HEC MONTRÉAL

**The Carry Trade and Currency Momentum Strategies :
At the daily frequency with the monthly and daily decision intervals**

par

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Résumé

Ce mémoire explore le rendement excédentaire journalier de deux stratégies de négociation en devise étrangère où le rééquilibrage du portefeuille est fait sur un base mensuelle d'abord et journalière ensuite. La première, communément appelée *carry trade*, consiste à emprunter dans la monnaie d'un pays où les taux d'intérêt sont bas et à investir dans un pays où les taux d'intérêt sont élevés. La deuxième, communément appelée *currency momentum*, consiste à acheter les monnaies ayant eu de hauts rendements dans le passé et de vendre les monnaies ayant eu de bas rendenments dans le passé. Premièrement, mes résultats suggèrent que les rendements journaliers des deux stratégies sont autocorrélés. Deuxièmement, le rééquilibrage journalier du portefeuille de *carry trade* semble améliorer le ratio de Sharpe, même en tenant compte des coûts de tansaction. Finalement, il semble possible d'améliorer davantage la performance du *carry trade* rééquilibré à chaque jour en utilisant un simple outil de gestion risque qui exploite l'autocorrélation des pertes journalières. L'outil de gestion de risque semble aussi rendre l'asymétrie de la distribution des rendements excédentaires moins négative. Ce constat remet en cause certaines explications sur la profitabilité du *carry trade* évoquant l'asymétrie des rendements ainsi que le risque de krach. Le rééquilibrage journalier et l'outil de gestion de risque ne permettent pas d'améliorer la performance du portefeuille de *currency momentum*. Tout de même, ce résultat peut agir de contrefactuel à la stratégie de *carry trade* optimale.

Mots-clés

Currency carry trade, currency momentum, fréquence journalière, rééquilibrage journalier

Abstract

This thesis explores the excess returns of two currency trading strategies at the daily frequency with monthly and daily portfolio rebalancing. The first strategy, so called the carry trade, consists of borrowing in low interest rate currencies and investing in high interest rate currencies. The second strategy, so called the currency momentum, consists of buying currencies with high recent returns and selling currencies with low recent returns. First, I find that examining the excess returns at the daily frequency suggests that there exists autocorrelation in the returns to both the carry trade and the currency momentum. Second, I find that there is value in rebalancing the carry trade portfolio on a daily basis as the returns, even net of transaction costs, exhibit a higher Sharpe ratio than with monthly portfolio rebalancing. Finally, I find that the autocorrelation in the daily losses to the carry trade can be exploited by a simple risk management tool to enhance the performance, as measured by the Sharpe ratio, of the carry trade with daily portfolio rebalancing. The skewness of the optimal carry trade also becomes less negative, which challenges previous explanations of the carry trade profitability invoking return skewness and crash risk. Daily rebalancing as well as the simple risk management tool do not enhance the performance of the currency momentum, but can act as a counterfactual to the optimal carry trade.

Keywords

Currency carry trade, currency momentum, daily frequency, daily decision interval

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List of acronyms

CAPM Capital asset pricing model

CCAPM Consumption capital asset pricing model

CIP Covered interest rate parity

FCU Foreign currency unit

FCU/USD Foreign currency unit per U.s dollar

FX Foreign exchange

GMM Generalized method of moments

HML High minus low

i.i.d. Independently and identically distributed

SDF Stochastic discount factor

UIP Uncovered interest rate parity

USD U.S. dollar

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Introduction

According to the uncovered interest rate parity (UIP), if investors are risk neutral and form rational expectations, expected currency depreciation should be equal to the interest rate differentials between foreign and domestic risk-free interest rates. However, since Hansen and Hodrick (1980) and Fama (1984) a number of empirical studies show that exchange rate changes do not offset the interest rate differentials. Rather, the opposite holds true empirically: high interest rate currencies tend to appreciate while low interest rate currencies tend to depreciate[1]. The international economics literature refers to this empirical finding as the "UIP puzzle", the "forward premium anomaly", or the "forward premium puzzle". As a result, the carry trade — a trading strategy that borrows in currencies with low interest rates and invests in currencies with high interest rates — takes advantage of the UIP puzzle and has been documented to be profitable.

In addition, Okunev and White (2003), Burnside et al. (2011b), Asness et al. (2013), Menkhoff et al. (2012b), and Rafferty (2012) all find evidence on the existence of cross-sectional momentum profits in the currency market[2]. As a results, the currency momentum strategy — a trading strategy which buys currencies with high recent returns and sell currencies with low recent returns — represents another currency market puzzle.

This paper will focus on the risk-based approaches attempting to explain the returns to

[1]See Hodrick (1987) and Engel (1996) for thorough reviews of the large literature documenting the failure of the UIP. See Froot and Thaler (1990) and Lewis (1994) for survey articles as well.

[2]Jegadeesh and Titman (1993, 2001) are the first to document momentum profits in the equity market. They find that simply buying stocks with high recent returns and selling stocks with low recent returns results is a profitable investment strategy.

both the carry trade and the currency momentum strategies. Time-varying risk premia means that if a currency trading strategy delivers investors low returns in bad times, then the strategy's profits are simply compensation for investor's higher risk exposure. Yet, empirical studies have not been able to convincingly identify risk factors that drive these premia. First, the returns to the carry trade and to the currency momentum strategy cannot be explained by traditional measures of risk (Burnside, 2011a; Burnside et al., 2011b,a; Menkhoff et al., 2012b). Second, some risk factors derived directly from portfolios of sorted currencies can successfully explain the variations in carry trade returns (Lustig et al., 2011; Menkhoff et al., 2012a). However, these same factors cannot adequately account for variations in currency momentum returns and equity returns (Burnside et al., 2011b; Menkhoff et al., 2012b; Burnside, 2011a). In addition, the literature focuses on crash risk as a possible explanation for carry trade returns, which are generally negatively skewed (Brunnermeier et al., 2009; Rafferty, 2012; Dobrynskaya, 2014; Lettau et al., 2014). More specifically, Rafferty (2012) develops a global currency skewness risk factor and finds that it is empirically important in pricing the cross-section of carry trade returns and, in part, the cross-section of momentum returns. Third, explanations of carry trade returns based on rare disasters (Burnside et al., 2011a; Jurek, 2014; Farhi et al., 2009; Farhi and Gabaix, 2016) leave unexplained the profitability of the currency momentum strategy (Burnside et al., 2011b). Finally, more recent studies challenge previous risk-based explanations of currency excess returns (Bekaert and Panayotov, 2019; Daniel et al., 2017). Specifically, while most of the literature exclusively focuses on the characteristics of currency excess returns at the monthly frequency, Daniel et al. (2017) are amongst the first to study the returns to the carry trade at the daily frequency. They find that a large fraction of the documented negative skewness characterizing carry trade returns at the monthly frequency is a result of a sequence of daily losses rather than large single-day drops. This finding challenges previous crash-risk based explanations of currency excess returns.

The main contribution of this paper is to study the returns to both the carry trade and the currency momentum strategies at different frequencies and different decision intervals previously considered in the literature. I start by forming two sets of portfolios of sorted currencies. First, I construct carry trade portfolios where an investor is long in high interest rate currencies and short in low interest rate currencies. Second, I construct currency momentum portfolios where an investor is long in currencies with high past excess returns and short in currencies with low past excess returns. I take the viewpoint of a U.S. investor and consider exchange rates against the U.S. dollar (USD). My data covers the period from November 1983 to May 2019, and I study a cross-section of up to 37 currencies. I go beyond earlier research on carry trade and currency momentum by 1) comparing the descriptive statistics of returns at the monthly and daily frequencies while keeping the monthly decision interval, 2) constructing the portfolios and studying the returns with the daily decision interval, and 3) assessing if a simple risk management tool can enhance the performance of all the strategies listed in 1) and 2).

In line with the literature, I find large and significant monthly returns to the carry trade and to the currency momentum portfolios with monthly decision intervals. In addition, analyzing the carry trade returns before and after 2010 suggests that the carry trade is still alive even in the post Great Recession period. Consistent with the work of Brunnermeier et al. (2009), carry trade returns at the monthly frequency are negatively skewed. On the other hand, currency momentum returns at the monthly frequency are positively skewed, which is consistent with Burnside et al. (2011b); Menkhoff et al. (2012b); Rafferty (2012). Next, I describe carry trade and currency momentum returns at the daily frequency while retaining the monthly portfolio rebalancing widely used in the literature. I find the the performance of both strategies as measured by the Sharpe ratio — which is the ratio of the mean to the standard deviation of the returns — stays similar with the monthly decision interval independently of the returns' frequency. However, I find that the skewness of the monthly carry trade returns is far more negative than what it would be if the daily carry trade returns were independently and identically distributed (*i.i.d.*), while the skewness of the monthly momentum returns is far more positive than what it would be if the daily momentum returns were *i.i.d.*. My results suggest that the returns to both strategies at the daily frequency are not *i.i.d.* and, therefore, there can be autocorrelation in the gains and losses to both currency trading strategies. Daily losses (or gains) could cumulate to create very large losses (or gains) at the monthly frequency.

Knowing that there can be autocorrelation in the returns to both strategies, I construct carry trade and currency momentum portfolios with daily rebalancing and examine if the daily decision interval can improve the returns' properties. The carry trade with daily rebalancing yields a statistically significantly different from zero excess return of up to 12.45% per annum (9.54% net of transaction costs), as opposed to 6.66% (5.94% net of transactions costs) with monthly rebalancing. The performance of the carry trade, as measured by the Sharpe ratio, seems to be higher with the daily decision interval than with the monthly decision interval. Hence, although daily portfolio rebalancing significantly increases the number of transactions per month, it still yields extra profit; there is extra value in rebalancing more frequently. However, the currency momentum with daily rebalancing does not yield a statistically significantly different from zero excess return when I account for transaction costs. I show that, as expected, daily rebalancing largely increases the number of transactions per month. So, knowing that Menkhoff et al. (2012b) note that momentum portfolios are skewed towards currencies with high transaction costs, it makes sense that the currency momentum does not seem to improve when subjected to daily rebalancing.

The autocorrelation in the returns of both strategies hints that if a pattern can be successfully identified in the losses to both the carry trade and the currency momentum strategies, then it should be possible to design a risk management tool which aims at improving the performance of both strategies with monthly and daily rebalancing. Based on the findings of Daniel et al. (2017), I design a risk management tool based on the following two decision thresholds: 1) exit the trading strategy after two days of consecutive losses, with one loss being greater than one standard deviation, and 2) enter back into the trading strategy after one day of positive return. I find that the risk management tool enhance the performance, as measured by the Sharpe ratio, of the carry trade with both monthly and daily portfolio rebalancing. The optimal carry trade with daily rebalancing is the best performing portfolio analyzed in this paper with a Sharpe ratio as high as 1.51 (1.19 net of transaction costs). Indeed, this key result seems to confirm that there exists autocorrelation in the losses to the carry trade, which can then be exploited by implementing a risk management tool to enhance the performance of this currency trading strategy. In addition, I find the skewness of the carry portfolios becomes less negative with the risk management tool. These findings challenge some of the past conceptual interpretations of the carry trade, such as the crash risk based interpretation which take roots in the negative skewness of returns according to Brunnermeier et al. (2009). On the other hand, I find that the risk management tool does not seem to improve the performance of the currency momentum strategy. The absence of improvement suggests that the gains and losses to the currency momentum are random. The absence of improvement can also act as a counterfactual to the optimal carry trade — that is in the absence of autocorrelation, the currency trading strategy cannot be improved with the risk management tool. So if the performance of the carry trade can be enhanced with the risk management tool, it suggests, once again, that there exists a pattern in the daily losses to the carry trade.

The remainder of this paper proceeds as follows. I selectively discuss earlier literature. Chapter 1 details my data, the currency portfolios' construction procedure with the monthly decision interval and describes the returns' properties at the monthly and the daily frequencies. Chapter 2 details the currency portfolios' construction procedure with the daily decision interval and compares the returns' properties of the portfolios that are rebalanced daily to the ones presented in Chapter 1 that are rebalanced monthly. Chapter 3 introduces the risk management tool and discusses how it can improve the performance of the currencies trading strategies and lead to an optimal currency portfolio, if applicable. Lastly, I conclude. Additional Tables and Figures can be found in Appendices A, B, and C.

Literature review

First, this section presents the use of portfolios of sorted currencies as a key methodological innovation for the empirical study of currency excess returns. Second, I review the literature attempting to explain currency excess returns with conventional risk factors and with risk factors derived directly from portfolios of sorted currencies. Third, I outline some of the more recent findings in the literature that leave unexplained currency excess returns by challenging previous risk-based explanations.

From UIP regressions to portfolios of sorted currencies

The traditional UIP test consists of regressing changes in exchange rates on a constant and on the interest rate differentials between the home and foreign countries. For the most part, the constants are not equal to 0 and the slope coefficients are never equal to 1, and often negative. So, this result implies that investors obtain positive currency excess returns when investing in high interest rate currencies relative to the home currency. Traditionally, the study of currency excess returns has started with the estimation of such UIP-like regressions.

Inspired by the Fama and French (1993) approach for equity returns, Lustig and Verdelhan (2007) introduce an alternative approach to studying the cross-section of currency excess returns. It consists of simply sorting currencies into portfolios according to their forward discount against the U.S. dollar (USD). The sorting is done period by period and the portfolios are rebalanced accordingly. This sorting procedure produces portfolios with monotonically increasing average returns from the portfolio with the smallest forward discount to the portfolio with the highest forward discount. So, as UIP-like regressions, this approach shows that investors can profit from taking long positions in baskets of currencies with currently high interest rates and taking short positions in baskets of currencies with currently low interest rates. However, this approach is more direct than UIP-like regressions since it does not require any pre-estimation and it does not depend on the history of interest rate differentials for individual currency pairs. In addition, data on the bid-ask spreads for forward currency markets are readily available, which represents an advantage when accounting for transaction costs of currency trading strategies such as the carry trade and the currency momentum strategies. Accordingly, I will form portfolios sorted by forward discounts to study the returns to the carry trade strategy and portfolios sorted by lagged currency excess returns to study the returns to the currency momentum strategy.

Standard risk factors

Lustig and Verdelhan (2007) examine the returns to the carry trade through the consumption capital asset pricing model (CCAPM) and find that returns of high interest rate currencies co-move with U.S. non-durable and durable consumption growth, whereas returns of low interest rate currencies serve as a hedge against domestic consumption risk. However, Burnside (2011b) and Burnside et al. (2011a) argue that the consumption betas of currency portfolios are not statistically significant and economically too small to explain high carry trade returns. More generally, standard risk factor models, namely the capital asset pricing model (CAPM), the Fama and French (1993) three-factor model, and the CAPM with industrial production do not have sufficient explanatory power (Burnside, 2011a). The returns to the carry trade are either uncorrelated with U.S. market factors or the market betas are too small and the models estimated for currency and stock portfolios jointly are rejected. Burnside et al. (2011b) show that a wider set of conventional risk factors still cannot explain the returns to the carry trade as well as the returns to the currency momentum strategy. Menkhoff et al. (2012b) arrive to a similar conclusion regarding the returns to the currency momentum. Overall there seem to be no unifying risk-based explanation of returns in the currency and equity markets. Consequently, the literature has found that measures of risk derived directly from portfolios of sorted currencies perform better than traditional risk factors when attempting to explain carry trade and currency momentum returns.

Risk factors derived from portfolios of sorted currencies

HML carry and global currency volatility factors

Lustig et al. (2011) use two datasets — a larger one containing 37 different currencies and a smaller one containing the currencies of only 15 developed countries — from 1983 to 2010 to sort currencies into six equally weighted portfolios based on their forward discount relative to the USD. The portfolios account for transaction costs and are rebalanced at the end of each month. Using a method in line with the Arbitrage Pricing Theory of Ross (2013), Lustig et al. (2011) construct two risk factors to price the cross-section of the six currency portfolios. The first risk factor is called the dollar risk factor and is denoted RX. It is the average excess return of the six currency portfolios and it represents the average currency excess return of a large set of currencies against the USD. The second risk factor is denoted HML_{FX}. It is the return differential between the portfolio with the largest forward discount and the one with the smallest forward discount and it represents a carry trade risk factor. Lustig et al. (2011) find that high interest rate currencies load more on the second factor than low interest rate currencies. The heterogeneity in exposure to the HML_{FX} factor accounts for most of the cross-sectional variation in the average excess return between high and low interest rate currencies. Burnside (2011a) successfully replicates the findings of Lustig et al. (2011) but finds it dissatisfying to explain carry trade returns with the HML_{FX} factor, when originally empirical research was attempting to explain the returns to the HML_{FX} portfolio itself.

Similarly, Menkhoff et al. (2012a) sort currencies into five currency portfolios according to their forward discount at the end of each month. 2012a built a factor analogous to the RX factor, but instead of the HML_{FX} factor, they construct a foreign exchange (FX) volatility factor to investigate the empirical performance of unexpected changes in FX market volatility as a pricing factor[3]. Menkhoff et al. (2012a) construct the FX volatility factor on a monthly basis by taking the average intramonth realized volatility of the daily log changes in each currency of the sample against the USD. They find that global FX volatility is a key driver of risk premia in the cross section of carry trade returns. In other words, since the carry trade performs poorly in times of unexpectedly high volatility, excess returns to the carry trade are a compensation for time-varying risk. Again, Burnside (2011a) replicates and confirms the main finding of Menkhoff et al. (2012a).

While the carry trade risk factors proposed by Lustig et al. (2011) and Menkhoff et al. (2012a) are successful in explaining the variations in currency portfolios sorted by their forward discount relative to the USD, they are not able to adequately account for variations in momentum sorted currency portfolios (Burnside et al., 2011b; Menkhoff et al., 2012b). In addition, these risk factors fail to explain equity portfolio returns (Burnside, 2011a). Still, there seem to be no unifying risk-based explanation of returns within the currency market and between the currency and the equity markets.

Currency crash risk

Breedon (2001) characterizes carry trade returns as "going up the stairs and coming down the elevator". Since, several papers investigate the hypothesis that crash risk accounts for the forward premium puzzle. Brunnermeier et al. (2009) relate currency crash risk to liquidity spirals. Carry trades drive exchange rate dynamics as liquidity moves slowly from low interest rate currencies (i.e. funding currencies) to high interest rate currencies

[3]The work of Menkhoff et al. (2012a) is inspired by Ang et al. (2006) who provide evidence that exposure to volatility helps explain stock returns.

(i.e. investment currencies). As a result, high interest rate currencies appreciate gradually. However, when liquidity eventually dries up, the high interest rate currencies crash relative to the low interest rate currencies. This generates negative skewness of high interest rate currencies relative to low interest rate currencies at times of liquidity shortages for currency investors. However, this explanation does not seem to hold for currency momentum returns. In fact, multiple empirical studies find that the monthly returns to the currency momentum strategy are actually positively skewed (Burnside et al., 2011b; Menkhoff et al., 2012b; Rafferty, 2012).

Inspired by the work of Brunnermeier et al. (2009), Rafferty (2012) introduces a global currency skewness risk factor that reflects the average realized skewness of a group of high interest rate investment currencies relative to a group of low interest rate funding currencies. Rafferty (2012) finds that this risk factor is empirically important in pricing the cross-section of carry trade returns. It also has some success in pricing cross sections of currency portfolios sorted on currency momentum with a 1 month formation period and a 1 month investment horizon. So far, it is the only risk based factor that is successful in explaining the returns to both the carry trade and the currency momentum portfolios.

Dobrynskaya (2014) develops a global downside market risk factor to explain currency returns. The factor uses the downside market beta, the "disaster beta" and the coskewness with respect to the global stock market return. All three measures are conditional on low market returns or high market volatility. Dobrynskaya (2014) finds a clear risk–return relationship: high-interest rate currencies have high and statistically significant downside market risk, while low-interest rate currencies have zero downside risk and hence can serve as a hedging instrument. In addition, the downside market factor explains the returns to the carry trade better than other factors previously proposed in the literature. Finally, estimates of the downside beta premium are similar in the currency and the stock markets. Similarly, Lettau et al. (2014) find that the model with the the downside risk factor has better explanatory power than the traditional unconditional CAPM in the currency, the equity, the bond, and the commodity markets. Although both studies employ different methodologies, they both suggest that the carry trade crashes in the worst states of the world, when the global stock market plunges or when a disaster occurs (Dobrynskaya, 2014; Lettau et al., 2014).

Rare disasters and peso problems

Burnside et al. (2011a), Jurek (2014), Farhi et al. (2009), and Farhi and Gabaix (2016) argue that the returns to the carry trade can, in part, be explained by the presence of rare disasters or peso problems. All these studies compare the unhedged returns to the carry trade to the hedged ones that use currency options data to eliminate rare disasters or peso problems. Rare disasters are defined as low probability events that may occur in sample but that may be under-represented in sample relative to their true frequency in population. Peso problems are unprecedented in sample, yet not impossible. Both rare disasters and peso problems might have a very big impact on asset prices. Burnside et al. (2011a) find that returns to the hedged carry trade are smaller than the corresponding returns to the unhedged carry trade, suggesting that the average payoff to the unhedged carry trade reflects a peso problem. In addition, they find that the peso state is characterized by a higher stochastic discount factor (SDF) instead of very large losses to the unhedged carry trade in that state; meaning that "even though the losses of the unhedged carry trade in the peso state are moderate, the investor attaches great importance to those losses" (Burnside et al., 2011a). Jurek (2014) exploits data on out-of-the-money options and an hedging method that uses all bilateral option pairs rather than just USD denominated ones as Burnside et al. (2011a). Jurek (2014) shows that at most one-third of the average return to the carry trade is explained by peso states. Farhi et al. (2009) and Farhi and Gabaix (2016) also find evidence of rare disaster risk by using options and comparing the returns of unhedged and hedged carry trade portfolios. With regards to currency momentum returns, Burnside et al. (2011b) find little evidence against the peso event, but they do find conflicting results for the rare disaster hypothesis. In fact, in sample rare disasters characterized by heavy losses to the carry trade, such as the financial crisis of 2008, were highly profitable periods for the currency momentum strategy. Therefore, the rare disaster risk-based explanation for carry trade returns leaves unexplained the in-sample profitability of the currency momentum strategy.

Recent challenges to previous explanations

Bekaert and Panayotov (2019) document the existence of good and bad carry trades. In fact, the authors find that reducing the set of tradable currencies of equally weighted carry trades creates an "enhanced" portfolio with an improved return profile relative to the benchmark carry trade employing all G-10 currencies. The distinction between good and bad carry trades challenges previous conceptual interpretations of the carry trade. For instance, certain cross sections of currency returns can be explained by good carry trades at least as well as by previously suggested currency market risk factors (Lustig et al., 2011; Menkhoff et al., 2012a). Furthermore, previous explanations of carry trade returns, such as crash risk (Brunnermeier et al., 2009; Rafferty, 2012; Dobrynskaya, 2014; Lettau et al., 2014) and the peso problem hypothesis (Burnside et al., 2011a; Jurek, 2014; Farhi et al., 2009; Farhi and Gabaix, 2016) strongly predict the returns of bad carry trades.

Daniel et al. (2017) decompose the standard carry trade into dollar-neutral-carry and dollar-carry components and analyze returns to the carry trade at the daily frequency while retaining the monthly decision interval. The dollar-neutral component takes positions only in non-USD currencies while the dollar component depends on whether the dollar interest rate is below or above the median interest rate. First, Daniel et al. (2017) find that it is the dollar-neutral component of the carry trade that is exposed to downside risk, even if it is the dollar-carry component that is responsible for most of the high average return earned by the carry trade. Hence, differences in portfolio construction challenges previous explanations of carry trade returns based on downside risk (Brunnermeier et al., 2009; Rafferty, 2012; Dobrynskaya, 2014; Lettau et al., 2014). Second, studying the returns to the carry trade at the daily frequency reveals that "a large fraction of the documented negative return skewness of carry trades results from the time varying return autocorrelations of daily carry returns: the large drawdowns in carry trade returns result from sequences of losses rather than large single-day drops" (Daniel et al., 2017).

Overall, studying the returns to the carry trade at the daily frequency can provide valuable insights for previous risk-based explanations derived at the monthly frequency. For instance, "negative skewness at the monthly level can stem from extreme negatively skewed daily returns or from a sequence of persistent, negative daily returns that are not necessarily negatively skewed". Daniel et al. (2017) find that it is the second alternative that seems to hold true. Therefore, such work can have important implications for theoretical explanations of currency excess returns and for risk management. The work of Daniel et al. (2017) on currency excess returns at the daily frequency represents my paper's starting point.

Chapter 1

Data and describing currency portfolios with the monthly decision interval

First, in this section, I begin by defining an excess currency return and how it is implemented using forward contracts. Second, I present the data that is used to construct currency returns and the samples used in this paper. Third, I construct two different sets of portfolios of sorted currencies, namely carry portfolios and momentum portfolios. While always retaining the monthly decision interval, I present the properties of both sets of portfolios at the monthly and at the daily frequencies.

1.1 Currency excess returns

I consider a U.S. based investor. I use S_t to denote the spot exchange rate in foreign currency unit per U.S. dollar (FCU/USD). This means that an increase in S_t corresponds to a depreciation of the foreign currency and/or an appreciation of the USD. I use i_t to denote the interest rate on riskless USD denominated securities and i_t^* to denote the interest rate on riskless FCU denominated securities with the same maturity. Abstracting from transaction costs, borrowing 1 USD at the domestic interest rate i_t, using this to buy S_t FCU to be invested at the foreign interest rate i_t^*, and converting the proceeds back into

USD at maturity at the exchange rate $\frac{1}{S_{t+1}}$ gives a currency excess return of:

$$Z_{t+1} = (1+i_t^*)\left(\frac{S_t}{S_{t+1}}\right) - (1+i_t) \tag{1.1}$$

Since Fama (1984), most of the literature works in logarithm of spot exchange rates for ease of exposition and notation. The log of equation 1.1 is:

$$z_{t+1} = i_t^* - i_t - \Delta s_{t+1} \tag{1.2}$$

where z_{t+1} denotes the log currency excess return, $i_t^* - i_t$ denotes the interest rate differential, and Δs_{t+1} denotes the log spot exchange rate change. The covered interest rate parity (CPI) implies that:

$$\frac{(1+i_t^*)}{(1+i_t)} = \frac{F_t}{S_t} \tag{1.3}$$

where F_t denotes the forward exchange rate in FCU/USD with the same maturity as i_t and i_t^*. In log, equation 1.3 becomes:

$$i_t^* - i_t = f_t - s_t \tag{1.4}$$

where f_t denotes the log of the forward exchange rate. Akram et al. (2008) study high-frequency deviations from CIP and conclude that it holds at the daily or lower frequencies. Hence, the log currency excess return in equation 1.2 can be calculated simply from the log of the forward and spot exchange rates:

$$\begin{aligned} z_{t+1} &= f_t - s_t - \Delta s_{t+1} \\ &= f_t - s_{t+1} \end{aligned} \tag{1.5}$$

1.1.1 Transaction costs

I define the investor's actual realized excess return net of transaction cost, i.e. the log currency excess return net of the bid-ask spread. As Menkhoff et al. (2012a,b), I imagine three scenarios in which bid-ask spreads are deducted from log excess returns whenever a currency enters and/or exits a portfolio. First, for a long position in a foreign currency that enters a portfolio at time *t* and exits the portfolio one month later at time *t+1*, the net log excess return is given by: $z^l_{t+1} = f^b_t - s^a_{t+1}$. Here, the investor buys the foreign currency or equivalently sells the dollar forward at the bid price (f^b) at time *t*, and sells the foreign currency or equivalently buys dollars at the ask price (s^a_{t+1}) in the spot market at time *t+1*. Similarly, for a short position of the same scenario, the net log excess return is given by: $z^s_{t+1} = -f^a_t + s^b_{t+1}$. Second, for a long position in a foreign currency that enters a portfolio at time *t* but stays in the portfolio one month later at time *t+1*, the net log excess return is given by: $z^l_{t+1} = f^b_t - s_{t+1}$. Similarly, for a short position of the same scenario, the net log excess return is given by: $z^s_{t+1} = -f^a_t + s_{t+1}$. Third, for a long position in a foreign currency that exits a portfolio at time *t+1* but was already in the portfolio one month earlier at time *t*, the net log excess return is given by: $z^l_{t+1} = f^b_t - s^a_{t+1}$. Similarly, for a short position of the same scenario, the net log excess return is given by: $z^s_{t+1} = -f^a_t + s^b_{t+1}$. Notice that the investor always incurs transaction costs in the forward leg of his position since forward contracts typically have a maturity of one month. The investor does not always incur transaction costs in the spot market leg of his position, since trading depends on whether or not the investor stay invested in the foreign currency. Finally, when accounting for transaction costs, I will establish a new position in each single currency in the first month of my sample and I will sell all positions in the last month of my sample.

1.2 Data

I use daily spot and forward exchange rates in FCU/USD from November 1983 to May 2019. The full dataset contains at most 37 different currencies of: Australia, Austria, Belgium, Canada, Hong Kong, Czech Republic, Denmark, Euro area, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Italy, Japan, Kuwait, Malaysia, Mexico, Netherlands, New Zealand, Norway, Philippines, Poland, Portugal, Saudi Arabia, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, and the United Kingdom. The euro series starts in January 1999. After this date, I exclude the euro area countries and keep only the euro series. In addition, I only keep currencies for which I have forward and spot rates in the current and subsequent period. The full dataset replicates the same currency coverage as in Lustig et al. (2011).

As Lustig et al. (2011), I delete the following observations from the sample due to large failures of CIP: South Africa from the end of July 1985 to the end of August 1985; Malaysia from the end of August 1998 to the end of June 2005; Indonesia from the end of December 2000 to the end of May 2007; Turkey from the end of October 2000 to the end of November 2001; and United Arab Emirates from the end of June 2006 to the end of November 2006.

As a robustness check, I also a study a smaller dataset that contains only the G-10 currencies, minus the USD, over the same time period. The smaller dataset contains at most 9 different currencies from the following countries: Australia, Canada, euro area joined with historical data from Germany, Japan, New Zealand, Norway, Sweden, Switzerland, and the United Kingdom. The smaller dataset replicates the same currency coverage as in Daniel et al. (2017). They explicitly exclude the European currencies other than the euro (and its predecessor, the Deutsche mark), because traders engaged in the "convergence trade" prior to the creation of the euro, which was a form of carry trade predicated on a bet that the euro would be created in which case the interest rates in the high interest rate countries such as Italy, Portugal, and Spain, would come down and those currencies would strengthen relative to the Deutsche mark (Daniel et al., 2017). A peso problem exists in these data because there was uncertainty about whether the euro would indeed be created: if the euro had not succeeded, the high interest rate currencies would have suffered large devaluations relative to the Deutsche mark, drastically lowering the return to the convergence trade (Daniel et al., 2017). In addition, emerging market currencies are excluded in the sample of Daniel et al. (2017) since nominal interest rates denominated in these currencies also incorporate some sovereign risk premiums. Sovereign risk must be eliminated since I assume currency investors only bear pure FX risk.

