenous generation of risk. I show that the carry trade itself generates arbitrage-driven risk through exchange rate movement; more profitable carry trades take on more arbitrage-driven risk. In this way, *alpha* (return) is actually a determinant of *beta* (risk), going against traditional asset-pricing theory. The anomaly returns of the carry trade persist in part because the trade itself generates risk.

This research has some qualifications. My analysis takes advantage of the growing amount of data on emerging carry trades, but it could benefit from more detailed data on futures position and carry trade activity. This would help distinguish the period when carry trade activity was low from the period when it was high. For emerging markets specifically, it would help disentangle and perhaps magnify the effect of arbitrage for economies with highly fluctuating interest rate differentials. Additionally, my intention is not to claim the carry trade as the only channel for generating currency risk. Rather, arbitrage-driven risk complements the literature on the forward premium by providing an additional, endogenous channel through which the carry trade can require risk premia.

My findings provide several directions for future research. To detangle country-specific risk from arbitrage-driven risk, future scholarship on the carry trade could consider credit default swaps. My study evaluates and quantifies the impact of shocks to investor funding on currencies with floating exchange rates – future research could compare the carry trades of emerging market currencies with managed exchange rates (e.g. Chinese yuan). Additionally, my data focuses on the US dollar as the funding currency, so the model suggests that exchange rates fluctuate with shocks to US investors' funding specifically. In fact, using another currency as the funding currency could appear risky because US investors hold a large fraction of the market. Future research could consider the degree to which the FX market covaries with shocks to US investor funding. Finally, the framework of arbitrage-driven risk could be applied to other asset classes. For example, scholarship could consider the relationship between credit markets or commodities and shocks to investor funding.

Appendix A: Currencies by Economic Market and Exchange Rate Classification

Classifications of currencies based on IMF *World Economic Outlook* (2019) and IMF AREAER (2018). I use these classifications to identify advanced and emerging economies with floating exchange rates. I complement the IMF classifications with the Ilzetzki et al. (2017) classification of floating versus managed exchange rates by country by month (listed in Appendix B). This table does not include currencies with a currency board or no separate legal tender.

Advanced Economy (Floating)	**Advanced Economy (Pegged/Controlled)**	**Emerging Economy (Floating)**	
Australian Dollar	Danish Krone	Albanian Lek	Mongolian Tugrik[1]
Canadian Dollar	Hong Kong Dollar	Argentine Peso	Mozambican Metical
Czech Koruna		Armenian Dram	Paraguayan Guarani
Euro		Brazilian Real	Peruvian Sol
Icelandic Krona		Chilean Peso	Philippine Peso
Israeli Sheqel		Colombian Peso	Polish Zloty
Japanese Yen		Georgian Lari[1]	Romanian Leu
New Zealand Dollar		Ghanain Cedi[1]	Russian Ruble
Norwegian Krone		Hungarian Forint	Seychelles Rupee
Singaporean Dollar		Indian Rupee	Somali Shilling[1]
South Korean Won		Jamaican Dollar	South African Rand
Swedish Krona		Kazakh Tenge	Thai Baht
Swiss Franc		Malgasy Ariary	Turkish Lira
Taiwanese Dollar		Malaysian Ringgit	Ugandan Shilling
UK Pound		Mauritian Rupee	Ukrainian Hryvnia
		Mexican Peso	Uruguayan Peso
		Moldovan Leu	Zambian Kwacha
Emerging Economy (Pegged/Controlled)			
Afghan Afghani	Egyptian Pound	Libyan Dinar	Sierra Leonean Leone
Algerian Dinar	Eritrean Nakfa	Malawian Kwacha	Singaporean Dollar
Anglolan Kwanza	Ethiopian Birr	Maldivian Rufiyaa	Solomon Dollar
Aruban Guilder	Fijian Dollar	Mauritian Rupee	South Sudanese Pound
Azerbaijanian Manat	Gambian Dalasi	Moroccan Dirham	Sri Lankan Rupee
Bahamian Dollar	Guatemalan Quetzal	Myanmar Kyat	Surinamese Dollar
Bahraini Dinar	Guinean Franc	Namibian Dollar	Swazi Lilangeni
Bangladeshi Taka	Guyanese Dollar	Nepalese Rupee	Syrian Pound
Barbadian Dollar	Haitian Gourde	Nicaraguan Cordoba	Tajik Somoni
Belizian Dollar	Honduran Lempira	Nigerian Naira	Tanzanian Shilling
Bhutanese Ngultrum	Indonesian Rupiah	Macedonian Denar	Tongan Pa'anga
Bolivian Boliviano	Iranian Riyal	Omani Rial	Trinidad Dollar
Botswana Pula	Iraqi Dinar	Pakistani Rupee	Tunisian Dinar
Burundian Franc	Jordanian Dinar	Papua Kina	Turkmenian Manat
Cambodian Riel	Kenyan Shilling	Qatari Riyal	UAE Dirham
Cape Verdean Escudo	Kuwaiti Dinar	Rwandan Franc	Uzbek Som
Chinese Yuan	Kyrgyz Som	Samoan Tala	Vanuatuan Vatu
Comoran Franc	Laotian Kip	Sao Tome Dobra	Vietnamese Dong
Costa Rican Colon	Lebanese Pound	Saudi Arabian Riyal	Yemeni Rial
Croatian Kuna	Lesotho Loti	Serbian Dinar	Zimbabwean Dollar
Dominican Peso	Liberian Dollar		

