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JEL Classification: F31, G12, G15, G40

Keywords: foreign exchange, currency returns, prospect theory, Limits to Arbitrage

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Prospect Theory and Currency Returns: Empirical Evidence *

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September 7, 2020

Abstract

We empirically investigate the role of prospect theory in the foreign exchange market. Using the historical distribution of exchange rate changes, we construct a currency-level measure of prospect theory value and find that it negatively forecasts future currency excess returns. High prospect theory value currencies significantly underperform low prospect theory value currencies. The predictability is higher when arbitrage is limited and during periods of excess speculative demand of irrational traders. These findings are consistent with the hypothesis that investors mentally represent currencies by their historical distributions or charts and evaluate the distribution in the way described by prospect theory.

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1 Introduction

The classical present-value relation suggests that asset prices should reflect the discounted expected future fundamentals. However, it is well recognized that investor trading behavior may also influence asset prices for reasons beyond fundamental news, such as the "animal spirits" (Keynes 1936) or "noise trading" (De Long, Shleifer, Summers & Waldman 1990). The foreign exchange (FX) market offers an ideal venue to understand non-fundamental determinants of asset prices. As the largest financial market in the world, the FX market is known for its unique institutional features, including high trading volume, the dominance of sophisticated investors, and the absence of short-selling constraints.[1] Prima facie, these institutional features imply that mispricing should be eliminated rapidly given the ease of arbitrage, hence the effects of investor behavior on exchange rates are expected to be limited. On the contrary, the well-known "exchange rate-fundamental disconnect puzzle" (Meese & Rogoff 1983, Mark 1995, Engel & West 2005, Rossi 2013) and the "obstinate passion" of FX professionals to use technical trading rules as well as the profitability of these strategies (Allen & Taylor 1990, Menkhoff & Taylor 2007, Neely, Weller & Ulrich 2009, Hsu, Taylor & Wang 2016) indicate that investor behavior should play a critical role in shaping exchange rate movements. These two pieces of "seemingly" conflicting evidence naturally inspire a comprehensive empirical investigation in the FX market from a behavioral finance perspective, which remains underexplored in the literature.

Our paper fills this gap and empirically examines the role of prospect theory in explaining the cross-section of currency returns. Prospect theory introduced by Kahneman & Tversky (1979) is a more realistic decision-making framework to evaluate risk, compared to the conventional and rational expected utility framework. A recent empirical study by Barberis, Mukherjee & Wang (2016) shows that prospect theory values predict the cross-section of stock returns. Different from existing studies in stock markets, we empirically investigate prospect theory in currency markets. Currency markets, along

[1] According to the 2016 Bank of International Settlement tri-annual survey (BIS 2016), the aggregate daily turnover in the global foreign exchange markets is 5.1 trillion US dollar. Financial institutions other than reporting dealers dominate other market participants and they represent 51% of total turnover. Reporting dealers and non-financial customers account for 42% and 7% of total turnover respectively.

with the distinctive institutional features mentioned above, provide us a unique empirical setting to understand the role of prospect theory in explaining asset returns under a more stringent condition.

The intuition as to why prospect theory may explain the cross-sectional variations of future currency returns is straightforward. Assuming the currency market consists of two types of investors: rational investors thinking in line with the expected utility framework, and irrational investors evaluate risk in the way described by prospect theory. Then these irrational investors are more willing to hold high prospect theory value (more appealing) currencies, while they want to sell low prospect theory value (unattractive) currencies. If these investors account for a non-trivial proportion of the total currency investor population, then their trading activities will shift demand of currencies, and therefore affect expected currency returns in the equilibrium. Specifically, they will bid high prospect theory value currencies to be temporarily appreciated and overvalued. Then these currencies will earn lower expected returns in the future. A similar logic applies to low prospect theory value currencies. In summary, we expect that prospect theory value should be negatively associated with expected currency returns in the subsequent period.

Our findings lend strong empirical support for this prediction. We find that the prospect theory value, derived from the historical distribution of exchange rate changes, negatively and significantly forecasts the cross-section of future currency excess returns. The predictive relation is not only statistically significant but also economically meaningful. A one standard deviation increase in prospect theory value is associated with a 3.6% per annum drop of currency returns in the following month. The predictive power remains strong when controlling for other currency characteristics. Moreover, sorting currencies into five portfolios based on prospect theory values, we find that high prospect theory value currencies significantly underperform their lower value pairs by about 5% per annum. A long-short strategy buying (shorting) low (high) prospect theory value currencies– prospect theory premium (PTP) –has only moderate correlations with other currency risk factors, equity risk factors, and hedge fund factors. Abnormal returns (alphas) after controlling for these factors remain statistically significant at 1%. After controlling for currency risk factors, equity market factors, or hedge fund factors, alphas are 4.92%, 4.48%, and 4.93% per annum respectively, comparable to the long-short return spread in magnitude.

Previous studies document that betas to traditional FX risk factors significantly explain the cross-section of currency returns (see, e.g., Lustig & Verdelhan (2007), Lustig, Roussanov & Verdelhan (2011), Menkhoff, Sarno, Schmeling & Schrimpf (2012)). Our results, however, show that systematic exposures to the PTP factor do not adequately explain the cross-sectional variations of individual currency returns. Instead, the currency-level prospect theory value remains to be negatively and significantly correlated with future currency returns. Therefore, the profitability of the PTP strategy can hardly be attributed to systematic risk premia, including either due to noise trader risk of De Long et al. (1990) or any other omitted risk factor that correlates with PTP returns. Instead, our findings speak in favor of the existence of mispricing at the individual currency level (characteristic) rather than the explanation of systematic risk exposure (covariance).

To further test the mispricing hypothesis, we interact the prospect theory value variable with proxies of limits to arbitrage, speculative demand, and investors' attention. We find that the predictive power is strengthened when the FX market volatility, the global risk aversion, and the financial market stress are high, namely when arbitragers are more difficult to correct for mispricing. Moreover, the predictive relation is also stronger when the global investor sentiment is high, and the relation is weaker when investors pay more attention to macro-fundamentals and hence pay less attention to the historical currency performance, due to the limited attention capacity. Collectively, both the difficulty for rational arbitragers to remove mispricing and the propensity of irrational traders to trade speculatively contribute to the predictive pattern.

Our empirical evidence is robust to a battery of additional exercises. First, we show that the results are not due to a specific choice of parameters when constructing the prospect theory value or a choice of a sample period. Second, our prospect theory strategy returns are still economically significant after taking account of the bid-ask spreads. Third, we show that other behavioral indicators cannot explain our portfolio strategy returns. Forth, our results are robust to alternative numbers of currencies and different quote currencies.

The overall contribution of this paper is two-fold. First, our paper enriches the growing literature of cross-sectional return predictability in currency markets by introducing a new predictor and a new currency portfolio strategy. Previous studies already document that carry trade (Lustig & Verdelhan 2007, Lustig et al. 2011), momentum (Burnside, Eichenbaum & Rebelo 2011, Menkhoff et al. 2012), and value (Asness, Moskowitz & Pedersen 2013, Menkhoff, Sarno, Schmeling & Schrimpf 2017) are important currency portfolio strategies.[2] Different from existing studies, we contribute to the field by introducing a new currency predictor formally motivated by a behavioral finance theory, arguably the first in the literature. Our prospect theory value sorted currency portfolios expand the scope of investment opportunity sets for practical currency portfolio managers, and more importantly offer a new challenge to existing asset pricing models in the literature.

This paper also adds to the literature about the asset pricing implications of prospect theory by providing novel empirical evidence beyond equity markets. Barberis & Huang (2008) propose a theoretical model linking prospect theory with asset prices and predict that expected skewness is priced in the cross-section of stock returns.[3] Barberis et al. (2016) initially examine the cross-sectional return predictability of prospect theory value in US and international stock returns. Zhong & Wang (2018) study prospect theory in the cross-section of corporate bonds. To the best of our knowledge, our paper is the first to analyze the cross-sectional return predictability implications of prospect theory in currency markets, an important asset class beyond equity. Echoing existing prospect theory related studies in equity markets, our paper in currency markets provides "out-of-sample" evidence about the role of prospect theory in explaining asset returns. Although currency markets differ from stock markets in various aspects, our empirical evidence implies that the irrational trading behavior described by prospect theory may exist in different asset classes and may have a common source.

Despite the commonality, our findings in currency markets are unique in at least three

[2] An incomplete list of other currency portfolios also includes volatility risk premia (Della Corte, Ramadorai & Sarno 2016), global imbalance (Della Corte, Riddiough & Sarno 2016), economic momentum (Dahlquist & Hasseltoft 2020), and output gap (Colacito, Riddough & Sarno 2020) etc. Throughout the paper, we only focus on carry, momentum, and value for their popularity and data availability considerations.

[3] Kumar (2009), Boyer, Mitton & Vorkink (2010), Bali, Cakici & Whitelaw (2011), and Conrad, Dittmar & Ghysels (2013) find that expected skewness are priced in stock markets.

aspects. Initially, we suggest that sophisticated institutional investors may trade speculatively. Barberis et al. (2016) document that the predictive power of prospect theory value is stronger for stocks with lower institutional ownership. The strong predictive power we uncovered in a market dominated by sophisticated institutional investors implies that even these investors may encounter severe cognitive bias and trade speculatively. Hence our paper also adds to the growing literature about speculative trading of institutional investors.[4]

Moreover, the strength of our currency portfolio strategy even in highly liquid currency markets (developed economies and G10) provides a challenge to the conventional wisdom that arbitrage activities are easier when markets are more liquid.[5] Furthermore, besides the important role of limits to arbitrage in the predictive relation as mentioned in Barberis et al. (2016) and as we confirm empirically, we provide additional evidence that speculative trading activities of irrational traders (or limited attention of retailer investors) also matter. The idea that both limits to arbitrage and speculative trading contribute to the mispricing is consistent with De Long et al. (1990) and Baker & Wurgler (2006). Our findings are also in line with Bali, Hirshleifer, Peng & Tang (2019). They provide evidence that investor attention plays a key role in explaining lottery-related anomalies.

A closely related study is Chabi-Yo & Song (2012). These authors investigate the role of probability weighting of rare events in predicting the aggregate currency market return and pricing carry trade and momentum returns. Our paper is essentially different from theirs in several respects. First, while prospect theory and rank dependent utility (Quiggin 1993), which they rely on, are closely related, our paper conducts arguably the first formal empirical investigation of prospect theory in currency markets, while their paper focuses only on probability weighting. Second, the focus of our paper is the cross-sectional return

[4]Existing studies consider the role of institutional investors in improving or distorting the market efficiency. For example, Campbell, Ramadorai & Schwartz (2009) and Boehmer & Kelley (2009) show that institutional investors exploit mispricing and improve informational efficiency. However, in the AFA presidential address, Stein (2009) suggests that institutional ownership may adversely influence price efficiency. Our result is consistent with the recent paper by Goetzmann, Kim, Kumar & Wang (2015). These authors show that the perception of mispricing and the trading decisions of institutional investors are affected by investor mood.

[5]Similarly, Avramov, Cheng & Hameed (2016) find that equity momentum profits are larger rather than smaller in more liquid states, which contradicts to the conventional wisdom that arbitrage is easy when the overall market is more liquid.

predictability; in contrast, these authors focus on the aggregate time-series predictability. Third, our measure is based on historical information, while their currency option-based measure is forward-looking. Therefore, these two measures essentially contain different sets of information. Unlike option-based measures, our return-based measure can be easily applied to much longer samples and a broader set of currencies. Hence it better fits our purpose of a comprehensive empirical investigation of the cross-sectional return predictability in currency markets.[6]

This paper is also related to existing behavioral and technical analysis studies in FX markets. Frankel & Froot (1990) is one of the first behavioral studies in FX markets. Kozhan & Salmon (2009) and Beber, Breedon & Buraschi (2010) consider the impacts of uncertainty aversion and heterogeneous beliefs respectively. Burnside, Han, Hirshleifer & Wang (2011), Ilut (2012), and Yu (2012) provide interpretations of the forward premium puzzle or carry trades from overconfidence, ambiguity, and sentiment perspectives. Another group of studies investigates the profitability of technical trading rules in FX markets (Taylor & Allen 1992, Menkhoff & Taylor 2007, Neely et al. 2009, Neely & Weller 2012, Hsu et al. 2016). Existing behavioral or technical studies either mainly focus on the theoretical perspective or use time-series regressions to explain or predict currency returns. Instead, our paper emphasizes on the cross-sectional currency return predictability with a new predictor motivated by prospect theory.

The remainder of the paper is organized as follows. Section 2 introduces the main properties of prospect theory and develops our main testable hypotheses. Section 3 describes the data and the variable construction. Section 4 reports our main empirical findings. Section 5 summarizes the results for comprehensive robustness checks. We provide some concluding remarks in a final section.

[6]OTC traded currency options are only available on five strikes, therefore their estimated distributions and especially tails rely heavily on interpolation and extrapolation. Moreover, currency options are only liquid traded in a few selected currencies and for relatively short sample periods from 1997 afterward. These practical issues may restrict the use of the option-based measure in currency markets.

2 Prospect Theory in Currency Markets

In this section, we firstly introduce the main properties of prospect theory and then provide three main testable hypotheses to motivate our following empirical analysis.

2.1 Main Properties of Prospect Theory

Investing in currency markets is risky, given the fluctuations in exchange rates. Currency investors need to evaluate risk when making their investment decisions. A conventional decision-making framework is the expected utility theory, which is a building block for several classical models in financial economics. Despite the popularity of the expected utility theory, experimental evidence, however, shows that investor behavior in the real world frequently deviates from what expected utility theory predicts. Existing studies have already considered various forms of non-expected utility models to explain currency returns.[7] However, whether prospect theory, another powerful and more realistic decision-making framework, may contribute to explaining currency returns remain unclear.

Introduced by Kahneman & Tversky (1979), prospect theory offers an alternative and realistic description of investor behaviors, compared with the expected utility framework. Tversky & Kahneman (1992) propose a modified version of the theory termed cumulative prospect theory, which is more widely used in financial economics and is the one we focus on in this paper. While prospect theory was initially used to describe choice under risk in the laboratory, several studies apply prospect theory to explain stock returns since Benartzi & Thaler (1995). Barberis, Huang & Santos (2001) provide a framework with loss aversion and show that it explains puzzles related to equity premium, excess volatility, return predictability, and low correlation between stock returns and consumption growths. Barberis & Huang (2008) focus on probability weighting and derive the prediction that skewness is priced in stock returns.

[7]For example, Lustig & Verdelhan (2007) apply Yogo (2006)'s consumption-based model with recursive utility and durable goods to explain carry trade returns. Verdelhan (2010) provides a habit-formation based explanation for the currency risk premium. Colacito & Croce (2013) and Colacito, Croce, Gavazzoni & Ready (2018) use a long run risk model to understand forward premium puzzle and the cross-section of currency risk premia respectively. These approaches modify the conventional expected utility and better account for return patterns in currency markets within the rational framework.

Prospect theory differs from expected utility theory in two important respects. First, within the expected utility framework, the utility function is assumed to be continuously differentiable, and it is a concave function of terminal wealth. In contrast, the prospect theory value function is a function of gains and losses relative to a reference point. The function is kinked at zero and is concave at gains but convex at losses. Therefore, prospect theory value function better captures real-world investor's loss aversion and the focus on the incremental change of wealth rather than the terminal wealth level. Second, while the relation between probabilities of events and weights is linear in the expected utility framework, prospect theory introduces a non-linear probability weighting function. Such a weighting function captures the gambling preference of investors in the real world to overweight extreme tail events. The theory also models investors' perception of gain probabilities differently from loss probabilities. Collectively, these properties ensure that prospect theory offers a more realistic description of the way investors evaluate risk compared to the rational expected utility framework.

2.2 Hypothesis Development

What does prospect theory tell about currency returns? Our first research question considers the predictive relation between prospect theory value and subsequent currency excess return. Barberis et al. (2016) provide a mean-variance framework and show theoretically that that prospect theory value is negatively associated with future stock excess returns. These authors also provide empirical evidence in the US and international stock markets to support this negative relationship.