1.3 Carry portfolios

1.3.1 Monthly frequency

The first group of portfolios of sorted currencies allocates currencies of the full sample to five portfolios based on their forward discount relative to the USD observed at the end of each month. As per equation 1.4, sorting according to forward discounts is equivalent to sorting on interest rate differentials. Portfolios are rebalanced at the end of each month. They are ranked from low to high interest rate: portfolio C1 contains the 20% currencies with the lowest interest rates relative to the USD (or smallest forward discounts), and portfolio C5 contains the 20% currencies with the highest interest rates relative to the USD (or highest forward discounts). I compute the log currency excess return for portfolio j, z_{t+1}^{j}, by taking the average of the log currency excess returns in each portfolio j. The average return of portfolios C1 to C5, denoted Agv., simply represents the average return of a strategy that borrows money in the U.S and invests it in foreign money markets. The return difference between portfolio C5 and portfolio C1, denoted high minus low (HML), represents the carry trade strategy, which borrows money in low interest rate countries and invests it in high interest rate countries' money markets. For the smaller sample of G10 currencies minus the USD, I follow the same method but sort currencies only into three portfolios[1].

Descriptive statistics of the monthly returns for portfolios C1 to C5, their Avg., and for the HML carry trade portfolio are reported in Table 1. Panel A shows results for the full sample of 37 currencies and Panel B shows results for the smaller sample of G10 currencies minus the USD. There is a striking pattern of monotonically increasing average excess return from portfolio C1 to C5 for the full sample and from portfolio C1 to C3 for the G10 sample. I also report heteroskedasticity consistent standard errors on these average returns between squared brackets. The average return of portfolios C1, C3, C4,

[1]During the sample period, and especially at the beginning, there are too few currencies available in the G10 sample to form five portfolios. I choose to form three portfolios to replicate the Carry Trade ETF of Deutsche Bank, which is accessible even for retail investors.

and C5 is statistically significantly different from zero for the full sample. For the G10 sample, portfolios C1 to C3 have a statistically significantly average return different from zero. Most importantly, the carry trade yields an important average log excess return of 6.66% and 5.46% for the full sample and the G10 sample respectively. Both of these HML average excess returns are statistically significantly different from zero as well. The carry trade strategy also yields a relatively high Sharpe ratio of 0.69 for the full sample and 0.62 for the G10 sample. Here and throughout the rest of the paper, I do not report the standard error for the Sharpe ratio. I realize the Sharpe ratio is a random variable. However, reporting the distribution properties of a ratio, including the heteroskedacticity consistent standard error, requires the use of a bootstrap analysis or a generalized method of moment (GMM) framework, which is beyond the scope of this paper. Consistent with the work of Brunnermeier et al. (2009), high interest rate currency portfolios are more negatively skewed. As a result, the HML carry portfolio is negatively skewed for both samples. High interest rate currency portfolios also have higher excess kurtosis. Finally, looking at the Avg. return in Table 1 suggests that a U.S. investor earns an average log excess return of 1.60% for holding the 37 currencies included in the full sample and an average log excess return 1.03% for holding the 9 currencies included in the G10 sample. Table 2 and Table 3 report the descriptive statistics of the monthly returns for portfolios C1 to C5, their Avg., and for the HML carry trade portfolio before 2010 and after 2010 respectively. Before 2010, the carry trade for the full sample has a Shape ratio of 0.72, which decreases to 0.63 after 2010. However, most interestingly, the carry trade for the G10 sample has a Sharpe ratio of 0.62 before 2010, which stays relatively the same at 0.63 after 2010. So, it appears that the carry trade, for the G10 sample in particular, is not a puzzle only attributable to the sample period ending in 2010; in other words, the carry trade is not dead. Appendix A reports descriptive statistics before and after 2010 for every carry trade strategies analyzed in this paper. Table 4 reports descriptive statistics of the monthly returns net of transaction costs for portfolios C1 to C5, their Avg., and for the HML carry trade portfolio. Note that for portfolio C1 I report *minus* the actual net log excess return, because the investor is short in these currencies. I will do so for all other tables reporting descriptive statistics of returns net of transaction costs in this paper. For both samples, the log excess returns net of transaction costs present similar patterns than that of the log excess returns without the bid-ask spreads. The main difference consists of smaller mean net returns and, consequently, smaller Sharpe ratios across all portfolios. More specifically, the mean net return decreases by 0.72% to 5.94% for the full sample and by 0.28% to 5.18% for the G10 sample, whereas the Sharpe ratio slightly decreases to 0.61 for the full sample and 0.59 for the G10 sample. The standard deviation, the skewness, and the excess kurtosis in Table 4 remain very close to the ones reported in Table 1 for all portfolios. For more insight behind the net carry returns, Figure B.1 and Figure B.2 show the number of transactions per month for the carry trade with monthly rebalancing for the full sample and the G10 sample respectively.

Figure 1 shows cumulative log excess returns for the HML carry trade portfolio for all countries and for the smaller sample of G10 countries. Figure 2 shows cumulative HML returns net of transaction costs. Interestingly, prior to approximately 2005, Figure 1 shows that the carry trade for both samples behaved similarly. It is only in the last part of the sample period that including a broader set of currencies seems to improve the returns to the carry trade. For net carry trade returns, the pattern slightly differs. On Figure 2 it appears that between approximately 1995 and 2005 the carry trade for the sample of G10 currencies is actually performing better than the carry trade for the full sample. Thereafter, including a broader set of currencies still seems to improve the returns to the carry trade, although the difference is less important than on Figure 1.

1.3.2 Daily frequency

Daniel et al. (2017) point out that the literature has almost exclusively focused on the characteristics of carry trade returns at the monthly frequency. So, I describe carry trade returns at the daily frequency while retaining the monthly decision interval. I chose to study the daily returns to carry portfolios that are rebalanced monthly to remain consistent with most of the literature, but also because my data consists of forward exchange rates with 1-month maturities. In other words, I do not have quotes on forward exchange rates for arbitrary maturities that are necessary to close out positions within a month. Again, I allocate currencies of the full sample to five portfolios based on their forward discount relative to the USD observed at the end of each month. I allocate currencies of the smaller G10 sample to three portfolios. Portfolios are rebalanced at the end of each month. Assuming that there is 21 trading days in a month, equation 1.5 becomes:

$$z_{t+1} = \frac{f_t - s_t}{21} - \Delta s_{t+1} \tag{1.6}$$

where z_{t+1} represents the log currency excess return at the daily frequency, $\frac{f_t - s_t}{21}$ represents the end of month forward discount prorated per day, and Δs_{t+1} represents the daily change in the log spot exchange rate. I compute the daily log currency excess return for portfolio j, z^j_{t+1}, by taking the average of the daily log currency excess returns in each portfolio j.

Descriptive statistics of the daily returns for portfolios C1 to C5, their Avg., and for the HML carry trade portfolio are reported in Table 5. Panel A shows results for the full sample of 37 currencies and Panel B shows results for the smaller sample of G10 currencies minus the USD. As in Table 1, both samples present a striking pattern of monotonically increasing average excess return from portfolio C1 to C5 for the full sample and from portfolio C1 to C3 for the G10 sample. Let me focus on the log excess returns to the HML carry portfolio at the daily frequency. The carry trade yields a statistically significantly different from zero average log excess return of 6.57% and 4.17% for the full sample and the G10 sample respectively. These annualized daily average returns are fairly closed to their monthly counterparts reported in Table 1. The annualized daily standard deviations of HML returns in Table 5 are slightly smaller than the annualized monthly standard deviations reported in Table 1. According to Daniel et al. (2017) the smaller first-order autocorrelation coefficient at the daily frequency potentially explains this result. Most importantly, comparing the Sharpe ratio of HML returns in Table 5 to the Sharpe ratio of HML returns reported in Table 1 suggests that the performance of the carry trade is approximately the same with the monthly decision interval independently of the returns' frequency. The Sharpe ratio at the daily frequency is 0.75 for the full sample and 0.47 for the G10 sample. The main differences between carry trade returns at the monthly and at the daily frequency lie in the higher central moments of the returns' distribution of both samples. Interestingly, Table 5 shows that the skewness of HML returns is less negative than the one reported in Table 1 for the full sample and the G10 sample. In addition, Table 5 shows that the excess kurtosis of HML returns is higher than the one reported in Table 1 for both samples. There is no need to report daily carry trade returns net of transaction costs since the rebalancing is still done on a monthly basis as in Table 4.

When interpreting carry trade at the daily frequency, Daniel et al. (2017) assess if the daily returns are *i.i.d.* to see if there can exist autocorrelation in the losses to the carry trade. Assuming there is 21 trading days in a month, if the daily returns were *i.i.d.*, the annualized mean and the annualized standard deviation at the daily and the monthly frequency would be the same, the standardized daily skewness would be $\sqrt{21}$ times the standardized monthly skewness, and the standardized daily kurtosis would be 21 times the standardized monthly kurtosis (Daniel et al., 2017). Table 6 reports the ratios, normalized by their values under the *i.i.d.* assumption, of the monthly central moments to the daily central moments for the HML portfolio of both samples. Table 6 highlights the considerable differences between the higher central moments of the daily carry trade returns and the monthly carry trade returns. The ratios of the standardized monthly skewness to daily skewness in Table 6 are 11.90 and 5.30 for the full sample and the G10 sample respectively. This indicates that the skewness of the monthly returns is far more negative than what it would be if the daily returns were *i.i.d.*. The ratios of the standardized monthly excess kurtosis to daily excess kurtosis in Table 6 are also above the value implied by the *i.i.d.* assumption. Overall, my results are consistent with Daniel et al. (2017) and suggest that the returns to the carry trade at the daily frequency are not *i.i.d.*. Therefore, there can be autocorrelation in the losses to the carry trade, which means that daily losses could cumulate to create very large losses at the monthly frequency.

Figure 3 shows cumulative daily log excess returns for the HML carry trade portfolio for all countries and for the smaller sample of G10 countries. Figure 3 shows a similar pattern than Figure 1, although including a broader set of currencies seems to improve the returns to the carry trade as soon as approximately 2000.

1.4 Momentum portfolios

1.4.1 Monthly frequency

The second group of portfolios of sorted currencies allocates currencies of the full sample to five portfolios based on their lagged return over the previous one month. These portfolios are held for one month. In other words, the form of momentum I consider has a one month formation period and a one month holding period[2]. Portfolios are rebalanced at the end of each month. They are ranked from from low to high lagged excess return: portfolio M1 contains the 20% currencies with the lowest lagged log excess returns (or "looser currencies"), and portfolio M5 contains the 20% currencies with the highest lagged log excess returns (or "winner currencies"). I compute the log currency excess return for portfolio j, z^j_{t+1}, by taking the average of the log currency excess returns in each portfolio j. Avg. represents the average return of portfolios M1 to M5. The return difference between portfolio M5 and portfolio M1, denoted HML, represents the currency momentum strategy, which goes long in winner currencies and short in looser currencies. For the smaller sample of G10 currencies, I follow the same method but sort currencies into three portfolios[3].

Descriptive statistics of the monthly returns for portfolios M1 to M5, their Avg., and for the HML currency momentum portfolio are reported in Table 7. Panel A shows results for

[2]Menkhoff et al. (2012b) document that this strategy yields the strongest results and presents the hardest challenge when trying to understand momentum returns in currency markets.

[3]During the sample period, and especially at the beginning, there are too few currencies available in the G10 sample to form five portfolios. I choose to form three portfolios to replicate the Currency Momentum ETF of Deutsche Bank, which is accessible even for retail investors.

the full sample of 37 currencies and Panel B shows results for the smaller sample of G10 currencies minus the USD. There is a pattern of increasing average excess return for both samples, although the pattern for the full sample appears not as strong since M2 has a higher average excess return than M3. I also report heteroskedasticity consistent standard errors on these average returns between squared brackets. The mean return of portfolios M1, M2, M4, and M5 is statistically significantly different from zero for the full sample, while for the G10 sample it is the case for the mean return of portfolios M2 and M3. More importantly, the HML momentum strategy for the full sample has an average log excess return of 6.27% that is statistically significantly different from zero and yields a relatively high Sharpe ratio of 0.66. For the G10 sample, the HML average log excess return of 2.95% and the HML Sharpe ratio of 0.35 are less important. So, it appears that the currency momentum strategy is more of an emerging market puzzle. Consistent with the literature (Burnside et al., 2011b; Menkhoff et al., 2012b; Rafferty, 2012) the skewness pattern of currency momentum portfolios is much different than that of carry trade portfolios. Table 7 suggests that high momentum portfolios do not tend to be more negatively skewed. In fact, I find that the monthly returns to the HML currency momentum strategy are positively skewed for both samples. Finally, low momentum currency portfolios have higher excess kurtosis. Table 8 reports descriptive statistics of the monthly returns net of transaction costs for portfolios M1 to M5, their Avg., and for the HML currency momentum portfolio. For both samples, the average net log excess returns and, consequently, the Sharpe ratios reported in Table 8 are largely smaller than their counterparts reported in Table 7. More specifically, the mean net return decreases by 2.72% to 3.55% for the full sample and by 1.64% to 1.31% for the G10 sample, whereas the Sharpe ratio decreases to 0.37 for the full sample and 0.15 for the G10 sample. This was expected, since "adjusting returns for bid-ask spreads lowers the profitability of momentum strategies significantly since momentum portfolios are skewed towards currencies with high transaction costs" (Menkhoff et al., 2012b). In addition, for the G10 sample, the mean net log excess return of portfolios M1 to M3 is not statistically significantly different from zero. More importantly, the mean net log excess return of the HML currency momentum strategy which buys M3 and sells M1 is also not statistically significantly different from zero for the G10 sample. This result reinforces that the currency momentum puzzle does not really apply to G10 currrencies and is more of an emerging market puzzle. The standard deviation, the skewness, and the excess kurtosis in Table 8 remain very close to the ones reported in Table 7 for all portfolios. For more insight behind the net momentum returns, Figure B.3 and Figure B.4 show the number of transactions per month for the currency momentum strategy with monthly rebalancing of the full sample and the G10 sample respectively.

Figure 4 shows cumulative log excess returns for the HML currency momentum portfolio for all countries and for the smaller sample of G10 countries. Figure 5 shows cumulative HML returns net of transaction costs. For the entire sample period the broader set of currencies displays higher cumulative returns on both Figure 4 and Figure 5. For the smaller sample of G10 currencies, the HML currency momentum strategy is only characterized by increasing cumulative returns between approximately 1990 and 2000, as shown on Figure 4 and Figure 5. Thereafter, it seems that the currency momentum puzzle does not apply to the sample of G10 currencies minus the USD. Interestingly, Figure 4 and Figure 5 show that currency momentum for the full sample is characterized by decreasing cumulative log excess returns since approximately 2010.

1.4.2 Daily frequency

Just like the carry trade literature, the currency momentum literature has almost exclusively focused on the characteristics of currency momentum returns at the monthly frequency. So, I describe currency momentum returns at the daily frequency while retaining the monthly decision interval, for the same reasons discussed in subsection 1.3.2. Again, I form five currency momentum portfolios with a one month formation period and a one month holding period for the full sample and three currency momentum portfolios with the same criteria for the G10 sample. Portfolios are rebalanced at the end of each month and daily log currency excess returns are calculated using equation 1.6. I compute the daily log currency excess return for portfolio j, z^j_{t+1}, by taking the average of the daily log currency excess returns in each portfolio j.

Descriptive statistics of the daily returns for portfolios M1 to M5, their Avg., and for the HML currency momentum portfolio are reported in Table 9. Panel A shows results for the full sample of 37 currencies, and Panel B shows results for the smaller sample of G10 currencies minus the USD. Table 9 presents a pattern of monotonically increasing average excess return that is very similar to the one reported in Table 7. Let me focus on the log excess returns to the HML currency momentum portfolio at the daily frequency. The currency momentum strategy yields a statistically significantly different from zero mean log excess return of 6.10% and 2.83% for the full sample and the G10 sample respectively. These annualized daily average returns are fairly closed to their monthly counterparts reported in Table 7. In addition, for both samples the annualized daily standard deviation of HML returns is similar to the one reported in Table 7. Consequently, with the monthly decision interval, the performance of the currency momentum strategy, as measured by the Sharpe ratio, is approximately the same independently of the returns' frequency. The Sharpe ratio at the daily frequency is 0.64 for the full sample and 0.34 for the G10 sample. The main differences between momentum returns at the monthly and at the daily frequency lie in the higher central moments of the returns' distribution of both samples. Interestingly, Table 9 shows that the skewness of HML returns for the full sample becomes negative at the daily frequency, while the skewness of HML returns for the G10 sample remains similar. In addition, Table 9 shows that the excess kurtosis of HML returns is higher that the one reported in Table 7 for both samples. Again, there is no need to report daily currency momentum returns net of transaction costs since the rebalancing is still done on a monthly basis as in Table 8.

Table 10 reports the ratios, normalized by their values under the *i.i.d.* assumption presented in subsection 1.3.2, of the monthly central moments to the daily central moments for the HML portfolio of both samples. Table 10 highlights the considerable differences between the higher central moments of the daily currency momentum returns and the monthly currency momentum returns. For the full sample, the ratio of the standardized monthly skewness to daily skewness of -26.35 in Table 10 indicates that the skewness of the monthly returns is far more positive than what it would be if the daily returns were *i.i.d.* — in fact, if the daily returns where *i.i.d.* the monthly skewness would be negative. For the G10 sample, the ratio of the standardized monthly skewness to daily skewness of 8.02 in Table 10 indicates that the skewness of the monthly returns is more positive that it would be if the daily returns where *i.i.d.*. The ratios of the standardized monthly excess kurtosis to daily excess kurtosis in Table 10 are also above the value implied by the *i.i.d.* assumption. Overall, my results suggest that the returns to the currency momentum at the daily frequency are not *i.i.d.*.

Figure 6 shows cumulative daily log excess returns for the HML currency momentum portfolio for all countries and for the smaller sample of G10 countries. Overall, Figure 6 shows a similar pattern than Figure 4.

Table 1: Descriptive Statistics of Monthly Carry Trade Returns

This table reports statistics of currency portfolios sorted on their 1 month forward discount relative to the USD at the end of each month. The currencies of the full sample are sorted into 5 portfolios. Portfolio C1 contains the 20% of currencies with the lowest forward discounts, while portfolio C5 contains the 20% of currencies with the highest forward discounts. Avg. denotes the average return of the five currency portfolios and HML denotes a carry portfolio that is long in portfolio C5 and short in portfolio C1. The G10 currencies are sorted into 3 portfolios. All the log excess returns are **monthly** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015). The sample period ranges from November 1983 to May 2019.

Panel A: All Countries

Portfolio	C1	C2	C3	C4	C5	Avg.	HML
Mean	-2.45	0.66	2.27	3.33	4.21	1.60	6.66
	[1.21]	[1.23]	[1.33]	[1.37]	[1.85]	[1.21]	[1.61]
Standard Deviation	7.24	7.37	7.92	8.17	11.03	7.21	9.62
	[0.86]	[0.87]	[0.94]	[0.97]	[1.31]	[0.86]	[1.14]
Sharpe Ratio	-0.34	0.09	0.29	0.41	0.38	0.22	0.69
Skewness	-0.00	-0.36	-0.19	-0.32	-1.21	-0.41	-1.22
	[0.12]	[0.12]	[0.12]	[0.12]	[0.12]	[0.12]	[0.12]
Excess Kurtosis	0.92	2.01	2.03	1.96	5.45	1.04	4.32
	[0.24]	[0.24]	[0.24]	[0.24]	[0.24]	[0.24]	[0.24]
AC(1)	0.02	0.05	0.08	0.10	0.11	0.08	0.09
	(0.63)	(.030)	(0.08)	(0.04)	(0.02)	(0.08)	(0.06)

Panel B: G10 Countries

Portfolio	C1	C2	C3	Avg.	HML
Mean	-1.88	1.39	3.58	1.03	5.46
	[1.52]	[1.34]	[1.70]	[1.35]	[1.48]
Standard Deviation	9.08	7.98	10.12	8.04	8.82
	[1.08]	[0.95]	[1.20]	[0.95]	[1.05]
Sharpe Ratio	-0.21	0.17	0.35	0.13	0.62
Skewness	0.14	-0.22	-0.41	-0.14	-0.81
	[0.12]	[0.12]	[0.12]	[0.12]	[0.12]
Excess Kurtosis	0.59	1.08	1.52	0.66	2.05
	[0.24]	[0.24]	[0.24]	[0.24]	[0.24]
AC(1)	0.04	0.09	0.10	0.08	0.10
	(0.45)	(0.07)	(0.04)	(0.11)	(0.04)

Figure 1: Cumulative Monthly Carry Trade Returns

This figure shows monthly cumulative log excess returns of the carry trade portfolios with monthly rebalancing. The solid black line corresponds to all countries, while the gray line corresponds to the sample of G10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

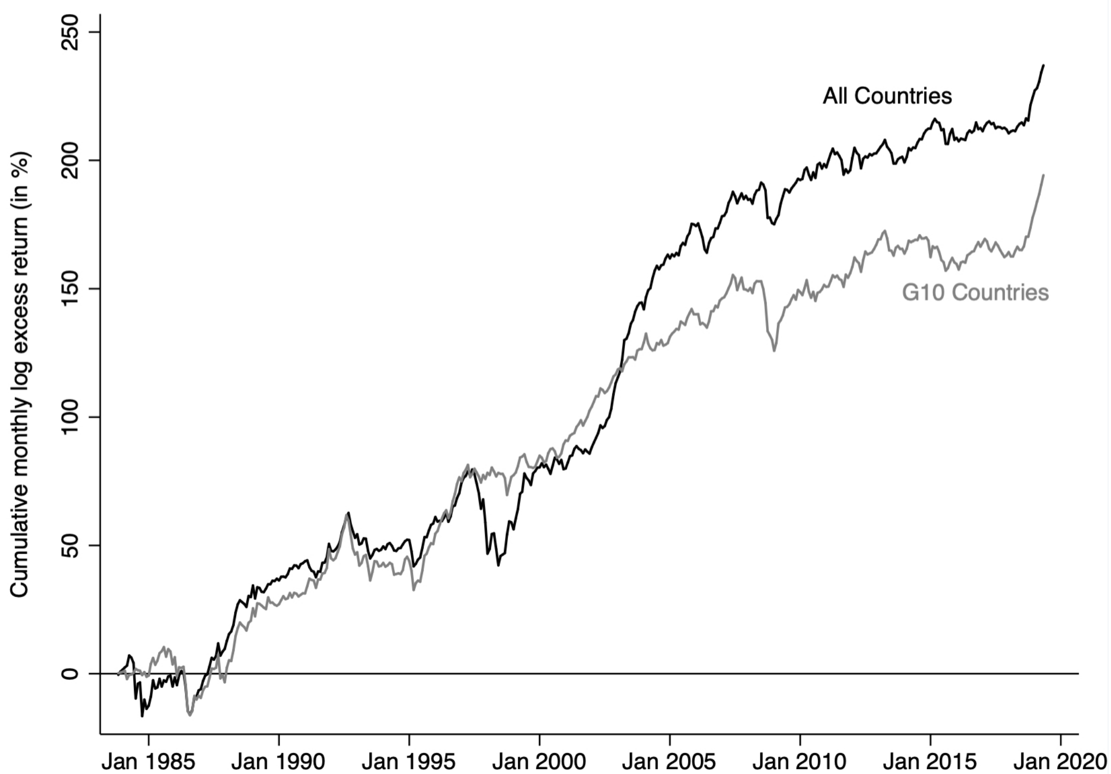


Table 2: Descriptive Statistics of Monthly Carry Trade Returns Before 2010 Only

This table reports statistics of currency portfolios sorted on their 1 month forward discount relative to the USD at the end of each month for the sample period ranging from November 1983 to December 2009. The currencies of the full sample are sorted into 5 portfolios. Portfolio C1 contains the 20% of currencies with the lowest forward discounts, while portfolio C5 contains the 20% of currencies with the highest forward discounts. Avg. denotes the average return of the five currency portfolios and HML denotes a carry portfolio that is long in portfolio C5 and short in portfolio C1. The G10 currencies are sorted into 3 portfolios. All the log excess returns are **monthly** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015).

Panel A: All Countries							
Portfolio	C1	C2	C3	C4	C5	Avg.	HML
Mean	-1.92	1.17	3.34	4.57	5.45	2.52	7.37
	[1.51]	[1.53]	[1.61]	[1.63]	[2.28]	[1.46]	[2.01]
Standard Deviation	7.70	7.81	8.24	8.32	11.65	7.48	10.30
	[1.07]	[1.08]	[1.14]	[1.15]	[1.61]	[1.04]	[1.43]
Sharpe Ratio	-0.25	0.15	0.41	0.55	0.47	0.34	0.72
Skewness	-0.01	-0.43	-0.30	-0.23	-1.32	-0.44	-1.34
	[0.14]	[0.14]	[0.14]	[0.14]	[0.14]	[0.14]	[0.14]
Excess Kurtosis	0.83	1.84	2.14	1.82	5.66	0.95	4.34
	[0.27]	[0.27]	[0.27]	[0.27]	[0.27]	[0.27]	[0.27]
AC(1)	0.02	0.07	0.13	0.15	0.16	0.13	0.10
	(0.69)	(0.22)	(0.02)	(0.01)	(0.00)	(0.02)	(0.06)

Panel B: G10 Countries					
Portfolio	C1	C2	C3	Avg.	HML
Mean	-1.03	2.77	4.69	2.14	5.72
	[1.88]	[1.57]	[1.97]	[1.59]	[1.81]
Standard Deviation	9.64	8.05	10.06	8.14	9.25
	[1.33]	[1.11]	[1.39]	[1.13]	[1.28]
Sharpe Ratio	-0.11	0.34	0.47	0.26	0.62
Skewness	0.12	-0.30	-0.49	-0.18	-0.91
	[0.14]	[0.14]	[0.14]	[0.14]	[0.14]
Excess Kurtosis	0.51	1.35	1.93	0.69	2.25
	[0.27]	[0.27]	[0.27]	[0.27]	[0.27]
AC(1)	0.03	0.16	0.19	0.14	0.11
	(0.59)	(0.01)	(0.00)	(0.01)	(0.06)

Table 3: Descriptive Statistics of Monthly Carry Trade Returns After 2010 Only

This table reports statistics of currency portfolios sorted on their 1 month forward discount relative to the USD at the end of each month for the sample period ranging from January 2010 to May 2019. The currencies of the full sample are sorted into 5 portfolios. Portfolio C1 contains the 20% of currencies with the lowest forward discounts, while portfolio C5 contains the 20% of currencies with the highest forward discounts. Avg. denotes the average return of the five currency portfolios and HML denotes a carry portfolio that is long in portfolio C5 and short in portfolio C1. The G10 currencies are sorted into 3 portfolios. All the log excess returns are **monthly** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015).

Panel A: All Countries							
Portfolio	C1	C2	C3	C4	C5	Avg.	HML
Mean	-3.92	-0.78	-0.72	-0.12	0.77	-0.95	4.69
	[1.88]	[1.95]	[2.26]	[2.50]	[2.96]	[2.08]	[2.42]
Standard Deviation	5.78	5.97	6.92	7.69	9.09	6.37	7.43
	[1.34]	[1.38]	[1.60]	[1.78]	[2.10]	[1.48]	[1.72]
Sharpe Ratio	-0.68	-0.13	-0.10	-0.02	0.08	-0.15	0.63
Skewness	-0.11	0.01	0.15	-0.73	-0.68	-0.40	-0.29
	[0.23]	[0.23]	[0.23]	[0.23]	[0.23]	[0.23]	[0.23]
Excess Kurtosis	-0.05	1.87	1.20	2.27	2.44	1.33	0.55
	[0.45]	[0.45]	[0.45]	[0.45]	[0.45]	[0.45]	[0.45]
AC(1)	0.02	-0.06	-0.11	-0.09	-0.15	-0.12	0.01
	(0.83)	(0.51)	(0.24)	(0.34)	(0.10)	(0.21)	(0.93)

Panel B: G10 Countries					
Portfolio	C1	C2	C3	Avg.	HML
Mean	-4.24	-2.44	0.50	-2.06	4.74
	[2.38]	[2.52]	[3.35]	[2.51]	[2.45]
Standard Deviation	7.30	7.72	10.29	7.69	7.52
	[1.69]	[1.79]	[2.38]	[1.78]	[1.74]
Sharpe Ratio	-0.58	-0.32	0.05	-0.27	0.63
Skewness	0.03	-0.02	-0.20	-0.05	-0.29
	[0.23]	[0.23]	[0.23]	[0.23]	[0.23]
Excess Kurtosis	-0.20	0.42	0.57	0.60	-0.11
	[0.45]	[0.45]	[0.45]	[0.45]	[0.45]
AC(1)	0.05	-0.15	-0.15	-0.13	0.07
	(0.58)	(0.10)	(0.12)	(0.16)	(0.45)

Table 4: Descriptive Statistics of Monthly Carry Trade Returns Net of Transaction Costs

This table reports statistics of currency portfolios sorted on their 1 month forward discount relative to the USD at the end of each month. The currencies of the full sample are sorted into 5 portfolios. Portfolio C1 contains the 20% of currencies with the lowest forward discounts, while portfolio C5 contains the 20% of currencies with the highest forward discounts. Avg. denotes the average return of the five currency portfolios and HML denotes a carry portfolio that is long in portfolio C5 and short in portfolio C1. The G10 currencies are sorted into 3 portfolios. All the **net** log excess returns are **monthly** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015). The sample period ranges from November 1983 to May 2019.