[1]Consistent interest rate data unavailable for time period considered (September 1989 – September 2019).

Appendix B: Comparing the IMF (2018) and Ilzetzki et al. (2017) Exchange Rate Classifications

My analysis considers all currencies with floating exchange rates according to the IMF (2018) classification (Appendix A) and the Ilzetzki et al. (2017) classification. Data Start is the first month of interest rate data obtained by currency. Interest rates are 3-month interbank rates where available and interest rates on treasury bills otherwise (Datastream). *De Jure* Floated is the month that official government policy adopted a floating or managed floating exchange rate. Ilzetzki Floated is the month in which exchange rates were floated according to the Ilzetzki et al. (2017) classification, a *de facto* view of exchange rate flexibility. According to Ilzetzki et al. (2017), a flexible currency is ranked 11 or higher (floating, managed float, or moving band).

Advanced Economies				Emerging Economies							
	Data Start	*De Jure* Floated	Ilzetzki Floated		Data Start	*De Jure* Floated	Ilzetzki Floated		Data Start	*De Jure* Floated	Ilzetzki Floated
Australia	1967m12	1982m12	1982m12	Albania	1994m6	1992m1	--	Moldova	1995m3	1993m11	--
Canada	1959m12	1970m6	2002m6	Argentina[3]	1991m4	2001m12	2015m11	Mozambique	2000m1	1992m4	2015m6
Czech Republic	1992m12	1997m5	--	Armenia	2001m2	2009m3	--	Paraguay	1990m12	1999m2	1999m7
Euro Area[1]	1986m1	1971m9	1973m1	Belarus	1995m10	--	1992m1	Peru[3]	1995m4	1991m7	2003m1
Iceland	1987m10	2001m4	2001m4	Brazil[3]	1994m12	1999m1	1999m2	Philippines[3]	1987m1	1993m6	--
Israel	1991m12	1997m6	1991m2	Brunei	2003m12	--	1967m6	Poland	1991m5	1999m4	1999m4
Japan	1959m12	1973m3	1977m12	Chile[3]	1981m12	1999m9	1999m9	Romania	1995m8	1990m1	1990m1
New Zealand	1973m11	1985m3	1973m7	Colombia[3]	1984m1	1999m9	1999m10	Russia	1995m3	2014m11	2014m11
Norway	1978m12	1992m12	1973m4	Hungary	1990m12	2008m2	--	Seychelles	2011m1	2008m11	--
Singapore	1995m1	--	1973m7	India[3]	1981m1	1993m3	--	South Africa	1980m12	1974m6	1995m3
South Korea[3]	1985m12	1997m12	1997m12	Jamaica	1980m10	1984m1	--	Thailand	1992m1	1997m7	1997m8
Sweden	1981m12	1992m11	2008m9	Kazakhstan[3]	2004m2	2015m8	2015m11	Turkey	1995m12	2001m2	2001m2
Switzerland	1973m12	1973m3	1973m12	Madagascar	1994m4	1985m7	1985m7	Uganda	1992m12	1981m7	--
Taiwan[2,3]	1989m11	1979m2	--	Malaysia[3]	1982m7	2005m7	2005m7	Ukraine	2001m3	2014m2	2014m2
United Kingdom	1985m12	1992m9	1992m9	Mauritius	1998m4	1994m7	--	Uruguay[3]	1997m12	2002m6	--
				Mexico	1980m10	1995m1	1995m1	Zambia	1992m7	1994m1	--

Note: -- indicates that either official government policy (*de jure*) or Ilzetzki et al. (*de facto*) do not consider the currency floating for the time period considered.