Currency markets differ from equity markets in trading mechanisms and market participants, as we illustrated in Section 1. However, if a fraction of currency investors indeed deviate from the expected utility in their decision-making processes, and assess the risk of currency in line with prospect theory, then their trading activities following prospect theory should affect expected currency returns in the equilibrium.[8]

[8]To notice, we do not assume all currency market participants to be irrational or all investors must be thinking in the way describe by prospect theory. Instead, as in Barberis et al. (2016), as long as a non-trivial proportion of total investors depart from expected utility and think according to prospect theory, prospect theory value will affect expected return. In the mean-variance framework, they show that expected excess return is negatively related to the fraction of prospect theory investors in the

To establish the relation between prospect theory value and currency return, we need to construct a measure of prospect theory value at the currency level. The empirical use of prospect theory requires two steps. First, investors need to form a mental *representation* of a risk. Analogue to Barberis et al. (2016) in equity markets, we suggest that a group of currency investors deviate from fully rational expected utility and think in line with prospect theory. These investors mentally represent the risk of a currency using the past distribution of exchange rate returns. The historical exchange rate price chart is perhaps the first piece of information that will appear to investors when searching for information about currency. Hence, investors are very likely to use price charts (and therefore the exchange rate past distributions) to form a mental representation about how risky the currency is. This mental representation is particularly relevant in the FX market. The well-documented "exchange rate-fundamental disconnect puzzle" (e.g. Meese & Rogoff (1983)) makes the macro information less useful in understanding short-run exchange rate movements. Besides, the wide use of technical trading rules in the FX market also confirms that investors indeed heavily rely on historical information about exchange rate price charts when making investment decisions. Taylor & Allen (1992) provide direct evidence that over 90% of their survey respondents used technical analysis when trading currencies.

The second step is that investors need to *value* whether such a representation is appealing or not. We apply the Tversky & Kahneman (1992) formula to the past distribution of exchange rate changes and construct currency-level prospect theory value, which reflects how appealing a currency to a prospect theory investor. We provide a more formal description of the empirical construction of currency-level prospect theory value in Section 3 below.

The intuition about the negative relationship between currency-level prospect theory value and future currency return is straightforward: prospect theory investors tend to buy more appealing (high prospect theory value) currencies and sell unattractive (low prospect theory value) currencies on average, even in the absence of macro signals or rational risk-based reasons. If these investors account for a non-trivial proportion of total

population. The fraction is a strictly increasing function of prospect theory value.

currency investors, then trading activities of these investors will push appealing currencies to be temporally appreciated and overvalued, as a result, these currencies will earn lower expected returns on average. Therefore, our first hypothesis is:

Hypothesis 1 (Predictability): *The prospect theory value of a currency past return distribution negatively predicts the subsequent period currency return in the cross-section.*

The next research question is what could be potential economic mechanisms to drive this predictive pattern? We consider two plausible explanations. Our first potential explanation is that the predictive relation may reflect systematic exposures to common factors.[9] Although our main predictor is motivated by a behavioral theory, the potential return predictability pattern may still partially be explained by systematic exposures to common factors for several reasons. Initially, previous studies (Lustig et al. 2011, Verdelhan 2018) document that currency returns have a strong factor structure. Therefore, exposures to global currency risk factors should explain a large proportion of currency return variations. The cross-section return predictive pattern by prospect theory may, therefore, be interpreted as exposures to some known or unknown global risk factors.

Moreover, the predictive relation may also be explained by the noise trader risk. Noise trader risk is generated due to the unpredictability of irrational investors' sentiments, e.g. see De Long et al. (1990). Arbitrageurs, being risk-averse, do not aggressively exploit existing mispricing because of fear that the mispricing gap widens in the nearest future. Therefore, even if the predictive pattern is not fully captured by conventional risk factors, it may still be generated by exposure to noise trade risk.

Furthermore, more recent studies suggest that stock returns may be exposed to common mispricing factors. Stambaugh & Yuan (2017) show that a mispricing factor aggregating information from eleven anomalies improves the pricing performance in stock markets. Daniel, Hirshleifer & Sun (2020) propose a three-factor model with a market factor, a short-horizon behavioral factor, and a long-horizon behavioral factor. They find that the model explains a set of stock market anomalies. Therefore, the potential

[9] The systematic exposures to a common factor may include not only conventional systematic risk factors but also systematic behavioral factors.

predictive relation by prospect theory may also be attributed to exposure to a potential common mispricing factor. Collectively, we investigate whether the predictive relation can be captured by systematic exposures to common factors. Therefore, our second hypothesis is:

Hypothesis 2 (Systematic Exposures to Common Factors): *The negative relation between the prospect theory value and the subsequent period currency return is fully explained by the systematic exposures to common factors.*

Even without systematic exposures to common factors, the predictive return pattern may still exist due to mispricing at the characteristic level. Daniel & Titman (1997), for example, show that firm characteristics predict stock returns even controlling for systematic risk exposures. In currency markets, previous studies such as Lustig et al. (2011) and Ranaldo & Soderlind (2010) discuss whether the betas to common factors or the safe-haven characteristics better explain currency carry trade returns.

If currency investors are fully rational and arbitrage activities in currency markets are costless and risk-free, then any mispricing should be eliminated instantaneously, i.e. we should not observe the predictive relation. In reality, investors are subjective to sentiment (De Long et al. 1990), while betting against mispricing is costly and risky (Shleifer & Vishny 1997). Namely, mispricing depends on two important elements: speculative trading and limits to arbitrage (Baker & Wurgler 2006). If not all investors are fully rational, the time-varying speculative demand of these irrational investors may contribute to the predictive pattern. Moreover, real market arbitrage is limited due to the presence of trading frictions and constrained capital (see Gromb & Vayanos (2010) for a survey on limits to arbitrage literature). Therefore, when arbitrage is risky or the arbitrage capital is in shortage, rational arbitragers are not able to eliminate mispricing immediately. Hence, limits to arbitrage may also generate mispricing. To understand the mispricing-based explanation, we check whether the predictive relation is more pronounced when arbitrage is difficult, and when the propensity of speculative demand is high. Therefore, our third hypothesis is:

Hypothesis 3 (Limits to Arbitrage and Speculative Demand): *The negative relation between the prospect theory value and the currency subsequent return is strengthened during periods of limited arbitrage and high speculative demand of irrational investors.*

3 Data and Variable Construction

3.1 Data

Spot and one-month forward exchange rates at the daily frequency from January 1, 1985 to February 28, 2018 are collected from Barclays and Reuters through Datastream. Our main empirical analysis relies on mid-quote data, but we also use bid and ask quotes to construct transaction cost adjusted returns in the robustness checks. We focus on the end of month observations S_t and F_t in direct quotes. Namely, exchange rates are quoted in terms of units of US dollar (USD) per one unit of foreign currency (FCU). An increase in S_t refers to an appreciation of the FCU and a depreciation of the USD.[10]

Our main empirical analysis focuses on a sample consisting of fifteen exchange rates of developed economy currencies against the US dollar, including Australia, Belgium, Canada, Denmark, Euro Area, France, Germany, Italy, Japan, Netherlands, New Zealand, Norway, Sweden, Switzerland, and the United Kingdom. A similar sample has been used by Lustig et al. (2011) and Menkhoff et al. (2012). We denote it as the Developed Economies sample.[11] These currencies or G10 (after the Euro introduction in 1999) are highly liquid and account for more than 67% of the total trading volume of global FX markets (BIS 2016). They are also commonly used to construct currency strategies in practice. For instance, Deutsche Bank Currency Harvest is an ETF tracking currency

[10] In the robustness checks, we show that our results are robust to alternative quote currencies (Table A7 in the Internet Appendix).

[11] In the robustness checks, we show that our results hold for extended lists of countries (Table A5 in the Internet Appendix). We also reproduce our main empirical results using 37 developed and emerging currencies as in Lustig et al. (2011) (Table A8 to Table A13 in the Internet Appendix). Our main results remain valid.

carry trade performance using G10 currencies. Using these liquid and major currencies allows us to conduct sharper tests for our predictions based on prospect theory.

3.2 Currency Prospect Theory Value

In the spirit of Barberis et al. (2016), we construct a currency-level empirical measure of prospect theory value tk_t^i for currency i at time t. To do so, we consider a series of K consecutive spot exchange rate returns Δs from time $t-K+1$ to t . Suppose that among those K returns, there are m negative returns and n positive returns (so that $K = n+m$). Sorting them from negative to positive value in an ascending order, we re-denote them as:

$$\Delta s_{-m}, \frac{1}{K}; ...; \Delta s_{-1}, \frac{1}{K}; \Delta s_1, \frac{1}{K}; ...; \Delta s_n, \frac{1}{K}.$$

Assuming equal probability for each return over the period, therefore each probability is $\frac{1}{K}$. The prospect theory value (tk_t^i for Tversky & Kahneman (1992)) is constructed as follows,

$$\begin{aligned} tk_t^i = \sum_{i=-m}^{n} \pi_i v(\Delta s_i) = \; & \textstyle\sum_{i=-m}^{-1} v(\Delta s_i) \left[w^-(\frac{i+m+1}{K}) - w^-(\frac{i+m}{K}) \right] \\ & + \textstyle\sum_{i=1}^{n} v(\Delta s_i) \left[w^+(\frac{n-i+1}{K}) - w^+(\frac{n-i}{K}) \right], \end{aligned} \tag{1}$$

where $v(.)$ is the value function and π is the probability weighting function, i.e. the $w^-(.) - w^-(.)$ or $w^+(.) - w^+(.)$ for negative or positive returns respectively, and K is the number of returns within the period of interest. $w^-(.)$ and $w^+(.)$ are defined below.

We use exchange rate returns to compute prospect theory value, as it is intuitive to assess the attractiveness of a currency based on its historical price chart, and hence the past exchange rate return distribution. Following the literature, we set $K = 60$, namely, we rely on the past five years monthly exchange rate returns to construct a prospect theory value every month.[12]

[12] In the robustness checks, we also consider using distributions of currency excess returns to construct currency prospect theory values. We also show that our results are robust to a set of different K values. These results are documented in Table A1 in the Internet Appendix.

The functional forms of the value and probability weighting functions are specified as follows,

$$v(x) = \begin{cases} x^\alpha,\ x \geq 0 \\ -\lambda(-x)^\alpha,\ x < 0, \end{cases}$$

$$w^+(p) = \frac{P^\gamma}{(p^\gamma + (1-p)^\gamma)^{1/\gamma}},$$
$$w^-(p) = \frac{P^\delta}{(p^\delta + (1-p)^\delta)^{1/\delta}}.$$

Here, α, λ, γ, and δ are parameters for value and probability weighting functions. α governs the curvature of the value function. λ captures the severity of the kink. So higher the λ, more loss averse the investor is. γ and δ control the overweights of tails. Lower values of γ and δ imply more overweighting of tails. We use the set of original parameter values from Tversky & Kahneman (1992) based on experimental evidence, i.e. $\alpha = 0.88$, $\lambda = 2.25$, $\gamma = 0.61$, and $\delta = 0.69$. These parameter values are also used by Barberis et al. (2016) for individual stock returns.[13]

3.3 Currency Excess Returns and Control Variables

Currency excess return rx_{t+1} is defined as the return from buying one unit of foreign currency in the forward market and then liquidating the position in the spot market when the forward contract gets matures one month later:

$$rx_{t+1} = \frac{S_{t+1} - F_t}{S_t}. \tag{2}$$

Currency excess return can be further decomposed into two components, namely the spot exchange rate return $\Delta s_{t+1} = (S_{t+1} - S_t)/S_t$ and the forward discount $fd_t = (F_t - S_t)/S_t$.[14]

[13] In the robustness check, we also consider different components of the total prospect theory value (Table A4 in the Internet Appendix): loss version (1,2.25,1,1), convexity/concavity(0.8,1,1,1), and probability weighting (1,1,0.61,0.69) by adjusting the parameter values following Barberis et al. (2016).

[14] We follow the literature and use simple return rather than log return in our empirical analysis, to avoid the potential joint normality assumption in the later asset pricing tests. Nevertheless, results are qualitatively unchanged when log returns are used. Throughout our paper, we mainly use lower case variables to denote currency-specific or market-wide variables we used the empirical analysis and use capital letters to denote (tradable) risk factors or trading strategies to avoid potential confusions.

The first component, exchange rate return, is also the input variable we used to construct prospect theory value as described in Section 3.2. If covered interest rate parity (CIP) holds, the second component can also be closely approximated by the foreign to the US interest rate differentials.[15] Hence the return can be represented as

$$rx_{t+1} = \frac{S_{t+1} - S_t}{S_t} - \frac{F_t - S_t}{S_t} \approx \frac{S_{t+1} - S_t}{S_t} + (i_t^* - i_t), \tag{3}$$

where i_t^* and i_t refer to foreign and domestic one-month interest rates.

We also control for past returns that typically enter the momentum and value portfolio constructions. To construct currency momentum portfolios, we calculate the past three-month cumulative exchange rate returns ($rx_{t-3,t}$) as in Menkhoff et al. (2012) and Della Corte, Ramadorai & Sarno (2016). Following Asness et al. (2013) and Dahlquist & Hasseltoft (2020), we use the negative of the past five years real exchange rate changes ($rx_{t-5y,t}$) as the signal to form currency value portfolios. We collect monthly CPI data from the OECD main economic indicator database to construct the currency value signal.

Specifically, we define

$$\begin{aligned} rx_{t-3,t} &= \sum_{i=1}^{3} \Delta s_{t-i}, \\ rx_{t-5y,t} &= \log\left(\frac{\bar{S}_{t-5y}}{S_t}\right) - \left[\log\left(\frac{\bar{cpi}^*_{t-5y}}{cpi^*_t}\right) - \log\left(\frac{\bar{cpi}_{t-5y}}{cpi_t}\right)\right], \end{aligned}$$

where cpi_t and cpi_t^* are the CPI in the US and foreign country. $\bar{S}_{t-5y}$, $\bar{cpi}^*_{t-5y}$, and $\bar{cpi}_{t-5y}$ refer to the lagged 5 year (the average of 4.5 year and 5.5 year) exchange rates and CPIs. The detail constructions of currency portfolios and risk factors are described in the Internet Appendix A.

Table 1 presents summary statistics (Panel A) and correlations (Panel B) among variables of interest.[16]

[15] The CIP holds generally (Taylor 1987, Taylor 1989, Akram, Rime & Sarno 2008). A few recent studies suggest that CIP condition violates in the recent financial crisis (Rime, Schrimpf & Syrstad 2017, Du, Tepper & Verdelhan 2018).

[16] The past three-month cumulative exchange rate return ($rx_{t-3,t}$) has more observations than currency excess return, as it only relies on spot exchange rate data.

Table 1 about here

Currencies appreciate on average against the USD in our sample. The average excess return is 0.12% per month with a standard deviation of 3.01%. Forward discount is also positive on average. Despite positive excess returns, the average prospect theory value is negative. This means that loss-averse traders perceive declines in exchange rates during the sample more painfully than joy from currencies appreciation. Unconditionally, the prospect theory value is positively correlated with contemporaneous excess returns and negatively correlated with the forward discount. Hence high prospect theory value currencies have high past returns and lower interest rates relative to the US on average. The prospect theory value is also negatively correlated with the subsequent period currency excess return. This negative relation indicates these high prospect theory value currencies tend to depreciate in the future, consistent with our hypothesis 1. We resort to formal empirical analysis in the next section to examine the return predictive power of prospect theory value in currency markets.

4 Empirical Findings

4.1 Cross-Sectional Currency Return Predictability

In this section, we test the predictive relation between prospect theory value and future currency returns as described in hypothesis 1. We start by estimating the following panel regression

$$rx^i_{t+1} = \gamma_t + \beta_1 tk^i_t + \delta X^i_t + u^i_{t+1}, \tag{4}$$

where γ_t includes year and currency fixed effects dummies to absorb all omitted variables relate to time trend or a specific currency. The currency-specific control variables X^i_t include the forward discount fd^i_t, the past three-month cumulative exchange rate return $rx^i_{t-3,t}$, and the negative of the past five-year real exchange rate change $rx^i_{t-5y,t}$. These characteristics are typically used to form currency carry, momentum, and value portfolios and are related to future currency excess returns as shown in the literature. We aim to check whether the prospect theory value contains incremental predictive power for currency returns after controlling these existing predictors. The standard errors are clustered by currency to correct for estimation errors related to a specific currency. Table 2 presents the estimation results.