Panel A: All Countries							
Portfolio	C1	C2	C3	C4	C5	Avg.	HML
Mean	-2.19	0.19	1.69	2.66	3.75	1.22	5.94
	[1.21]	[1.23]	[1.33]	[1.37]	[1.85]	[1.21]	[1.62]
Standard Deviation	7.24	7.35	7.90	8.18	11.06	7.21	9.66
	[0.86]	[0.87]	[0.94]	[0.97]	[1.31]	[0.86]	[1.15]
Sharpe Ratio	-0.30	0.03	0.21	0.33	0.34	0.17	0.61
Skewness	0.00	-0.37	-0.21	-0.35	-1.22	-0.42	-1.23
	[0.12]	[0.12]	[0.12]	[0.12]	[0.12]	[0.12]	[0.12]
Excess Kurtosis	0.91	2.00	2.03	1.96	5.46	1.04	4.35
	[0.24]	[0.24]	[0.24]	[0.24]	[0.24]	[0.24]	[0.24]
AC(1)	0.02	0.05	0.08	0.10	0.11	0.09	0.09
	(0.63)	(0.31)	(0.10)	(0.04)	(0.02)	(0.08)	(0.06)

Panel B: G10 Countries					
Portfolio	C1	C2	C3	Avg.	HML
Mean	-1.74	1.15	3.44	0.95	5.18
	[1.52]	[1.34]	[1.70]	[1.35]	[1.48]
Standard Deviation	9.07	7.98	10.12	8.03	8.82
	[1.08]	[0.95]	[1.20]	[0.95]	[1.05]
Sharpe Ratio	-0.19	0.14	0.34	0.12	0.59
Skewness	0.14	-0.23	-0.41	-0.13	-0.81
	[0.12]	[0.12]	[0.12]	[0.12]	[0.12]
Excess Kurtosis	0.59	1.06	1.51	0.65	2.05
	[0.24]	[0.24]	[0.24]	[0.24]	[0.24]
AC(1)	0.04	0.09	0.10	0.08	0.10
	(0.45)	(0.07)	(0.04)	(0.11)	(0.04)

Figure 2: Cumulative Monthly Carry Trade Returns Net of Transaction Costs

This figure shows monthly cumulative net log excess returns of the carry trade portfolios with monthly rebalancing. The solid black line corresponds to all countries, while the gray line corresponds to the sample of G10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

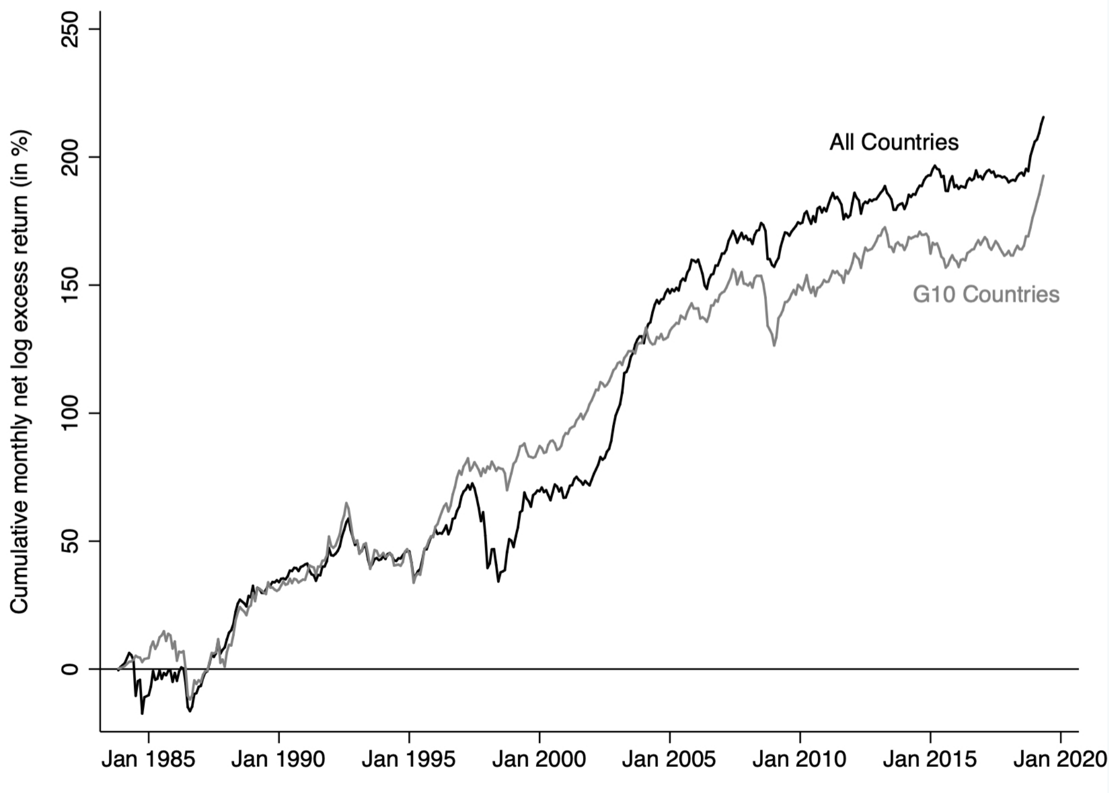


Table 5: Descriptive Statistics of Daily Carry Trade Returns with Monthly Rebalancing

This table reports statistics of currency portfolios sorted on their 1 month forward discount relative to the USD at the end of each month. The currencies of the full sample are sorted into 5 portfolios. Portfolio C1 contains the 20% of currencies with the lowest forward discounts, while portfolio C5 contains the 20% of currencies with the highest forward discounts. Avg. denotes the average return of the five currency portfolios and HML denotes a carry portfolio that is long in portfolio C5 and short in portfolio C1. The G10 currencies are sorted into 3 portfolios. All the log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015). The sample period ranges from November 1983 to May 2019.

Panel A: All Countries							
Portfolio	C1	C2	C3	C4	C5	Avg.	HML
Mean	-2.01	0.35	1.97	3.33	4.56	1.64	6.57
	[1.09]	[1.08]	[1.17]	[1.22]	[1.55]	[1.02]	[1.45]
Standard Deviation	6.60	6.56	7.09	7.38	9.39	6.21	8.81
	[0.77]	[0.77]	[0.83]	[0.86]	[1.09]	[0.72]	[1.03]
Sharpe Ratio	-0.30	0.05	0.28	0.45	0.49	0.26	0.75
Skewness	0.45	0.22	0.09	0.06	-0.34	0.13	-0.47
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
Excess Kurtosis	5.86	4.83	5.11	5.64	9.28	4.59	9.64
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]
AC(1)	0.01	0.01	0.02	0.03	0.06	0.04	0.03
	(0.33)	(.18)	(0.03)	(0.00)	(0.00)	(0.00)	(0.00)
Panel B: G10 Countries							
Portfolio	C1		C2		C3	Avg.	HML
Mean	-1.16		1.35		3.01	1.07	4.17
	[1.40]		[1.29]		[1.60]	[1.25]	[1.45]
Standard Deviation	8.49		7.82		9.68	7.56	8.80
	[0.99]		[0.91]		[1.13]	[0.88]	[1.03]
Sharpe Ratio	-0.14		0.17		0.31	0.14	0.47
Skewness	0.34		0.19		-0.19	0.25	-0.70
	[0.03]		[0.03]		[0.03]	[0.03]	[0.03]
Excess Kurtosis	3.99		5.40		5.81	4.22	7.20
	[0.05]		[0.05]		[0.05]	[0.05]	[0.05]
AC(1)	0.00		-0.01		0.00	-0.00	0.02
	(0.71)		(0.29)		(0.92)	(0.65)	(0.09)

Table 6: Normalized Ratios of Central Moments of Carry Trade Returns

This table reports the ratios of the monthly returns central moments to the daily returns central moments for the HML carry portfolios. The ratios are normalized by the expected ratios if the daily returns were *i.i.d.*. It follows that if daily returns were *i.i.d.*, all the normalized ratios would be approximately 1.

Panel A: All Countries	
	HML
Mean	1.01
Standard Deviation	1.09
Sharpe Ratio	0.92
Skewness	11.90
Excess Kurtosis	9.41
Panel B: G10 Countries	
	HML
Mean	1.31
Standard Deviation	1.00
Sharpe Ratio	1.32
Skewness	5.30
Excess Kurtosis	5.98

Figure 3: Cumulative Daily Carry Trade Returns with Monthly Rebalancing

This figure shows daily cumulative log excess returns of the carry trade portfolios with monthly rebalancing. The solid black line corresponds to all countries, while the gray line corresponds to the sample of G10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

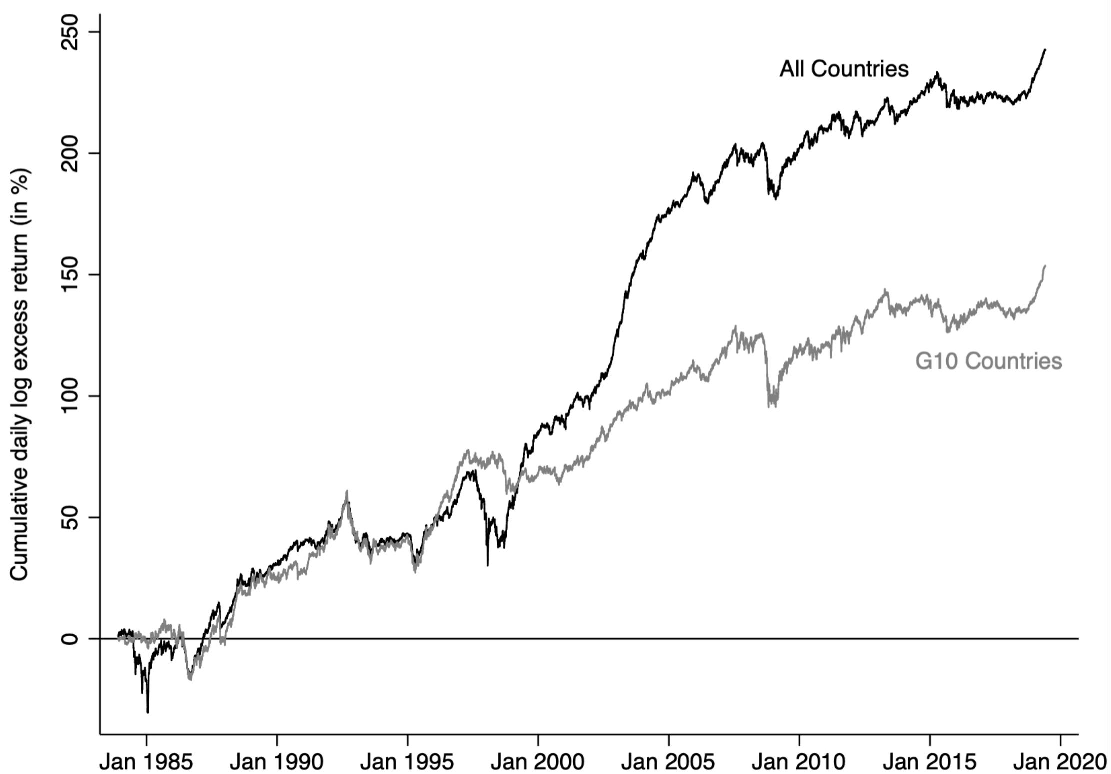


Table 7: Descriptive Statistics of Monthly Currency Momentum Returns

This table reports statistics of currency portfolios sorted on their excess return over the previous 1 month at the end of each month. The currencies of the full sample are sorted into 5 portfolios. Portfolio M1 contains the 20% of currencies with the lowest excess return over the previous month, while portfolio M5 contains the 20% of currencies with the highest excess return over the previous month. Avg. denotes the average return of the five currency portfolios and HML denotes a momentum portfolio that is long in portfolio M5 and short in portfolio M1. The G10 currencies are sorted into 3 portfolios. All the log excess returns are **monthly** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015). The sample period ranges from November 1983 to May 2019.

Panel A: All Countries							
Portfolio	M1	M2	M3	M4	M5	Avg.	HML
Mean	-1.75	1.65	1.08	2.87	4.52	1.68	6.27
	[1.56]	[1.39]	[1.34]	[1.30]	[1.48]	[1.20]	[1.60]
Standard Deviation	9.29	8.27	7.97	7.75	8.82	7.14	9.55
	[1.10]	[0.98]	[0.95]	[0.92]	[1.05]	[0.85]	[1.13]
Sharpe Ratio	-0.19	0.20	0.14	0.37	0.51	0.23	0.66
Skewness	-0.82	-0.48	-0.15	-0.06	0.20	-0.35	0.46
	[0.12]	[0.12]	[0.12]	[0.12]	[0.12]	[0.12]	[0.12]
Excess Kurtosis	3.82	3.47	1.48	1.41	0.93	0.87	2.27
	[0.24]	[0.24]	[0.24]	[0.24]	[0.24]	[0.24]	[0.24]
AC(1)	-0.03	0.04	0.07	0.09	0.12	0.08	-0.00
	(0.55)	(0.36)	(0.17)	(0.08)	(0.02)	(0.10)	(0.93)

Panel B: G10 Countries					
Portfolio	M1	M2	M3	Avg.	HML
Mean	-0.85	1.79	2.10	1.01	2.95
	[1.59]	[1.52]	[1.47]	[1.35]	[1.42]
Standard Deviation	9.47	9.07	8.73	8.05	8.48
	[1.13]	[1.08]	[1.04]	[0.96]	[1.01]
Sharpe Ratio	-0.09	0.20	0.24	0.13	0.35
Skewness	-0.46	-0.20	0.13	-0.14	0.07
	[0.12]	[0.12]	[0.12]	[0.12]	[0.12]
Excess Kurtosis	1.90	0.94	0.79	0.64	2.78
	[0.24]	[0.24]	[0.24]	[0.24]	[0.24]
AC(1)	0.08	0.05	0.04	0.08	-0.02
	(0.10)	(0.33)	(0.38)	(0.10)	(0.63)

Figure 4: Cumulative Monthly Currency Momentum Returns

This figure shows monthly cumulative log excess returns of the currency momentum portfolios with monthly rebalancing. The solid black line corresponds to all countries, while the gray line corresponds to the sample of G10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

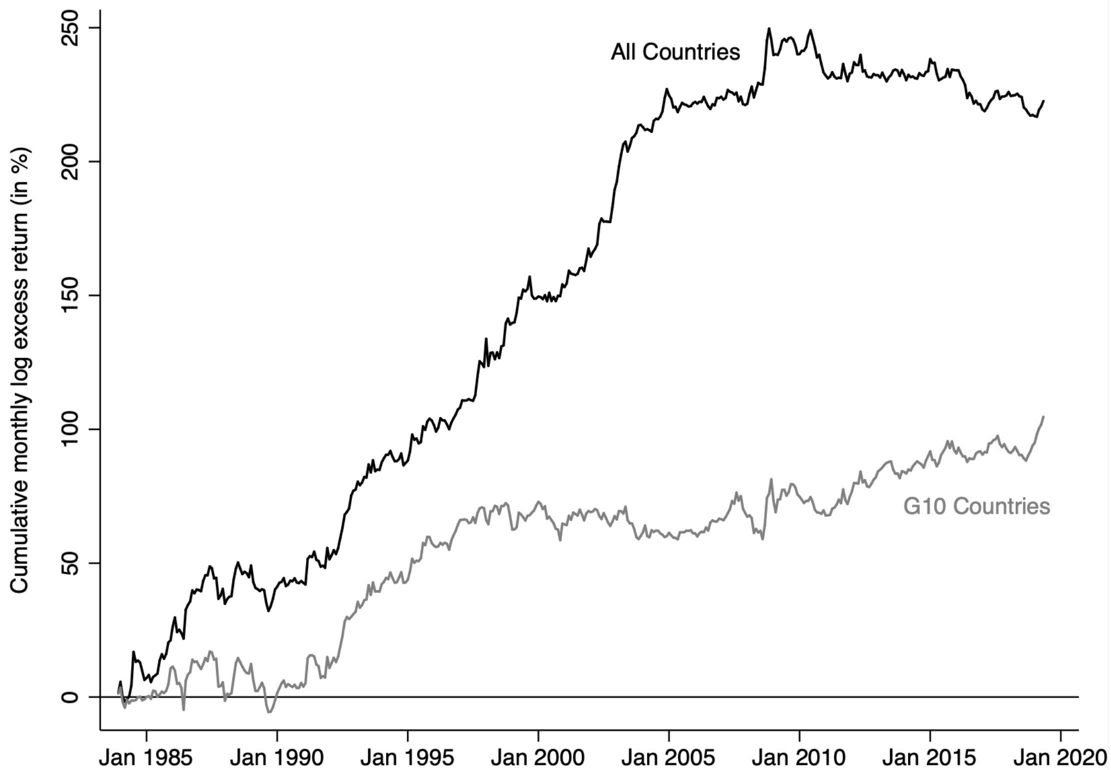


Table 8: Descriptive Statistics of Monthly Currency Momentum Returns Net of Transaction Costs

This table reports statistics of currency portfolios sorted on their excess return over the previous 1 month at the end of each month. The currencies of the full sample are sorted into 5 portfolios. Portfolio M1 contains the 20% of currencies with the lowest excess return over the previous month, while portfolio M5 contains the 20% of currencies with the highest excess return over the previous month. Avg. denotes the average return of the five currency portfolios and HML denotes a momentum portfolio that is long in portfolio M5 and short in portfolio M1. The G10 currencies are sorted into 3 portfolios. All the **net** log excess returns are **monthly** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015). The sample period ranges from November 1983 to May 2019.

Panel A: All Countries							
Portfolio	M1	M2	M3	M4	M5	Avg.	HML
Mean	-0.50	0.44	-0.04	1.65	3.05	0.92	3.55
	[1.57]	[1.38]	[1.34]	[1.30]	[1.48]	[1.20]	[1.61]
Standard Deviation	9.34	8.23	7.99	7.76	8.85	7.14	9.62
	[1.11]	[0.98]	[0.95]	[0.92]	[1.05]	[0.85]	[1.14]
Sharpe Ratio	-0.05	0.05	-0.01	0.21	0.34	0.13	0.37
Skewness	-0.75	-0.52	-0.17	-0.08	0.16	-0.36	0.40
	[0.12]	[0.12]	[0.12]	[0.12]	[0.12]	[0.12]	[0.12]
Excess Kurtosis	3.77	3.50	1.49	1.46	0.91	0.87	2.30
	[0.24]	[0.24]	[0.24]	[0.24]	[0.24]	[0.24]	[0.24]
AC(1)	-0.04	0.04	0.06	0.08	0.11	0.07	-0.00
	(0.44)	(0.40)	(0.19)	(0.09)	(0.03)	(0.13)	(0.93)

Panel B: G10 Countries					
Portfolio	M1	M2	M3	Avg.	HML
Mean	-0.05	1.05	1.26	0.76	1.31
	[1.60]	[1.52]	[1.47]	[1.35]	[1.44]
Standard Deviation	9.51	9.07	8.74	8.05	8.57
	[1.13]	[1.08]	[1.04]	[0.96]	[1.02]
Sharpe Ratio	-0.01	0.12	0.14	0.09	0.15
Skewness	-0.45	-0.21	0.12	-0.14	0.03
	[0.12]	[0.12]	[0.12]	[0.12]	[0.12]
Excess Kurtosis	1.87	0.94	0.79	0.65	2.79
	[0.24]	[0.24]	[0.24]	[0.24]	[0.24]
AC(1)	0.08	0.04	0.04	0.08	-0.02
	(0.10)	(0.36)	(0.42)	(0.11)	(0.70)

Figure 5: Cumulative Monthly Currency Momentum Returns Net of Transaction Costs

This figure shows monthly cumulative net log excess returns of the currency momentum portfolios with monthly rebalancing. The solid black line corresponds to all countries, while the gray line corresponds to the sample of G10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

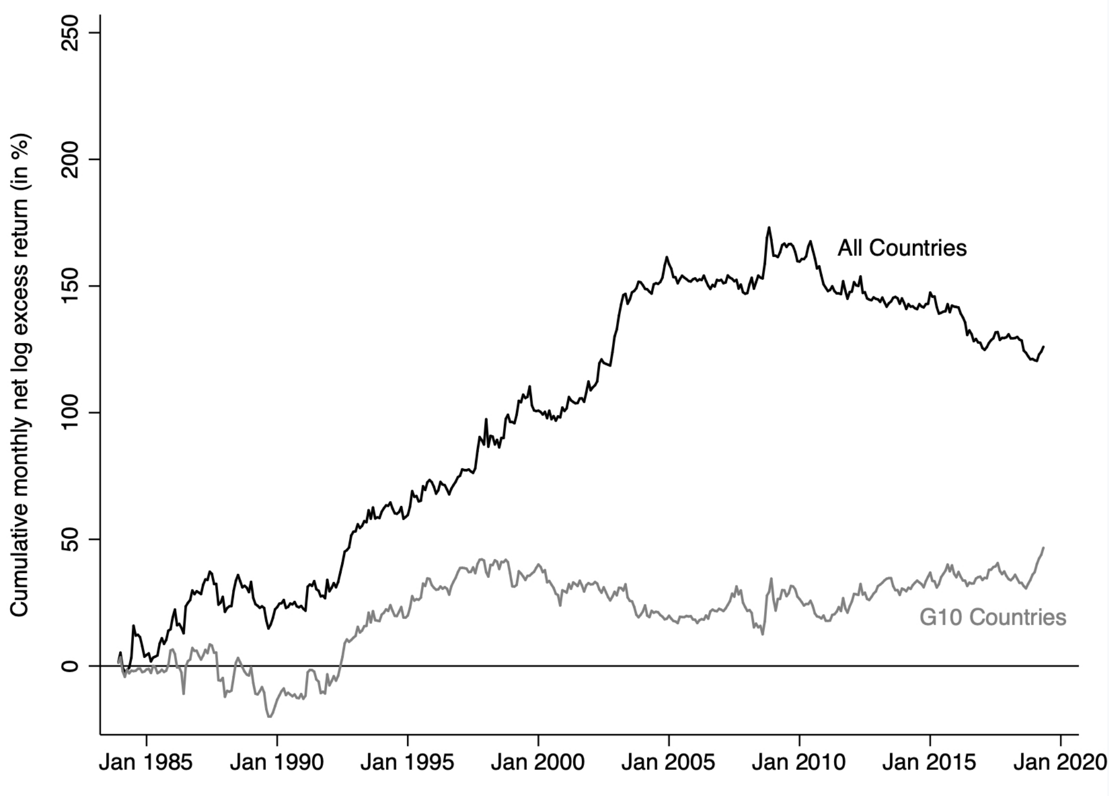


Table 9: Descriptive Statistics of Daily Currency Momentum Returns with Monthly Rebalancing

This table reports statistics of currency portfolios sorted on their excess return over the previous 1 month at the end of each month. The currencies of the full sample are sorted into 5 portfolios. Portfolio M1 contains the 20% of currencies with the lowest excess return over the previous month, while portfolio M5 contains the 20% of currencies with the highest excess return over the previous month. Avg. denotes the average return of the five currency portfolios and HML denotes a momentum portfolio that is long in portfolio M5 and short in portfolio M1. The G10 currencies are sorted into 3 portfolios. All the log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015). The sample period ranges from November 1983 to May 2019.

Panel A: All Countries

Portfolio	M1	M2	M3	M4	M5	Avg.	HML
Mean	-1.57	1.73	1.10	2.82	4.53	1.72	6.10
	[1.40]	[1.20]	[1.15]	[1.18]	[1.34]	[1.02]	[1.58]
Standard Deviation	8.49	7.29	6.97	7.15	8.11	6.18	9.55
	[0.99]	[0.85]	[0.81]	[0.83]	[0.95]	[0.72]	[1.12]
Sharpe Ratio	-0.18	0.24	0.16	0.39	0.56	0.28	0.64
Skewness	-0.01	0.24	0.06	0.08	-0.15	0.15	-0.08
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
Excess Kurtosis	10.41	8.21	5.68	7.02	4.42	4.75	5.57
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]
AC(1)	0.06	0.03	0.01	0.03	0.03	0.04	0.04
	(0.00)	(0.01)	(0.17)	(0.01)	(0.00)	(0.00)	(0.00)

Panel B: G10 Countries

Portfolio	M1	M2	M3	Avg.	HML
Mean	-0.65	2.02	2.18	1.18	2.83
	[1.46]	[1.41]	[1.43]	[1.25]	[1.39]
Standard Deviation	8.83	8.53	8.62	7.55	8.41
	[1.03]	[1.00]	[1.01]	[0.88]	[0.98]
Sharpe Ratio	0.07	0.24	0.25	0.16	0.34
Skewness	0.06	0.27	-0.06	0.24	0.04
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
Excess Kurtosis	5.77	4.56	3.81	4.23	4.86
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]
AC(1)	-0.00	0.00	-0.00	-0.00	0.02
	(0.90)	(0.86)	(0.87)	(0.64)	(0.12)

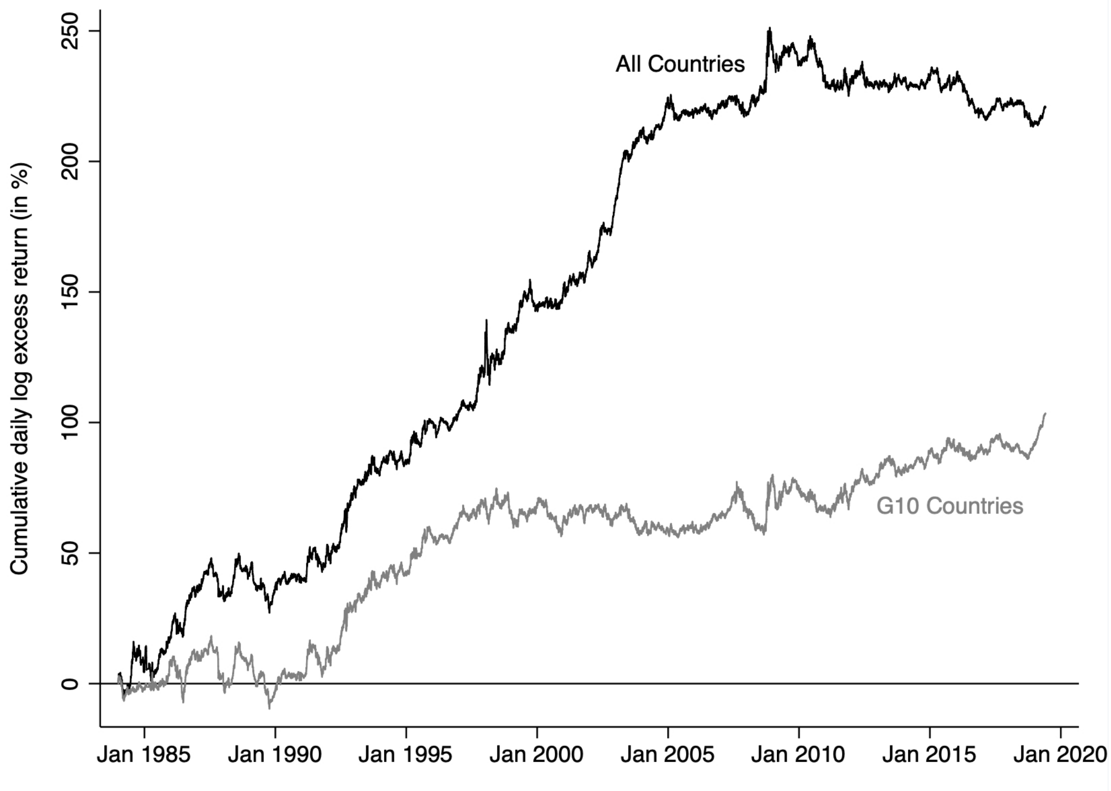
Table 10: Normalized Ratios of Central Moments of Currency Momentum Returns

This table reports the ratios of the monthly returns central moments to the daily returns central moments for the HML currency momentum portfolios. The ratios are normalized by the expected ratios if the daily returns were *i.i.d.*. It follows that if daily returns were *i.i.d.*, all the normalized ratios would be approximately 1.

Panel A: All Countries	
	HML
Mean	1.03
Standard Deviation	1.00
Sharpe Ratio	1.03
Skewness	-26.35
Excess Kurtosis	8.56
Panel B: G10 Countries	
	HML
Mean	1.04
Standard Deviation	1.01
Sharpe Ratio	1.03
Skewness	8.02
Excess Kurtosis	12.01

Figure 6: Cumulative Daily Currency Momentum Returns with Monthly Rebalancing

This figure shows daily cumulative log excess returns of the currency momentum portfolios with monthly rebalancing at the end of each month. The solid black line corresponds to all countries, while the gray line corresponds to the sample of G10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.



Chapter 2

Describing currency portfolios with the daily decision interval

Chapter 1 suggests that with a monthly decision interval the carry trade and the currency momentum at the monthly and the daily frequencies perform similarly, as measured by the Sharpe ratio. However, Chapter 1 also suggests that the returns at the daily frequency of both strategies are not consistent with the *i.i.d.* assumption. In other words, there can exist autocorrelation in the returns, which mean that daily losses could cumulate to create very large losses at the monthly frequency. Hence, it is worth constructing carry and momentum portfolios with a daily decision interval and examine their returns' properties, which is what I do in this section.

I make two important assumptions when constructing the portfolios of sorted currencies. First, I assume that there is 21 trading days in each month. Second, for the purpose of computing daily returns, I assume that the investor can earn the previous day's forward discount prorated per day.

2.1 Carry portfolios with daily rebalancing

The first group of portfolios of sorted currencies with a daily decision interval consists of carry portfolios. I allocate currencies of the full sample to five portfolios based on their forward discount prorated per day relative to the USD observed at the end of each day. As opposed to section 1.3 where portfolios are rebalanced monthly, here portfolios are rebalanced at the end of each day. The daily log currency excess return is calculated using equation 1.6, in which $\frac{f_t - s_t}{21}$ represents the previous day's forward discount prorated per day. I compute the daily log currency excess return for portfolio j,z^j_{t+1}, by taking the average of the daily log currency excess returns in each portfolio j. For the smaller sample of G10 currencies minus the USD, I follow the same method but sort currencies only into three portfolios.