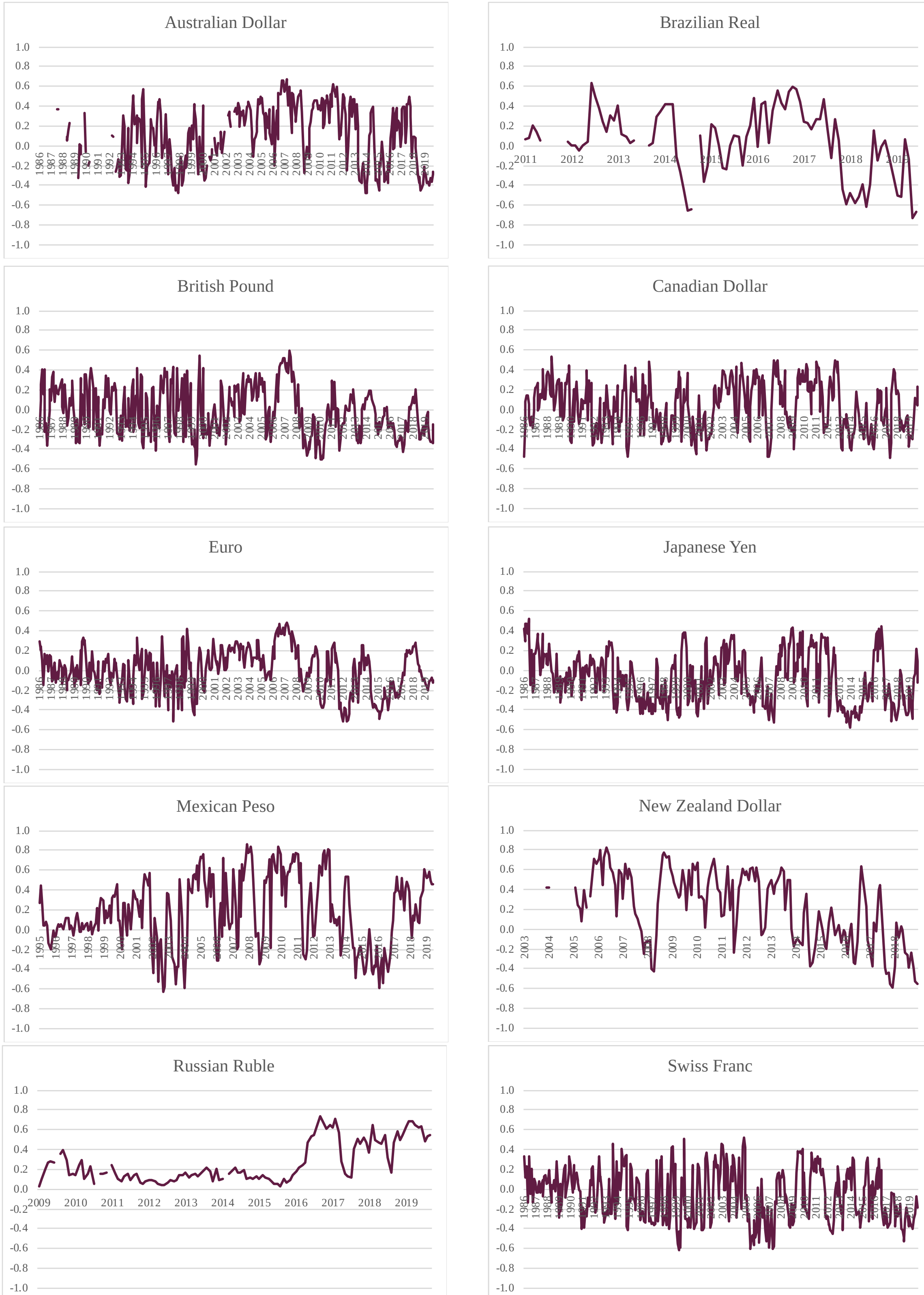
[1] Euro data was spliced with Deutsche Mark data before January 1999 in line with literature.
[2] Not included in Ilzetzki et al. classification.
[3] These currencies cannot be traded off-shore by law. However, they all participate in the non-deliverable forward market, indicating that investors can still buy and sell the currency.