Table 2 about here

The prospect theory value is negatively related to the future excess returns and the coefficient in front of it is statistically significant at the 1% level. The magnitude is economically large: one standard deviation increase in tk_t value decreases the future excess returns by about 0.30% per month (about 3.60% per annum).[17] The effect is robust to the inclusion of the control variables.[18] Hence, our results not only support the negative predictive relation as mentioned in hypothesis 1 but also confirm that the predictive power is incremental to existing currency-level characteristics.

To assess the economic value of the predictability in more detail, we move on to construct currency prospect theory value portfolios. At the beginning of each month, we sort all currencies into five portfolios according to the value of tk_t. Currencies in portfolio 1 (P_1) have the lowest values of tk_t, namely they are more unattractive based on prospect theory and exchange rate return distribution. Currencies in portfolio 5 (P_5) have the highest values of tk_t, namely they are more appealing. We hold portfolios for one month and record their returns, and then re-balance portfolios according to the latest signals every month.

Table 3 about here

Table 3 presents main results for prospect theory value sorted currency portfolios. Currency excess returns (in Panel A) drop monotonically from P_1 (low tk_t value) to P_5 (high tk_t value). The long-short strategy (prospect theory premium or PTP) buying P_1 and shorting P_5 produces a statistically significant return spread of 0.42% per month (or 5.04% per year) and a Sharpe ratio of 0.17 per month (or 0.59 per year).[19] The strategy

[17]0.30% is calculated as 0.33 (coefficient) times 0.91% (standard deviation of independent variable).

[18]Results are qualitatively unchanged when monthly lagged excess return is included. Therefore the negative relation is not due to liquidity provision and short-term reversal.

[19]We use tk to denote the prospect theory value characteristics and PTP to denote the long-short strategy based on tk sorted portfolios to avoid any confusion.

also has positive skewness and moderate kurtosis. Hence the new strategy is unlikely to be affected by market crash risk. For exchange rate returns (in Panel B), we observe a similar monotonic decreasing pattern and significant return spread, suggesting that tk_t has predictive power for spot exchange rate returns. Namely, the spot exchange rate predictability rather than the persistent interest differentials better accounts for the return spread of prospect theory sorted portfolios. The positive skewness and the dominance of spot exchange rate predictability also differentiate the new strategy from carry trades.

Figure 1 about here

The decreasing patterns for both currency excess returns and exchange rate returns are also illustrated in Figure 1. Overall, our results provide strong evidence to support hypothesis 1, i.e. high prospect theory value currencies significantly underperform their low value pairs in future currency excess returns.

Table 4 about here

In addition to the predictive relation and the portfolio performance in time $t+1$, we are also interested in who are those high tk currencies and what properties do they present. In Table 4, we consider contemporaneous characteristics for tk sorted portfolios, when they are formed in time t. In contrast to the decreasing predictive pattern, as we observed in Table 3, we document an increasing tk-return relation for the contemporaneously sorted portfolios. High tk currencies have high average returns, low standard deviations, and positive skewness on average when we form portfolios. Results hold for both currency excess returns (Panel A) and exchange rate returns (Panel B). Namely, these currencies present appealing characteristics that investors are willing to hold, confirming their definition of high prospect theory value currencies.

These high tk currencies on average have low rate differentials, high past exchange rate returns, and low long-term real exchange rate changes (Panel C). Hence, one may wonder whether the profitability of the prospect theory value portfolio strategy is related to existing currency portfolio strategies, especially for carry trade, given the significant spread of forward discount. To address this concern, we report the top five currencies within each portfolio in terms of their frequencies (percentage of time in the portfolio) in Panel D. Low *tk* portfolio (P1) consists of traditional high-interest rate currencies such as Australian dollar (AUD) and New Zealand dollar (NZD), but also contains low-interest rate currencies, such as Japanese yen (JPY). High *tk* portfolio (P5) consists of traditional low-interest rate currencies such as Japanese yen (JPY) and Swiss francs (CHF), but also includes high-interest rate currency such as British pound (GBP). Therefore, although on average high *tk* portfolio has low-interest rate currencies, prospect theory value portfolios are essentially different from carry trade portfolios, consistent with the portfolio performance as shown in Table 3. High *tk* currencies are not necessarily safe-haven currencies either. Figure 2 illustrates the differential currency compositions of edge portfolios for prospect theory valued sorted portfolios and carry trade portfolios respectively.

Figure 2 about here

We also plot cumulative returns for the PTP strategy along with the cumulative returns of the three other well-known currency portfolio strategies: carry (CAR), momentum (MOM), and value (VAL) in Figure 3. See the Internet Appendix A for the construction of these factor strategies. It shows that the PTP strategy dominates the value strategy and outperforms the momentum strategy in most of the time. The new strategy also performs comparable with the carry strategy.[20] These portfolio results, along with the regression results in Table 2, support that the predictive power of prospect theory value for currency excess returns is unique, and it cannot be subsumed by existing currency characteristics.

Figure 3 about here

4.2 Asset Pricing Tests

Given the strong and negative predictive relation documented above, we then explore several potential explanations for the predictability. In this section, we first check risk-

[20] In an unreported analysis, we show that PTP has low correlations with existing currency factor strategies (0.15 with CAR, -0.13 with MOM, and 0.27 with VAL).

based explanations.

We consider whether the documented predictability can be rationalized by the compensations for existing known systematic risk factors. We empirically examine risk-based explanations from both time-series and cross-sectionally perspectives. Table 5 reports time-series regressions of our strategies on well-known risk factors used in the literature. We consider three categorize of factors: currency, equity, and hedge fund factors. The set of currency factors includes the dollar (DOL), carry (CAR), momentum (MOM), and value (VAL). As equity risk factors, we use the factors from Carhart (1997) including Fama & French (1992) market (MKT), size (SMB), value (HML) and the momentum (WML). Finally, the set of hedge fund factors include the bond (BO), currency (CU), commodity (CO) trend-following factors, the equity market (EQ), size spread (SS), bond market (BM) and credit spread (CS) factors of Fung & Hsieh (2004). We consider them here because hedge funds are important participants in currency markets, hence risk factors affecting their performance may also affect their trading on currencies. The descriptions of the factor constructions are presented in the Internet Appendix A. We regress PTP to these three sets of factors respectively using time-series spanning regressions. If PTP cannot be spanned by these risk factors, then the predictive power of tk is unlikely due to risk-based explanations.

Table 5 about here

PTP has positive exposure to the currency carry factor, negative exposure to momentum and value factors, but insignificant exposure to the dollar factor (see Panel A). PTP is also exposed to the equity market and momentum factors (see Panel B). Among the set of hedge fund factors, only the trend-following factor in commodity markets significantly associates with the returns to PTP (see Panel C). All these three categories of factor models explain only limited fractions of PTP variations. Specifically, currency factors, equity factors, and hedge fund factors explain 9.70%, 6.13%, and 1.58% of the total variations of PTP returns respectively. The abnormal returns (alphas) of PTP, controlling for these factors, are slightly lower but remain comparable in economic magnitudes to the return spread in Table 3. The abnormal returns drop to 0.41% per month (about

4.92% per year), 0.37% (about 4.48% per year), and 0.41% (about 4.93% per year) in the cases of currency, equity, and hedge fund factors. In all three cases, the alphas remain statistically significant at the 1% level. Therefore, the PTP strategy cannot be fully spanned by the considered risk factors.[21]

More generally, if the excess returns to PTP strategy serve as a compensation for bearing some sort of risk (either because of some omitted risk factor or stemming from the presence of irrational investors in the market, e.g., noise trader risk), we should observe a risk-return trade-off.[22] To test this prediction, we apply Fama & MacBeth (1973) two-stage regressions to conduct cross-sectional asset pricing tests. Previous asset pricing studies in currency markets largely rely on currency portfolios as main test assets, we instead focus on the individual currency-level asset pricing tests.[23] In the first stage, we run time-series regressions of each individual currency returns to risk factors to obtain factor loadings. We then run cross-sectional regressions of average currency returns on factor loadings in the second stage estimate risk price λ. We use Newey & West (1987) standard errors to obtain t-statistics. We use PTP along with other currency factors, i.e. dollar (DOL), carry (CAR), momentum (MOM), and value (VAL) factors as our main candidate risk factors. If PTP betas indeed explain the cross-sectional variations of currency excess returns, then PTP itself may represent a new source of risk or it may

[21] In an unreported analysis, we also consider reverse-spanning regressions. Specifically, we use the carry factor (CAR) as the dependent variable and prospect theory premium (PTP) as the independent variable. Carry alpha is 0.31% per month (3.78% per year) and it is marginally significant (t-statistics of 1.86). PTP coefficient is positive and significant (t-statistics of 2.29). Further including dollar, momentum, and value factors turns the carry alpha to insignificant (t-statistics of 1.49). PTP coefficient remains positive and significant (t-statistics of 2.55). These results, along with our findings in Table 5, support that prospect theory value contains distinctive predictive power for currency return, even though it has some overlapping with carry trade in currency compositions.

[22] As explained in Section 2, the predictive pattern may be interpreted as exposures to common factors. These common factors include not only traditional systematic risk factors but may also systematic mispricing factors (Stambaugh & Yuan 2017, Daniel et al. 2020). If the predictive relation can be explained by any common factors, we expect that the long-short return spread of tk sorted currency portfolios, i.e. PTP should be significantly correlated with these factors. Hence, if exposures to PTP are priced in currency returns, then this evidence supports the common factor pricing explanation.

[23] Recent studies (Lewellen, Nagel & Shanken 2010, Ang, Liu & Schwarz 2018) suggest that portfolios also create strong factor structure and destroy information by shrinking betas. The issue is particularly severe in currency markets when the dimension of portfolios is low (e.g. five portfolios). Lewellen et al. (2010) suggest that the strong factor structure of test portfolios may cause misleading asset pricing results, i.e. a model may have small pricing error and high cross-sectional R-square, even if the factor is not priced. Kan & Zhang (1999*a*) and Kan & Zhang (1999*b*) argue that even "useless factors", which do not have significant betas, may have significant prices of risks if test assets have a strong factor structure. Therefore, we consider the cross-section of individual currency excess returns as our main test assets.

capture some omitted risk factors.

In addition to the inclusion of factor betas, we also include the lagged prospect theory value tk_t to test if the cross-sectional predictability of prospect theory value survives after controlling for exposures to traditional risk factors. Besides, including tk_t also allows us to understand whether risk exposure or currency-specific characteristic (or mispricing) mainly drives currency returns.[24] We recognize that it is empirically challenging to fully disentangle betas (covariance risks) from characteristics. An analogue example in currency markets is explaining carry trade return with systematic risk exposures or characteristics (e.g. safe-haven currencies)(Lustig et al. 2011, Ranaldo & Soderlind 2010). However, if the characteristic is still associated with future returns when factor exposures are controlled , then we may cast doubt on the pure beta-based explanation for the prospect theory premium.

Table 6 about here

Table 6 presents cross-sectional asset pricing results. Two main findings are worth mentioning. Firstly, we observe that PTP beta is not significantly priced in the cross-section of individual currency returns. The insignificant price of risk estimate casts doubt on a risk-based explanation for the profitability of prospect theory value portfolio. [25] Secondly and more importantly, we find that the currency-level prospect theory value tk_{t-1} is negative and significantly related to future currency returns, even when factor betas are included. Our evidence suggests that prospect theory value characteristic (tk) dominants covariance risk (PTP betas) in explaining currency returns. Fully ruling out one explanation from another is difficult in the covariance vs. characteristic debate, especially

[24]See Daniel & Titman (1997), Daniel, Titman & Wei (2001), Davis, Fama & French (2000) for the covariance vs. characteristics debates.

[25]In addition to the currency-level asset pricing tests, we also consider PTP beta sorted portfolios in the Internet Appendix Table A14. If PTP is indeed priced in currency markets, we expect to observe significant return spreads for beta sorted portfolios. We find that the long-short return spread is statistically significant and is economically meaningful (0.40% per month or 4.80% per year). However, despite the significant return spreads, we observe that the beta-return relation is not monotonic. If PTP indeed represents a systematic risk factor, we expect to see a strictly monotonic beta-return relation. Moreover, we find that prospect theory value tk is monotonic decreasing in beta sorted portfolios, implying the high correlation between tk and PTP betas. Therefore, our results suggest that PTP is unlikely to be a systematic risk factor in currency markets.

when factor loadings and characteristics may be highly correlated. Our findings suggest that systematic exposures to common factors are unlikely to be the main source of the predictive power contained in currency prospect theory value, and hence do not support our hypothesis 2. Therefore, we proceed with alternative explanations (mispricing) to further understand the predictability.

4.3 Limits to Arbitrage, Sentiment, and Limited Attention

Our previous results show that risk-based explanations cannot fully rationalize the predictive power of prospect theory value. In this section, we provide further evidence about how limits to arbitrage and the speculative trading of irrational investors contribute to the predictability.

We first check whether the predictive power is consistent with explanations of limits to arbitrage. Existing studies (Pedersen, Mitchell & Pulvino 2007, Duffie 2010, Gromb & Vayanos 2010, Acharya, A.Lochstoer & Ramadorai 2013) show that limits to arbitrage can generate predictive return patterns, because market frictions may deploy arbitrage capital, which will subsequently affect future returns. Previous studies have already linked the profitability of currency momentum (Menkhoff et al. 2012, Filippou, Gozluklu & Taylor 2018), and that of currency volatility risk premia (Della Corte, Ramadorai & Sarno 2016) strategies to limits to arbitrage.

Intuitively, rational arbitragers are more likely to stop or postpone their arbitrage (mispricing correction) activities when the FX market is volatile and illiquid, the risk aversion is high, the funding constraint is tight, and the financial stress is high. If limits to arbitrage enhance the predictive pattern, we expect that the interaction term ($tk_{t-1} \times lta_{t-1}$) is negative and significant. Namely, it strengthens the negative predictive relation between tk and future currency returns.

We use panel data regression to understand the role of limits to arbitrage in explaining the predictability:

$$rx^i_{t+1} = \gamma^i_t + \beta_0 tk^i_t + \beta_1 tk^i_t \times lta_t + \beta_2 lta_t + X^i_t + u^i_{t+1}, \quad (5)$$

where lta denotes one of the aggregate limits to arbitrage proxies, X_t^i includes currency-specific characteristics including the forward discount, the past three-month cumulative exchange rate return, and the negative of the past five-year real exchange rate change, γ_t^i contains currency and time fixed effects dummies. For limits to arbitrage proxies, we consider FX volatility (vol^{FX}), FX illiquidity (bas) as well as arbitrage risk proxies used in Della Corte, Ramadorai & Sarno (2016): CBOE VIX (vix), TED spread (ted), and Fed FSI (fsi). FX volatility and FX illiquidity (bas) are constructed using the cross-sectional averages of the within-month daily standard deviation of exchange rate return and daily bid-ask spread. VIX is the 30-days option implied volatility index (VIX index) issued by the Chicago Board of Options Exchange (CBOE). TED spread is the yield difference between the 3-month US Treasury bill and the 3-month LIBOR. FSI is the financial stress index issued by the St. Louis Federal Reserve Bank. The measure uses the principal component of a set of volatility and liquidity measures to capture the degree of financial stress in the markets. We use the levels of these variables to measure limits to arbitrage. Standard errors are clustered at the currency level.

TABLE 7 ABOUT HERE

Table 7 presents limits to arbitrage results. We focus on the interaction term ($tk_{t-1} \times lta_{t-1}$). Consistently with our hypothesis 3, the interaction term is negative and significant when FX volatility, CBOE VIX, and Fed FSI are high. Namely, the negative predictive relation between prospect theory value and currency return is stronger when the FX market is volatile, when the global risk aversion is high, and when the degree of financial stress is high. These high limits to arbitrage periods make the correction for mispricing by rational arbitragers more difficult, hence mispricing (and the predictive relation) persists. When using the market average of currency bid-ask spreads as a measure of currency illiquidity, the effect tk_t on future excess returns weakens (the interaction is positive). One plausible explanation is that speculative trading activities also decline, similar to arbitrage activities, when the overall market is illiquid. Therefore, the decline of predictive power is in line with the reduction of speculative trading. For TED spread, the result is insignificant. Overall, our results show that limits to arbitrage matter for the predictability, but it is unlikely to be the sole driving force and the effects depend on the arbitrage risk measures.[26]

Next, we examine how the speculative demands of irrational traders affect the predictability. Intuitively, the presumption for the return predictive power of tk is that prospect theory investors account for a significant proportion of all investors. Therefore, we expect that when the speculative demands of these irrational investors are high or the number of irrational investors in the economy increases, the tk-return predictive relation due to mispricing should be stronger. Empirically, it is difficult to measure the latent and speculative demands of these irrational traders directly, especially in the disaggregate markets, such as currency markets. Therefore, we rely on two indirect proxies for the speculative demand: investor sentiment and retailer investor attention in our empirical analysis.