Descriptive statistics of the daily returns for portfolios C1 to C5, their Avg., and for the HML carry trade portfolio are reported in Table 11. Panel A shows results for the full sample of 37 currencies and Panel B shows results for the smaller sample of G10 currencies minus the USD. As in Table 1 and Table 5, both samples present a striking pattern of monotonically increasing average excess return from portfolio C1 to C5 for the full sample and from portfolio C1 to C3 for the G10 sample. Let me focus on the log excess returns to the HML carry portfolio with daily rebalancing. The carry trade yields a statistically significantly different from zero average log excess return of 12.45% and 10.30% for the full sample and the G10 sample respectively. These annualized daily average returns are considerably higher than their counterparts reported in Table 1 and Table 5. In addition, the annualized daily standard deviations in Table 11 are lower than the ones reported in Table 1 and Table 5. Consequently, the performance of the carry trade, as measured by the Sharpe ratio, seems to be higher with the daily decision interval than with the monthly decision interval. In fact, the Sharpe ratio is 1.45 for the full sample and 1.17 for the G10 sample. Both of these considerably higher Sharpe ratios represent the main different between the carry portfolios with daily and monthly rebalancing. The higher central moments of the daily returns' distribution with the daily decision interval in Table 11 remain similar to those of the daily returns' distribution with the monthly decision interval reported in Table 5. Table 11 shows that the skewness and the excess kurtosis for both samples are similar to the ones reported in Table 5. Table 12 reports descriptive statistics of the daily returns net of transaction costs for portfolios C1 to C5, their Avg., and for the HML carry portfolio. For both samples, the net log excess returns in Table 12 present similar patterns than that of the log excess returns without the bid-ask spreads reported in Table 11. The main difference consists of smaller mean net returns and, consequently, smaller Sharpe ratios across all portfolios. More specifically, the mean net return decreases by 2.91% to 9.54% for the full sample and by 1.69% to 8.61% for the G10 sample, whereas the Sharpe ratio decreases to 1.11 for the full sample and 0.98 for the G10 sample. The standard deviation, the skewness, and the excess kurtosis in Table 12 remain very close to the ones reported in Table 11 for all portfolios.

Figure 9 and Figure 10 show the number of transactions per month for the carry trade strategy with daily rebalancing of the full sample and the G10 sample respectively. Figure B.1 and Figure B.2 show that monthly rebalancing can reach a maximum close to 15 transactions per month for the full sample and close to 10 transactions per month for the G10 sample. With daily portfolio rebalancing, Figure 9 and Figure 10 show that the number of transactions per month can reach a maximum close to 150 for both samples. Most importantly, the average number of transactions per month with daily rebalancing is 33 for the full sample and 19 for the G10 sample, as opposed to 3 and 1 respectively with monthly portfolio rebalancing. Although daily portfolio rebalancing increases the number of transactions per month, the higher Sharpe ratio, even net of transaction costs, suggest that there is extra value in rebalancing the carry trade more frequently.

It is worth comparing the point estimates of the carry trade with daily rebalancing for the G10 sample to those of the enhanced carry trade of Bekaert and Panayotov (2019). Recall that Bekaert and Panayotov (2019) find an enhanced version of the carry trade for a sample including all G10 currencies by constructing it only from certain subsets of currencies, or, equivalently, by excluding certain currencies altogether from the carry trade. The average "good carry trade" of Bekaert and Panayotov (2019) has a Sharpe ratio of 0.47 and a negative skewness of -0.33, while the Sharpe ratio and the skewness of the carry trade with daily rebalancing for the G10 sample are 1.17 and -0.67 respectively. Comparing my results to the ones of Bekaert and Panayotov (2019) suggests that daily rebalancing can further enhance the performance of the carry trade as measured by the Sharpe ratio, but cannot improve the negative skewness.

Figure 7 shows cumulative daily log excess returns for the HML carry trade portfolio with daily rebalancing for all countries and for the smaller sample of G10 countries. Figure 8 shows cumulative HML daily returns net of transaction costs. The cumulative returns with the daily decision interval on Figure 7 appear systemically higher than the cumulative returns with the monthly decision interval on Figure 1 and Figure 3. The same can be said for cumulative net returns with the daily decision interval on Figure 8. Figure 7 shows that including a broader set of currencies seems to improve the returns to the carry trade for the entire sample period. Interestingly, on Figure 8 it appears that the carry trade for both samples behaved similarly between approximately 1995 to 2003. It is in the last part of sample period that the sample of 37 currencies has higher cumulative net returns.

2.2 Momentum portfolios with daily rebalancing

The second group of portfolios of sorted currencies with a daily decision interval consists of momentum portfolios. I allocate currencies of the full sample to five portfolios based on their lagged return over the previous month. Still assuming there is 21 trading days in a month, the lagged return over the previous month can be calculated from equation 1.5, in which $z_t = f_{t-21} - s_t$. Portfolios are rebalanced at the end of each day, which means that the portfolios are no longer held for one month as in section 1.4. In other words, the form of momentum I now consider has a one month formation period but the holding period is no longer set to one month; it can vary. The daily log currency excess return is calculated using equation 1.6, in which $\frac{f_t - s_t}{21}$ represents the previous day's forward discount prorated per day. I compute the daily log currency excess return for portfolio j, z_{t+1}^{j}, by taking the average of the daily log currency excess returns in each portfolio j. For the smaller sample of G10 currencies minus the USD, I follow the same method but sort currencies only into three portfolios.

Descriptive statistics of the daily returns for portfolios M1 to M5, their Avg., and for the HML currency momentum portfolio are reported in Table 13. Panel A shows results for the full sample of 37 currencies and Panel B shows results for the smaller sample of G10 currencies minus the USD. There is a pattern of monotonically increasing average excess return from portfolio M1 to M5 for the full sample and from portfolio M1 to M3 for the G10 sample. The pattern of increasing average return is more striking than in Table 7 and Table 9. Let me focus on the log excess returns to the HML momentum portfolio with daily rebalancing. The currency momentum yields a statistically significantly different from zero average log excess return of 4.72% and 2.33% for the full sample and the G10 sample respectively. Interestingly, these annualized daily average returns are slightly lower than their counterparts reported in Table 7 and Table 9. In addition, the annualized daily standard deviations in Table 13 are similar to the ones reported in Table 7 and Table 9. Consequently, the performance of the currency momentum, as measured by the Sharpe ratio, seems to be lower with the daily decision interval than with the monthly decision interval. In fact, the Sharpe ratio is 0.49 for the full sample and 0.27 for the G10 sample. These lower Sharpe ratios represent the main different between the momentum portfolios with daily and monthly rebalancing. The higher central moments of the daily returns' distribution with the daily decision interval in Table 13 remain similar to those of the daily returns' distribution with the monthly decision interval reported in Table 9. Table 13 shows that the skewness of both samples is similar to the one reported in Table 9, while the excess kurtosis of both samples is slightly higher than the one reported in Table 9. Table 14 reports descriptive statistics of the momentum returns net of transaction costs for portfolios M1 to M5, their Avg., and for the HML momentum portfolio. Most importantly, for both samples, the mean net HML momentum return is negative and is not statistically significantly different from zero. Consequently, the Sharpe ratio reported in Table 14 is also negative for both samples. The central moments other than the mean in Table 14 remain very close to the ones reported in Table 13.

Figure 13 and Figure 14 show the number of transactions per month and the turnover ratio for the currency momentum strategy with daily rebalancing of the full sample and the G10 sample respectively. Figure 13 and Figure 14 shows that with daily rebalancing the number of transactions per month increases to reach a maximum of approximately 150 and 80 for the full sample and the G10 sample respectively, as opposed to approximately 25 and 12 with monthly rebalancing as shown on Figure B.3 and Figure B.4. Most importantly, the average number of transactions per month with daily portfolio rebalancing is 72 for the full sample and 39 for the G10 sample, as opposed to 13 and 7 respectively with monthly portfolio rebalancing. As opposed to the carry trade, since "momentum portfolios are skewed towards currencies with high transaction costs" (Menkhoff et al., 2012b) and since daily rebalancing largely increases the number of transactions per month, it seems that there is no extra value in rebalancing the currency momentum more frequently. In fact, with daily rebalancing it seems that the profits are traded away since rebalancing on a daily basis leads to a negative and not statistically significantly different from zero mean net return for both samples as well as a negative Sharpe ratio.

Figure 11 shows cumulative daily log excess returns for the HML currency portfolio with daily rebalancing for all countries and for the smaller sample of G10 countries. Figure 12 shows cumulative HML daily returns net of transaction costs. The cumulative returns of both samples with the daily decision interval on Figure 11 appear to follow the same pattern as the cumulative returns of both samples with the monthly decision interval on Figure 4 and Figure 6 up until approximately 2010. Thereafter, Figure 11 shows that currency momentum returns for both samples are characterized by decreasing cumulative log excess returns, and more so than previously noted on Figure 4 and Figure 6 for the full sample. Finally, Figure 12 shows that the cumulative net returns with daily rebalancing appear systematically lower than the cumulative net returns with monthly rebalancing on Figure 5. In fact, a little after 2010 for the full sample and a little bit before 2010 for the G10 sample, the cumulative daily net log excess returns with daily rebalancing is in negative territory, although it appears that there is a small rebound for both samples towards 2019 at the very end of the sample period.

Table 11: Descriptive Statistics of Daily Carry Trade Returns with Daily Rebalancing

This table reports statistics of currency portfolios sorted on their 1 month forward discount prorated per day relative to the USD at the end of each **day**. The currencies of the full sample are sorted into 5 portfolios. Portfolio C1 contains the 20% of currencies with the lowest forward discounts, while portfolio C5 contains the 20% of currencies with the highest forward discounts. Avg. denotes the average return of the five currency portfolios and HML denotes a carry portfolio that is long in portfolio C5 and short in portfolio C1. The G10 currencies are sorted into 3 portfolios. All the log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show p-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015). The sample period ranges from November 1983 to May 2019.

Panel A: All Countries							
Portfolio	C1	C2	C3	C4	C5	Avg.	HML
Mean	-4.97	0.32	1.92	4.01	7.48	1.75	12.45
	[1.09]	[1.08]	[1.17]	[1.21]	[1.51]	[1.02]	[1.42]
Standard Deviation	6.61	6.56	7.08	7.36	9.14	6.19	8.60
	[0.77]	[0.76]	[0.83]	[0.86]	[1.06]	[0.72]	[1.00]
Sharpe Ratio	-0.75	0.05	0.27	0.55	0.82	0.28	1.45
Skewness	0.24	0.23	0.16	-0.07	-0.35	0.14	-0.55
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
Excess Kurtosis	4.64	5.53	5.82	6.07	7.94	4.63	7.96
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]
AC(1)	0.02	0.02	0.02	0.03	0.05	0.04	0.02
	(0.08)	(0.03)	(0.03)	(0.00)	(0.00)	(0.00)	(0.03)

Panel B: G10 Countries					
Portfolio	C1	C2	C3	Avg.	HML
Mean	-4.30	1.15	6.00	0.95	10.30
	[1.42]	[1.27]	[1.59]	[1.24]	[1.45]
Standard Deviation	8.62	7.73	9.64	7.56	8.82
	[1.00]	[0.90]	[1.12]	[0.88]	[1.03]
Sharpe Ratio	-0.50	0.15	0.62	0.13	1.17
Skewness	0.36	0.15	-0.17	0.25	-0.67
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
Excess Kurtosis	4.29	4.67	5.92	4.25	6.92
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]
AC(1)	0.00	-0.00	-0.01	-0.00	0.01
	(0.67)	(0.81)	(0.62)	(0.76)	(0.34)

Figure 7: Cumulative Daily Carry Trade Returns with Daily Rebalancing

This figure shows daily cumulative log excess returns of the carry trade portfolios with daily rebalancing. The solid black line corresponds to all countries, while the gray line corresponds to the sample of G10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

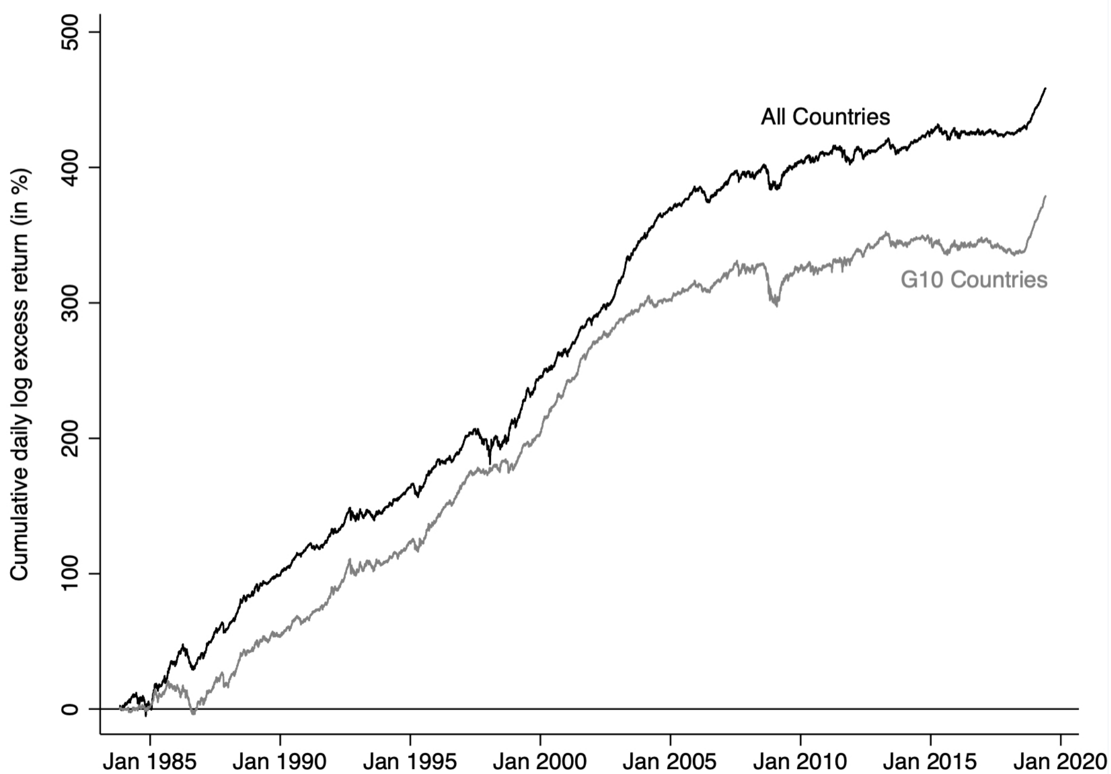


Table 12: Descriptive Statistics of Daily Carry Trade Returns Net of Transaction Costs with Daily Rebalancing

This table reports statistics of currency portfolios sorted on their 1 month forward discount prorated per day relative to the USD at the end of each **day**. The currencies of the full sample are sorted into 5 portfolios. Portfolio C1 contains the 20% of currencies with the lowest forward discounts, while portfolio C5 contains the 20% of currencies with the highest forward discounts. Avg. denotes the average return of the five currency portfolios and HML denotes a carry portfolio that is long in portfolio C5 and short in portfolio C1. The G10 currencies are sorted into 3 portfolios. All the **net** log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015). The sample period ranges from November 1983 to May 2019.

Panel A: All Countries							
Portfolio	C1	C2	C3	C4	C5	Avg.	HML
Mean	-3.85	-1.78	-0.51	1.23	5.69	0.16	9.54
	[1.09]	[1.08]	[1.17]	[1.21]	[1.50]	[1.02]	[1.41]
Standard Deviation	6.60	6.57	7.10	7.36	9.12	6.19	8.58
	[0.77]	[0.76]	[0.83]	[0.86]	[1.06]	[0.72]	[1.00]
Sharpe Ratio	-0.58	-0.27	-0.07	0.17	0.62	0.03	1.11
Skewness	0.26	0.20	0.11	-0.10	-0.39	0.12	-0.59
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
Excess Kurtosis	4.66	5.45	5.81	6.07	7.85	4.59	7.91
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]
AC(1)	0.02	0.02	0.02	0.03	0.05	0.04	0.02
	(0.08)	(0.03)	(0.04)	(0.00)	(0.00)	(0.00)	(0.06)

Panel B: G10 Countries					
Portfolio	C1	C2	C3	Avg.	HML
Mean	-3.48	-0.15	5.13	0.50	8.61
	[1.42]	[1.27]	[1.59]	[1.25]	[1.45]
Standard Deviation	8.61	7.74	9.64	7.56	8.81
	[1.00]	[0.90]	[1.12]	[0.88]	[1.03]
Sharpe Ratio	-0.40	-0.02	0.53	0.07	0.98
Skewness	0.36	0.14	-0.17	0.25	-0.68
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
Excess Kurtosis	4.28	4.63	5.92	4.24	6.94
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]
AC(1)	0.00	-0.00	-0.01	-0.00	0.01
	(0.70)	(0.84)	(0.60)	(0.76)	(0.40)

Figure 8: Cumulative Daily Carry Trade Returns Net of Transaction Costs with Daily Rebalancing

This figure shows daily cumulative net log excess returns of the carry trade portfolios with daily rebalancing. The solid black line corresponds to all countries, while the gray line corresponds to the sample of G10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

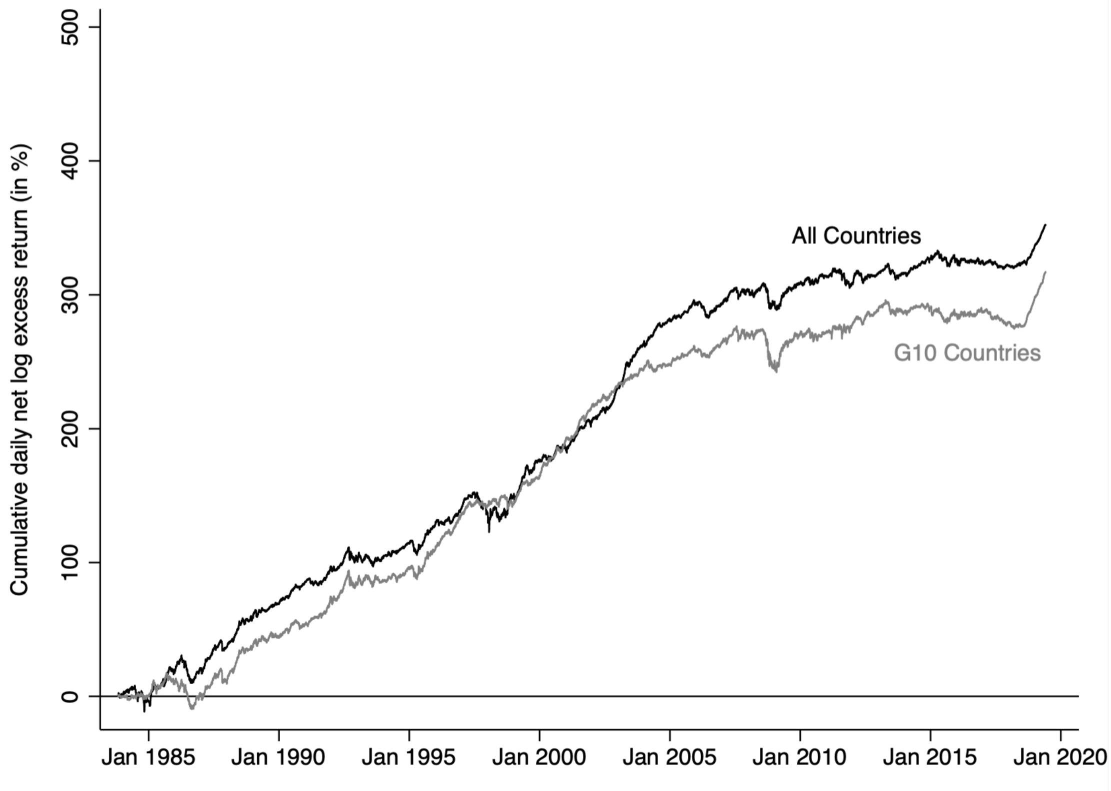


Figure 9: Number of Monthly Transactions for the Carry Trade of the Full Sample with Daily Rebalancing

This figure shows the number of transactions per month for the carry trade portfolio with daily rebalancing for the full sample of 37 currencies. The sample period ranges from November 1983 to May 2019.

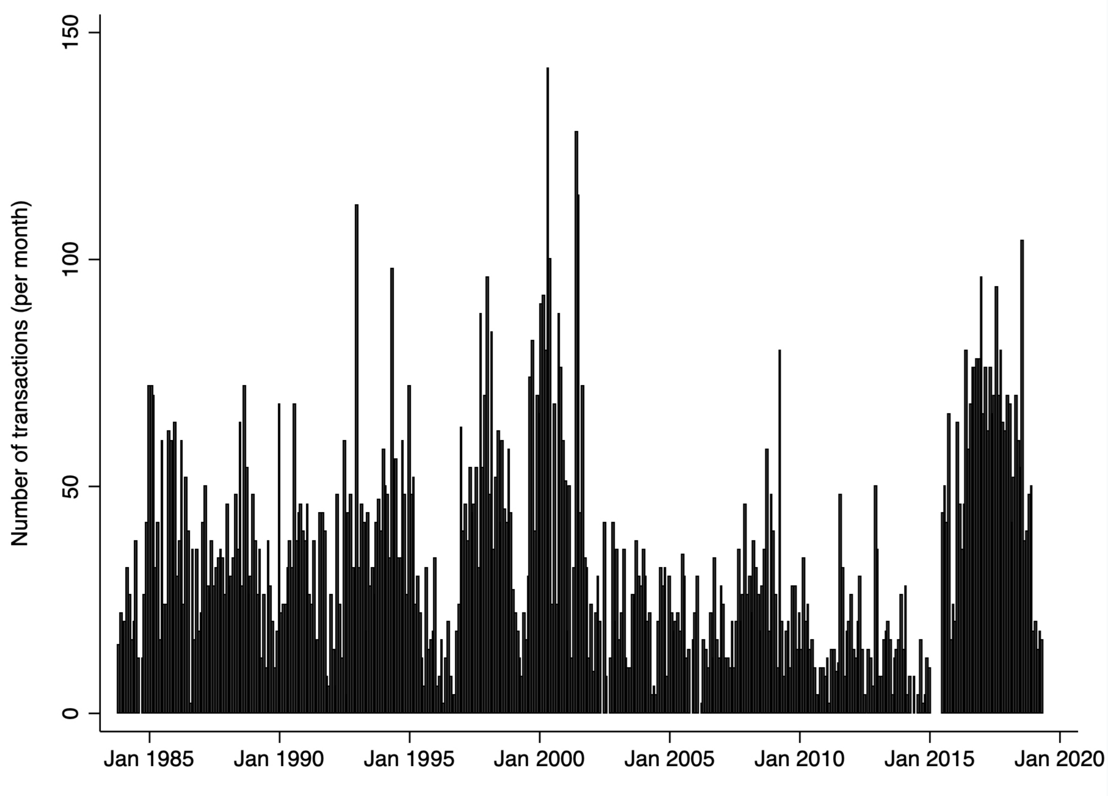


Figure 10: Number of Monthly Transactions for the Carry Trade of the G10 Sample with Daily Rebalancing

This figure shows the number of transactions per month for the carry trade portfolio with daily rebalancing for the G10 sample of 10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

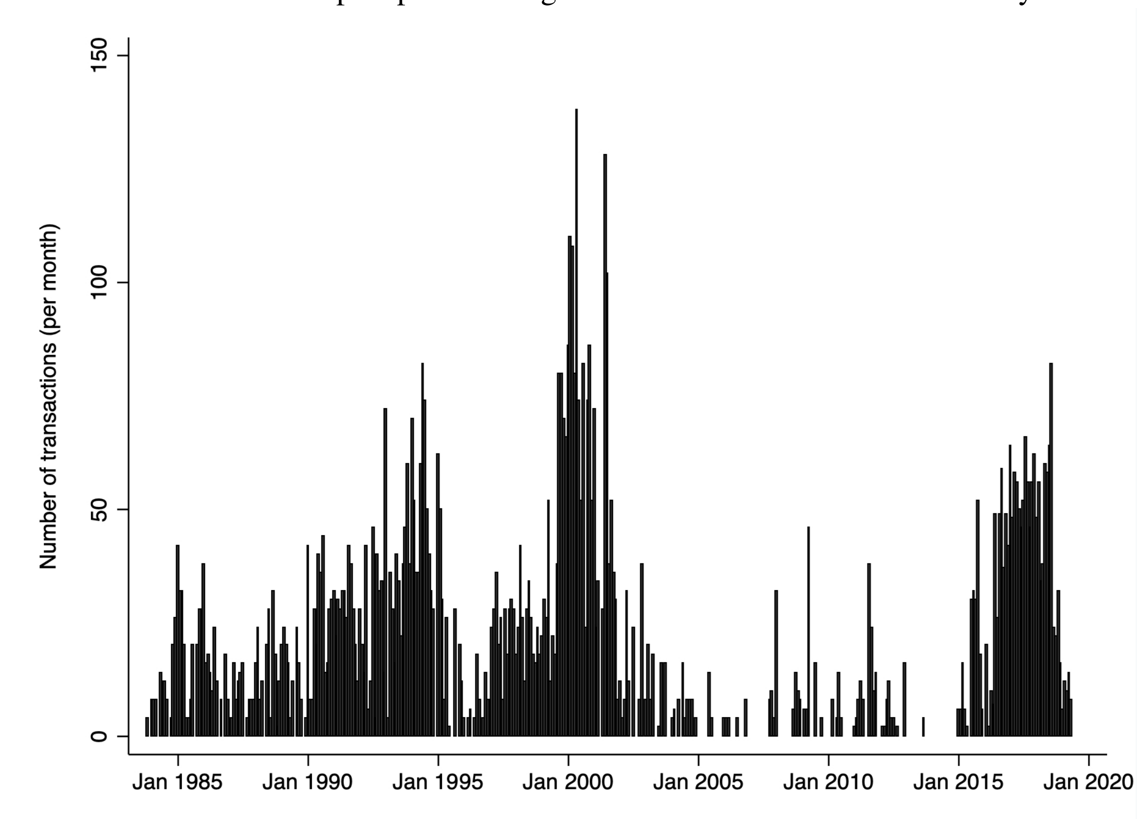


Table 13: Descriptive Statistics of Daily Currency Momentum Returns with Daily Rebalancing

This table reports statistics of currency portfolios sorted on their excess return over the previous 1 month at the end of each **day**. The currencies of the full sample are sorted into 5 portfolios. Portfolio M1 contains the 20% of currencies with the lowest excess return over the previous month, while portfolio M5 contains the 20% of currencies with the highest excess return over the previous month. Avg. denotes the average return of the five currency portfolios and HML denotes a momentum portfolio that is long in portfolio M5 and short in portfolio M1. The G10 currencies are sorted into 3 portfolios. All the log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015). The sample period ranges from November 1983 to May 2019.

Panel A: All Countries							
Portfolio	M1	M2	M3	M4	M5	Avg.	HML
Mean	-0.90	1.06	1.16	3.17	3.82	1.66	4.72
	[1.45]	[1.19]	[1.14]	[1.14]	[1.31]	[1.02]	[1.57]
Standard Deviation	8.77	7.25	6.91	6.94	7.92	6.16	9.56
	[1.02]	[0.84]	[0.81]	[0.81]	[0.92]	[0.72]	[1.11]
Sharpe Ratio	-0.10	0.15	0.17	0.46	0.48	0.27	0.49
Skewness	0.06	0.10	0.13	0.07	0.06	0.16	-0.07
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
Excess Kurtosis	10.62	9.06	5.99	5.53	5.08	4.62	6.85
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]
AC(1)	0.05	0.04	0.02	0.03	0.02	0.04	0.02
	(0.00)	(0.00)	(0.02)	(0.01)	(0.15)	(0.00)	(0.11)

Panel B: G10 Countries					
Portfolio	M1	M2	M3	Avg.	HML
Mean	-0.22	0.99	2.11	0.96	2.33
	[1.49]	[1.40]	[1.40]	[1.25]	[1.42]
Standard Deviation	9.03	8.52	8.50	7.57	8.64
	[1.05]	[0.99]	[0.99]	[0.88]	[1.01]
Sharpe Ratio	-0.02	0.12	0.25	0.13	0.27
Skewness	0.15	0.19	0.09	0.25	0.07
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
Excess Kurtosis	7.16	4.32	3.84	4.23	6.57
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]
AC(1)	-0.01	0.01	-0.01	-0.00	-0.02
	(0.63)	(0.49)	(0.15)	(0.79)	(0.09)

Figure 11: Cumulative Daily Currency Momentum Returns with Daily Rebalancing

This figure shows daily cumulative log excess returns of the currency momentum portfolios with daily rebalancing. The solid black line corresponds to all countries, while the gray line corresponds to the sample of G10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

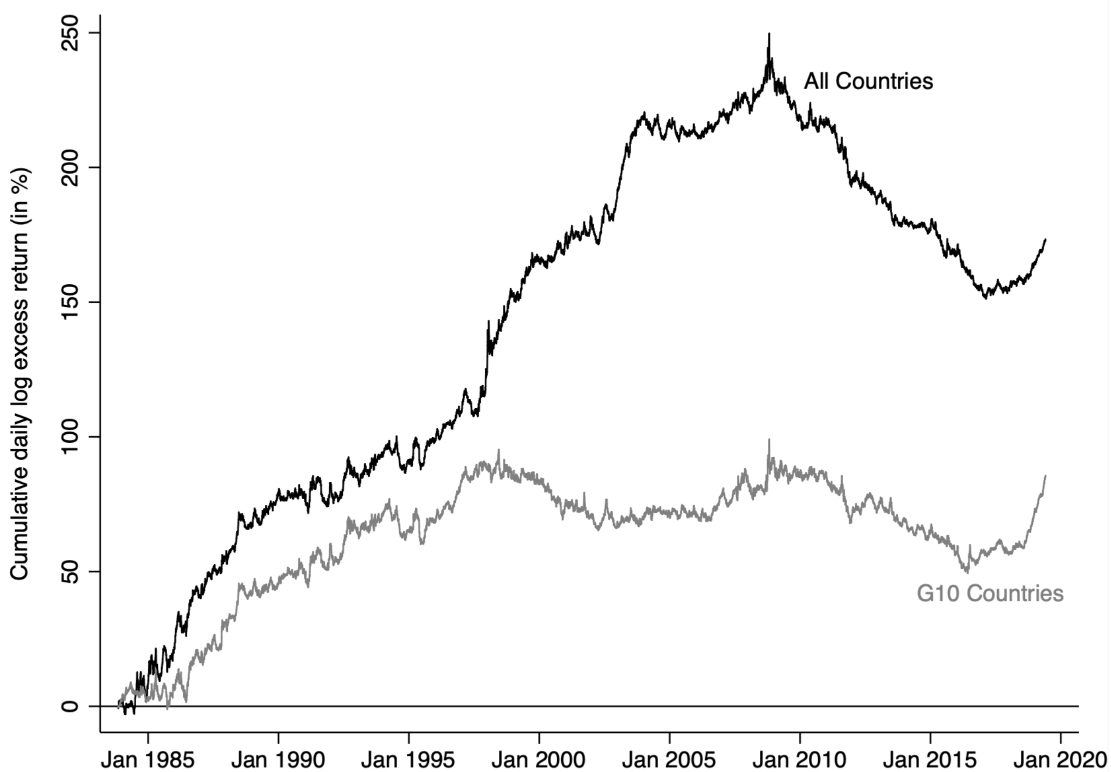


Table 14: Descriptive Statistics of Daily Currency Momentum Returns Net of Transaction Costs with Daily Rebalancing

This table reports statistics of currency portfolios sorted on their excess return over the previous 1 month at the end of each **day**. The currencies of the full sample are sorted into 5 portfolios. Portfolio M1 contains the 20% of currencies with the lowest excess return over the previous month, while portfolio M5 contains the 20% of currencies with the highest excess return over the previous month. Avg. denotes the average return of the five currency portfolios and HML denotes a momentum portfolio that is long in portfolio M5 and short in portfolio M1. The G10 currencies are sorted into 3 portfolios. All the **net** log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015). The sample period ranges from November 1983 to May 2019.