Appendix C: Summary Statistics (Emerging Carry Trades)

Summary statistics of 32 emerging carry trades to the USD (listed in Appendix B). The interest rate differential (IRD) captures perceived return and Funding Beta measures risk due to external shocks to funding. I define the pre-arbitrage period as September 1989-August 2004 and the post-arbitrage period as September 2004-September 2019. Interest rate differentials are mean values.

	Interest Rate Differential	Funding Beta	Funding Beta SD	Interest Rate Differential	Funding Beta	Funding Beta SD
Albania	11.92	-1.645	16.86	3.554	-.825	2.849
Argentina	9.560	-1.331	57.27	15.13	3.500	25.36
Armenia	6.889	7.554	10.21	9.074	4.723	6.534
Belarus	27.63	12.72	12.75	1.49	1.943	10.18
Brazil	21.69	-5.487	37.16	1.72	-2.132	10.11
Brunei	-.058	1.272	1.199	-1.213	.799	.897
Chile	8.590	-6.288	44.73	2.141	1.672	2.314
Colombia	19.76	-2.716	20.87	4.445	.814	6.871
Hungary	12.91	.400	13.89	2.908	.001	11.05
India	4.164	.263	2.670	5.442	-.395	4.264
Jamaica	21.21	-.472	25.38	8.507	2.339	6.004
Kazakhstan	4.688	4.787	13.45	4.720	2.566	8.787
Madagascar	10.29	1.745	19.35	9.130	1.218	3.373
Malaysia	.792	-1.249	2.382	1.636	.968	4.009
Mauritius	6.307	-.546	7.415	3.187	.338	17.20
Mexico	17.15	.162	63.88	4.706	.160	4.218
Moldova	21.60	2.103	69.32	7.583	-1.884	28.95
Mozambique	18.22	-8.645	18.91	11.11	3.503	18.12
Paraguay	14.46	3.070	26.61	1.958	1.056	22.38
Peru	7.171	-1.261	32.89	2.088	2.106	4.502
Philippines	8.656	-.368	21.27	1.940	.000	5.440
Poland	19.23	-2.857	14.51	2.016	.597	2.318
Romania	47.91	-15.439	99.56	4.503	.987	8.651
Russia	8.635	-2.761	19.12	9.200	4.900	24.32
Seychelles	4.229	-.661	3.063	6.250	5.759	10.94
South Africa	8.467	-1.412	12.33	5.309	1.591	7.037
Thailand	3.432	1.095	13.01	1.003	-.775	19.89
Turkey	64.12	-1.706	40.96	11.50	-.223	16.75
Uganda	10.38	3.646	29.69	8.571	.110	13.45
Ukraine	11.04	2.959	30.99	17.25	2.221	23.01
Uruguay	23.96	.028	90.25	3.291	-.100	11.24
Zambia	38.85	-2.996	167.6	12.97	-.351	15.67
Total (Avg.)	**15.43**	**-.501**	**32.48**	**5.722**	**1.162**	**11.14**

Appendix D: Futures Position for 10 Currency Carry Trades (to USD)



Source: CFTC. Futures position is defined as net long-minus-short positions divided by total open interest of noncommercial (speculative) traders.

Appendix E: Examining Political Regime and State Fragility

To extend the Proposition 1 results for emerging carry trades, I examine political regime and state fragility using two datasets (by country by year) from the Center for Systemic Peace. While most advanced states maintain near perfect scores in the post-arbitrage period as full democracies without any state fragility, the scores are more variable for emerging economies. I test whether political regime and state fragility complicate the relationship between the interest rate differential and funding risk.