Previous studies (Baker & Wurgler 2006, Stambaugh, Yu & Yuan 2012, Antoniou, Doukas & Subrahmanyam 2013, Antoniou, Doukas & Subrahmanyam 2016) extensively document the important role of investor sentiment in affecting the cross-section of stock returns. In the FX market, Yu (2012) provides a sentiment-based explanation for the forward premium puzzle. We conjecture that, when the global investor sentiment is high, irrational investors in the FX market are more likely to speculate, or the proportion of irrational investors in the total currency investor population increases. Therefore, we expect that sentiment should enhance the negative predictive relation. We use the consumer confidence indices (CCI) from the Global Financial Database (GFD) for our sample economies to construct a global measure of investor sentiment.[27] We use the cross-sectional average of the country level log change of CCI to obtain a global measure

[26]In addition to aggregate limits to arbitrage risk proxies, we also consider the effect of currency-specific limits to arbitrage measures on the tk-return relation using a double sorted portfolio approach in the Internet Appendix Table A15. We also show that results vary when different measures are used. We find that the predictive relation is stronger when currency-specific idiosyncratic volatility is high, consistent with our prediction. Results using currency-specific bid-ask spread is insignificant. The tk-return relation remains strong regardless of whether the degree of covered interest rate parity (CIP) deviation is low or high.

[27]In the robustness check, we also use up to 32 available consumer confidence indices to construct a global sentiment index, when we consider a sample of developed and emerging economies in the Internet Appendix Table A12.

of sentiment (*sent*). We estimate the following panel data regression:

$$rx^i_{t+1} = \gamma^i_t + \beta_0 tk^i_t + \beta_1 tk^i_t \times sent_t + \beta_2 sent_t + X^i_t + u^i_{t+1}, \tag{6}$$

where X^i_t include currency-specific characteristics including the forward discount, the past three-month cumulative exchange rate return, and the negative of the past five-year real exchange rate change, γ^i_t contains currency and time fixed effects dummies. We cluster standard errors by currency.

Table 8 about here

Table 8 reports the estimation results. The prospect theory value tk_t remains negatively and significantly associated with future currency returns as before. The interaction term $tk_t \times sent_t$ is negative and highly significant. Therefore, our evidence supports that the negative predictive relation between tk_t and future currency returns is stronger when the global investor sentiment is high. When sentiment is high, more irrational investors trade speculatively, and hence they enlarge the mispricing captured by the prospect theory value. As a result, the predictive relation becomes stronger.

Baker & Wurgler (2006) suggest that investor sentiment affects the cross-section of stock returns through two channels: difficult to value (speculative trading) and limits to arbitrage. They also recognize that it is difficult to differentiate these two channels, as stocks that are more subject to speculative trading are usually also hard to value. Our empirical setting is slightly different, as we mainly focus on the effect of time-varying limits to arbitrage and sentiment on the cross-sectional return predictability. Our existing results already provide evidence to support the role of limits to arbitrage. We further proceed with an alternative measure of speculative trading, using limited investor attention.

Attention is a scarce cognitive resource (Kahneman 1973). Existing studies (Peng & Xiong 2006, Barber & Odean 2008, Da, Engelberg & Gao 2011) analyze the role of attention in affecting asset prices. More recently, Bali et al. (2019) show that the attention of retail investors is a driving force for the lottery-demand related phenomena in stock markets. Following the literature, we use the log change of Google searching volume (gsv) around the world from Google Trend to measure attention.[28] We focus on the Google searching volume (GSV) of six terms related to either foreign exchange or macro-fundamental variables: "FX", "GDP", "Inflation", "Unemployment", "Interest rate" and "Central bank".[29] The intuition is as follows. In the real world, investors have a limited capacity for attention. When important macroeconomic announcements or events occur, investors pay more attention to macro news, and hence their attention, or the ability to track and process other information declines, due to their limited attention capacity. Namely, they will pay less attention to other signals, such as the historical performance of exchange rates (price chart) or technical trading rules. Consequently, they are less likely to trade speculatively and to evaluate a currency according to prospect theory. Specifically, we expect the predictive power of tk drops when investor attention shifts to macro-fundamentals.

We consider the following specification.

$$rx^i_{t+1} = \gamma^i_t + \beta_0 tk^i_t + \beta_1 tk^i_t \times gsv_t + \beta_2 gsv_t + X^i_t + u^i_{t+1}, \tag{7}$$

where gsv_t is the log change of Google searching volume corresponding to one of the attention proxies, X^i_t include currency-specific characteristics including the forward discount, the past three-month cumulative exchange rate return, and the negative of the past five-year real exchange rate change, γ^i_t contains currency and time fixed effects dummies. We cluster standard errors by currency. We expect the interaction term of tk and gsv is positive and significant.

Table 9 about here

Table 9 reports the estimation results. The coefficient on tk^i_t remains negative and significant at the 1% level. The interaction terms $tk^i_t \times gsv_t$ are all positive and significant, in

[28] We initially search for the name of each currency, we do not find clear evidence as both the attention measure and the interaction with TK are generally insignificant. Hence, we move on the search for conventional macro-fundamental variables, which are critical for FX traders.

[29] Our empirical analysis in this part starts from January 2004 to match with the starting date of GSV data from Google Trend.

line with our prediction. Our results suggest that the tk-return relation is weakened when investors pay more attention to macroeconomic fundamentals. Therefore, investors pay less attention to exchange rate historical distribution (price chart) or technical trading rules. Consequently, the tk-return relation drops given the decline of speculative trading activities. Our findings provide evidence to support the speculative demand-based explanation for the predictability.

In summary, our empirical findings show that both limits to arbitrage and speculative demand of irrational trades contribute to understanding the predictive relation between prospect theory value and future currency excess returns.

5 Robustness Checks and Further Analysis

In this section, we briefly summarize our results for robustness checks and additional analysis reported in Tables A1 to A13 in the Internet Appendix. First, we consider alternative measures of prospect theory value (Table A1). Using different formation periods or replacing exchange rate changes by currency excess returns when constructing prospect theory value does not affect our main findings qualitatively. We also show that allowing for exponentially decaying of returns destroys the predictive relation. Replacing prospect theory value by expected utility value does not reproduce the predictive pattern. Hence, the functional form of prospect theory value, i.e. the way how currency investors evaluate the mentally represented risks, is critical to generate the documented predictive pattern.

Second, we investigate the performance of our strategy for different sub-sample periods (Table A2). The strategy PTP is significant in non-recession periods, while it is insignificant but still outperforms other currency strategies in recession periods. Furthermore, PTP remains significant both before and after financial crises. Therefore, our results are generally stable across different sub-sample periods.

Moreover, we also show that the strategy performance remains when we control for transaction costs (Table A3). All prospect theory value components, i.e. loss aversion, convexity/concave, and probability weighting contribute to the predictability (Table A4).

Portfolio results are qualitatively unchanged when we consider alternative numbers of currencies (Table A5), including Group 10 (G10) currencies, 20 developed and emerging currencies, and 37 developed and emerging currencies, as used in Lustig et al. (2011). Using 48 currencies, as in Menkhoff et al. (2012), turns the return spread to insignificant. Nevertheless, the negative relation retains.[30] The negative prospect theory value-return relation holds for different currencies in general. Our strategy remains profitable when controlling for other factors motivated by behavioral theories (Table A6) including skewness, extreme returns (MAX and MIN), and 52 week high and low returns (Boyer et al. 2010, Bali et al. 2011, Li & Yu 2012). Replacing USD by different quote currencies does not qualitatively affect our main findings (Table A7).

Finally, we reproduce our main empirical results using 37 developed and emerging currencies in Table A8 to Table A13. Our main results still hold true. Therefore, the predictive power of prospect theory value is pervasive for currencies in both developed and emerging economies in general.

In summary, our main findings remain valid when comprehensive robustness checks and additional tests are considered.

6 Conclusion

This paper empirically investigates prospect theory in currency markets. We conjecture that currencies with higher prospect theory values earn lower expected returns. Using the historical distribution of exchange rate returns, we construct a measure of the prospect theory value at the individual currency level. Our empirical evidence supports that the currency-level prospect theory value negatively and significantly predicts the subsequent month currency excess returns, even controlling for other currency characteristics. Moreover, a long-short strategy based on the prospect theory value generates statistically significant and economically tangible profits. The strategy has only moderate

[30] A possible explanation for the insignificant relation when 48 currencies are used is due to the illiquidity of some infrequently traded emerging currencies. As these currencies are unlikely to attract attention, investors may less likely to evaluate their historical distributions in the way described by prospect theory. And hence the *tk*-return relation is weaker. The idea is consistent with our findings in Section 4.3. Market illiquidity destroys rather than enhances the predictive power of prospect theory value, as it may depress not only rational arbitrage activities but also speculative trading activities.

correlations with existing currency factor strategies.

We then explore several potential explanations for the predictability. We show that the predictability can hardly be explained by exposures to common factors. Instead, the predictability is in line with the mispricing at the individual currency level. We find that both limits to arbitrage and the speculative demands of irrational investors contribute to the predictive relation. Our main results remain strong after conducting a set of comprehensive robustness checks.

Overall, this paper provides novel empirical evidence that the prospect theory value is an important and non-redundant driver for the cross-sectional variations of currency excess returns.

References

Acharya, V., A.Lochstoer, L. & Ramadorai, T. (2013), 'Limits to arbitrage and hedging: evidence from commodity markets', *Journal of Financial Economics* **109**, 441–465.

Akram, Q. F., Rime, D. & Sarno, L. (2008), 'Arbitrage in the foreign exchange market: Turning on the microscope', *Journal of International Economics* **76**(2), 237–253.

Allen, H. & Taylor, M. P. (1990), 'Charts, noise and fundamentals in the London foreign exchange market', *Economic Journal* **100**(400), 49–59.

Ang, A., Liu, J. & Schwarz, K. (2018), 'Using stocks or portfolios in tests of factor models', *American Economic Review* . forthcoming.

Antoniou, C., Doukas, J. A. & Subrahmanyam, A. (2013), 'Cognitive dissonance, sentiment, and momentum', *Journal of Financial and Quantitative Analysis* **48**(1), 245–275.

Antoniou, C., Doukas, J. A. & Subrahmanyam, A. (2016), 'Investor sentiment, beta, and the cost of equity capital', *Management Science* **62**(2), 347–367.

Asness, C. S., Moskowitz, T. J. & Pedersen, L. H. (2013), 'Value and momentum everywhere', *Journal of Finance* **68**(3), 929–985.

Avramov, D., Cheng, S. & Hameed, A. (2016), 'Time-varying liquidity and momentum profits', *Journal of Financial and Quantiative Analysis* **51**(6), 1897–1923.

Baker, M. & Wurgler, J. (2006), 'Investor sentiment and the cross-Section of stock returns', *Journal of Finance* **61**(4), 1645–1680.

Bali, T. G., Cakici, N. & Whitelaw, R. F. (2011), 'Maxing out: Stocks as lotteries and the cross-section of expected returns', *Journal of Financial Economics* **99**(2), 427–446.

Bali, T. G., Hirshleifer, D. A., Peng, L. & Tang, Y. (2019), Attention, social interaction, and investor attraction to lottery stocks, Working papers series, Baruch College Zicklin School.

Barber, B. M. & Odean, T. (2008), 'All that glitters: The effect of attention and news on the buying behavior of individual and institutional Investors', *Review of Financial Studies* **21**(2), 785–818.

Barberis, N. & Huang, M. (2008), 'Stocks as lotteries: The implications of probability weighting for security prices', *American Economic Review* **98**(5), 2066–2100.

Barberis, N., Huang, M. & Santos, T. (2001), 'Prospect theory and asset prices', *Quarterly Journal of Economics* **116**(1), 1–53.

Barberis, N., Mukherjee, A. & Wang, B. (2016), 'Prospect theory and stock returns: An empirical test', *Review of Financial Studies* **29**(11), 3068–3107.

Beber, A., Breedon, F. & Buraschi, A. (2010), 'Differences in beliefs and currency risk premiums', *Journal of Financial Economics* **98**(3), 415–438.

Benartzi, S. & Thaler, R. H. (1995), 'Myopic loss aversion and the equity premium puzzle', *The Quarterly Journal of Economics* **110**(1), 73–92.

BIS (2016), Foreign exchange turnover in april 2016, Triennial central bank survey, Bank of International Settlement.

Boehmer, E. & Kelley, E. K. (2009), 'Institutional investors and the informational efficiency of prices', *Review of Financial Studies* **22**(9), 3563–3594.

Boyer, B., Mitton, T. & Vorkink, K. (2010), 'Expected idiosyncratic skewness', *Review of Financial Studies* **23**(1), 169–202.

Burnside, C., Eichenbaum, M. & Rebelo, S. (2011), 'Carry trade and momentum in currency markets', *Annual Review of Financial Economics* **3**(1), 511–535.

Burnside, C., Han, B., Hirshleifer, D. & Wang, T. Y. (2011), 'Investor overconfidence and the forward premium puzzle', *Review of Economic Studies* **78**(2), 523–558.

Campbell, J., Ramadorai, T. & Schwartz, A. (2009), 'Caught on tape: Institutional trading, stock returns, and earnings announcements', *Journal of Financial Economics* **92**(1), 66–91.

Carhart, M. M. (1997), ' On persistence in mutual fund performance', *Journal of Finance* **52**(1), 57–82.

Chabi-Yo, F. & Song, Z. (2012), Probability weighting of rare events and currency returns, Working papers series, Ohio State University.

Colacito, R. & Croce, M. M. (2013), 'International asset pricing with recursive preferences', *Journal of Finance* **68**(6), 2651–2686.

Colacito, R., Croce, M. M., Gavazzoni, F. & Ready, R. (2018), 'Currency risk factors in a recursive multicountry economy', *Journal of Finance* **73**(6), 2719–2756.

Colacito, R., Riddough, S. J. & Sarno, L. (2020), 'Business cycle and currency returns', *Journal of Financial Economics* **137**(3), 659–678.

Conrad, J., Dittmar, R. F. & Ghysels, E. (2013), 'Ex ante skewness and expected stock returns', *Journal of Finance* **68**(1), 85–124.

Da, Z., Engelberg, J. & Gao, P. (2011), 'In search of attention', *Journal of Finance* **66**(5), 1461–1499.

Dahlquist, M. & Hasseltoft, H. (2020), 'Economic momentum and currency returns', **136**(1), 152–167.

Daniel, K. D., Hirshleifer, D. A. & Sun, L. (2020), 'Short- and long-horizon behavioral factors', *Review of Financial Studies* . forthcoming.

Daniel, K. & Titman, S. (1997), 'Evidence on the characteristics of cross sectional variation in stock returns', *Journal of Finance* **52**(1), 1–33.

Daniel, K., Titman, S. & Wei, J. (2001), ' Explaining the cross-section of stock returns in Japan: Factors or characteristics?', *Journal of Finance* **56**(2), 743–766.

Davis, J. L., Fama, E. F. & French, K. R. (2000), 'Characteristics, covariances, and average returns: 1929 to 1997', *Journal of Finance* **55**(1), 389–406.

De Long, B., Shleifer, A., Summers, L. & Waldman, R. (1990), ‘Noise trader risk in financial markets’, *Journal of Political Economy* **98**(4), 703–738.

Della Corte, P., Ramadorai, T. & Sarno, L. (2016), ‘Volatility risk premia and exchange rate predictability’, *Journal of Financial Economics* **120**(1), 21–40.

Della Corte, P., Riddiough, S. J. & Sarno, L. (2016), ‘Currency premia and global imbalances’, *Review of Financial Studies* **29**(8), 2161–2193.

Du, W., Tepper, A. & Verdelhan, A. (2018), ‘Deviations from covered interest rate parity’, *Journal of Finance* **73**(3), 915–957.