Panel A: All Countries							
Portfolio	M1	M2	M3	M4	M5	Avg.	HML
Mean	1.65	-4.11	-4.43	-2.00	0.76	-1.63	-0.89
	[1.45]	[1.19]	[1.14]	[1.15]	[1.31]	[1.02]	[1.59]
Standard Deviation	8.81	7.24	6.93	6.95	7.97	6.16	9.62
	[1.03]	[0.84]	[0.81]	[0.81]	[0.93]	[0.72]	[1.12]
Sharpe Ratio	0.19	-0.57	-0.64	-0.29	0.09	-0.26	-0.09
Skewness	0.10	0.04	0.06	0.02	0.00	0.13	-0.10
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
Excess Kurtosis	10.68	8.92	5.92	5.58	5.19	4.57	6.86
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]
AC(1)	0.05	0.03	0.02	0.03	0.02	0.04	0.02
	(0.00)	(0.00)	(0.02)	(0.00)	(0.15)	(0.00)	(0.07)

Panel B: G10 Countries					
Portfolio	M1	M2	M3	Avg.	HML
Mean	1.35	-1.97	0.47	-0.05	-0.88
	[1.49]	[1.40]	[1.40]	[1.25]	[1.43]
Standard Deviation	9.05	8.52	8.51	7.57	8.69
	[1.06]	[0.99]	[0.99]	[0.88]	[1.01]
Sharpe Ratio	0.15	-0.23	0.06	-0.01	-0.10
Skewness	0.15	0.17	0.08	0.24	0.06
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
Excess Kurtosis	7.12	4.31	3.85	4.21	6.50
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]
AC(1)	-0.00	0.01	-0.01	-0.00	-0.01
	(0.70)	(0.50)	(0.17)	(0.80)	(0.16)

Figure 12: Cumulative Daily Currency Momentum Returns Net of Transaction Costs with Daily Rebalancing

This figure shows daily cumulative net log excess returns of the currency momentum portfolios with daily rebalancing. The solid black line corresponds to all countries, while the gray line corresponds to the sample of G10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

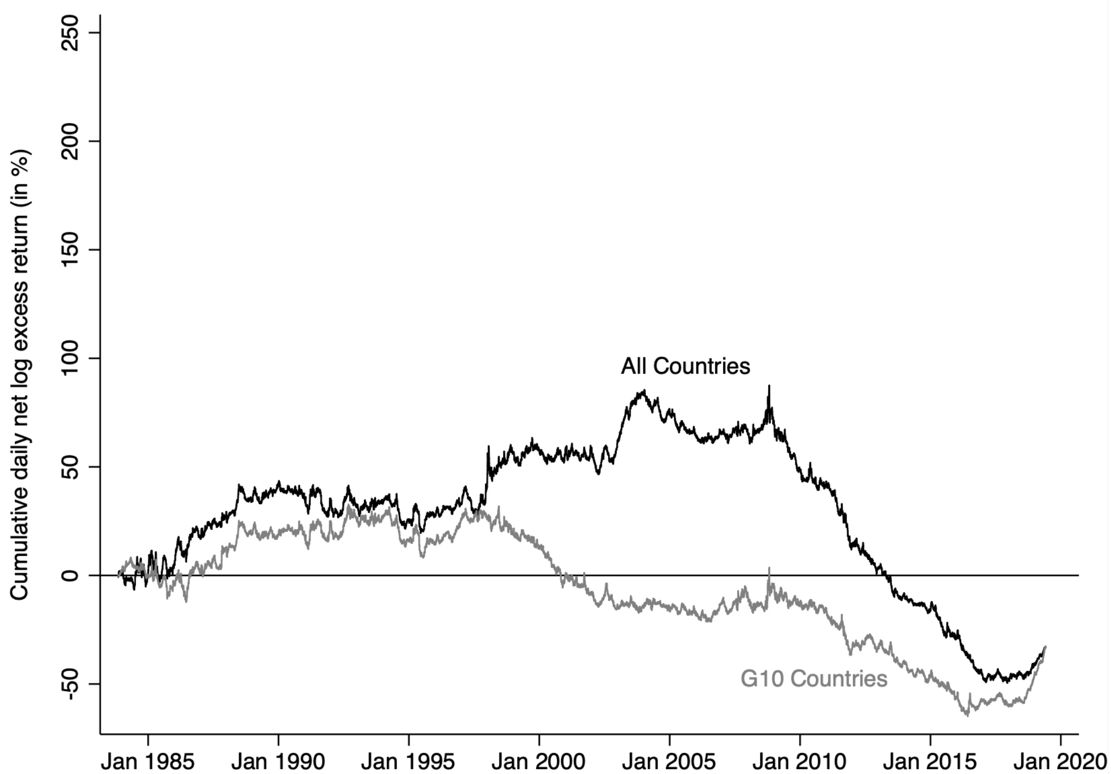


Figure 13: Number of Monthly Transactions for the Momentum Portfolio of the Full Sample with Daily Rebalancing

This figure shows the number of transactions per month for the currency momentum portfolio with daily rebalancing for the full sample of 37 currencies. The sample period ranges from November 1983 to May 2019.

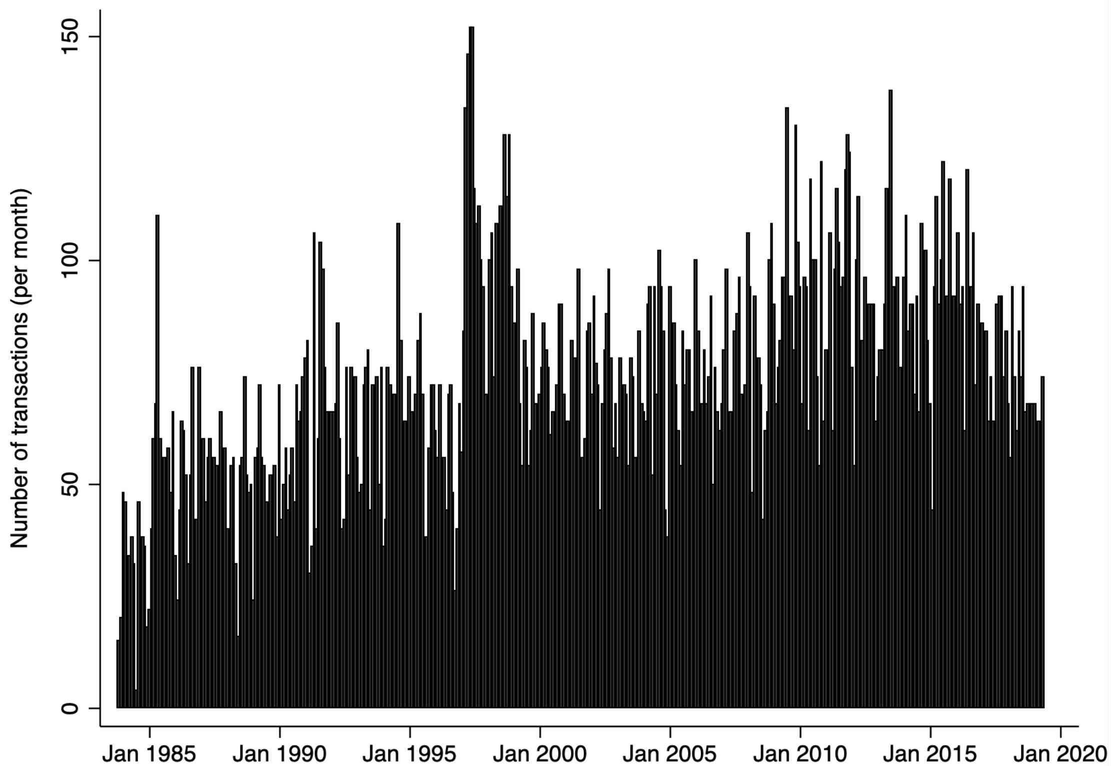
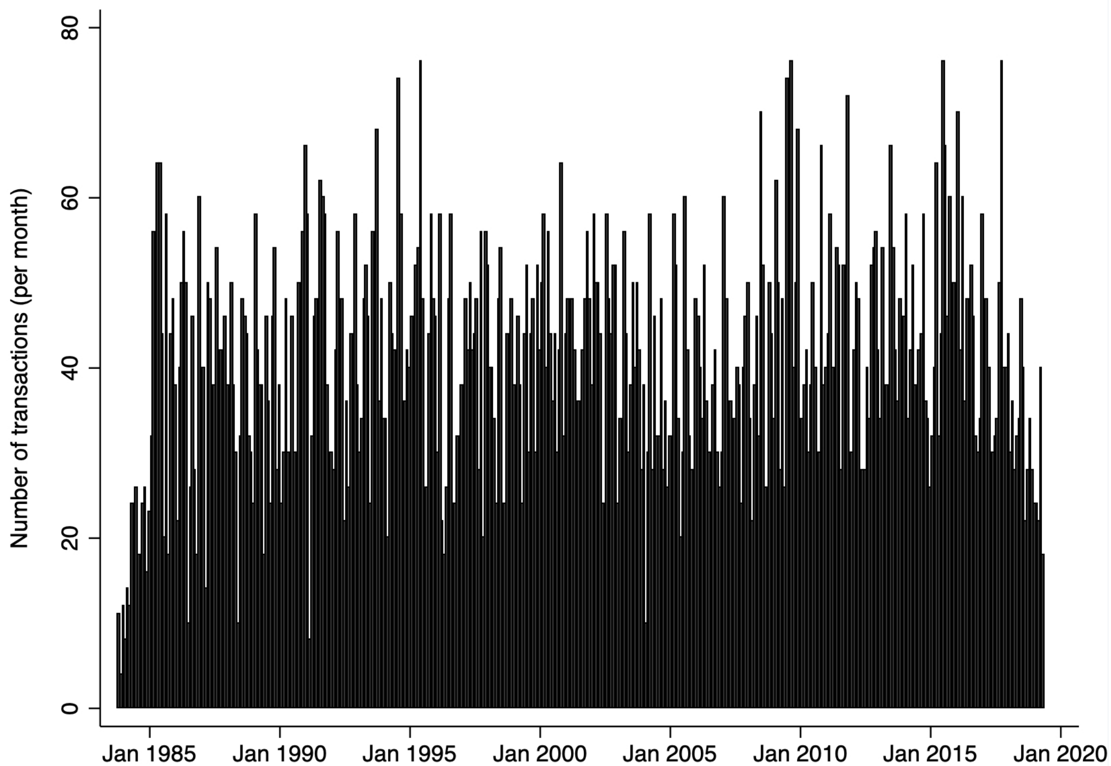


Figure 14: Number of Monthly Transactions for the Momentum Portfolio of the G10 Sample with Daily Rebalancing

This figure shows the number of transactions per month for the currency momentum portfolio with daily rebalancing for the G10 sample of 10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.



Chapter 3

Analyzing the impact of a risk management tool on the performance of currency portfolios

In this section, I design a risk management tool which aims at exploiting the autocorrelations in the losses of the carry trade and the currency momentum to improve the performance of both strategies with both the monthly and the daily decision intervals.

I design a risk management tool which builds on the findings of Daniel et al. (2017). They find that for an equally weighted carry trade strategy, the ten worst pure drawdowns occur over a period of at least two days to at most 11 days. So, the optimal version of the carry trade designed in this paper is characterized by two decision thresholds: 1) exit the carry trade after two days of consecutive losses, with one loss being greater than one standard deviation, and 2) enter back into the carry trade after one day of positive return. The same decision thresholds will apply to the optimal currency momentum portfolios.

3.1 Optimal carry portfolios

3.1.1 Monthly rebalancing

To assess if the risk management tool can enhance the performance of the widely studied carry trade with the monthly decision interval, I first construct the optimal strategy for the daily carry trade returns with monthly rebalancing reported in Table 5. Descriptive statistics of the daily returns for the optimal carry trade with monthly rebalancing are reported in Table 15. Panel A shows results for the full sample of 37 currencies and Panel B shows results for the smaller sample of G10 currencies minus the USD. The optimal carry trade yields a statistically significantly different from zero average log excess return of 6.36% and 4.57% for the full sample and the G10 sample respectively. These mean returns are slightly lower than their counterparts in Table 5. However, the annualized daily standard deviations in Table 15 are also lower than their counterparts in Table 5. As a result, the performance of the optimal carry trade, as measured by the Sharpe ratio, seems to be higher when daily HML returns with monthly rebalancing are subjected to the risk management tool. In fact, the Sharpe ratio is 0.88 for the full sample and 0.64 for the G10 sample. These higher Sharpe ratios represent the first main difference between the optimal carry returns in Table 15 and the returns reported in Table 5. The second noticeable difference lies in the higher central moments of the optimal daily returns' distribution. Without the risk management tool, Table 5 reported a skewness of -0.47 for the HML returns of the full sample and -0.70 for the HML returns of the G10 sample. With the risk management tool, Table 15 shows that the skewness becomes less negative at -0.38 for the full sample and -0.49 for the G10 sample. These findings challenge some of the past conceptual interpretations of the carry trade, such as the crash risk based interpretation which take roots in the negative skewness of returns according to Brunnermeier et al. (2009). However, recall that the average "good carry trade" of Bekaert and Panayotov (2019) has a Sharpe ratio of 0.47 and a negative skewness of -0.33, which can be compared to the results of the optimal carry trade with monthly rebalancing for the G10 sample.

Comparing my results to the ones of Bekaert and Panayotov (2019) suggests that the risk management tool can further enhance the performance of the carry trade as measured by the Sharpe ratio, but cannot improve the negative skewness as well as Bekaert and Panayotov (2019). Finally, the excess kurtosis of the optimal carry trade in Table 15 is higher than the one reported in Table 5 for both samples. Descriptive statistics of the daily returns net of transaction costs for the optimal carry trade with monthly rebalancing are reported in Table 16. For both samples, the log excess returns net of transaction costs in Table 16 present similar patterns than that of the log excess returns without the bid-ask spreads reported in Table 15. For both samples, the main difference consists of a smaller mean net return and, consequently, a smaller Sharpe ratio. More specifically, the mean net return decreases by 0.99% to 5.37% for the full sample and by 0.40% to 4.17% for the G10 sample, whereas the Sharpe ratio decreases to 0.72 for the full sample and 0.55 for the G10 sample. For more insight behind the net carry returns, Figure B.5 and Figure B.6 show the number of transactions per month for the optimal carry trade strategy with monthly rebalancing of the full sample and the G10 sample respectively.

Figure 15 shows cumulative daily log excess returns for the HML optimal carry trade portfolio with monthly rebalancing for all countries and for the smaller sample of G10 countries. Figure 16 shows cumulative daily HML optimal returns net of transaction costs. The pattern on Figure 15 is similar to the one presented on Figure 3. On Figure 15 it appears that the optimal carry trade for both samples behaved similarly prior to approximately 2003. It is only in the last part of the sample period that including a broader set of currencies seems to improve the returns to the optimal carry trade. The same applies to the net optimal carry trade returns on Figure 16, although between approximately 1993 and 2000, it appears that the optimal carry trade for the sample of G10 currencies is actually performing better than the carry trade for the full sample.

3.1.2 Daily rebalancing

The results in Chapter 2 section 2.1 strongly suggest that the carry trade with the daily decision interval performs better than the carry trade with the monthly decision interval. Now, let's assess if the risk management tool can enhance furthermore that performance by constructing the optimal strategy for the daily carry trade returns with daily rebalancing reported in Table 11. Descriptive statistics of the daily returns for the optimal carry trade with daily rebalancing are reported in Table 17. Panel A shows results for the full sample of 37 currencies and Panel B shows results for the smaller sample of G10 currencies minus the USD. The optimal carry trade yields a statistically significantly different from zero average log excess return of 11.00% and 9.66% for the full sample and the G10 sample respectively. These mean returns are slightly lower than their counterparts in Table 11. However, the annualized daily standard deviations in Table 17 are also lower than their counterparts in Table 11. As a result, the performance of the optimal carry trade, as measured by the Sharpe ratio, seems to be higher when daily HML returns with daily rebalancing are subjected to the risk management tool. In fact, the Sharpe ratio is 1.51 for the full sample and 1.31 for the G10 sample. These higher Sharpe ratios represent the first main difference between the optimal carry returns in Table 17 and the returns reported in Table 11. The second noticeable difference lies in the higher central moments of the optimal daily returns' distribution for the G10 sample especially. Without the risk management tool, Table 11 reported a skewness of -0.55 for the HML returns of the full sample and -0.67 for the HML returns of the G10 sample. With the risk management tool, Table 17 shows that the skewness becomes less negative at -0.53 for the full sample and most importantly -0.35 for the G10 sample. Again, recall that the average "good carry trade" of Bekaert and Panayotov (2019) has a Sharpe ratio of 0.47 and a negative skewness of -0.33. Comparing my results for the G10 sample to the ones of Bekaert and Panayotov (2019) suggests that daily rebalancing combined with the risk management tool can greatly enhance the performance of the carry trade as measured by the Sharpe ratio, and can also improve the skewness almost as well as Bekaert and Panayotov (2019).

Finally, the excess kurtosis of the optimal carry trade in Table 17 is higher than the one reported in Table 11 for the full sample only. Descriptive statistics of the daily returns net of transaction costs for the optimal carry trade with daily rebalancing are reported in Table 18. For both samples, the log excess returns net of transaction costs in Table 18 present similar patterns than that of the log excess returns without the bid-ask spreads reported in Table 17. For both samples, the main difference consists of a smaller mean net return and, consequently, a smaller Sharpe ratio. More specifically, the mean net return decreases by 2.35% to 8.65% for the full sample and by 1.36% to 8.30% for the G10 sample, whereas the Sharpe ratio decreases to 1.19 for the full sample and 1.13 for the G10 sample. For more insight behind the net carry returns, Figure B.7 and Figure B.8 show the number of transactions per month for the optimal carry trade strategy with daily rebalancing for the full sample and the G10 sample respectively. Note that the introduction of the risk management tool increases the average number of transactions per month to 43 for the full sample, from 33 in Chapter 2 Section 2.1, and to 27 for the G10 sample, from 19 in Chapter 2 Section 2.1.

Figure 17 shows cumulative daily log excess returns for the HML optimal carry trade portfolio with daily rebalancing for all countries and for the smaller sample of G10 countries. Figure 18 shows cumulative daily HML optimal returns net of transaction costs. Although it is not strikingly apparent on Figure 17 and Figure 18, the Sharpe ratios reported in Table A.14 and Table A.16 suggest that the optimal carry trade of the G10 sample performs better than the optimal carry trade of the full sample. The pattern on Figure 17 is similar to the one presented on Figure 7 and the pattern on Figure 18 is also similar to the one presented on Figure 8.

3.2 Optimal momemtum portfolios

3.2.1 Monthly rebalancing

To assess if the risk management tool can enhance the performance of the currency momentum with a monthly decision interval, I first construct the optimal strategy for the daily momentum returns with monthly rebalancing reported in Table 9. Descriptive statistics of the daily returns for the optimal currency momentum strategy with monthly rebalancing are reported in Table 19. Panel A shows results for the full sample of 37 currencies and Panel B shows results for the smaller sample of G10 currencies minus the USD. The optimal momentum yields a statistically significantly different from zero average log excess return of 5.36% and 2.35% for the full sample and the G10 sample respectively. These mean returns are slightly lower than their counterparts in Table 9. The annualized daily standard deviations in Table 19 are also lower than their counterparts in Table 9, but not enough to notably reduce the Sharpe ratio of both samples. As a result, the performance of the optimal momentum strategy, as measured by the Sharpe ratio, seems to be similar when daily HML returns with monthly rebalancing are subjected to the risk management tool. In fact, the Sharpe ratio is 0.65 for the full sample and 0.32 for the G10 sample. The main difference between the optimal momentum returns in Table 19 and the returns reported in Table 9 lies in the higher central moments of the optimal daily returns' distribution. Without the risk management tool, Table 9 reported a skewness of -0.08 for the HML returns of the full sample and 0.04 for the HML returns of the G10 sample. With the risk management tool, Table 19 shows that the skewness becomes slightly positive at 0.03 for the full sample and increases to 0.19 for the G10 sample. The excess kurtosis of the optimal currency momentum returns in Table 19 is higher than the one reported in Table 9 for both samples.

Figure 19 shows cumulative daily log excess returns for the HML optimal currency momentum portfolio with monthly rebalancing for all countries and for the smaller sample of G10 countries. The pattern on Figure 19 is very similar to the one presented on Figure

6. On Figure 19 it appears that the cumulative returns to the optimal momentum portfolio for the full sample have been decreasing since approximately 2010 whereas the cumulative returns to the optimal momentum portfolio for the G10 sample have been flat since approximately 2000.

Appendix C reports the descriptive statistics of 1) the daily returns net of transaction costs for the optimal currency momentum strategy with monthly rebalancing, 2) the daily returns for the optimal currency momentum strategy with daily rebalancing, and 3) the daily returns net of transaction costs for the optimal currency momentum strategy with daily rebalancing. The number of transactions per month for the optimal momentum of both samples with monthly and daily rebalancing are shown on Figures B.9, B.10, B.11, and B.12. Similarly to Table 19, Tables C.1, C.2, and C.3 in Appendix C suggest that the risk management tool does not improve the performance of the currency momentum strategy as measured by the Sharpe ratio. The fact that the performance of the currency momentum strategy stays relatively the same with and without the optimal risk management tool suggests that the currency momentum gains and losses are randomly distributed — there seem to be no pattern in the losses to the currency momentum. Such a result for the currency momentum strategy can act as a counterfactual for the carry trade. The fact that the performance of the carry trade in subsection 3.1.1 and subsection 3.1.2 is improved by the risk management tool suggests that there is in fact a pattern in the drawdowns to the carry trade.

Table 15: Descriptive Statistics of Daily Returns for the Optimal Carry Trade with Monthly Rebalancing

This table reports statistics of the optimal carry trade strategy with monthly rebalancing. The optimal strategy is constructed from the series of daily log excess HML returns in Table 5. The optimal strategy is guided by the following decision thresholds: 1) exit the carry trade after two days of consecutive negative returns, with one daily losses being greater than one standard deviation and 2) enter back into the carry trade after one day of positive return. I assume a log excess return of zero while being out of the strategy. All the log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015). The sample period ranges from November 1983 to May 2019.

Panel A: All Countries	
	HML
Mean	6.36
	[1.19]
Standard Deviation	7.21
	[0.84]
Sharpe Ratio	0.88
Skewness	-0.38
	[0.03]
Excess Kurtosis	12.47
	[0.05]
AC(1)	0.03
	(0.00)
Panel B: G10 Countries	
	HML
Mean	4.57
	[1.18]
Standard Deviation	7.14
	[0.83]
Sharpe Ratio	0.64
Skewness	-0.49
	[0.03]
Excess Kurtosis	8.56
	[0.05]
AC(1)	0.03
	(0.00)

Figure 15: Cumulative Daily Returns for the Optimal Carry Trade with Monthly Rebalancing

This figure shows daily cumulative log excess returns for the optimal carry trade strategy with monthly rebalancing. The solid black line corresponds to all countries, while the gray line corresponds to the sample of G10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

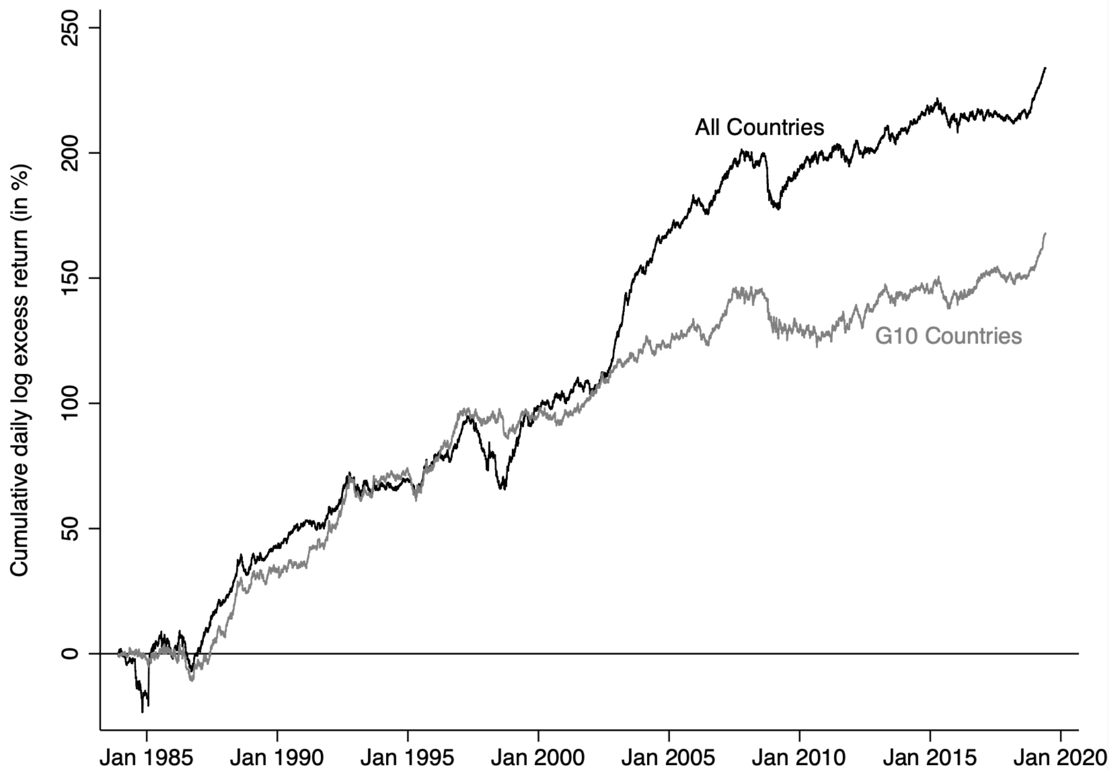


Table 16: Descriptive Statistics of Daily Returns Net of Transaction Costs for the Optimal Carry Trade with Monthly Rebalancing

This table reports statistics of the optimal carry trade strategy with monthly rebalancing net of transaction costs. The optimal strategy is constructed from the series of daily log excess HML returns in Table 5. The optimal strategy is guided by the following decision thresholds: 1) exit the carry trade after two days of consecutive negative returns, with one daily losses being greater than one standard deviation and 2) enter back into the carry trade after one day of positive return. I assume a log excess return of zero while being out of the strategy. All the **net** log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015). The sample period ranges from November 1983 to May 2019.

Panel A: All Countries	
	HML
Mean	5.37
	[1.22]
Standard Deviation	7.41
	[0.86]
Sharpe Ratio	0.72
Skewness	-0.35
	[0.03]
Excess Kurtosis	13.05
	[0.05]
AC(1)	0.03
	(0.00)
Panel B: G10 Countries	
	HML
Mean	4.17
	[1.24]
Standard Deviation	7.52
	[0.88]
Sharpe Ratio	0.55
Skewness	-0.51
	[0.03]
Excess Kurtosis	6.63
	[0.05]
AC(1)	0.01
	(0.17)

Figure 16: Cumulative Daily Returns Net of Transaction Costs for the Optimal Carry Trade with Monthly Rebalancing

This figure shows daily cumulative net log excess returns for the optimal carry trade strategy with monthly rebalancing. The solid black line corresponds to all countries, while the gray line corresponds to the sample of G10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

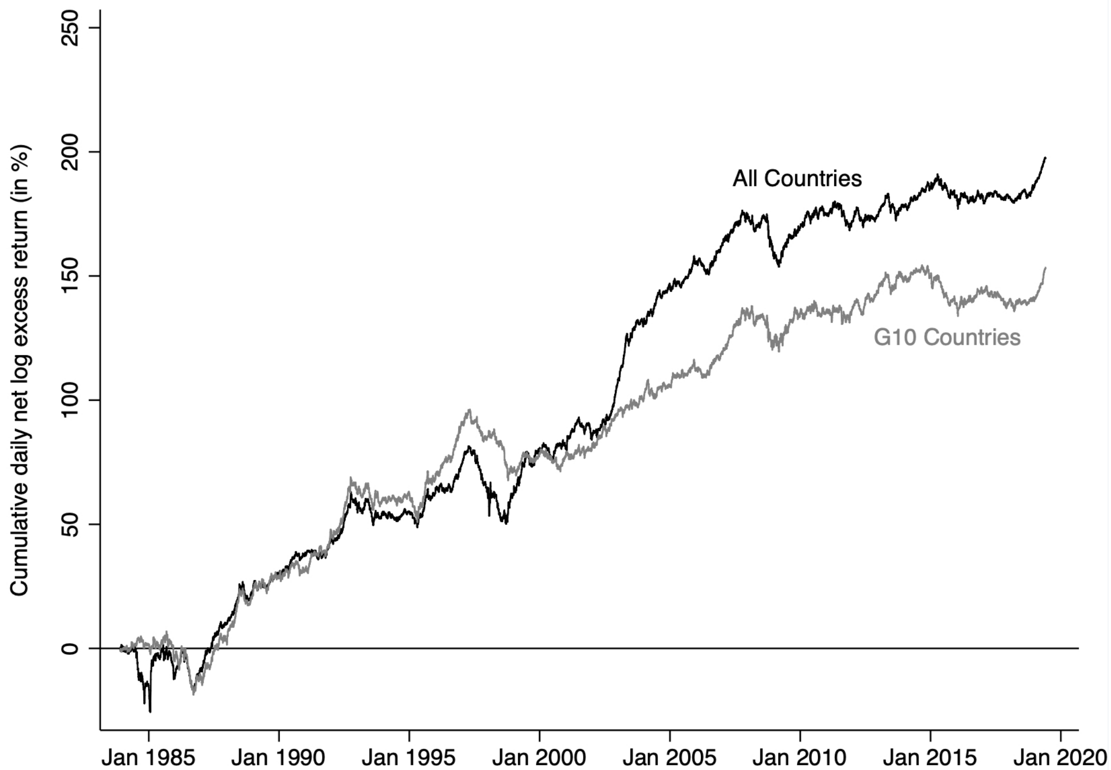


Table 17: Descriptive Statistics of Daily Returns for the Optimal Carry Trade with Daily Rebalancing

This table reports statistics of the optimal carry trade strategy with daily rebalancing. The optimal strategy is constructed from the series of daily log excess HML returns in Table 11. The optimal strategy is guided by the following decision thresholds: 1) exit the carry trade after two days of consecutive negative returns, with one daily losses being greater than one standard deviation and 2) enter back into the carry trade after one day of positive return. I assume a log excess return of zero while being out of the strategy. All the log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015). The sample period ranges from November 1983 to May 2019.