First, I consider the Polity classification, which rates countries' political regimes based on their political participation, chief executive power, and executive recruitment (Marshall et al., 2019). I scale the Polity2 variable such that 0=Full Autocracy and 10=Full Democracy, according to the authors' specifications. Second, I consider the State Fragility Index, which rates the efficacy and legitimacy of countries' economic, political, security, and social policies (Marshall & Elzinga-Marshall, 2017). I scale the State Fragility Index such that 0=Least Fragile and 10=Most Fragile, according to the authors' specifications. The sample skews more democratic (the median political regime score is 9, standard deviation 1.678) and less fragile (the median state fragility score is 2.8, standard deviation 1.761). So, I divide into subsamples based on full sample's 75th percentile: Democratic Regime is defined as scoring 8 or above (top 3/4th of sample) and Autocratic Regime as below 8 (bottom 1/4th of sample) on the Polity2 variable. Low State Fragility is defined as scoring 4.4 or below (top 3/4th of sample) and High State Fragility as above 4.4 (bottom 1/4th of sample) on the State Fragility Index. While these scores based on the 75th percentile do not necessarily mirror the authors' definition of an autocratic or highly fragile state, they capture the variation in my sample specifically.

Table 12: Funding Risk Through the Lens of Political Regime and State Fragility

(Emerging Carry Trades)

This table demonstrates that political regime and state fragility have little effect on the relationship between the interest rate differential and funding risk for 32 emerging carry trades. The results confirm that the interest rate differential predicts funding risk for both democratic and more autocratic regimes (Columns 1-2) as well as high and low fragility states (Columns 3-4). The indicators (by country by year) are based on the Polity2 variable and State Fragility Index by the Center for Systemic Peace. Subsamples were based on the 75th percentile of the full sample for each indicator. The interest rate differential (IRD) captures perceived return and Funding Beta measures risk due to external shocks to funding. I define the pre-arbitrage period as September 1989-August 2004 and the post-arbitrage period as September 2004-September 2019. For countries that adopted a floating exchange rate after September 2004, the adoption date is used as the structural break. In parentheses are standard errors that are robust to heteroskedasticity and account for serial correlation through Newey-West with a lag of 15 years and clustering by year.

Baseline: $\beta_{it}^{\text{post,Democratic}} = b_0 + b_1\, IRD_{it}^{\text{post,Democratic}} + b_2\, \beta_{it}^{\text{pre,Democratic}} + \epsilon_{it}$

	Post-Arbitrage Funding Beta			
	(1)	(2)	(3)	(4)
Post-Arbitrage IRD	0.406**			
(Democratic Regime)	(0.206)			
Post-Arbitrage IRD		0.354***		
(Autocratic Regime)		(0.135)		
Post-Arbitrage IRD			0.597**	
(Low State Fragility)			(0.232)	
Post-Arbitrage IRD				0.567**
(High State Fragility)				(0.241)
Pre-Arbitrage Funding Beta	0.135	-0.624	0.102	-0.358
	(0.132)	(0.687)	(0.125)	(0.239)
Constant	2.437	-5.104***	3.490*	1.409
	(1.169)	(1.547)	(2.107)	(1.852)
p-Test	*0.829*		*0.959*	
Observations	307	84	265	82
R^2	0.129	0.208	0.1667	0.358

Note: *** p<0.01, ** p<0.05, * p<0.1

My findings suggest that political regime and state fragility have little effect on the relationship between interest rate differentials and funding risk (Table 12). Both democratic and more autocratic regimes demonstrate significant relationships between interest rate differentials and funding risk (Columns 1-2). Likewise, both high and low fragility states demonstrate significant relationships between interest rate differentials and funding risk (Columns 3-4). The *p*-test demonstrates that the coefficients of the subsamples are not statistically different from each other. Interestingly, all the coefficients are larger than that of the full sample, indicating that separating countries by political regime and state fragility magnifies the impact of interest rate differentials in predicting funding risk. The subsamples may indirectly sort by profitability, amplifying the impact of a percentage point increase in the interest rate differential on risk due to shocks to investor funding.

References

Adrian, T., Etula, E., & Muir, T. (2014). Financial Intermediaries and the Cross-Section of Asset Returns. *The Journal of Finance*, *69*(6), 2557–2596.

Alper, C. E., Ardic, O. P., & Fendoglu, S. (2009). The Economics of the Uncovered Interest Parity Condition for Emerging Markets. *Journal of Economic Surveys*, *23*(1), 115–138.

Bansal, R., & Dahlquist, M. (2000). The forward premium puzzle: Different tales from developed and emerging economies. *Journal of International Economics*, *51*, 115–144.