Duffie, D. (2010), ‘Presidential address: Asset price dynamics with slow-moving capital’, *Journal of Finance* **65**(4), 1237–1267.

Engel, C. & West, K. D. (2005), ‘Exchange rates and fundamentals’, *Journal of Political Economy* **113**(3), 485–517.

Fama, E. F. & French, K. R. (1992), ‘The cross-section of expected stock returns’, *Journal of Finance* **47**(2), 427–65.

Fama, E. F. & MacBeth, J. D. (1973), ‘Risk, return, and equilibrium: Empirical tests’, *Journal of Political Economy* **81**(3), 607–636.

Filippou, I., Gozluklu, A. E. & Taylor, M. P. (2018), ‘Global political risk and currency momentum’, *Journal of Financial and Quantitative Analysis* **53**(5), 2227–2259.

Frankel, J. A. & Froot, K. A. (1990), ‘Chartists, fundamentalists, and trading in the foreign exchange market’, *American Economic Review* **80**(2), 181–185.

Fung, W. & Hsieh, D. A. (2004), ‘ Hedge fund benchmarks: A risk-factor-based approach’, *Financial Analyst Journal* **60**, 65–80.

Goetzmann, W. N., Kim, D., Kumar, A. & Wang, Q. (2015), ‘Weather-induced mood, institutional investors, and stock returns’, *Review of Financial Studies* **28**(1), 73–111.

Gromb, D. & Vayanos, D. (2010), 'Limits of arbitrage: the state of the theory', *Annual Review of Financial Economics* **2**, 251–275.

Hsu, P.-H., Taylor, M. P. & Wang, Z. (2016), 'Technical trading: Is it still beating the foreign exchange market?', *Journal of International Economics* **102**, 188–208.

Ilut, C. (2012), 'Ambiguity aversion: Implications for the uncovered interest rate parity puzzle', *American Economic Journal: Macroeconomics* **4**(3), 33–65.

Kahneman, D. (1973), *Attention and Effort*, Prentice-Hall, Englewood Cliffs, NJ.

Kahneman, D. & Tversky, A. (1979), 'Prospect theory: An analysis of decision under risk', *Econometrica* **47**(2), 263–291.

Kan, R. & Zhang, C. (1999*a*), 'GMM tests of stochastic discount factor models with useless factors', *Journal of Financial Economics* **54**(1), 103–127.

Kan, R. & Zhang, C. (1999*b*), 'Two-pass tests of asset pricing models with useless factors', *Journal of Finance* **54**(1), 203–235.

Keynes, J. M. (1936), *The General Theory of Employment, Interest, and Money.*

Kozhan, R. & Salmon, M. (2009), 'Uncertainty aversion in a heterogeneous agent model of foreign exchange rate formation', *Journal of Economic Dynamics and Control* **33**(5), 1106–1122.

Kumar, A. (2009), 'Who gambles in the stock market?', *Journal of Finance* **64**(4), 1889–1933.

Lewellen, J., Nagel, S. & Shanken, J. (2010), 'A skeptical appraisal of asset pricing tests', *Journal of Financial Economics* **96**(2), 175–194.

Li, J. & Yu, J. (2012), 'Investor attention, psychological anchors, and stock return predictability', *Journal of Financial Economics* **104**(2), 401–419.

Lustig, H., Roussanov, N. & Verdelhan, A. (2011), 'Common risk factors in currency markets', *Review of Financial Studies* **24**(11), 3731–3777.

Lustig, H. & Verdelhan, A. (2007), 'The cross section of foreign currency risk premia and consumption growth risk', *American Economic Review* **97**(1), 89–117.

Mark, N. C. (1995), 'Exchange rates and fundamentals: Evidence on long-horizon predictability', *American Economic Review* **85**(1), 201–218.

Meese, R. A. & Rogoff, K. (1983), 'Empirical exchange rate models of the seventies : Do they fit out of sample?', *Journal of International Economics* **14**(1-2), 3–24.

Menkhoff, L., Sarno, L., Schmeling, M. & Schrimpf, A. (2012), 'Currency momentum strategies', *Journal of Financial Economics* **106**(3), 660–684.

Menkhoff, L., Sarno, L., Schmeling, M. & Schrimpf, A. (2017), 'Currency value', *Review of Financial Studies* **30**(2), 416–441.

Menkhoff, L. & Taylor, M. P. (2007), 'The obstinate passion of foreign exchange professionals: Technical analysis', *Journal of Economic Literature* **45**(4), 936–972.

Neely, C. J. & Weller, P. A. (2012), Technical analysis in the foreign exchange market, *in* J. James, I. W. Marsh & L. Sarno, eds, 'Handbook of Exchange Rates', John Wiley & Sons.

Neely, C. J., Weller, P. A. & Ulrich, J. M. (2009), 'The adaptive markets hypothesis: Evidence from the foreign exchange market', *Journal of Financial and Quantitative Analysis* **44**(2), 467–488.

Newey, W. K. & West, K. D. (1987), 'A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix', *Econometrica* **55**(3), 703–08.

Pedersen, L. H., Mitchell, M. & Pulvino, T. (2007), 'Slow moving capital', *American Economic Review* **97**(2), 215–220.

Peng, L. & Xiong, W. (2006), 'Investor attention, overconfidence and category learning', *Journal of Financial Economics* **80**(3), 563–602.

Quiggin, J. C. (1993), *Generalized Expected Utility*, Kluwer-Nijhoff, Amsterdam.

Ranaldo, A. & Soderlind, P. (2010), 'Safe haven currencies', *Review of Finance* **14**(3), 385–407.

Rime, D., Schrimpf, A. & Syrstad, O. (2017), Segmented money markets and covered interest parity arbitrage, Working papers series, BI Norwegian Business School.

Rossi, B. (2013), 'Exchange rate predictability', *Journal of Economic Literature* **51**(4), 1063–1119.

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

Stambaugh, R. F., Yu, J. & Yuan, Y. (2012), 'The short of it: Investor sentiment and anomalies', *Journal of Financial Economics* **104**(2), 288–302.

Stambaugh, R. F. & Yuan, Y. (2017), 'Mispricing factors', *Review of Financial Studies* **30**(4), 1270–1315.

Stein, J. C. (2009), 'Presidential address: Sophisticated investors and market efficiency', *Journal of Finance* **64**(4), 1517–1548.

Taylor, M. P. (1987), 'Covered interest parity: A high-frequency, high-quality data study', *Economica* **54**(216), 429–438.

Taylor, M. P. (1989), 'Covered interest arbitrage and market turbulence', *Economic Journal* **99**(396), 376–391.

Taylor, M. P. & Allen, H. (1992), 'The use of technical analysis in the foreign exchange market', *Journal of International Money and Finance* **11**(3), 304–314.

Tversky, A. & Kahneman, D. (1992), 'Advances in prospect theory: Cumulative representation of uncertainty', *Journal of Risk and Uncertainty* **5**(4), 297–323.

Verdelhan, A. (2010), 'A habit-based explanation of the exchange rate risk premium', *Journal of Finance* **65**(1), 123–146.

Verdelhan, A. (2018), 'The share of systematic variation in bilateral exchange rates', *Journal of Finance* **73**(1), 375–418.

Yogo, M. (2006), 'A consumption based explanation of expected stock returns', *Journal of Finance* **61**(2), 539–580.

Yu, J. (2012), 'A sentiment-based explanation of the forward premium puzzle', *Journal of Monetary Ecconomics* **60**(4), 474–491.

Zhong, X. & Wang, J. (2018), 'Prospect theory and corporate bond returns: An empirical study', *Journal of Empirical Finance* **47**, 25–48.

Tables and Figures

Table 1: Summary Statistics

This table reports summary statistics of monthly currency excess returns and characteristics (Panel A) and the correlations among the variables (Panel B). The sample runs from January 1990 to February 2018 and covers 15 currencies of developed economies. rx is the currency excess return, fd is the forward discount, tk is the prospect theory value, $rx_{t-3,t}$ is the cumulative exchange rate return over the previous three months, $rx_{t-5y,t}$ is the negative of the past five-year real exchange rate change. Currency excess returns and characteristics are reported in percentage points.

Panel A: Currency Returns and Characteristics

	Mean	Std.dev	Min	Max	Nr.obs.
rx_t	0.12	3.01	-15.70	16.90	3,735
fd_t	0.07	0.26	-2.80	2.21	3,740
$rx_{t-3m,t}$	0.18	4.70	-33.80	24.30	5,085
$rx_{t-5y,t}$	-0.63	5.82	-18.70	24.80	3,875
tk_t	-2.55	0.91	-5.16	-0.02	3,740

Panel B: Correlations

	rx_t	fd_t	$rx_{t-3,t}$	$rx_{t-5y,t}$	tk_t
fd_t	0.07				
$rx_{t-3m,t}$	0.59	0.12			
$rx_{t-5y,t}$	0.00	-0.10	-0.04		
tk_t	0.09	-0.19	0.18	-0.08	
rx_{t+1}	0.07	0.04	0.08	0.02	-0.03

Table 2: Multivariate Regression Analysis

This table presents the estimates of the following panel regression $rx^i_{t+1} = \gamma^i_t + \beta_1 tk^i_t + \delta X^i_t + u^i_{t+1}$, where rx^i_{t+1} is the currency i excess return at month $t+1$, tk^i_t is the prospect theory value for currency i at time t, γ^i_t contains year and currency fixed effects dummied. The set of control variables X consists of the forward discount fd_t, the cumulative exchange rate return over the past three months $rx_{t-3,t}$, and the negative of the past five-year real exchange rate change $rx_{t-5y,t}$. t-statistics (reported in brackets) are based on standard errors clustered by currency. The sample runs from January 1990 to February 2018 and covers 15 currencies for developed economies.

	(1)	(2)	(3)	(4)	(5)
tk_{t-1}	-0.33	-0.34	-0.34	-0.36	-0.36
	[-4.04]	[-4.03]	[-3.62]	[-4.57]	[-4.06]
fd_{t-1}		-0.02			-0.01
		[-0.11]			[-0.03]
$rx_{t-3,t}$			0.00		0.00
			[0.18]		[0.21]
$rx_{t-5y,t}$				0.01	0.01
				[1.95]	[2.01]
Year FE	Yes	Yes	Yes	Yes	Yes
Curr FE	Yes	Yes	Yes	Yes	Yes
Nr.Obs	3,639	3,639	3,639	3,597	3,597
R^2	6.63%	6.63%	6.63%	6.72%	6.72%

Table 3: Prospect Theory Value Sorted Portfolios

This table reports excess returns and characteristics of prospect theory value sorted portfolios from January 1990 to February 2018 for the sample of 15 currencies for developed economies. P_1 to P_5 are portfolios sorted by prospect theory value (tk) from low to high. AVG and PTP (or low minus high) are average portfolio returns and returns of a strategy shorting high prospect theory value (P_5) and buying low prospect theory value portfolio (P_1). Returns are not adjusted for transaction costs. Monthly average returns and standard deviations are reported in percentage points. Skewness, kurtosis, monthly Sharpe ratio, and first order autocorrelation coefficients are reported. Figures in brackets are t-statistics based on Newey and West (1987) standard errors with optimal lag by Andrews (1991). We consider both currency excess return (Panel A) and the exchange rate return component (Panel B).

	P_1	P_2	P_3	P_4	P_5	AVG	PTP
	Panel A: Currency Excess Returns						
$Mean$	0.37	0.19	0.09	-0.02	-0.05	0.12	0.42
	[2.02]	[1.11]	[0.53]	[-0.14]	[-0.38]	[0.82]	[3.14]
$Std.dev$	3.04	2.86	2.82	2.50	2.15	2.33	2.44
$Skew$	-0.14	-0.05	-0.16	-0.27	-0.26	-0.18	0.23
$Kurt$	5.06	3.33	3.23	4.64	5.77	3.79	4.49
SR	0.12	0.07	0.03	-0.01	-0.02	0.05	0.17
$AR(1)$	0.09	0.03	0.09	0.01	0.11	0.09	0.10
p	(0.14)	(0.59)	(0.09)	(0.90)	(0.09)	(0.11)	(0.12)
	Panel B: Exchange Rate Returns						
$Mean$	0.23	0.12	0.05	-0.03	-0.08	0.06	0.31
	[1.28]	[0.71]	[0.29]	[-0.24]	[-0.60]	[0.41]	[2.29]
$Std.dev$	3.03	2.84	2.82	2.50	2.14	2.32	2.44
$Skew$	-0.18	-0.07	-0.19	-0.37	-0.21	-0.22	0.16
$Kurt$	5.15	3.35	3.32	4.92	5.82	3.86	4.60
SR	0.08	0.04	0.02	-0.01	-0.04	0.02	0.13
$AR(1)$	0.08	0.02	0.09	0.01	0.11	0.09	0.11
p	(0.16)	(0.70)	(0.11)	(0.83)	(0.11)	(0.14)	(0.10)

Table 4: Portfolio Characteristics and Compositions: Contemporaneous Sorts

This table reports excess returns and characteristics of prospect theory value contemporaneously sorted portfolios from January 1990 to February 2018 for the sample of 15 currencies for developed economies. P_1 to P_5 are prospect theory value sorted portfolios from low to high. AVG and PTP (or low minus high) are average portfolio returns and returns of a strategy shorting high prospect theory value (P_5) and buying low prospect theory value portfolio (P_1). We record average returns and characteristics values at the time portfolios are formed (contemporaneously). Returns are not adjusted for transaction costs. Monthly average returns and standard deviations are reported in percentage points. Skewness, kurtosis and monthly Sharpe ratio are reported. Figures in brackets are t-statistics based on Newey and West (1987) standard errors with optimal lag by Andrews (1991). We consider both currency excess return (Panel A) and the exchange rate return component (Panel B). We report average values of characteristics for each portfolio (in percentage points) in Panel C. We also report top 5 currencies in terms of their frequencies (in parenthesis) of each portfolio in Panel D. Namely, the percentage of time a currency is allocated into a specific portfolio.

	P_1	P_2	P_3	P_4	P_5	AVG	PTP
			Panel A: Currency Excess Returns				
$Mean$	0.09	0.08	0.14	0.13	0.24	0.13	0.15
	[0.43]	[0.40]	[0.91]	[0.90]	[2.01]	[0.94]	[0.90]
$Std.dev$	3.18	2.98	2.70	2.55	1.96	2.32	2.70
$Skew$	-0.28	-0.23	-0.23	0.01	0.29	-0.19	0.40
$Kurt$	4.69	3.51	3.96	4.37	4.49	3.80	6.53
SR	0.03	0.03	0.05	0.05	0.12	0.06	0.06
			Panel B: Exchange Rate Returns				
$Mean$	-0.06	0.00	0.10	0.12	0.21	0.07	0.27
	[-0.29]	[0.01]	[0.63]	[0.86]	[1.82]	[0.53]	[1.61]
$Std.dev$	3.17	2.97	2.71	2.53	1.95	2.31	2.69
$Skew$	-0.35	-0.27	-0.23	0.00	0.33	-0.23	0.52
$Kurt$	4.83	3.63	4.02	4.37	4.66	3.87	7.00
SR	-0.02	0.00	0.04	0.05	0.11	0.03	0.10
			Panel C: Other Characteristics				
fd_t	0.14	0.09	0.05	0.08	0.02	0.07	-0.13
	[5.52]	[3.32]	[2.03]	[2.09]	[0.51]	[3.18]	[-4.40]
$rx_{t-3m,t}$	0.04	0.15	0.27	0.19	0.60	0.25	0.56
	[0.07]	[0.29]	[0.62]	[0.48]	[1.84]	[0.62]	[1.15]
$rx_{t-5y,t}$	-0.78	-0.64	-0.84	-0.89	-0.20	-0.67	0.58
	[-1.11]	[-0.86]	[-1.23]	[-1.40]	[-0.36]	[-1.10]	[1.03]
tk	-3.33	-2.80	-2.57	-2.31	-1.73	-2.55	1.60
	[-30.81]	[-27.77]	[-25.65]	[-25.04]	[-24.05]	[-28.19]	[20.24]

Panel D: Portfolio Compositions

	P_1	P_2	P_3	P_4	P_5
$1st$	AUD (0.54)	NOK (0.52)	DKK (0.29)	DKK (0.35)	CAD (0.52)
$2nd$	NZD (0.41)	SEK (0.33)	GBP (0.22)	CAD (0.28)	JPY (0.44)
$3rd$	JPY (0.27)	NZD (0.21)	FRF (0.22)	CHF (0.22)	CHF (0.32)
$4th$	NOK (0.24)	CHF (0.19)	SEK (0.20)	AUD (0.18)	GBP (0.28)
$5th$	GBP (0.24)	GBP (0.15)	CHF (0.17)	SEK (0.17)	NZD (0.19)

Table 5: Asset Pricing: Time Series Tests

This table reports time series asset pricing tests for long-short strategy returns based on prospect theory value (or prospect theory premium PTP) from January 1990 to February 2018 for the sample of 15 currencies for developed economies. The dependent variable is the monthly excess returns on PTP strategy and the independent variables are the returns on the set of existing risk factors. We consider three sets of factors. Currency factors include dollar (DOL), carry (CAR), momentum (MOM), value (VAL). Equity factors include market (MKT), book to market value (HML), size (SMB), equity momentum (WML). Hedge fund factors include the bond (BO), currency (CU), and commodity (CO) trend-following factors, and the equity market (EQ), size spread (SS), bond market (BM) and credit spread (CS) factors of Fung and Hsieh (2004). We report α, βs, and adjusted R^2s. Numbers in brackets are t-statistics based on Newey-West standard errors. Monthly abnormal returns and betas are reported in percentage points.