Panel A: All Countries	
	HML
Mean	11.00
	[1.20]
Standard Deviation	7.26
	[0.85]
Sharpe Ratio	1.51
Skewness	-0.53
	[0.03]
Excess Kurtosis	9.19
	[0.05]
AC(1)	0.02
	(0.02)
Panel B: G10 Countries	
	HML
Mean	9.66
	[1.21]
Standard Deviation	7.35
	[0.86]
Sharpe Ratio	1.31
Skewness	-0.35
	[0.03]
Excess Kurtosis	5.01
	[0.05]
AC(1)	0.03
	(0.01)

Figure 17: Cumulative Daily Returns for the Optimal Carry Trade with Daily Rebalancing

This figure shows daily cumulative log excess returns for the optimal carry trade strategy with daily rebalancing. The solid black line corresponds to all countries, while the gray line corresponds to the sample of G10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

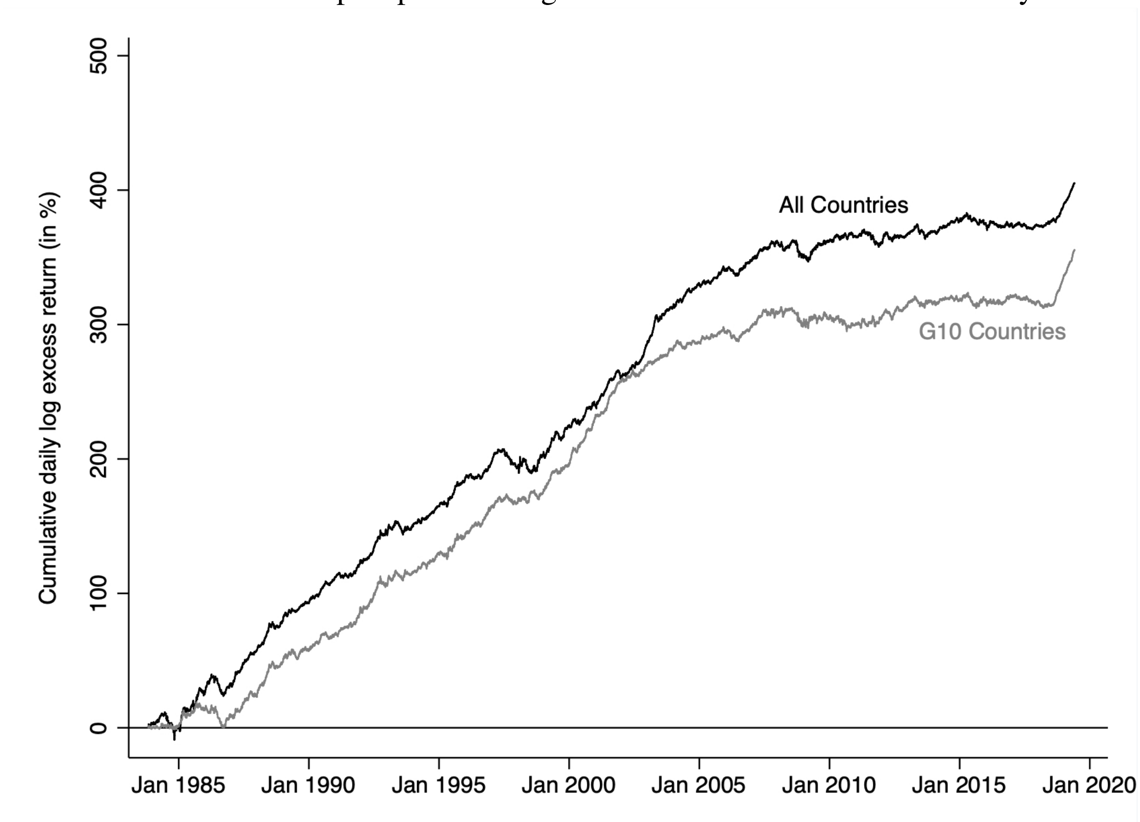


Table 18: Descriptive Statistics of Daily Returns Net of Transaction Costs for the Optimal Carry Trade with Daily Rebalancing

This table reports statistics of the optimal carry trade strategy with daily rebalancing. The optimal strategy is constructed from the series of daily log excess HML returns in Table 12. The optimal strategy is guided by the following decision thresholds: 1) exit the carry trade after two days of consecutive negative returns, with one daily losses being greater than one standard deviation and 2) enter back into the carry trade after one day of positive return. I assume a log excess return of zero while being out of the strategy. All the **net** log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015). The sample period ranges from November 1983 to May 2019.

Panel A: All Countries	
	HML
Mean	8.65
	[1.19]
Standard Deviation	7.25
	[0.84]
Sharpe Ratio	1.19
Skewness	-0.56
	[0.03]
Excess Kurtosis	9.26
	[0.05]
AC(1)	0.02
	(0.06)
Panel B: G10 Countries	
	HML
Mean	8.30
	[1.21]
Standard Deviation	7.33
	[0.85]
Sharpe Ratio	1.13
Skewness	-0.37
	[0.03]
Excess Kurtosis	5.01
	[0.05]
AC(1)	0.02
	(0.03)

Figure 18: Cumulative Daily Returns Net of Transaction Costs for the Optimal Carry Trade with Daily Rebalancing

This figure shows daily cumulative net log excess returns for the optimal carry trade strategy with daily rebalancing. The solid black line corresponds to all countries, while the gray line corresponds to the sample of G10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

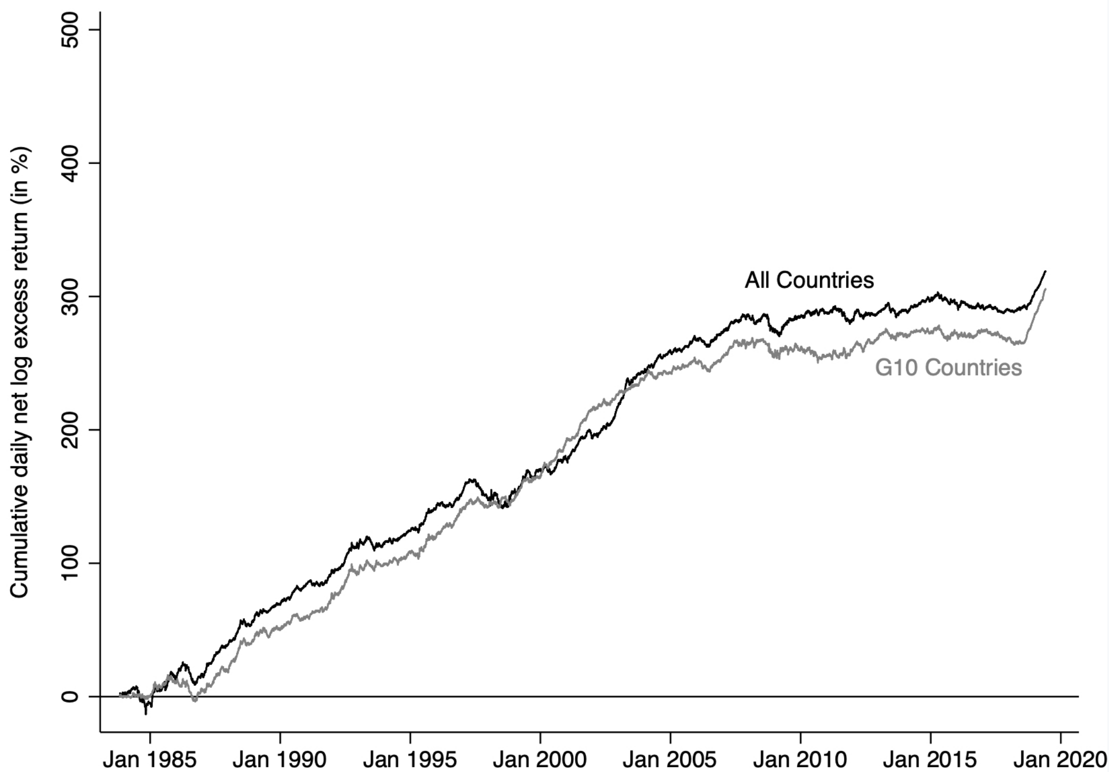


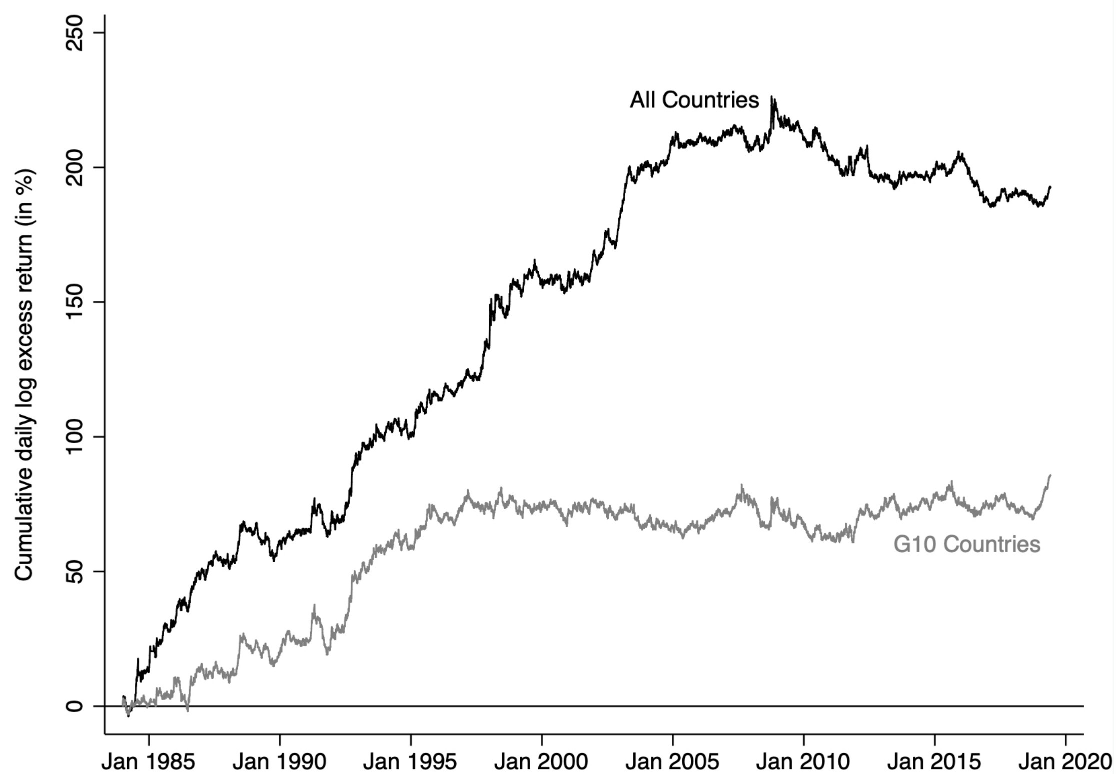
Table 19: Descriptive Statistics of Daily Returns for the Optimal Currency Momentum with Monthly Rebalancing

This table reports statistics of the optimal currency momentum strategy with monthly rebalancing. The optimal strategy is constructed from the series of daily log excess HML returns in Table 9. The optimal strategy is guided by the following decision thresholds: 1) exit the currency momentum strategy after two days of consecutive negative returns, with one daily losses being greater than one standard deviation and 2) enter back into the currency momentum strategy after one day of positive return. I assume a log excess return of zero while being out of the strategy. All the log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show p-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015). The sample period ranges from November 1983 to May 2019.

Panel A: All Countries	
	HML
Mean	5.36
	[1.36]
Standard Deviation	8.25
	[0.96]
Sharpe Ratio	0.65
Skewness	0.03
	[0.03]
Excess Kurtosis	8.34
	[0.05]
AC(1)	0.03
	(0.00)
Panel B: G10 Countries	
	HML
Mean	2.35
	[1.19]
Standard Deviation	7.22
	[0.84]
Sharpe Ratio	0.32
Skewness	0.19
	[0.03]
Excess Kurtosis	7.52
	[0.05]
AC(1)	0.00
	(0.87)

Figure 19: Cumulative Daily Returns for the Optimal Currency Momentum with Monthly Rebalancing

This figure shows daily cumulative log excess returns for the optimal currency momentum strategy with monthly rebalancing. The solid black line corresponds to all countries, while the gray line corresponds to the sample of G10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.



Conclusion

This paper documents the autocorrelation in the losses to the carry trade, which can be exploited to enhance the performance of the trading strategy by constructing carry trades with the daily decision interval and coupling it with a risk management tool. Such carry trades exhibit markedly different properties that are evident in return features like the Sharpe ratio and the skewness, and also challenges previous interpretations of carry trades.

Carry trades with the daily decision interval sort currencies based on their forward discount, prorated per day, relative to the USD observed at the end of each day. Then, the construction of optimal carry trades is guided by the implementation of a simple risk management tool, which is inspired by the findings of Daniel et al. (2017) and is characterized by the following decisions thresholds 1) exit the carry trade after two days of consecutive losses, with one loss being greater than one standard deviation, and 2) enter back into the carry trade after one day of positive return. The key new insight following from this implementation is that daily rebalancing coupled with the risk management tool can improve the performance of carry trades — that is it seems to increase the Sharpe ratio and contribute to a less negative skewness. Such results can speak for the autocorrelation in the losses to carrry trades, since, in the case of random gains and losses as for the currency momentum strategy, the daily decision interval coupled with the implementation of the risk management tool cannot improve the trading strategy's performance. Furthermore, these findings challenge some of the past conceptual interpretations of the carry trade, such as crash risk based interpretation which is mostly based on the negative skewness of returns.

The results in this paper, even though largely focused on the statistical properties of returns to currency trading strategies, should impact the study of currency trading strategies. First, while I find inconclusive to study currency momentum returns at the daily frequency with the daily decision interval, exploring carry trade returns in such a way can challenge the previous risk based explanation of the UIP puzzle based on crash risk and can provide new insights for other risk-based interpretations of the UIP puzzle. Second, in-depth studies of the patterns in the losses to the carry trade can have important implications for the risk management of currency trading strategies.

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Appendix A

Performance of Carry Trade Portfolios Before and After 2010

Table A.1: Descriptive Statistics of Monthly Carry Trade Returns Net of Transaction Costs Before 2010 Only

This table reports statistics of currency portfolios sorted on their 1 month forward discount relative to the USD at the end of each month for the sample period ranging from November 1983 to December 2009. The currencies of the full sample are sorted into 5 portfolios. Portfolio C1 contains the 20% of currencies with the lowest forward discounts, while portfolio C5 contains the 20% of currencies with the highest forward discounts. Avg. denotes the average return of the five currency portfolios and HML denotes a carry portfolio that is long in portfolio C5 and short in portfolio C1. The G10 currencies are sorted into 3 portfolios. All the **net** log excess returns are **monthly** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015).

Panel A: All Countries							
Portfolio	C1	C2	C3	C4	C5	Avg.	HML
Mean	-1.63	0.64	2.69	3.79	4.88	2.08	6.51
	[1.50]	[1.52]	[1.61]	[1.63]	[2.28]	[1.46]	[2.02]
Standard Deviation	7.69	7.79	8.22	8.34	11.68	7.48	10.35
	[1.07]	[1.08]	[1.14]	[1.15]	[1.62]	[1.04]	[1.43]
Sharpe Ratio	-0.21	0.08	0.33	0.45	0.42	0.28	0.63
Skewness	-0.01	-0.45	-0.32	-0.27	-1.33	-0.45	-1.35
	[0.14]	[0.14]	[0.14]	[0.14]	[0.14]	[0.14]	[0.14]
Excess Kurtosis	0.82	1.82	2.13	1.82	5.65	0.94	4.33
	[0.27]	[0.27]	[0.27]	[0.27]	[0.27]	[0.27]	[0.27]
AC(1)	0.02	0.07	0.12	0.15	0.16	0.13	0.10
	(0.68)	(0.23)	(0.03)	(0.01)	(0.00)	(0.02)	(0.06)

Panel B: G10 Countries					
Portfolio	C1	C2	C3	Avg.	HML
Mean	-0.89	2.50	4.53	2.05	5.42
	[1.88]	[1.57]	[1.97]	[1.59]	[1.81]
Standard Deviation	9.63	8.04	10.06	8.14	9.25
	[1.33]	[1.11]	[1.39]	[1.13]	[1.28]
Sharpe Ratio	-0.09	0.31	0.45	0.25	0.59
Skewness	0.13	-0.30	-0.49	-0.17	-0.90
	[0.14]	[0.14]	[0.14]	[0.14]	[0.14]
Excess Kurtosis	0.50	1.32	1.92	0.68	2.24
	[0.27]	[0.27]	[0.27]	[0.27]	[0.27]
AC(1)	0.03	0.16	0.19	0.14	0.11
	(0.59)	(0.01)	(0.00)	(0.01)	(0.06)

Table A.2: Descriptive Statistics of Monthly Carry Trade Returns Net of Transaction Costs After 2010 Only

This table reports statistics of currency portfolios sorted on their 1 month forward discount relative to the USD at the end of each month for the sample period ranging from January 2010 to May 2019. The currencies of the full sample are sorted into 5 portfolios. Portfolio C1 contains the 20% of currencies with the lowest forward discounts, while portfolio C5 contains the 20% of currencies with the highest forward discounts. Avg. denotes the average return of the five currency portfolios and HML denotes a carry portfolio that is long in portfolio C5 and short in portfolio C1. The G10 currencies are sorted into 3 portfolios. All the **net** log excess returns are **monthly** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015).

Panel A: All Countries							
Portfolio	C1	C2	C3	C4	C5	Avg.	HML
Mean	-3.75	-1.08	-1.10	-0.47	0.61	-1.16	4.36
	[1.88]	[1.95]	[2.25]	[2.50]	[2.96]	[2.08]	[2.42]
Standard Deviation	5.78	5.99	6.91	7.68	9.09	6.37	7.43
	[1.34]	[1.39]	[1.60]	[1.78]	[2.10]	[1.48]	[1.72]
Sharpe Ratio	-0.65	-0.18	-0.16	-0.06	0.07	-0.18	0.59
Skewness	-0.11	-0.00	0.15	-0.74	-0.68	-0.40	-0.30
	[0.23]	[0.23]	[0.23]	[0.23]	[0.23]	[0.23]	[0.23]
Excess Kurtosis	-0.04	1.84	1.21	2.29	2.44	1.33	0.54
	[0.45]	[0.45]	[0.45]	[0.45]	[0.45]	[0.45]	[0.45]
AC(1)	0.02	-0.06	-0.11	-0.09	-0.15	-0.12	0.01
	(0.86)	(0.52)	(0.23)	(0.34)	(0.10)	(0.20)	(0.94)

Panel B: G10 Countries					
Portfolio	C1	C2	C3	Avg.	HML
Mean	-4.12	-2.59	0.41	-2.10	4.53
	[2.38]	[2.51]	[3.35]	[2.51]	[2.45]
Standard Deviation	7.30	7.72	10.29	7.69	7.52
	[1.69]	[1.79]	[2.38]	[1.78]	[1.74]
Sharpe Ratio	-0.56	-0.34	0.04	-0.27	0.60
Skewness	0.03	-0.02	-0.20	-0.0.5	-0.29
	[0.23]	[0.23]	[0.23]	[0.23]	[0.23]
Excess Kurtosis	-0.20	0.43	0.58	0.61	-0.10
	[0.45]	[0.45]	[0.45]	[0.45]	[0.45]
AC(1)	0.05	-0.15	-0.15	-0.13	0.07
	(0.58)	(0.10)	(0.11)	(0.16)	(0.46)

Table A.3: Descriptive Statistics of Daily Carry Trade Returns with Monthly Rebalancing Before 2010 Only

This table reports statistics of currency portfolios sorted on their 1 month forward discount relative to the USD at the end of each month for the sample period ranging from November 1983 to December 2009. The currencies of the full sample are sorted into 5 portfolios. Portfolio C1 contains the 20% of currencies with the lowest forward discounts, while portfolio C5 contains the 20% of currencies with the highest forward discounts. Avg. denotes the average return of the five currency portfolios and HML denotes a carry portfolio that is long in portfolio C5 and short in portfolio C1. The G10 currencies are sorted into 3 portfolios. All the log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show p-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015).

Panel A: All Countries							
Portfolio	C1	C2	C3	C4	C5	Avg.	HML
Mean	-1.70	1.16	2.95	4.58	5.74	2.54	7.44
	[1.33]	[1.34]	[1.41]	[1.48]	[1.92]	[1.25]	[1.79]
Standard Deviation	6.93	6.96	7.32	7.70	9.95	6.52	9.32
	[0.94]	[0.95]	[1.00]	[1.05]	[1.35]	[0.89]	[1.27]
Sharpe Ratio	-0.25	0.17	0.40	0.59	0.58	0.39	0.80
Skewness	0.50	0.27	0.10	0.12	-0.37	0.16	-0.47
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
Excess Kurtosis	5.80	4.45	5.14	5.60	9.42	4.58	9.91
	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]
AC(1)	0.01	0.01	0.02	0.03	0.07	0.04	0.04
	(0.51)	(.47)	(0.11)	(0.02)	(0.00)	(0.00)	(0.00)

Panel B: G10 Countries					
Portfolio	C1	C2	C3	Avg.	HML
Mean	-0.33	2.67	4.09	2.14	4.42
	[1.70]	[1.53]	[1.87]	[1.48]	[1.74]
Standard Deviation	8.84	7.97	9.73	7.70	9.07
	[1.20]	[1.08]	[1.32]	[1.05]	[1.23]
Sharpe Ratio	-0.04	0.33	0.42	0.28	0.49
Skewness	0.38	0.32	-0.21	0.32	-0.77
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
Excess Kurtosis	3.79	5.78	6.71	4.61	7.77
	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]
AC(1)	-0.00	-0.01	0.00	-0.01	0.02
	(0.97)	(0.32)	(0.81)	(0.60)	(0.09)

Table A.4: Descriptive Statistics of Daily Carry Trade Returns with Monthly Rebalancing After 2010 Only

This table reports statistics of currency portfolios sorted on their 1 month forward discount relative to the USD at the end of each month for the sample period ranging from January 2010 to May 2019. The currencies of the full sample are sorted into 5 portfolios. Portfolio C1 contains the 20% of currencies with the lowest forward discounts, while portfolio C5 contains the 20% of currencies with the highest forward discounts. Avg. denotes the average return of the five currency portfolios and HML denotes a carry portfolio that is long in portfolio C5 and short in portfolio C1. The G10 currencies are sorted into 3 portfolios. All the log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015).

Panel A: All Countries							
Portfolio	C1	C2	C3	C4	C5	Avg.	HML
Mean	-2.87	-1.89	-0.73	-0.12	1.30	-0.86	4.17
	[1.79]	[1.70]	[2.05]	[2.05]	[2.43]	[1.69]	[2.32]
Standard Deviation	5.60	5.31	6.40	6.41	7.58	5.28	7.25
	[1.27]	[1.20]	[1.45]	[1.45]	[1.72]	[1.20]	[1.64]
Sharpe Ratio	-0.51	-0.36	-0.11	-0.02	0.17	-0.16	0.57
Skewness	0.16	-0.18	-0.01	-0.29	-0.20	-0.12	-0.49
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]
Excess Kurtosis	4.38	4.90	4.39	4.54	3.46	3.10	3.72
	[0.10]	[0.10]	[0.10]	[0.10]	[0.10]	[0.10]	[0.10]
AC(1)	0.02	0.04	0.03	0.04	0.01	0.05	-0.01
	(0.35)	(.06)	(0.10)	(0.04)	(0.47)	(0.02)	(0.78)

Panel B: G10 Countries					
Portfolio	C1	C2	C3	Avg.	HML
Mean	-3.45	-2.30	0.02	-1.91	3.47
	[2.39]	[2.37]	[3.05]	[2.30]	[2.56]
Standard Deviation	7.45	7.40	9.53	7.17	8.01
	[1.69]	[1.68]	[2.16]	[1.62]	[1.81]
Sharpe Ratio	-0.46	-0.31	0.00	-0.27	0.43
Skewness	0.15	-0.27	-0.14	-0.00	-0.39
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]
Excess Kurtosis	4.18	3.74	3.08	2.63	4.00
	[0.10]	[0.10]	[0.10]	[0.10]	[0.10]
AC(1)	0.01	-0.01	-0.01	-0.00	0.01
	(0.33)	(0.67)	(0.81)	(0.97)	(0.68)

Table A.5: Descriptive Statistics of Daily Carry Trade Returns with Daily Rebalancing Before 2010 only

This table reports statistics of currency portfolios sorted on their 1 month forward discount prorated per day relative to the USD at the end of each **day** for the sample period ranging from November 1983 to December 2009. The currencies of the full sample are sorted into 5 portfolios. Portfolio C1 contains the 20% of currencies with the lowest forward discounts, while portfolio C5 contains the 20% of currencies with the highest forward discounts. Avg. denotes the average return of the five currency portfolios and HML denotes a carry portfolio that is long in portfolio C5 and short in portfolio C1. The G10 currencies are sorted into 3 portfolios. All the log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015).

Panel A: All Countries							
Portfolio	C1	C2	C3	C4	C5	Avg.	HML
Mean	-5.23	0.92	2.94	5.25	9.69	2.72	14.92
	[1.34]	[1.34]	[1.40]	[1.49]	[1.84]	[1.25]	[1.74]
Standard Deviation	6.95	6.96	7.30	7.75	9.60	6.48	9.03
	[0.94]	[0.94]	[0.99]	[1.05]	[1.30]	[0.88]	[1.23]
Sharpe Ratio	-0.75	0.13	0.40	0.68	1.01	0.42	1.65
Skewness	0.27	0.28	0.20	-0.04	-0.40	0.18	-0.60
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
Excess Kurtosis	4.48	5.02	5.87	6.05	8.28	4.63	8.46
	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]
AC(1)	0.02	0.02	0.02	0.03	0.06	0.04	0.02
	(0.21)	(0.14)	(0.08)	(0.01)	(0.00)	(0.00)	(0.06)

Panel B: G10 Countries					
Portfolio	C1	C2	C3	Avg.	HML
Mean	-4.30	2.67	7.78	2.05	12.08
	[1.72]	[1.51]	[1.85]	[1.48]	[1.73]
Standard Deviation	8.97	7.86	9.64	7.69	9.04
	[1.22]	[1.07]	[1.31]	[1.04]	[1.23]
Sharpe Ratio	-0.48	0.34	0.81	0.27	1.34
Skewness	0.37	0.30	-0.18	0.32	-0.76
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
Excess Kurtosis	4.13	4.50	6.97	4.65	7.70
	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]
AC(1)	-0.00	-0.00	-0.00	-0.00	0.01
	(0.98)	(0.87)	(0.71)	(0.72)	(0.45)

Table A.6: Descriptive Statistics of Daily Carry Trade Returns with Daily Rebalancing After 2010 only

This table reports statistics of currency portfolios sorted on their 1 month forward discount prorated per day relative to the USD at the end of each **day** for the sample period ranging from January 2010 to May 2019. The currencies of the full sample are sorted into 5 portfolios. Portfolio C1 contains the 20% of currencies with the lowest forward discounts, while portfolio C5 contains the 20% of currencies with the highest forward discounts. Avg. denotes the average return of the five currency portfolios and HML denotes a carry portfolio that is long in portfolio C5 and short in portfolio C1. The G10 currencies are sorted into 3 portfolios. All the log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015).

Panel A: All Countries							
Portfolio	C1	C2	C3	C4	C5	Avg.	HML
Mean	-4.23	-1.36	-0.93	0.55	1.33	-0.93	5.56
	[1.77]	[1.70]	[2.06]	[1.96]	[2.47]	[1.69]	[2.32]
Standard Deviation	5.54	5.30	6.44	6.12	7.71	5.28	7.24
	[1.26]	[1.20]	[1.46]	[1.39]	[1.75]	[1.20]	[1.64]
Sharpe Ratio	-0.76	-0.26	-0.14	0.00	0.17	-0.18	0.77
Skewness	0.05	-0.16	-0.04	-0.32	-0.18	-0.11	-0.31
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]
Excess Kurtosis	3.95	6.42	5.03	3.75	3.44	3.11	2.45
	[0.10]	[0.10]	[0.10]	[0.10]	[0.10]	[0.10]	[0.10]
AC(1)	0.03	0.04	0.03	0.04	0.02	0.05	0.01
	(0.12)	(0.04)	(0.18)	(0.03)	(0.22)	(0.02)	(0.49)

Panel B: G10 Countries					
Portfolio	C1	C2	C3	Avg.	HML
Mean	-4.33	-3.09	1.04	-2.13	5.37
	[2.42]	[2.36]	[3.08]	[2.30]	[2.62]
Standard Deviation	7.55	7.35	9.61	7.18	8.17
	[1.71]	[1.67]	[2.18]	[1.63]	[1.85]
Sharpe Ratio	-0.57	-0.42	0.11	-0.30	0.66
Skewness	0.28	-0.40	-0.15	-0.01	-0.36
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]
Excess Kurtosis	4.26	5.08	3.00	2.68	3.44
	[0.10]	[0.10]	[0.10]	[0.10]	[0.10]
AC(1)	0.02	-0.01	-0.01	-0.00	0.01
	(0.25)	(0.78)	(0.68)	(0.98)	(0.57)

Table A.7: Descriptive Statistics of Daily Carry Trade Returns Net of Transaction Costs with Daily Rebalancing Before 2010 Only

This table reports statistics of currency portfolios sorted on their 1 month forward discount prorated per day relative to the USD at the end of each **day** for the sample period ranging from November 1983 to December 2009. The currencies of the full sample are sorted into 5 portfolios. Portfolio C1 contains the 20% of currencies with the lowest forward discounts, while portfolio C5 contains the 20% of currencies with the highest forward discounts. Avg. denotes the average return of the five currency portfolios and HML denotes a carry portfolio that is long in portfolio C5 and short in portfolio C1. The G10 currencies are sorted into 3 portfolios. All the **net** log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015).