BIS. (2019). Triennial Central Bank Survey—Foreign exchange turnover in April 2019. *Bank of International Settlements*, 23.

Brunnermeier, M. K., Nagel, S., & Pedersen, L. H. (2008). Carry Trades and Currency Crashes. *NBER Macroeconomics Annual*, *23*, 313–348.

Burnside, C. (2014). The Carry Trade in Industrialized and Emerging Markets. *Journal Economia Chilena*, *17*(2), 44.

Cho, T. (2017). Turning Alphas into Betas: Arbitrage and Endogenous Risk. *Harvard University, Working Paper*, 80.

Cho, T. (2019). Turning Alphas into Betas: Arbitrage and the Cross-section of Risk. *Journal of Financial Economics*, 65.

Curcuru, S., Vega, C., & Hoek, J. (2010). Measuring carry trade activity. *International Finance Corporation*, *34*, 18.

Dohmen, B. (2014, September 4). *Carry Trade: The Multi-Trillion Dollar Hidden Market*. Forbes. https://www.forbes.com/sites/investor/2014/09/04/carry-trade-the-multi-trillion-dollar-hidden-market/

Drechsler, I., & Drechsler, Q. F. (2014). *The Shorting Premium and Asset Pricing Anomalies* (Working Paper No. 20282). National Bureau of Economic Research.

Fama, E. F. (1984). Forward and spot exchange rates. *Journal of Monetary Economics*, *14*(3), 319–338.

Farhi, E., & Gabaix, X. (2016). Rare Disasters and Exchange Rates. *The Quarterly Journal of Economics*, *131*(1).

Frankel, J., & Poonawala, J. (2010). The forward market in emerging currencies: Less biased than in major currencies. *Journal of International Money and Finance*, *29*(3), 585–598.

Frazzini, A., & Pedersen, L. H. (2014). Betting against beta. *Journal of Financial Economics*, *111*(1), 1–25.

Friedman, M. (1953). The Case for Flexible Exchange Rates. *Essays in Positive Economics*, *157*, 203.

Galati, G., & Melvin, M. (2004). *Why Has FX Trading Surged? Explaining the 2004 Triennial Survey* (ID 1967461). Bank of International Settlements.

Heath, A., Galati, G., & McGuire, P. (2007). Evidence of Carry Trade Activity. *BIS Quarterly Review*.

Ilzetzki, E., Reinhart, C. M., & Rogoff, K. S. (2017). Exchange Arrangements Entering the Twenty-First Century: Which Anchor will Hold? *NBER, Working Paper 23134*.

IMF. (2018). *Annual Report on Exchange Arrangements and Exchange Restrictions 2018*. International Monetary Fund.

IMF. (2019, April). *World Economic Outlook, April 2019: Growth Slowdown, Precarious Recovery*. International Monetary Fund.

Knoll, M. S. (2008). The Ancient Roots of Modern Financial Innovation: The Early History of Regulatory Arbitrage. *University of Pennsylvania Faculty Scholarship, Paper 47*.

Kynge, J. (2014, September 29). *Surging US dollar threatens emerging markets' carry trades*. Financial Times. https://www.ft.com/content/27a516d8-47e4-11e4-be7b-00144feab7de

Ma, A. (2017). *Exploring the Risks of Anomaly Strategies*. Harvard University.

Marshall, M. G., & Elzinga-Marshall, G. (2017). *Global Report 2017: Conflict, Governance, and State Fragility*. Center for Systemic Peace.

Marshall, M. G., Gurr, T., & Jaggers, K. (2019). POLITY IV PROJECT: Political Regime Characteristics and Transitions, 1800-2018, Dataset Users' Manual. *Center for Systemic Peace*, 86.

Meese, R. A., & Rogoff, K. (1983). Empirical exchange rate models of the seventies: Do they fit out of sample? *Journal of International Economics*, *14*(1), 3–24.

Nagel, S. (2012). Evaporating Liquidity. *The Review of Financial Studies*, *25*(7), 57.

Setser, B. (2007, March 15). *Just how big is the yen carry trade?* Council on Foreign Relations. https://www.cfr.org/blog/just-how-big-yen-carry-trade

Shleifer, A., & Vishny, R. W. (1997). The Limits of Arbitrage. *The Journal of Finance*, *52*(1), 35–55.