Panel A: Currency Factors

α	β_{DOL}	β_{CAR}	β_{MOM}	β_{VAL}	$\bar{R}^2$
0.41	-1.35	13.63	-11.57	-26.13	9.70%
[3.30]	[-0.20]	[2.79]	[-2.08]	[-2.37]	

Panel B: Equity Factors

α	β_{MKT}	β_{HML}	β_{SMB}	β_{WML}	$\bar{R}^2$
0.37	9.35	6.06	7.43	-7.20	6.13%
[2.94]	[2.38]	[1.33]	[1.18]	[-2.43]	

Panel C: Hedge Fund Factors

α	β_{BO}	β_{CU}	β_{CO}	β_{EQ}	β_{SS}	β_{BM}	β_{CS}	$\bar{R}^2$
0.41	-1.14	0.54	-3.07	3.61	-0.63	51.52	46.72	1.58%
[2.99]	[-0.87]	[0.65]	[-2.57]	[0.69]	[-0.13]	[0.54]	[0.26]	

Table 6: Asset Pricing: Cross-Sectional Tests

This table reports individual currency-level asset pricing results for the sample of 15 currencies for developed economies. We use Fama-MacBeth two-stage regression to estimate price of risk. The dependent variable is the monthly unconditional individual currency excess return. The independent variables are the betas of the corresponding currency excess return on the following risk factors: dollar (DOL), carry (CAR), momentum (MOM), value (VAL), and the excess returns on the prospect theory value (PTP). We also include the lagged prospect theory value tk_{t-1}. Numbers in brackets are t-statistics based on Newey-West standard errors. Regression coefficients are reported in percentage points.

	(1)	(2)	(3)	(4)
β_{PTP}	-0.79	-0.49	0.00	-0.42
	[-1.45]	[-0.83]	[0.00]	[-0.64]
β_{DOL}	0.20	-0.04	0.04	-0.52
	[0.67]	[-0.13]	[0.10]	[-0.80]
β_{CAR}			0.61	0.51
			[0.44]	[0.35]
β_{MOM}			-0.04	-0.08
			[-0.03]	[-0.04]
β_{VAL}			-1.60	-0.05
			[-1.69]	[-0.04]
tk_{t-1}		-20.82		-38.50
		[-2.23]		[-2.01]
$Const$	0.02	-0.38	-0.11	-0.48
	[0.15]	[-1.71]	[-0.67]	[-1.89]
R^2	33.98%	47.45%	70.62%	80.32%

Table 7: Limits to Arbitrage

This table presents the estimates of the following panel regression $rx^i_{t+1} = \gamma^i_t + \beta_1 tk^i_t + \beta_2 tk^i_t \times la_t + \beta_3 la_t + \delta X^i_t + u^i_{t+1}$, where rx^i_{t+1} is the monthly currency i excess return at time $t+1$, tk^i_t is the prospect theory value for currency i at time t, γ^i_t contains year and currency fixed effects dummies. The set of control variables X consists of the forward discount fd^i_t, the cumulative exchange rate return over the past three months $rx_{t-3,t}$, and the negative of the past five-year real exchange rate change $rx_{t-5y,t}$. The limit to arbitrage variable lta_t corresponds to one of the following proxies: FX volatility vol^{FX}, FX illiquidity bas as well as arbitrage risk proxies used in (Della Corte, Ramadorai & Sarno 2016): CBOE VIX (vix), TED spread (ted), and Fed FSI (fsi). We use levels of these variables. t-statistics (reported in brackets) are based on standard errors clustered by currency. The sample runs from January 1990 to February 2018 and covers 15 currencies for developed economies.

	vol^{FX}	bas^{FX}	vix	ted	fsi
tk_{t-1}	0.06	-0.48	0.49	-0.39	-0.25
	[0.23]	[-6.11]	[3.08]	[-5.61]	[-2.89]
$tk_{t-1} \times lta_{t-1}$	-115.91	58.32	-4.11	0.10	-0.16
	[-1.91]	[2.92]	[-6.29]	[1.02]	[-4.56]
lta_{t-1}	-4.41	1.70	-0.08	0.00	0.00
	[-2.11]	[2.90]	[-4.75]	[0.40]	[1.27]
fd_{t-1}	-0.02	-0.05	0.26	0.16	0.14
	[-0.08]	[-0.18]	[0.95]	[0.54]	[0.48]
$rx_{t-3,t}$	0.00	0.00	0.00	-0.02	-0.01
	[0.13]	[0.09]	[0.00]	[-1.12]	[-0.48]
$rx_{t-5y,t}$	0.02	0.01	0.02	0.03	0.03
	[2.28]	[1.92]	[3.19]	[3.18]	[3.39]
Curr FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Cluster	Currency	Currency	Currency	Currency	Currency
Nr.Obs	3,597	3,597	2,996	2,996	2,996
R^2	7.02%	6.89%	8.67%	7.88%	8.04%

Table 8: Investor Sentiment

This table presents the estimates of the following panel regression $rx^i_{t+1} = \gamma^i_t + \beta_1 tk^i_t + \beta_2 tk^i_t \times sent_t + \beta_3 sent_t + \delta X^i_t + u^i_{t+1}$, where rx^i_{t+1} is the monthly currency i excess return at time $t+1$, tk^i_t is the prospect theory value for currency i at time t, γ^i_t contains year and currency fixed effects dummies. The set of control variables X^i_t consists of the forward discount fd^i_t, the cumulative exchange rate return over the past three months $rx_{t-3,t}$, and the negative of the past five-year real exchange rate change $rx_{t-5y,t}$. The investor sentiment variable $sent_t$ is defined as the cross-sectional average of the log change of the country-level consumer confidence index. t-statistics (reported in brackets) are based on standard errors clustered by currency. The sample runs from January 1990 to February 2018 and covers 15 currencies for developed economies.

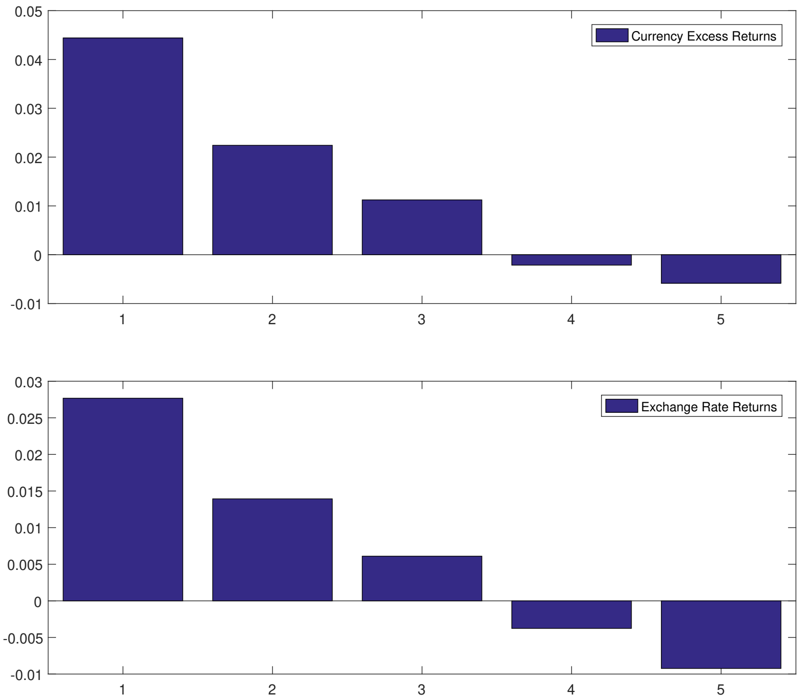
tk	-0.35	-0.39
	[-3.97]	[-4.01]
$tk \times sent$	-56.47	-51.83
	[-3.06]	[-2.63]
$sent$	-1.58	-1.49
	[-2.87]	[-2.62]
fd		-0.01
		[-0.05]
$rx_{t-3,t}$		0.00
		[0.24]
$rx_{t-5y,t}$		0.02
		[2.42]
Year FE	Yes	Yes
Curr FE	Yes	Yes
Cluster	Currency	Currency
Nr.Obs	3,529	3,480
R^2	6.15%	6.18%

Table 9: Limited Attention

This table presents the estimates of the following panel regression $rx^i_{t+1} = \gamma^i_t + \beta_1 tk^i_t + \beta_2 tk^i_t \times gsv_t + \beta_3 la_t + \delta X^i_t + u^i_{t+1}$, where rx^i_{t+1} is the monthly currency i excess return at time $t+1$, tk^i_t is the prospect theory value for currency i at time t, γ^i_t contains year and currency fixed effects dummies. The set of control variables X^i_t consists of the forward discount fd^i_t, the cumulative exchange rate return over the past three months $rx_{t-3,t}$, and the negative of the past five-year real exchange rate change $rx_{t-5y,t}$. The limited attention variable gsv_t corresponds to the log change of Google Searching Volume for one of the following terms: "FX", "GDP", "Inflation", "Unemployment", "Interest rate", and "Central bank". t-statistics (reported in brackets) are based on standard errors clustered by currency. The sample runs from January 2004 to February 2018 and covers 15 currencies for developed economies.

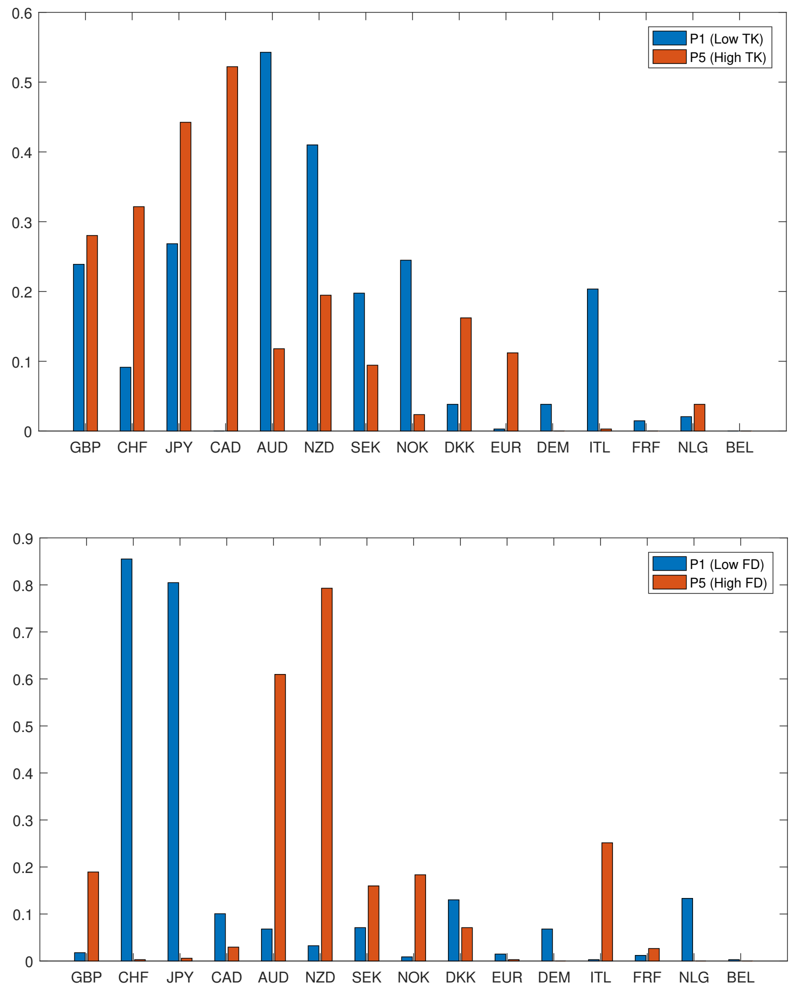
	"FX"	"GDP"	"Infl."	"Unempl."	"Interest Rate"	"Central Bank"
tk_{t-1}	-0.24	-0.27	-0.26	-0.29	-0.29	-0.25
	[-2.25]	[-2.75]	[-2.53]	[-2.86]	[-3.05]	[-2.55]
$tk_{t-1} \times gsv_{t-1}$	3.45	0.70	2.12	1.04	3.92	4.99
	[5.77]	[1.71]	[6.94]	[3.00]	[6.42]	[12.66]
gsv	0.08	0.01	0.04	0.02	0.07	0.10
	[7.39]	[1.32]	[3.88]	[2.03]	[4.53]	[6.38]
fd	-0.40	-0.37	-0.41	-0.34	-0.35	-0.45
	[-0.61]	[-0.59]	[-0.67]	[-0.54]	[-0.55]	[-0.71]
$rx_{t-5y,t}$	-0.01	0.00	0.00	-0.01	-0.01	-0.01
	[-0.52]	[0.29]	[0.29]	[-0.59]	[-1.00]	[-0.66]
$rx_{t-5y,t}$	0.01	0.01	0.01	0.01	0.01	0.01
	[1.10]	[0.85]	[0.80]	[0.92]	[0.57]	[0.90]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Curr FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	Currency	Currency	Currency	Currency	Currency	Currency
Nr.Obs	1,675	1,675	1,675	1,675	1,675	1,675
R^2	6.91%	6.50%	7.10%	6.40%	7.66%	7.61%

Figure 1: Currency Portfolio Returns Sorted by Prospect Theory Values



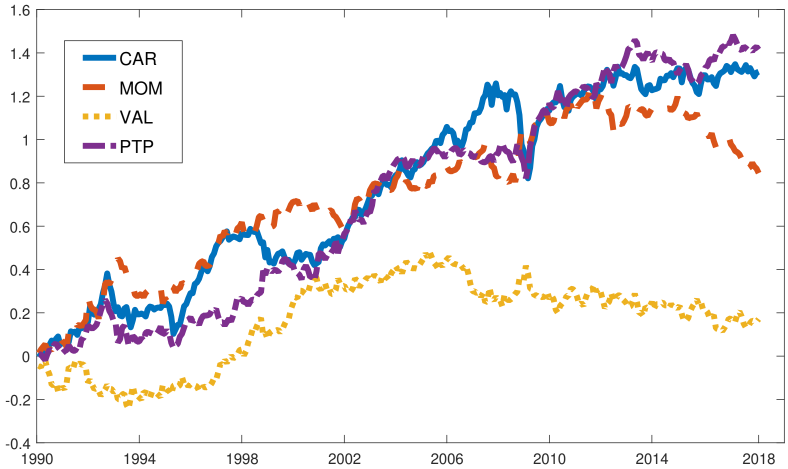
The figure illustrates annualized currency excess returns and exchange rate returns for portfolios sorted by prospect theory values for the sample of 15 currencies of developed economies from January 1990 to February 2018.

Figure 2: Currency Compositions of Prospect Theory Value and Carry Trade Portfolios



The figure plots the frequency of currency within P1 and P5 respectively for prospect theory sorted portfolios (upper panel) and for carry trade (forward discount or interest rate differential) sorted portfolios (lower panel). The sample covers 15 currencies of developed economies from January 1990 to February 2018.