Panel A: All Countries							
Portfolio	C1	C2	C3	C4	C5	Avg.	HML
Mean	-3.91	-1.56	0.07	1.91	7.46	0.80	11.37
	[1.33]	[1.34]	[1.41]	[1.49]	[1.84]	[1.25]	[1.73]
Standard Deviation	6.94	6.96	7.32	7.76	9.58	6.49	9.01
	[0.94]	[0.95]	[0.99]	[1.05]	[1.30]	[0.88]	[1.22]
Sharpe Ratio	-0.56	-0.22	0.01	0.25	0.78	0.12	1.26
Skewness	0.30	0.25	0.15	-0.07	-0.44	0.16	-0.65
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
Excess Kurtosis	4.50	4.94	5.86	6.05	8.18	4.59	8.40
	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]
AC(1)	0.01	0.02	0.02	0.03	0.06	0.04	0.02
	(0.22)	(0.14)	(0.09)	(0.01)	(0.00)	(0.00)	(0.09)

Panel B: G10 Countries					
Portfolio	C1	C2	C3	Avg.	HML
Mean	-3.31	1.11	6.70	1.50	10.01
	[1.72]	[1.51]	[1.85]	[1.48]	[1.74]
Standard Deviation	8.96	7.87	9.65	7.69	9.03
	[1.22]	[1.07]	[1.31]	[1.04]	[1.23]
Sharpe Ratio	-0.37	0.14	0.69	0.19	1.11
Skewness	0.37	0.30	-0.18	0.32	-0.77
	[0.03]	[0.03]	[0.03]	[0.03]	[0.03]
Excess Kurtosis	4.12	4.45	6.96	4.63	7.72
	[0.06]	[0.06]	[0.06]	[0.06]	[0.06]
AC(1)	-0.00	-0.00	-0.00	-0.00	0.01
	(0.93)	(0.91)	(0.68)	(0.72)	(0.52)

Table A.8: Descriptive Statistics of Daily Carry Trade Returns Net of Transaction Costs with Daily Rebalancing After 2010 Only

This table reports statistics of currency portfolios sorted on their 1 month forward discount prorated per day relative to the USD at the end of each **day** for the sample period ranging from January 2010 to May 2019. The currencies of the full sample are sorted into 5 portfolios. Portfolio C1 contains the 20% of currencies with the lowest forward discounts, while portfolio C5 contains the 20% of currencies with the highest forward discounts. Avg. denotes the average return of the five currency portfolios and HML denotes a carry portfolio that is long in portfolio C5 and short in portfolio C1. The G10 currencies are sorted into 3 portfolios. All the **net** log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015).

Panel A: All Countries							
Portfolio	C1	C2	C3	C4	C5	Avg.	HML
Mean	-3.70	-2.39	-2.12	-0.66	0.77	-1.62	4.47
	[1.77]	[1.70]	[2.06]	[1.96]	[2.47]	[1.69]	[2.32]
Standard Deviation	5.54	5.31	6.44	6.12	7.71	5.28	7.24
	[1.26]	[1.20]	[1.46]	[1.39]	[1.75]	[1.20]	[1.64]
Sharpe Ratio	-0.67	-0.45	-0.33	-0.11	0.10	-0.31	0.62
Skewness	0.05	-0.16	-0.04	-0.32	-0.18	-0.11	-0.31
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]
Excess Kurtosis	3.93	6.42	5.03	3.75	3.45	3.11	2.44
	[0.10]	[0.10]	[0.10]	[0.10]	[0.10]	[0.10]	[0.10]
AC(1)	0.03	0.04	0.03	0.05	0.02	0.05	0.01
	(0.12)	(0.03)	(0.18)	(0.03)	(0.23)	(0.02)	(0.48)

Panel B: G10 Countries					
Portfolio	C1	C2	C3	Avg.	HML
Mean	-3.93	-3.64	0.78	-2.26	4.71
	[2.42]	[2.36]	[3.08]	[2.30]	[2.62]
Standard Deviation	7.55	7.36	9.61	7.18	8.17
	[1.71]	[1.67]	[2.18]	[1.63]	[1.85]
Sharpe Ratio	-0.52	-0.49	0.08	-0.31	0.58
Skewness	0.28	-0.40	-0.15	-0.01	-0.36
	[0.05]	[0.05]	[0.05]	[0.05]	[0.05]
Excess Kurtosis	4.26	5.09	3.00	2.67	3.44
	[0.10]	[0.10]	[0.10]	[0.10]	[0.10]
AC(1)	0.02	-0.01	-0.01	-0.00	0.01
	(0.25)	(0.78)	(0.68)	(0.98)	(0.57)

Table A.9: Descriptive Statistics of Daily Returns for the Optimal Carry Trade with Monthly Rebalancing Before 2010 Only

This table reports statistics of the optimal carry trade strategy with monthly rebalancing for the sample period ranging from November 1983 to December 2009. The optimal strategy is constructed from the series of daily log excess HML returns in Table 5. The optimal strategy is guided by the following decision thresholds: 1) exit the carry trade after two days of consecutive negative returns, with one daily losses being greater than one standard deviation and 2) enter back into the carry trade after one day of positive return. I assume a log excess return of zero while being out of the strategy. All the log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015).

Panel A: All Countries	
	HML
Mean	7.16
	[1.47]
Standard Deviation	7.62
	[1,04]
Sharpe Ratio	0.94
Skewness	-0.40
	[0.03]
Excess Kurtosis	13.09
	[0.06]
AC(1)	0.03
	(0.01)
Panel B: G10 Countries	
	HML
Mean	4.81
	[1.41]
Standard Deviation	7.33
	[1.00]
Sharpe Ratio	0.66
Skewness	-0.53
	[0.03]
Excess Kurtosis	5.54
	[0.06]
AC(1)	0.04
	(0.00)

Table A.10: Descriptive Statistics of Daily Returns for the Optimal Carry Trade with Monthly Rebalancing After 2010 Only

This table reports statistics of the optimal carry trade strategy with monthly rebalancing for the sample period ranging from January 2010 to May 2019. The optimal strategy is constructed from the series of daily log excess HML returns in Table 5. The optimal strategy is guided by the following decision thresholds: 1) exit the carry trade after two days of consecutive negative returns, with one daily losses being greater than one standard deviation and 2) enter back into the carry trade after one day of positive return. I assume a log excess return of zero while being out of the strategy. All the log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015).

Panel A: All Countries	
	HML
Mean	4.14
	[1.90]
Standard Deviation	5.92
	[1.34]
Sharpe Ratio	0.70
Skewness	-0.29
	[0.05]
Excess Kurtosis	2.91
	[0.10]
AC(1)	0.03
	(0.21)
Panel B: G10 Countries	
	HML
Mean	3.90
	[2.11]
Standard Deviation	6.58
	[1.49]
Sharpe Ratio	0.59
Skewness	-0.33
	[0.05]
Excess Kurtosis	3.68
	[0.10]
AC(1)	0.01
	(0.73)

Table A.11: Descriptive Statistics of Daily Returns Net of Transaction Costs for the Optimal Carry Trade with Monthly Rebalancing Before 2010 Only

This table reports statistics of the optimal carry trade strategy with monthly rebalancing net of transaction costs for the sample period ranging from November 1983 to December 2009. The optimal strategy is constructed from the series of daily log excess HML returns in Table 5. The optimal strategy is guided by the following decision thresholds: 1) exit the carry trade after two days of consecutive negative returns, with one daily losses being greater than one standard deviation and 2) enter back into the carry trade after one day of positive return. I assume a log excess return of zero while being out of the strategy. All the **net** log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015).

Panel A: All Countries	
	HML
Mean	6.26
	[1.51]
Standard Deviation	7.84
	[1.07]
Sharpe Ratio	0.80
Skewness	-0.34
	[0.03]
Excess Kurtosis	13.65
	[0.06]
AC(1)	0.04
	(0.00)
Panel B: G10 Countries	
	HML
Mean	5.00
	[1.50]
Standard Deviation	7.78
	[1.09]
Sharpe Ratio	0.64
Skewness	-0.53
	[0.03]
Excess Kurtosis	7.07
	[0.06]
AC(1)	0.01
	(0.21)

Table A.12: Descriptive Statistics of Daily Returns Net of Transaction Costs for the Optimal Carry Trade with Monthly Rebalancing After 2010 Only

This table reports statistics of the optimal carry trade strategy with monthly rebalancing net of transaction costs for the sample period ranging from January 2010 to May 2019. The optimal strategy is constructed from the series of daily log excess HML returns in Table 5. The optimal strategy is guided by the following decision thresholds: 1) exit the carry trade after two days of consecutive negative returns, with one daily losses being greater than one standard deviation and 2) enter back into the carry trade after one day of positive return. I assume a log excess return of zero while being out of the strategy. All the **net** log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015).

Panel A: All Countries	
	HML
Mean	2.89
	[1.94]
Standard Deviation	6.06
	[1.37]
Sharpe Ratio	0.48
Skewness	-0.40
	[0.05]
Excess Kurtosis	3.07
	[0.10]
AC(1)	0.01
	(0.68)
Panel B: G10 Countries	
	HML
Mean	1.87
	[2.15]
Standard Deviation	6.73
	[1.52]
Sharpe Ratio	0.28
Skewness	-0.43
	[0.05]
Excess Kurtosis	3.69
	[0.10]
AC(1)	0.01
	(0.58)

Table A.13: Descriptive Statistics of Daily Returns for the Optimal Carry Trade with Daily Rebalancing Before 2010 Only

This table reports statistics of the optimal carry trade strategy with daily rebalancing for the sample period ranging from November 1983 to December 2009. The optimal strategy is constructed from the series of daily log excess HML returns in Table 11. The optimal strategy is guided by the following decision thresholds: 1) exit the carry trade after two days of consecutive negative returns, with one daily losses being greater than one standard deviation and 2) enter back into the carry trade after one day of positive return. I assume a log excess return of zero while being out of the strategy. All the log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015).

Panel A: All Countries	
	HML
Mean	13.36
	[1.46]
Standard Deviation	7.62
	[1.03]
Sharpe Ratio	1.75
Skewness	-0.56
	[0.03]
Excess Kurtosis	8.76
	[0.06]
AC(1)	0.03
	(0.03)
Panel B: G10 Countries	
	HML
Mean	11.28
	[1.44]
Standard Deviation	7.51
	[1.02]
Sharpe Ratio	1.50
Skewness	-0.33
	[0.03]
Excess Kurtosis	5.23
	[0.06]
AC(1)	0.03
	(0.01)

Table A.14: Descriptive Statistics of Daily Returns for the Optimal Carry Trade with Daily Rebalancing After 2010 Only

This table reports statistics of the optimal carry trade strategy with daily rebalancing for the sample period ranging from January 2010 to May 2019. The optimal strategy is constructed from the series of daily log excess HML returns in Table 11. The optimal strategy is guided by the following decision thresholds: 1) exit the carry trade after two days of consecutive negative returns, with one daily losses being greater than one standard deviation and 2) enter back into the carry trade after one day of positive return. I assume a log excess return of zero while being out of the strategy. All the log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015).

Panel A: All Countries	
	HML
Mean	4.42
	[1.97]
Standard Deviation	6.14
	[1.39]
Sharpe Ratio	0.72
Skewness	-0.43
	[0.05]
Excess Kurtosis	3.19
	[0.10]
AC(1)	0.01
	(0.68)
Panel B: G10 Countries	
	HML
Mean	5.15
	[2.20]
Standard Deviation	6.86
	[1.55]
Sharpe Ratio	0.75
Skewness	-0.43
	[0.05]
Excess Kurtosis	3.90
	[0.10]
AC(1)	0.01
	(0.54)

Table A.15: Descriptive Statistics of Daily Returns Net of Transaction Costs for the Optimal Carry Trade with Daily Rebalancing Before 2010 Only

This table reports statistics of the optimal carry trade strategy with daily rebalancing for the sample period ranging from November 1983 to December 2009. The optimal strategy is constructed from the series of daily log excess HML returns in Table 12. The optimal strategy is guided by the following decision thresholds: 1) exit the carry trade after two days of consecutive negative returns, with one daily losses being greater than one standard deviation and 2) enter back into the carry trade after one day of positive return. I assume a log excess return of zero while being out of the strategy. All the **net** log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015).

Panel A: All Countries	
	HML
Mean	10.51
	[1.47]
Standard Deviation	7.61
	[1.03]
Sharpe Ratio	1.38
Skewness	-0.60
	[0.03]
Excess Kurtosis	9.83
	[0.06]
AC(1)	0.02
	(0.08)
Panel B: G10 Countries	
	HML
Mean	9.63
	[1.44]
Standard Deviation	7.50
	[1.02]
Sharpe Ratio	1.28
Skewness	-0.35
	[0.03]
Excess Kurtosis	5.24
	[0.06]
AC(1)	0.03
	(0.03)

Table A.16: Descriptive Statistics of Daily Returns Net of Transaction Costs for the Optimal Carry Trade with Daily Rebalancing After 2010 Only

This table reports statistics of the optimal carry trade strategy with daily rebalancing for the sample period ranging from January 2010 to May 2019. The optimal strategy is constructed from the series of daily log excess HML returns in Table 12. The optimal strategy is guided by the following decision thresholds: 1) exit the carry trade after two days of consecutive negative returns, with one daily losses being greater than one standard deviation and 2) enter back into the carry trade after one day of positive return. I assume a log excess return of zero while being out of the strategy. All the **net** log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015).

Panel A: All Countries	
	HML
Mean	3.50
	[1.97]
Standard Deviation	6.14
	[1.39]
Sharpe Ratio	0.57
Skewness	-0.44
	[0.05]
Excess Kurtosis	3.20
	[0.10]
AC(1)	0.01
	(0.70)
Panel B: G10 Countries	
	HML
Mean	4.59
	[2.20]
Standard Deviation	6.86
	[1.55]
Sharpe Ratio	0.67
Skewness	-0.43
	[0.05]
Excess Kurtosis	3.90
	[0.10]
AC(1)	0.01
	(0.55)

Appendix B

Portfolio Turnovers

Figure B.1: Number of Monthly Transactions for the Carry Trade of the Full Sample with Monthly Rebalancing

This figure shows the number of transactions per month for the carry trade portfolio with monthly rebalancing for the full sample of 37 currencies. The sample period ranges from November 1983 to May 2019.

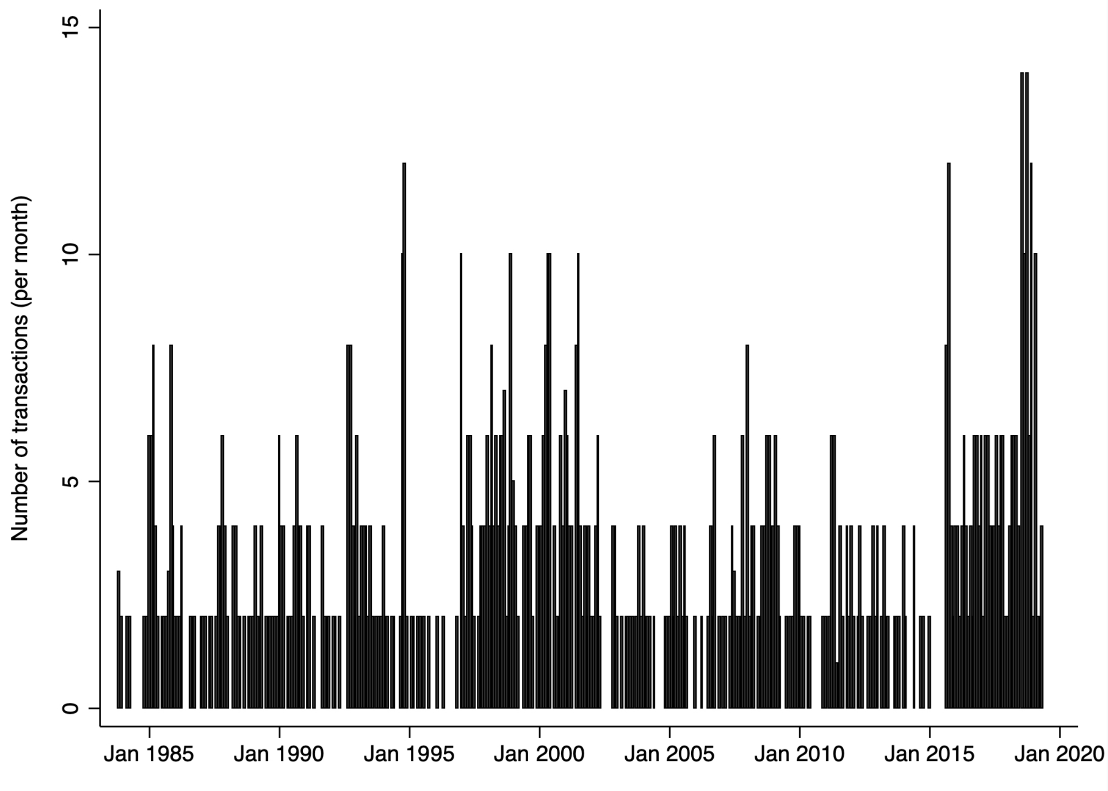


Figure B.2: Number of Monthly Transactions for the Carry Trade of the G10 Sample with Monthly Rebalancing

This figure shows the number of transactions per month for the carry trade portfolio with monthly rebalancing for the G10 sample of 10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

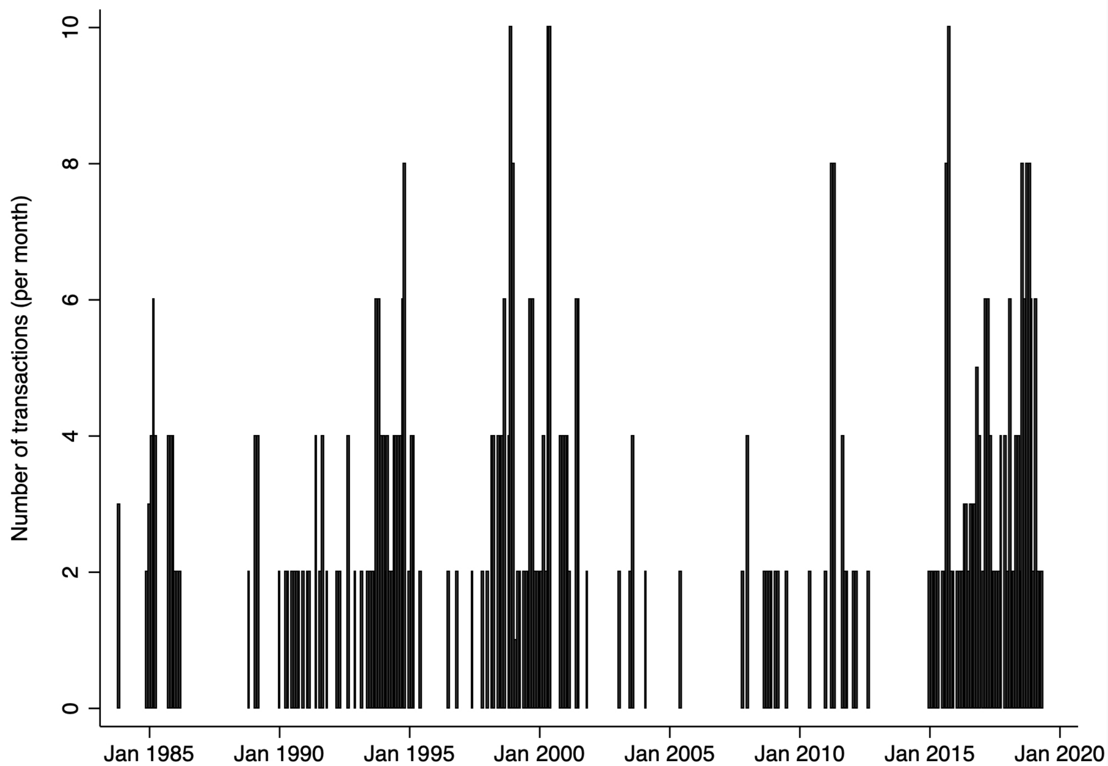


Figure B.3: Number of Monthly Transactions for the Momentum Portfolio of the Full Sample with Monthly Rebalancing

This figure shows the number of transactions per month for the currency momentum portfolio with monthly rebalancing for the full sample of 37 currencies. The sample period ranges from November 1983 to May 2019.

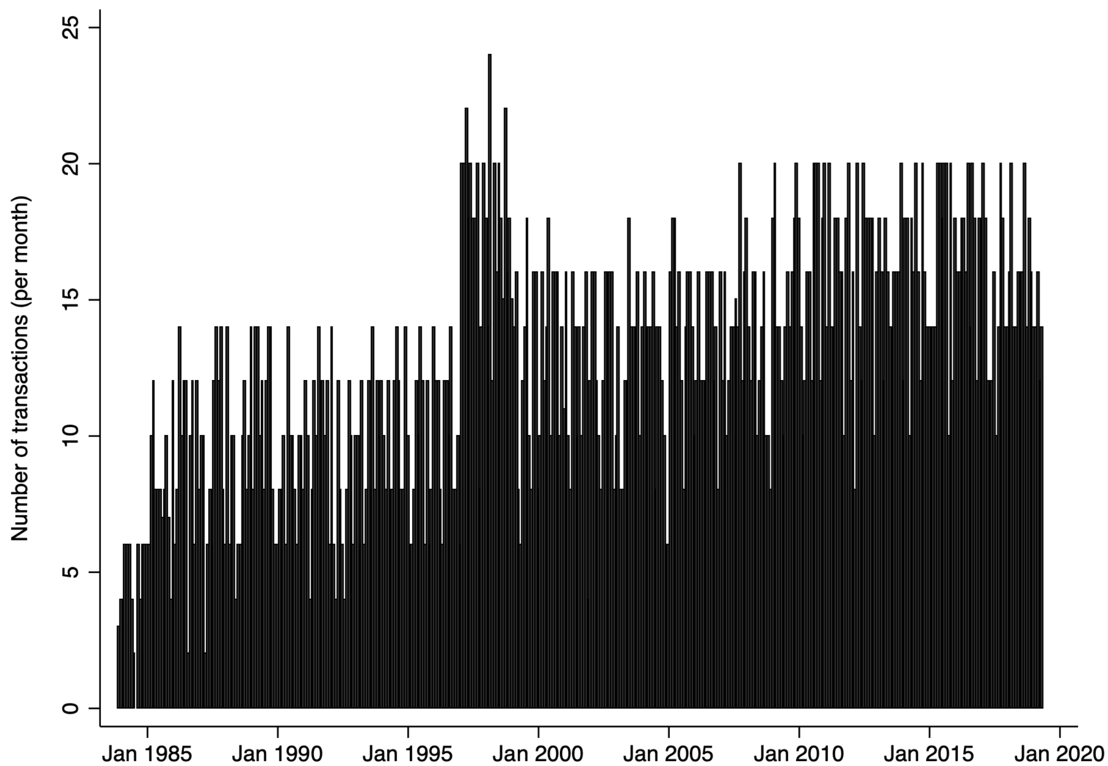


Figure B.4: Number of Monthly Transactions for the Momentum Portfolio of the G10 Sample with Monthly Rebalancing

This figure shows the number of transactions per month for the currency momentum portfolio with monthly rebalancing for the G10 sample of 10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

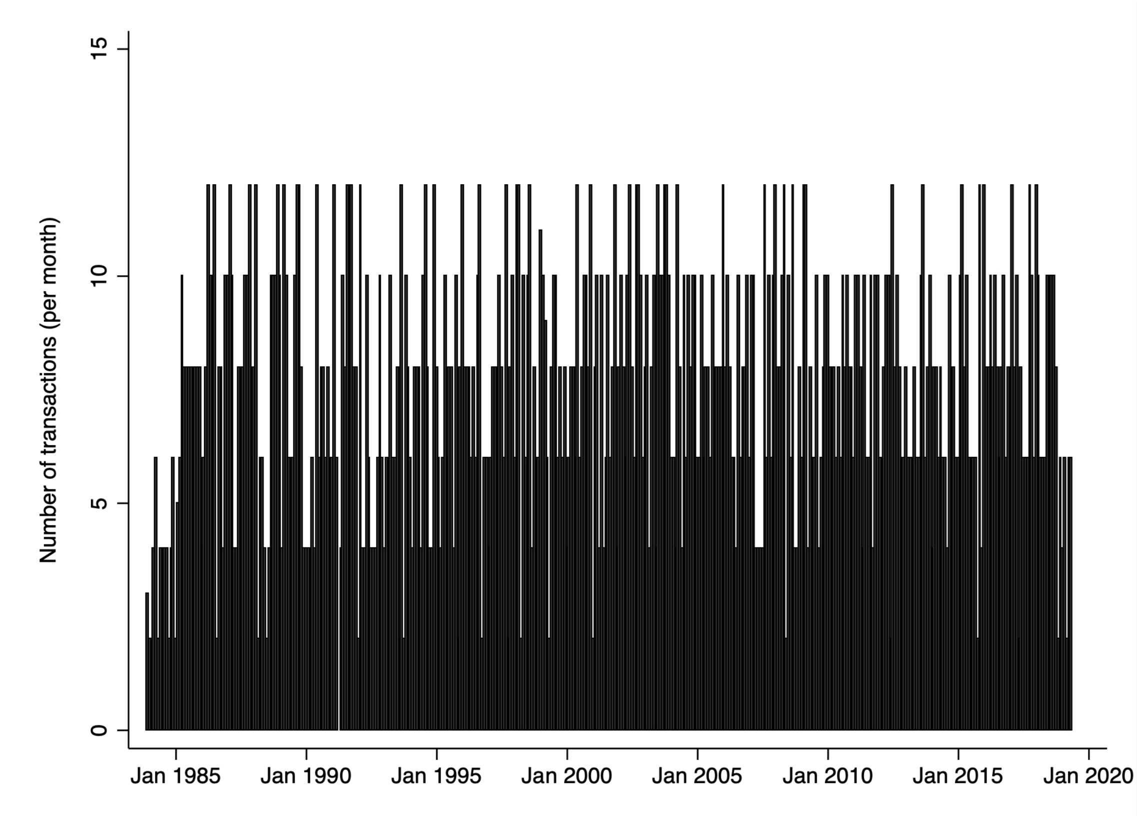


Figure B.5: Number of Monthly Transactions for the Optimal Carry Trade of the Full Sample with Monthly Rebalancing

This figure shows the number of transactions per month for the optimal carry trade portfolio with monthly rebalancing for the full sample of 37 currencies. The sample period ranges from November 1983 to May 2019.

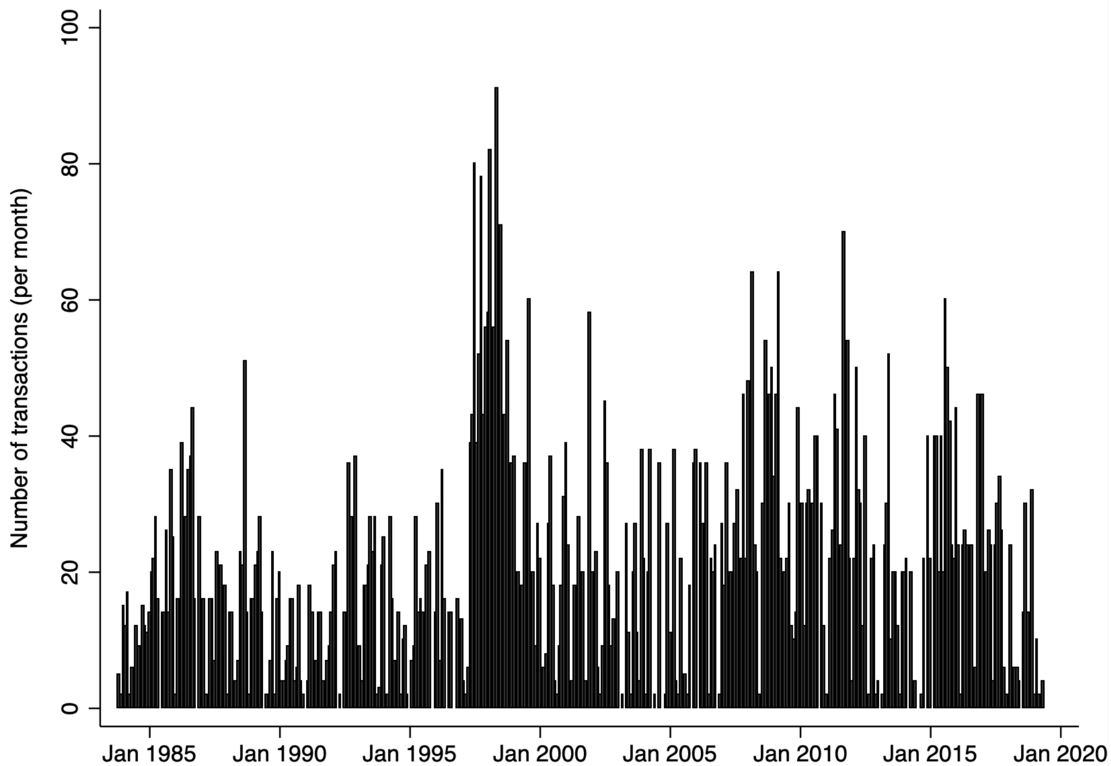


Figure B.6: Number of Monthly Transactions for the Optimal Carry Trade of the G10 Sample with Monthly Rebalancing

This figure shows the number of transactions per month for the optimal carry trade portfolio with monthly rebalancing for the G10 sample of 10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

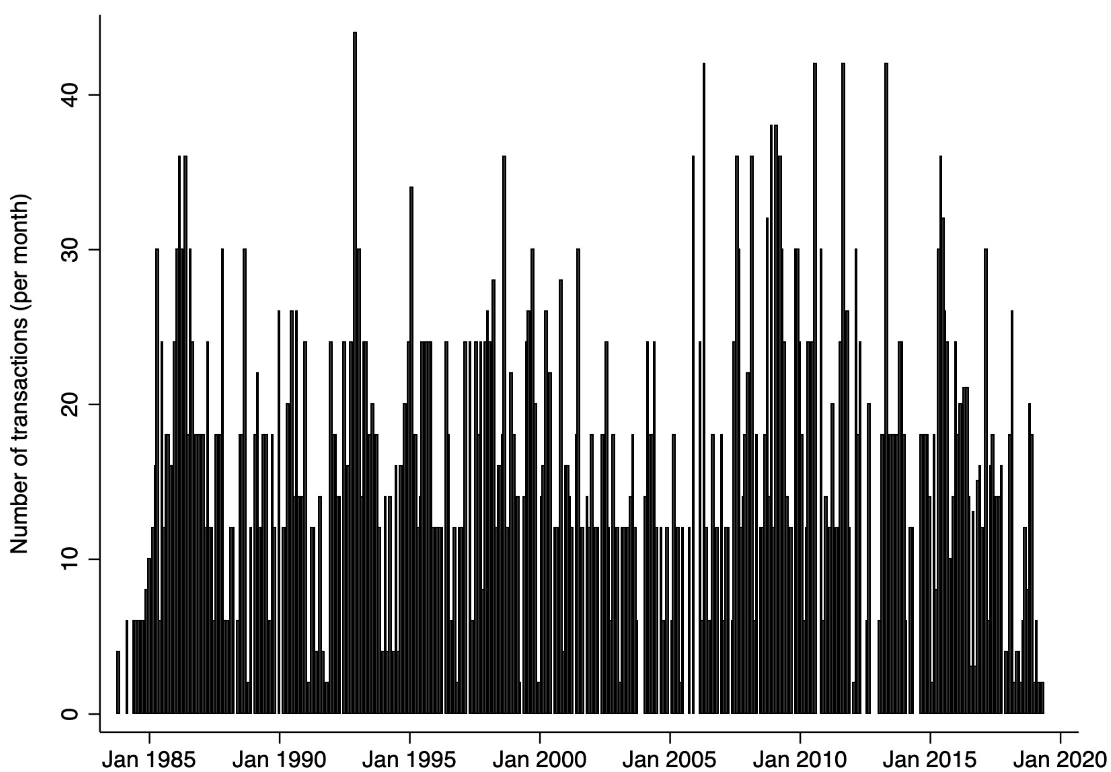


Figure B.7: Number of Monthly Transactions for the Optimal Carry Trade of the Full Sample with Daily Rebalancing

This figure shows the number of transactions per month for the optimal carry trade portfolio with daily rebalancing for the full sample of 37 currencies. The sample period ranges from November 1983 to May 2019.