Figure 3: Cumulative Returns for Currency Portfolio Strategies



The figure illustrates cumulative currency portfolio returns for carry (CAR), momentum (MOM), value (VAL), and prospect theory value (PTP) strategies. The sample covers 15 currencies of developed economies from January 1990 to February 2018.

Internet appendix to

"Prospect Theory and Currency Returns: Empirical Evidence "

(not for publication)

This appendix presents supplementary results not included in the main body of the paper.

A Description of Risk Factors

In this section, we briefly describe the construction of each of risk factors we used in the time series asset pricing tests in Section 4.1.

A.1 Currency Market Factors

We first consider five currency market factors, include Prospect Theory Value Factor, Dollar Factor, Carry Factor, Currency Momentum Factor, and Currency Value Factor.

Prospect Theory Value Factor (PTP) is the main factor proposed in our paper. We sort all currencies into five portfolios according to their latest prospect theory value (tk_t). tk_t is constructed as shown in Section 3. PTP is the zero-cost return spread of a strategy longing low tk_t (low prospect theory value) currencies and shorting high tk_t (high prospect theory value) currencies.

Dollar Factor (DOL) is the level of the cross-section of currency excess returns. The factor is constructed by taking the cross-sectional average of the returns of the forward discount (fd_t) sorted currency portfolios (carry trade portfolios).

Carry Factor (CAR) is the slope of the cross-section of carry trade returns. We sort all currencies into five portfolios according to their latest forward discounts (fd_t). CAR is the zero-cost return spread of a strategy longing high fd_t (interest rate differentials relative to US) currencies and shorting low fd_t (interest rate differentials relative to US) currencies.

Currency Momentum Factor (MOM) is the return spread of currency momentum portfolios. We sort all currencies into five portfolios according to their latest past three-month cumulative exchange rate returns ($rx_{t-3,t}$). MOM is the zero-cost return spread of a strategy longing high $rx_{t-3,t}$ (the best past performing) currencies and shorting low $rx_{t-3,t}$ (the worst past performing) currencies.

Currency Value Factor (VAL) is the return spread of currency value portfolios. We sort all currencies into five portfolios according to their latest values of the negative of the past five-year real exchange rate changes ($rx_{t-5y,t}$). Currencies with high (low) $rx_{t-5y,t}$ are undervalued (overvalued) currencies. VAL is the zero-cost return spread of a strategy longing the highest $rx_{t-5y,t}$ (undervalued) currencies and shorting the lowest $rx_{t-5y,t}$ (overvalued) currencies.

A.2 Equity Market Factors

We then introduce four equity market factors used in the Carhart (1997) four-factor model, which augments the Fama and French (1992) three-factor model with an equity momentum factor. These factors are downloaded from Professor Kenneth French's Data library
(http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html).

Market Factor (MKT) is the excess return of US equity market portfolio. The value-weighted returns of all CRSP firms minus one-month Treasury-bill rate.

Size Factor (SMB) is the average return on the three small (small capitalization) portfolios minus the average return on the three big (large capitalization) portfolios.

Equity Value Factor (HML) is the average return on the two value (high book to market ratio) portfolios minus the average return on the two growth (low book to market ratio) portfolios.

Equity Momentum Factor (WML) is the average return on the two high prior return (winner) portfolios minus the average return on the two low prior return (loser) portfolios. The prior return is formed by twelve months before to one month before the formation time (t-12 to t-1).

A.3 Hedge Fund Factors

We further describe the seven hedge fund factors based on Fung and Hsieh (2004). These factors are downloaded from Professor David Hsieh's website
(https://faculty.fuqua.duke.edu/ dah7/HFData.htm).

Bond Trend-Following Factor (BO), Currency Trend-Following Factor (CU) and Commodity Trend-Following Factor (CO) are trend-following factors in bond, currency, and commodity markets. The detailed constructions are shown in Fung and Hsieh (2001).

Equity Market Factor (EQ) is the Standard & Poors 500 index monthly total return available from Datastream.

Size Spread Factor (SS) is the Russell 2000 index monthly total return - Standard & Poors 500 monthly total return, available from Datastream.

Bond Market Factor (BM) is the monthly change in the 10-year treasury constant maturity yield (month end-to-month end), available from St. Louis Federal Reserve Bank.

Credit Spread Factor (CS) is the monthly change in the Moody's Baa yield less 10-year treasury constant maturity yield (month end-to-month end), available from St. Louis Federal Reserve Bank.

Table A1: Portfolio Excess Returns: Alternative Measures of Prospect Theory Value

This table reports monthly excess returns of prospect theory value sorted portfolios from January 1990 to February 2018 for the sample of 15 currencies for developed economies using alternative measures. P_1 to P_5 are currency prospect theory value sorted portfolios from low to high. AVG and PTP are average portfolio returns and returns of a strategy shorting high prospect theory value (P_5) and longing low prospect theory value portfolio (P_1). Returns not adjusted for transaction costs. Monthly average returns are reported in percentage points . Figures in brackets are t-statistics based on Newey and West (1987) standard errors with optimal lag by Andrews (1991).

	P_1	P_2	P_3	P_4	P_5	AVG	PTP
Panel A: Different Formation Periods							
$f = 36$	0.22	0.19	0.13	0.04	0.03	0.12	0.19
	[1.20]	[1.18]	[0.74]	[0.26]	[0.22]	[0.85]	[1.47]
$f = 48$	0.30	0.22	0.10	0.09	-0.08	0.13	0.38
	[1.64]	[1.26]	[0.65]	[0.61]	[-0.63]	[0.89]	[2.98]
$f = 72$	0.29	0.22	0.11	0.05	-0.04	0.12	0.33
	[1.55]	[1.31]	[0.65]	[0.33]	[-0.34]	[0.87]	[2.22]
Panel B: Different Variables							
rx	0.37	0.07	0.12	0.01	-0.03	0.11	0.41
	[2.29]	[0.37]	[0.71]	[0.05]	[-0.28]	[0.75]	[3.08]
fd	0.02	0.10	0.17	0.03	0.28	0.12	-0.27
	[0.10]	[0.63]	[1.12]	[0.20]	[1.56]	[0.85]	[-1.74]
Panel C: Different Functions: Exponential Decaying							
$\rho = 1$	0.37	0.19	0.09	-0.02	-0.05	0.12	0.42
	[2.02]	[1.11]	[0.53]	[-0.14]	[-0.38]	[0.82]	[3.14]
$\rho = 0.95$	0.25	0.12	0.08	0.08	0.10	0.13	0.15
	[1.48]	[0.63]	[0.50]	[0.57]	[0.78]	[0.89]	[1.18]
$\rho = 0.9$	0.21	0.14	0.11	0.08	0.09	0.13	0.12
	[1.23]	[0.76]	[0.66]	[0.51]	[0.71]	[0.90]	[0.82]
$\rho = 0.85$	0.20	0.09	0.20	0.01	0.13	0.13	0.07
	[1.14]	[0.55]	[1.13]	[0.08]	[1.00]	[0.90]	[0.50]
Panel D: Different Functions: Expected Utility							
$\lambda = 10$	0.19	0.24	0.23	0.03	-0.08	0.12	0.27
	[1.25]	[1.41]	[1.48]	[0.20]	[-0.56]	[0.87]	[1.91]
$\lambda = 5$	0.20	0.26	0.09	0.08	-0.02	0.12	0.22
	[1.41]	[1.54]	[0.59]	[0.45]	[-0.15]	[0.86]	[1.60]
$\lambda = 3$	0.21	0.22	0.04	0.08	-0.01	0.11	0.22
	[1.58]	[1.33]	[0.25]	[0.49]	[-0.03]	[0.78]	[1.56]

Table A2: Portfolio Excess Returns: Sub-Sample Analysis

This table reports currency portfolio performance for the sample of 15 currencies for developed economies under different sub-sample periods. We consider NBER recession and non-recession periods, and before (January 1990 to December 2006) and after (January 2007 to February 2018) financial crisis. Returns are not adjusted for transaction costs. Monthly returns and standard deviations are reported in percentage points. Skewness, kurtosis, and monthly Sharpe ratios are also reported. Figures in brackets are t-statistics based on Newey and West (1987) standard errors with optimal lag by Andrews (1991).

	CAR	*MOM*	*VAL*	*PTP*	*CAR*	*MOM*	*VAL*	*PTP*
Panel A: NBER Recessions								
	Recession				Non-Recession			
Mean	-0.39	0.67	0.27	0.77	0.48	0.20	0.03	0.38
	[-0.40]	[1.02]	[0.56]	[1.18]	[3.29]	[1.47]	[0.21]	[2.88]
Std	4.37	3.53	3.12	3.48	2.59	2.58	2.24	2.29
Skew	-0.46	1.23	0.42	0.05	-0.41	0.15	-0.29	0.22
Kurt	4.31	5.17	3.21	3.43	3.50	4.22	3.35	4.35
SR	-0.09	0.19	0.09	0.22	0.18	0.08	0.01	0.17
Panel B: Financial Crisis								
	Before Crisis				After Crisis			
Mean	0.53	0.45	0.15	0.45	0.17	-0.06	-0.10	0.37
	[2.88]	[2.86]	[0.90]	[2.67]	[0.56]	[-0.24]	[-0.53]	[1.69]
Std	2.44	2.55	2.29	2.35	3.33	2.87	2.40	2.57
Skew	-0.52	0.50	-0.14	0.18	-0.50	0.44	-0.03	0.29
Kurt	3.85	4.60	3.71	4.90	4.70	5.17	3.43	3.99
SR	0.22	0.18	0.06	0.19	0.05	-0.02	-0.04	0.14

Table A3: Transaction Costs Adjusted Portfolio Returns

This table reports returns and characteristics of prospect theory value sorted portfolios adjusted for transaction costs from January 1990 to February 2018 for the sample of 15 currencies for developed economies. P_1 to P_5 are prospect theory value sorted portfolios from low to high. AVG and PTP are average portfolio returns and returns of a strategy shorting high prospect theory value (P_5) and longing low prospect theory value portfolio (P_1). Returns are adjusted for transaction costs. Monthly average returns and standard deviations are reported in percentage points. Skewness, kurtosis, monthly Sharpe ratios, and first order autocorrelation coefficient (and p values) are also reported. Figures in brackets are t-statistics based on Newey and West (1987) standard errors with optimal lag by Andrews (1991). We consider both currency excess return (Panel A) and the exchange rate return component (Panel B).

	$P1$	$P2$	$P3$	$P4$	$P5$	AVG	PTP
				Panel A: Currency Excess Returns			
$Mean$	0.37	0.17	0.08	-0.04	-0.04	0.11	0.41
	[2.01]	[1.03]	[0.44]	[-0.31]	[-0.29]	[0.76]	[3.05]
Std	3.04	2.86	2.82	2.51	2.14	2.33	2.44
$Skew$	-0.14	-0.06	-0.18	-0.28	-0.26	-0.19	0.22
$Kurt$	5.07	3.33	3.25	4.64	5.74	3.80	4.47
SR	0.12	0.06	0.03	-0.02	-0.02	0.05	0.17
$AR(1)$	0.09	0.04	0.10	0.01	0.12	0.10	0.10
p	(0.12)	(0.51)	(0.07)	(0.86)	(0.08)	(0.09)	(0.12)
				Panel B: Exchange Rate Returns			
$Mean$	0.23	0.11	0.04	-0.05	-0.07	0.05	0.30
	[1.28]	[0.66]	[0.24]	[-0.37]	[-0.53]	[0.37]	[2.23]
Std	3.03	2.84	2.82	2.51	2.14	2.32	2.44
$Skew$	-0.19	-0.08	-0.21	-0.37	-0.21	-0.23	0.16
$Kurt$	5.16	3.35	3.35	4.92	5.80	3.87	4.58
SR	0.08	0.04	0.01	-0.02	-0.03	0.02	0.12
$AR(1)$	0.09	0.03	0.10	0.02	0.11	0.09	0.11
p	(0.14)	(0.62)	(0.09)	(0.82)	(0.10)	(0.12)	(0.10)

Table A4: Explanatory Power of Prospect Theory Value Components

This table reports returns prospect theory value component sorted portfolios from 1990 to 2018 for the sample of 15 currencies for developed economies using prospect theory value components, i.e. loss aversion (la), convexity and concave (ca), and probability weighting (pw). P_1 to P_5 are currency prospect theory value sorted portfolios from low to high. AVG and PTP are average portfolio returns and returns of a strategy shorting high prospect theory value (P_5) and longing low prospect theory value portfolio (P_1). Returns are not adjusted for transaction costs. Monthly average returns are reported in percentage points. Figures in brackets are t-statistics based on Newey and West (1987) standard errors with optimal lag by Andrews (1991).

	$P1$	$P2$	$P3$	$P4$	$P5$	AVG	PTP
			Panel A: Currency Excess Returns				
tk	0.37	0.19	0.09	-0.02	-0.05	0.12	0.42
	[2.02]	[1.11]	[0.53]	[-0.14]	[-0.38]	[0.82]	[3.14]
la	0.26	0.21	0.12	0.06	-0.08	0.11	0.33
	[1.56]	[1.27]	[0.69]	[0.38]	[-0.61]	[0.80]	[2.64]
cc	0.26	0.18	0.09	0.13	-0.09	0.12	0.35
	[1.83]	[1.03]	[0.58]	[0.82]	[-0.52]	[0.82]	[2.43]
pw	0.26	0.26	0.15	0.09	-0.16	0.12	0.41
	[1.68]	[1.52]	[0.89]	[0.60]	[-1.08]	[0.84]	[3.07]
			Panel B: Exchange Rate Returns				
tk	0.23	0.12	0.05	-0.03	-0.08	0.06	0.31
	[1.28]	[0.71]	[0.29]	[-0.24]	[-0.60]	[0.41]	[2.29]
la	0.18	0.16	0.05	-0.01	-0.13	0.05	0.31
	[1.16]	[1.00]	[0.29]	[-0.04]	[-1.03]	[0.38]	[2.47]
cc	0.21	0.10	0.03	0.07	-0.15	0.05	0.35
	[1.48]	[0.60]	[0.19]	[0.46]	[-0.91]	[0.38]	[2.55]
pw	0.15	0.18	0.07	0.01	-0.13	0.06	0.28
	[1.02]	[1.08]	[0.42]	[0.04]	[-0.88]	[0.40]	[2.10]

Table A5: Portfolio Excess Returns: Extended Samples of Currencies

This table reports returns and characteristics of prospect theory value sorted portfolios from January 1990 to February 2018 using different numbers of currencies. We consider extended sample of currencies include 48 developed& emerging currencies as in Menkhoff et al (2012), 37 developed & emerging currencies as in Lustig et al (2011), 20 developed & emerging currencies, and G10 currencies. P_1 to P_5 are prospect theory value sorted portfolios from low to high. AVG and PTP are average portfolio returns and returns of a strategy shorting high prospect theory value (P_5) and longing low prospect theory value portfolio (P_1). Returns are not adjusted for transaction costs. Monthly average returns and standard deviations are reported in percentage points .Skewness, kurtosis, and monthly Sharpe ratios are also reported. Figures in brackets are t-statistics based on Newey and West (1987) standard errors with optimal lag by Andrews (1991). We consider both currency excess return and the exchange rate return component.