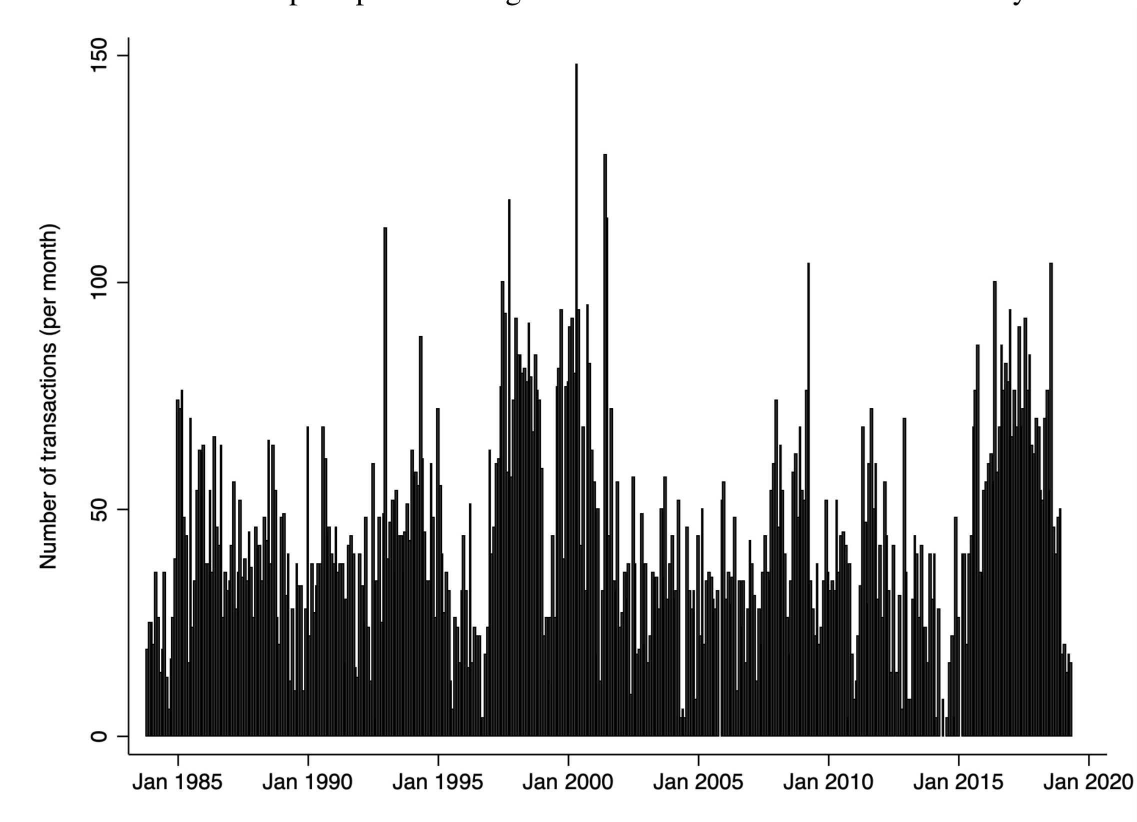


Figure B.8: Number of Monthly Transactions for the Optimal Carry Trade of the G10 Sample with Daily Rebalancing

This figure shows the number of transactions per month for the optimal carry trade portfolio with daily rebalancing for the G10 sample of 10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

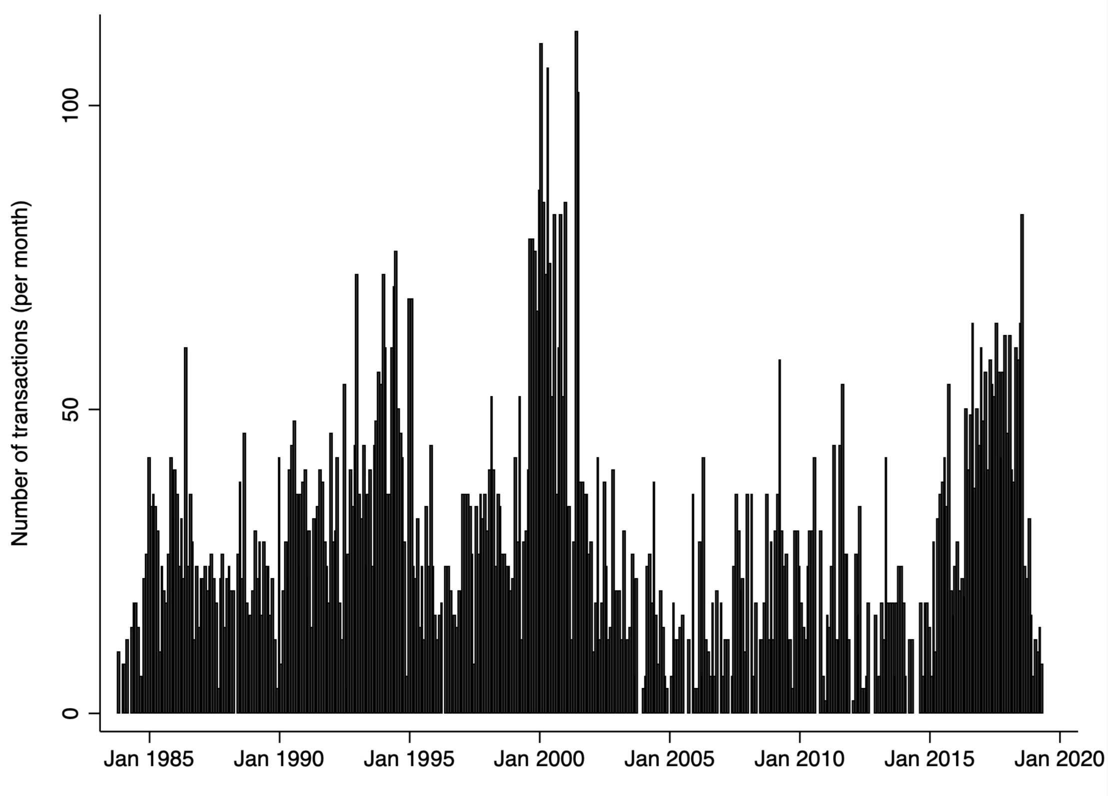


Figure B.9: Number of Monthly Transactions for the Optimal Momentum Portfolio of the Full Sample with Monthly Rebalancing

This figure shows the number of transactions per month for the optimal currency momentum portfolio with monthly rebalancing for the full sample of 37 currencies. The sample period ranges from November 1983 to May 2019.

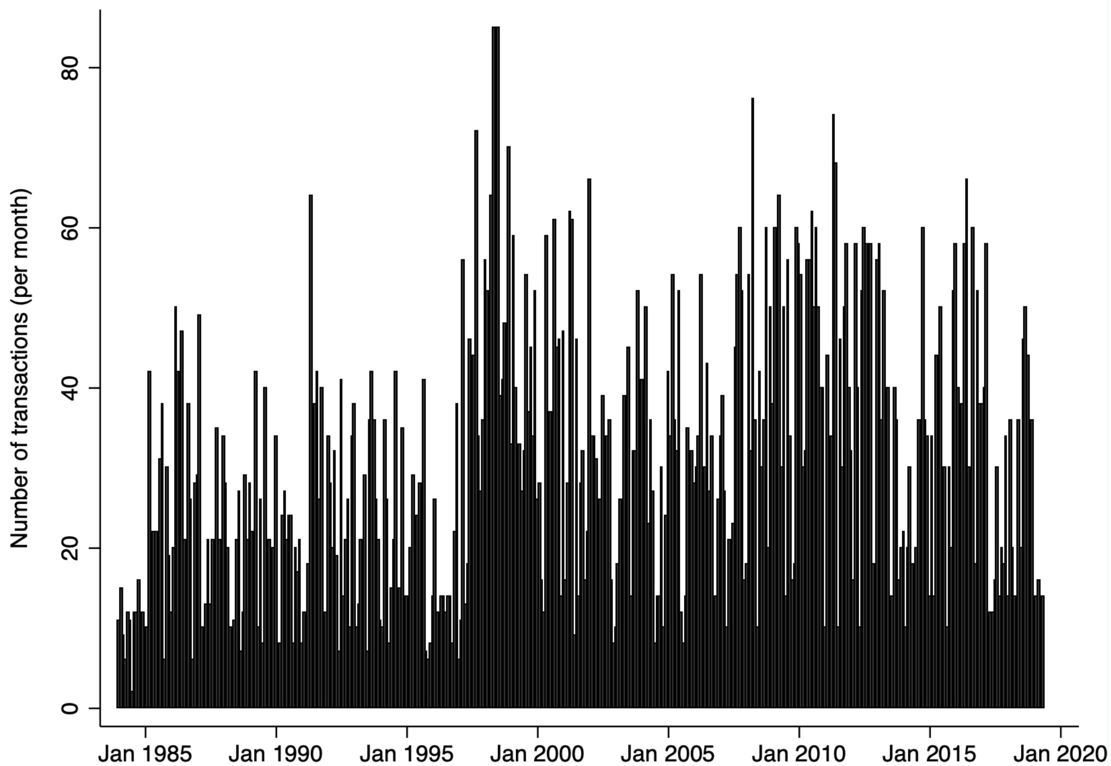


Figure B.10: Number of Monthly Transactions for the Optimal Momentum Portfolio of the G10 Sample with Monthly Rebalancing

This figure shows the number of transactions per month for the optimal curency momentum portfolio with monthly rebalancing for the G10 sample of 10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

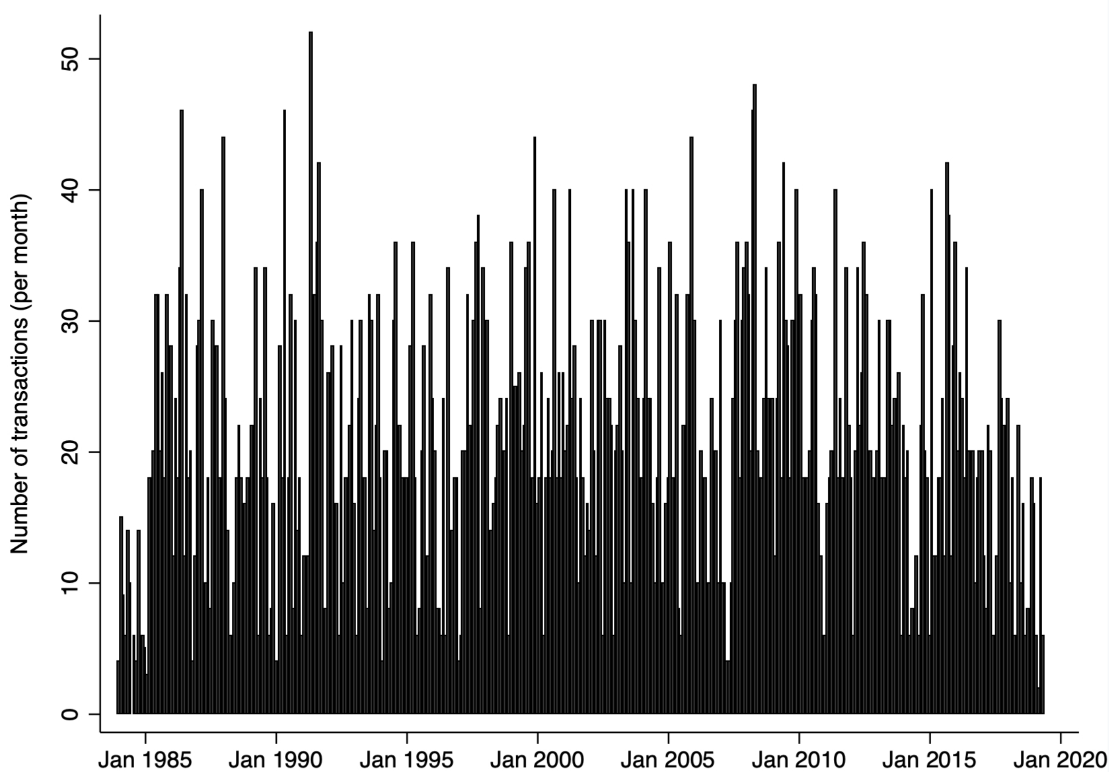


Figure B.11: Number of Monthly Transactions for the Optimal Momentum Portfolio of the Full Sample with Daily Rebalancing

This figure shows the number of transactions per month for the optimal currency momentum portfolio with daily rebalancing for the full sample of 37 currencies. The sample period ranges from November 1983 to May 2019.

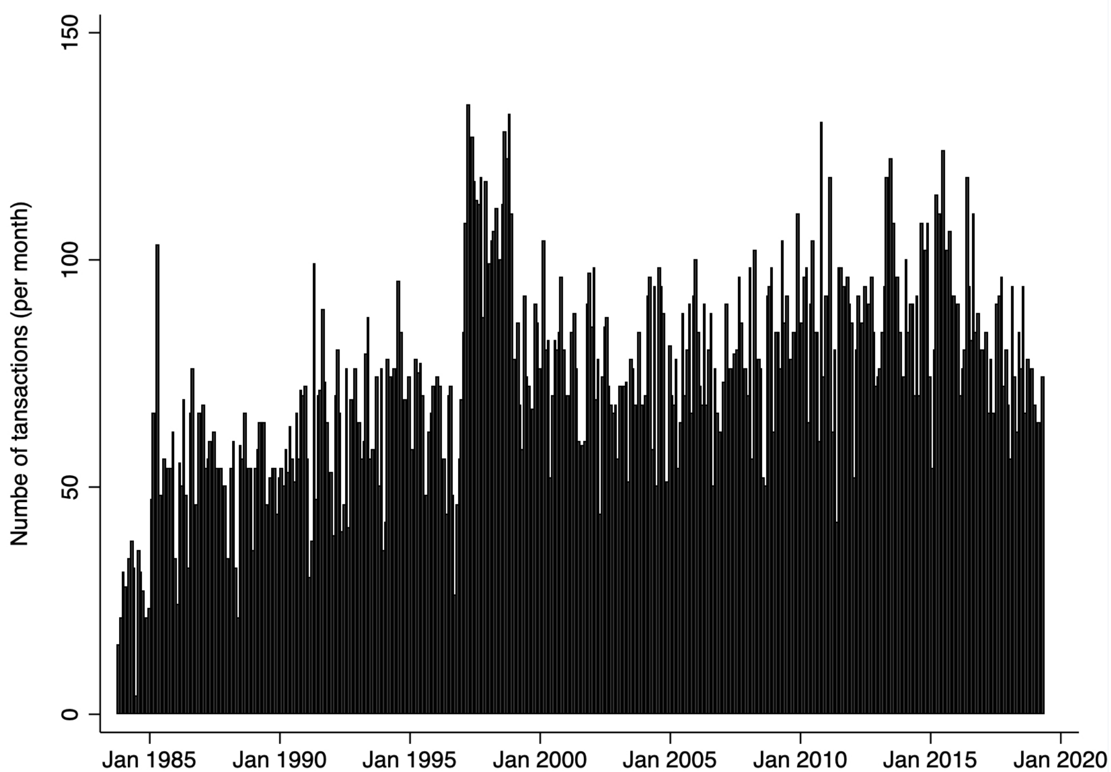
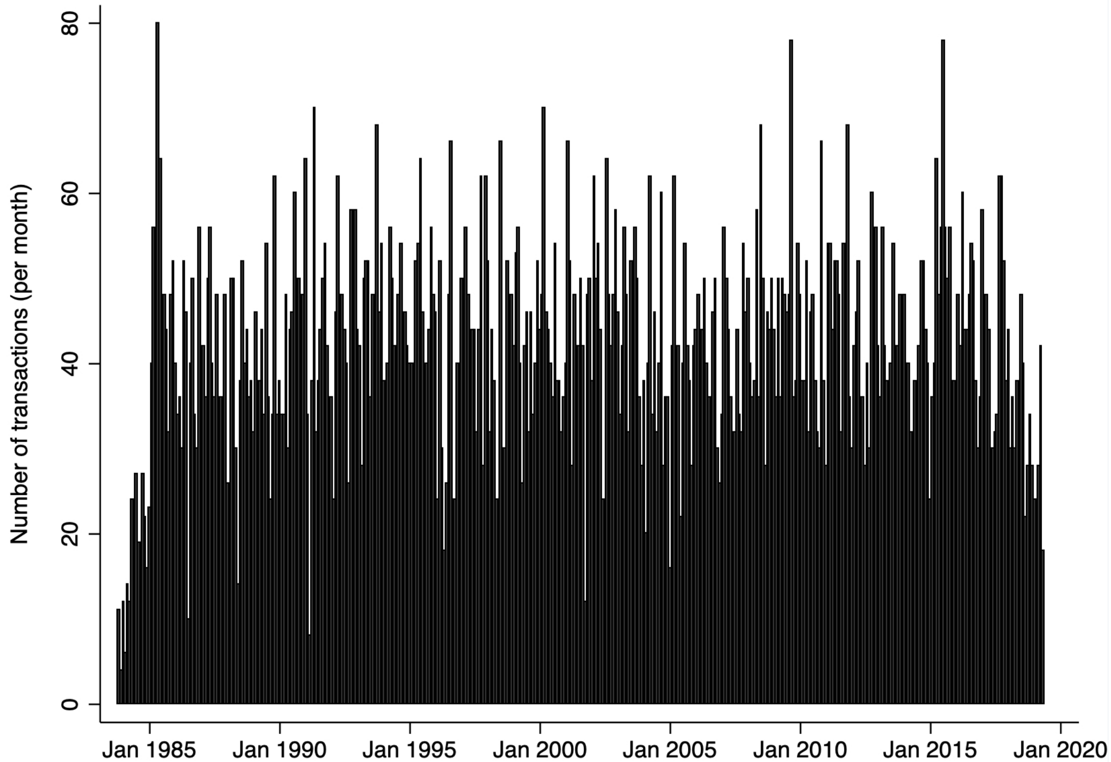


Figure B.12: Number of Monthly Transactions for the Optimal Momentum Portfolio of the G10 Sample with Daily Rebalancing

This figure shows the number of transactions per month for the optimal currency momentum portfolio with daily rebalancing for the G10 sample of 10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.



Appendix C

Optimal currency momentum portfolios

Table C.1: Descriptive Statistics of Daily Returns Net of Transaction Costs for the Optimal Currency Momentum with Monthly Rebalancing

This table reports statistics of the optimal currency momentum strategy with monthly rebalancing net of transaction costs. The optimal strategy is constructed from the series of daily log excess HML returns in Table 9. The optimal strategy is guided by the following decision thresholds: 1) exit the currency momentum strategy after two days of consecutive negative returns, with one daily losses being greater than one standard deviation and 2) enter back into the currency momentum strategy after one day of positive return. I assume a log excess return of zero while being out of the strategy. All the **net** log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015). The sample period ranges from November 1983 to May 2019.

Panel A: All Countries	
	HML
Mean	3.41
	[1.38]
Standard Deviation	8.36
	[0.98]
Sharpe Ratio	0.41
Skewness	-0.12
	[0.03]
Excess Kurtosis	7.84
	[0.05]
AC(1)	0.04
	(0.00)
Panel B: G10 Countries	
	HML
Mean	0.84
	[1.22]
Standard Deviation	7.36
	[0.86]
Sharpe Ratio	0.11
Skewness	-0.08
	[0.03]
Excess Kurtosis	5.44
	[0.05]
AC(1)	0.01
	(0.23)

Figure C.1: Cumulative Daily Returns Net of Transaction Costs for the Optimal Currency Momentum with Monthly Rebalancing

This figure shows daily cumulative net log excess returns for the optimal currency momentum strategy with monthly rebalancing. The solid black line corresponds to all countries, while the gray line corresponds to the sample of G10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

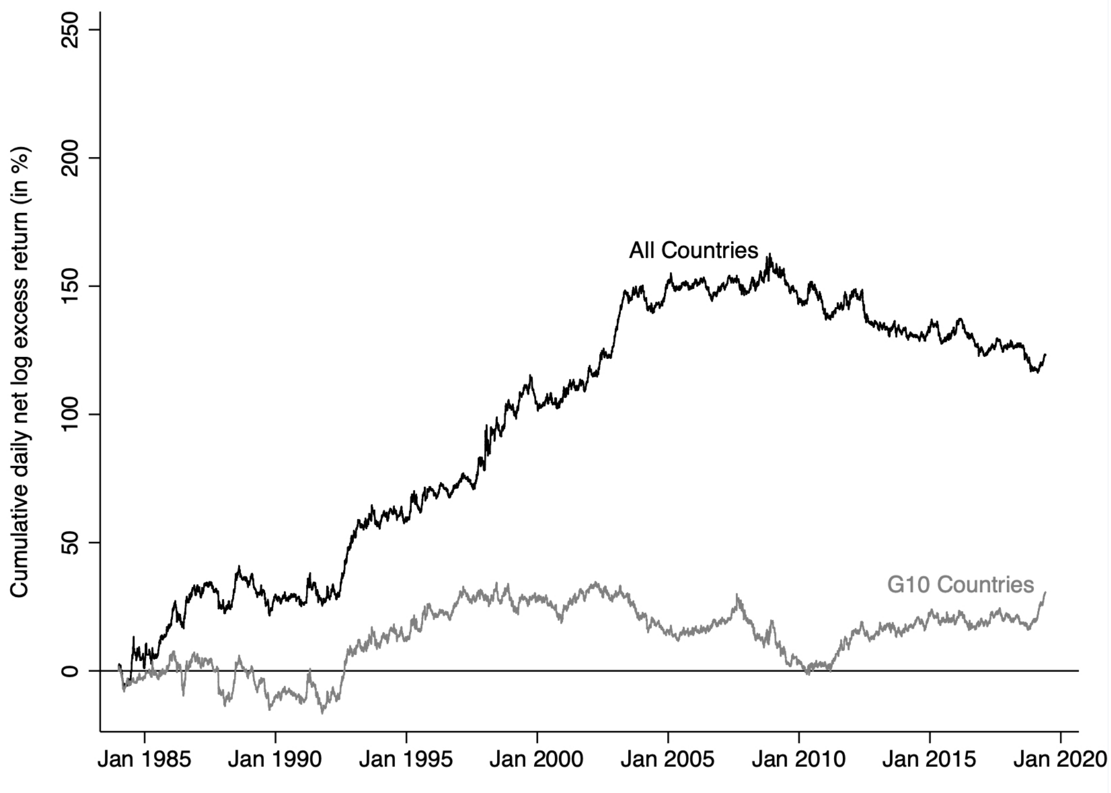


Table C.2: Descriptive Statistics of Daily Returns for the Optimal Currency Momentum with Daily Rebalancing

This table reports statistics of the optimal currency momentum strategy with daily rebalancing. The optimal strategy is constructed from the series of daily log excess HML returns in Table 13. The optimal strategy is guided by the following decision thresholds: 1) exit the currency momentum strategy after two days of consecutive negative returns, with one daily losses being greater than one standard deviation and 2) enter back into the currency momentum strategy after one day of positive return. I assume a log excess return of zero while being out of the strategy. All the log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015). The sample period ranges from November 1983 to May 2019.

Panel A: All Countries	
	HML
Mean	3.94
	[1.40]
Standard Deviation	8.47
	[0.99]
Sharpe Ratio	0.47
Skewness	-0.16
	[0.03]
Excess Kurtosis	9.97
	[0.05]
AC(1)	0.03
	(0.74)
Panel B: G10 Countries	
	HML
Mean	1.89
	[1.27]
Standard Deviation	7.70
	[0.90]
Sharpe Ratio	0.25
Skewness	0.18
	[0.03]
Excess Kurtosis	9.84
	[0.05]
AC(1)	-0.02
	(0.03)

Figure C.2: Cumulative Daily Returns for the Optimal Currency Momentum with Daily Rebalancing

This figure shows daily cumulative log excess returns for the optimal currency momentum strategy with daily rebalancing. The solid black line corresponds to all countries, while the gray line corresponds to the sample of G10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.

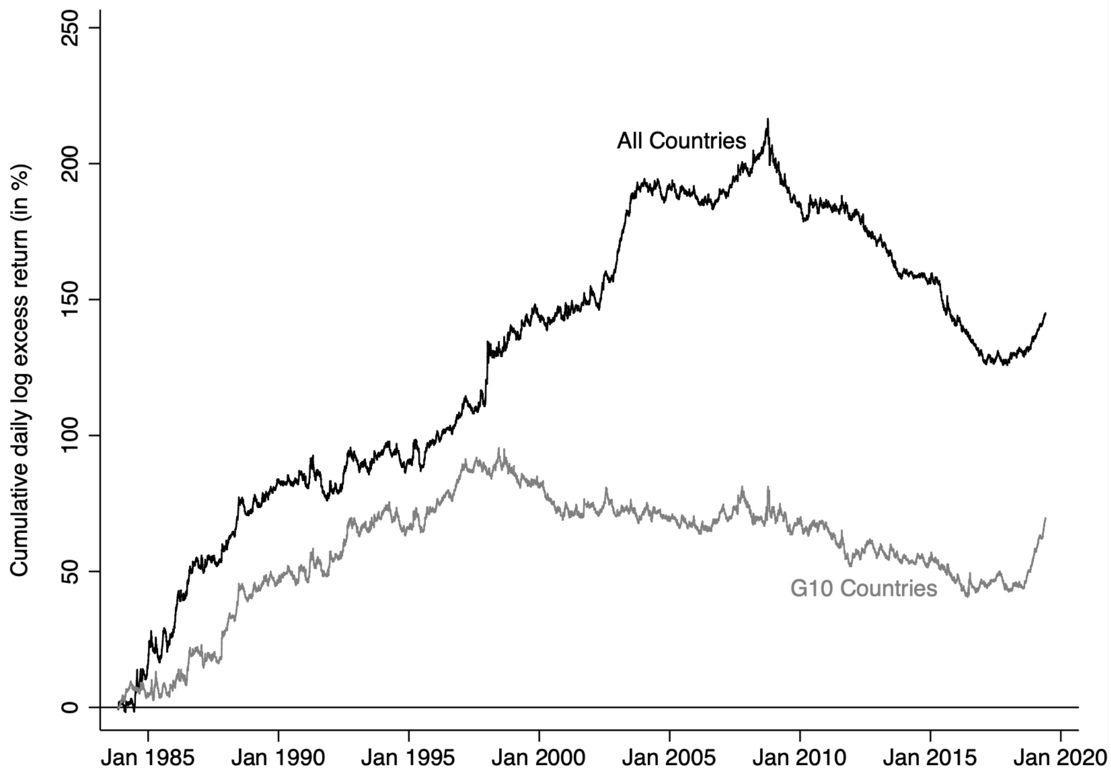


Table C.3: Descriptive Statistics of Daily Returns Net of Transaction Costs for the Optimal Currency Momentum with Daily Rebalancing

This table reports statistics of the optimal currency momentum strategy with daily rebalancing net of transaction costs. The optimal strategy is constructed from the series of daily log excess HML returns in Table 14. The optimal strategy is guided by the following decision thresholds: 1) exit the currency momentum strategy after two days of consecutive negative returns, with one daily losses being greater than one standard deviation and 2) enter back into the currency momentum strategy after one day of positive return. I assume a log excess return of zero while being out of the strategy. All the **net** log excess returns are **daily** and in USD, but the mean and the standard deviation are annualized and in percent. The Sharpe Ratio is also annualized. AC(1) corresponds to the first-order autocorrelation coefficient. Numbers in brackets show standard errors and numbers in parentheses show *p*-values. The standard errors of the mean returns are heteroskedasticity consistent while other standard errors are derived from McCrary (2015). The sample period ranges from November 1983 to May 2019.

Panel A: All Countries	
	HML
Mean	-0.33
	[1.40]
Standard Deviation	8.52
	[0.99]
Sharpe Ratio	-0.04
Skewness	-0.21
	[0.03]
Excess Kurtosis	10.01
	[0.05]
AC(1)	0.00
	(0.83)
Panel B: G10 Countries	
	HML
Mean	-0.47
	[1.28]
Standard Deviation	7.74
	[0.90]
Sharpe Ratio	-0.06
Skewness	0.15
	[0.03]
Excess Kurtosis	9.73
	[0.05]
AC(1)	-0.02
	(0.03)

Figure C.3: Cumulative Daily Returns Net of Transaction Costs for the Optimal Currency Momentum with Daily Rebalancing

This figure shows daily cumulative net log excess returns for the optimal currency momentum strategy with daily rebalancing. The solid black line corresponds to all countries, while the gray line corresponds to the sample of G10 currencies minus the USD. The sample period ranges from November 1983 to May 2019.