	$P1$	$P2$	$P3$	$P4$	$P5$	AVG	PTP
				Panel A: 48 Currencies			
$Mean$	0.26	0.33	0.10	0.06	0.06	0.16	0.20
	[1.02]	[2.13]	[0.63]	[0.56]	[1.14]	[1.29]	[0.82]
Std	3.16	2.53	2.64	1.86	0.85	1.93	2.85
$Skew$	0.29	-0.22	-0.35	-0.61	-0.30	-0.37	0.50
$Kurt$	4.54	3.86	4.08	5.90	7.17	4.35	4.91
SR	0.08	0.13	0.04	0.03	0.07	0.08	0.07
				Panel B: 37 Currencies			
$Mean$	0.39	0.29	0.08	0.03	-0.01	0.15	0.39
	[2.16]	[1.87]	[0.51]	[0.25]	[-0.12]	[1.33]	[2.48]
Std	2.96	2.52	2.53	1.86	0.80	1.90	2.62
$Skew$	-0.33	-0.16	-0.29	-0.49	-0.62	-0.43	-0.25
$Kurt$	5.12	3.69	4.02	5.72	9.24	4.38	4.73
SR	0.13	0.11	0.03	0.01	-0.01	0.08	0.15
				Panel C: 20 Currencies			
$Mean$	0.51	0.27	0.03	0.04	-0.05	0.16	0.56
	[1.98]	[1.68]	[0.16]	[0.35]	[-0.77]	[1.18]	[2.40]
Std	3.33	2.76	2.61	2.22	1.23	2.11	2.82
$Skew$	0.15	-0.10	-0.24	-0.14	-0.61	-0.22	0.53
$Kurt$	4.62	3.49	3.44	6.77	6.44	3.97	4.65
SR	0.15	0.10	0.01	0.02	-0.04	0.08	0.20
				Panel D: 10 Currencies			
$Mean$	0.34	0.19	0.03	0.05	-0.06	0.11	0.40
	[1.86]	[1.12]	[0.19]	[0.42]	[-0.46]	[0.78]	[2.91]
Std	3.09	2.81	2.95	2.41	2.19	2.27	2.56
$Skew$	-0.08	-0.05	-0.40	-0.09	-0.20	-0.16	0.32
$Kurt$	5.00	3.32	4.12	4.54	5.69	3.77	4.97
SR	0.11	0.07	0.01	0.02	-0.03	0.05	0.16

Table A6: Alternative Behavioral Factors

This table reports returns and characteristics of alternative behavioral indicators sorted portfolios from January 1990 to February 2018 for the sample of 15 currencies for developed economies. We consider skewness ($SKEW$), maximum daily return within a month(MAX), minimum daily return within a month (MIN), 52 week high (PTH), and 52 week low (PTL). P_1 to P_5 are alternative behavioral variables sorted portfolios from low to high. AVG and H/L are average portfolio returns and returns of a strategy longing high value of behavioral characteristics (P_5) and shorting low value portfolio (P_1). Returns are not adjusted for transaction costs. Monthly average returns and standard deviations are reported in percentage points. Skewness, kurtosis, and monthly Sharpe ratios are also reported. Figures in brackets are t-statistics based on Newey and West (1987) standard errors with optimal lag by Andrews (1991). We consider currency excess returns of these factors, correlations of these factors with PTP, and whether PTP can be explained by these behavioral factors. Monthly abnormal return and betas are reported in percentage points.

Panel A: Currency Excess Returns

	$P1$	$P2$	$P3$	$P4$	$P5$	AVG	H/L
$SKEW$	0.00	0.17	0.13	0.21	0.11	0.12	0.10
	[0.03]	[1.06]	[0.76]	[1.39]	[0.72]	[0.88]	[0.83]
MAX	-0.02	0.07	0.13	0.19	0.23	0.12	0.25
	[-0.13]	[0.41]	[0.77]	[1.22]	[1.28]	[0.84]	[1.81]
MIN	0.12	0.07	0.18	0.09	0.12	0.11	0.00
	[0.86]	[0.46]	[1.17]	[0.58]	[0.60]	[0.81]	[-0.01]
PTH	-0.05	0.19	0.14	0.19	0.08	0.11	0.13
	[-0.28]	[1.18]	[0.86]	[1.31]	[0.64]	[0.79]	[0.93]
PTL	0.10	0.12	0.09	0.16	0.15	0.13	0.05

Panel B: Correlations with PTP

	$SKEW$	MAX	MIN	PTH	PTL
$Corr_{TK}$	0.00	0.34	0.38	-0.50	-0.01

Panel C: Explaining PTP with Alternative Behavioral Factors

	α	$SKEW$	MAX	MIN	PTH	PTL	$\bar{R}^2$
	0.43	-2.84	14.68	12.76	-39.74	8.65	0.31
	[4.06]	[-0.41]	[2.07]	[1.60]	[-5.52]	[1.20]	

Table A7: Alternative Quote Currencies

This table reports returns and characteristics of prospect theory value sorted portfolios from January 1990 to February 2018 using different quote currencies for the sample of 15 currencies for developed economies. P_1 to P_5 are prospect theory value sorted portfolios from low to high. AVG and PTP are average portfolio returns and returns of a strategy shorting high prospect theory value portfolio (P_5) and longing low prospect theory value portfolio (P_1). Returns are not adjusted for transaction costs. Monthly average returns and standard deviations are reported in percentage points. Skewness, kurtosis, and monthly Sharpe ratios are also reported. Figures in brackets are t-statistics based on Newey and West (1987) standard errors with optimal lag by Andrews (1991). We consider GBP, CHF, and JPY as alternative quote currencies (other than USD).

	$P1$	$P2$	$P3$	$P4$	$P5$	AVG	PTP
			Panel A: GBP Quoted Currencies				
$Mean$	0.25	0.15	-0.09	-0.02	-0.09	0.04	0.33
	[1.46]	[1.09]	[-0.81]	[-0.17]	[-0.98]	[0.34]	[2.23]
Std	2.95	2.47	2.42	2.36	1.50	1.95	2.52
$Skew$	0.63	1.39	0.53	0.93	0.43	1.10	0.16
$Kurt$	5.24	10.24	5.72	6.21	7.54	7.73	4.39
SR	0.08	0.06	-0.04	-0.01	-0.06	0.02	0.13
			Panel B: CHF Quoted Currencies				
$Mean$	0.21	-0.01	0.12	0.01	-0.05	0.06	0.26
	[1.38]	[-0.07]	[1.05]	[0.11]	[-0.81]	[0.63]	[1.83]
Std	2.89	2.58	2.29	1.90	1.21	1.74	2.59
$Skew$	-0.23	-0.82	-0.95	-0.91	-0.52	-0.99	-0.14
$Kurt$	4.09	5.67	8.98	8.02	9.01	7.70	4.22
SR	0.07	0.00	0.05	0.01	-0.04	0.03	0.10
			Panel C: JPY Quoted Currencies				
$Mean$	0.36	0.38	0.14	0.17	0.11	0.23	0.25
	[1.70]	[1.84]	[0.65]	[0.91]	[1.08]	[1.36]	[1.62]
Std	3.64	3.63	3.62	3.31	1.97	2.99	2.61
$Skew$	-0.62	-0.55	-0.73	-0.71	-0.84	-0.72	-0.45
$Kurt$	5.92	5.09	4.77	4.98	4.96	5.40	6.33
SR	0.10	0.11	0.04	0.05	0.06	0.08	0.09

Table A8: Multivariate Regression Analysis: Developed & Emerging Economies

This table presents the estimates of the following panel regression $rx^i_{t+1} = \gamma^i_t + \beta_1 tk^i_t + \delta X^i_t + u^i_{t+1}$, where rx^i_{t+1} is the currency i excess return at time $t+1$, tk^i_t is the prospect theory value for currency i at time t, γ^i_t contains year and currency fixed effects dummied. The set of control variables X consists of the forward discount fd_t, the cumulative exchange rate return over the past three months $rx_{t-3,t}$, and the negative of the past five-year real exchange rate change $rx_{t-5y,t}$. t-statistics (reported in brackets) are based on standard errors clustered by currency. The sample runs from January 1990 to February 2018 and covers 37 currencies of developed and emerging economies.

	(1)	(2)	(3)	(4)	(5)
tk_{t-1}	-0.19	-0.12	-0.21	-0.25	-0.19
	[-2.91]	[-2.57]	[-2.73]	[-2.29]	[-2.10]
fd_{t-1}		0.91			0.89
		[11.26]			[10.48]
$rx_{t-3,t}$			0.02		0.00
			[1.14]		[0.37]
$rx_{t-5y,t}$				0.01	0.01
				[1.52]	[0.93]
Year FE	Yes	Yes	Yes	Yes	Yes
Curr FE	Yes	Yes	Yes	Yes	Yes
Nr.Obs	7,346	7,343	7,346	5,554	5,551
R^2	5.49%	7.13%	5.62%	6.55%	8.00%

Table A9: Time-Series Asset Pricing Tests: Developed & Emerging Economies

This table reports time series asset pricing tests for long-short strategy returns based on prospect theory value (or prospect theory premium PTP) from January 1990 to February 2018 for the 37 currencies of the developed and emerging economies sample. The dependent variable is the monthly excess returns on PTP strategy and the independent variables are the returns on the set of existing risk factors. We consider three sets of factors. Currency factors include dollar (DOL), carry (CAR), momentum (MOM), value (VAL). Equity factors include market (MKT), book to market value (HML), size (SMB), equity momentum (WML). Hedge fund factors include the bond (BO), currency (CU), and commodity (CO) trend-following factors, and the equity market (EQ), size spread (SS), bond market (BM) and credit spread (CS) factors of Fung and Hsieh (2004). We report α, βs, and adjusted R^2s. Numbers in brackets are t-statistics based on Newey-West standard errors. Monthly abnormal returns and betas are reported in percentage points.

Panel A: Currency Factors

α	β_{DOL}	β_{CAR}	β_{MOM}	β_{VAL}	$\bar{R}^2$
0.33	0.04	0.17	-0.01	-0.13	2.96%
[2.41]	[0.48]	[2.03]	[-0.13]	[-1.02]	

Panel B: Equity Factors

α	β_{MKT}	β_{HML}	β_{SMB}	β_{WML}	$\bar{R}^2$
0.26	22.90	-1.12	3.64	-4.36	14.37%
[1.63]	[4.39]	[-0.24]	[0.60]	[-1.28]	

Panel C: Hedge Fund Factors

α	β_{BO}	β_{CU}	β_{CO}	β_{EQ}	β_{SS}	β_{BM}	β_{CS}	$\bar{R}^2$
0.42	-2.52	-0.78	-0.78	-3.47	-0.12	32.53	-299.58	7.70%
[2.80]	[-1.94]	[-0.81]	[-0.61]	[-0.73]	[-0.03]	[0.35]	[-3.06]	

Table A10: Cross-Sectional Asset Pricing Tests: Developed & Emerging Economies

This table reports currency level asset pricing results from January 1990 to February 2018 for 37 currencies for the developed and emerging economies. We use Fama-MacBeth two stage regression to estimate price of risk. The dependent variable is the one-month ahead monthly unconditional individual currency excess return. The independent variables are the betas of the corresponding currency excess return on the following risk factors: dollar (DOL), carry (CAR), momentum (MOM), value (VAL), and the excess returns on the prospect theory value (PTP). We also include prospect theory value tk_t. Numbers in brackets are t-statistics based on Newey-West standard errors. Regression coefficients are reported in percentage points.

	(1)	(2)	(3)	(4)
β_{PTP}	0.31	-0.20	0.40	-0.02
	[1.55]	[-0.98]	[1.87]	[-0.09]
β_{DOL}	0.10	-0.37	-0.30	-0.74
	[0.25]	[-0.93]	[-0.63]	[-1.76]
β_{CAR}			0.46	0.17
			[0.65]	[0.22]
β_{MOM}			-0.20	-0.09
			[-0.45]	[-0.15]
β_{VAL}			0.27	0.54
			[0.58]	[1.08]
tk_{t-1}		-17.71		-13.95
		[-3.48]		[-2.56]
$Const$	-0.03	-0.16	0.00	-0.06
	[-0.41]	[-2.43]	[0.05]	[-1.47]
R^2	25.10%	33.20%	50.30%	57.80%

Table A11: Limits to Arbitrage: Developed & Emerging Economies

This table presents the estimates of the following panel regression $rx_{t+1}^i = \gamma_t^i + \beta_1 tk_t^i + \beta_2 tk_t^i \times la_t + \beta_3 la_t + \delta X_t^i + u_{t+1}^i$, where rx_{t+1}^i is the monthly currency i excess return at time $t+1$, tk_t^i is the prospect theory value for currency i at time t, γ_t^i contains year and currency fixed effects dummies. The set of control variables X consists of the forward discount fd_t^i, the cumulative exchange rate return over the past three months $rx_{t-3,t}$, and the negative of the past five-year real exchange rate change $rx_{t-5y,t}$. The limit to arbitrage variable la_t corresponds to one of the following proxies: FX volatility vol^{FX}, FX illiquidity bas as well as arbitrage risk proxies used in (Della Corte, Ramadorai & Sarno 2016): CBOE VIX (vix), TED spread (ted), and Fed FSI (fsi). We use levels of these variables. t-statistics (reported in brackets) are based on standard errors clustered by currency. The sample runs from January 1990 to February 2018 and covers 37 currencies for the developed and emerging economies.

	vol^{FX}	bas^{FX}	vix	ted	fsi
tk_{t-1}	0.21	-0.24	0.34	-0.18	-0.13
	[1.16]	[-2.53]	[2.71]	[-1.36]	[-1.43]
$tk_{t-1} \times lta_{t-1}$	-107.92	20.55	-2.33	0.01	-0.07
	[-2.62]	[2.17]	[-4.20]	[0.17]	[-2.48]
lta_{t-1}	4.22	0.75	-0.04	0.00	0.00
	[2.68]	[2.25]	[-2.12]	[1.34]	[0.24]
fd_{t-1}	0.89	0.89	0.88	0.97	0.93
	[10.23]	[10.20]	[11.90]	[13.07]	[12.30]
$rx_{t-3,t}$	0.00	-0.01	0.00	-0.02	-0.01
	[0.37]	[-0.44]	[0.05]	[-1.42]	[-0.64]
$rx_{t-5y,t}$	0.01	0.01	0.01	0.01	0.01
	[1.28]	[0.84]	[1.77]	[1.71]	[1.88]
Curr FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Cluster	Currency	Currency	Currency	Currency	Currency
Nr.Obs	5,551	5,551	4,910	4,910	4,910
R^2	8.28%	8.09%	9.56%	8.96%	9.09%

Table A12: Investor Sentiment: Developed & Emerging Economies

This table presents the estimates of the following panel regression $rx^i_{t+1} = \gamma^i_t + \beta_1 tk^i_t + \beta_2 tk^i_t \times sent_t + \beta_3 sent_t + \delta X^i_t + u^i_{t+1}$, where rx^i_{t+1} is the monthly currency i excess return at time $t+1$, tk^i_t is the prospect theory value for currency i at time t, γ^i_t contains year and currency fixed effects dummies. The set of control variables X^i_t consists of the forward discount fd^i_t, the cumulative exchange rate return over the past three months $rx_{t-3,t}$, and the negative of the past five-year real exchange rate change $rx_{t-5y,t}$. The investor sentiment variable $sent_t$ is defined as the cross-sectional average of the log change of the country level consumer confidence index across the available 32 developed& emerging economies. t-statistics (reported in brackets) are based on standard errors clustered by currency. The sample runs from January 1990 to February 2018 and covers 37 currencies for the developed and emerging economies.

tk	-0.18	-0.18
	[-2.55]	[-1.82]
$tk \times sent$	-40.91	-56.73
	[-3.41]	[-3.81]
$sent$	-0.86	-1.37
	[-2.84]	[-3.30]
fd		0.92
		[10.52]
$rx_{t-3,t}$		-0.01
		[-0.55]
$rx_{t-5y,t}$		0.01
		[0.78]
Year FE	Yes	Yes
Curr FE	Yes	Yes
Cluster	Currency	Currency
Nr.Obs	7,060	5,342
R^2	5.40%	8.01%

Table A13: Limited Attention: Developed & Emerging Economies

This table presents the estimates of the following panel regression $rx^i_{t+1} = \gamma^i_t + \beta_1 tk^i_t + \beta_2 tk^i_t \times gsv_t + \beta_3 la_t + \delta X^i_t + u^i_{t+1}$, where rx^i_{t+1} is the monthly currency i excess return at time $t+1$, tk^i_t is the prospect theory value for currency i at time t, γ^i_t contains year and currency fixed effects dummies. The set of control variables X^i_t consists of the forward discount fd^i_t, the cumulative exchange rate return over the past three months $rx_{t-3,t}$, and the negative of the past five-year real exchange rate change $rx_{t-5y,t}$. The limited attention variable gsv_t corresponds to the log change of Google Searching Volume for one of the following terms: "FX", "GDP", "Inflation", "Unemployment", "Interest rate", and "Central bank". t-statistics (reported in brackets) are based on standard errors clustered by currency. The sample runs from January 2004 to February 2018 and covers 37 currencies for the developed and emerging economies.

	"FX"	"GDP"	"Infl."	"Unempl."	"Interest Rate"	"Central Bank"
tk_{t-1}	-0.21	-0.22	-0.22	-0.22	-0.22	-0.21
	[-2.88]	[-3.10]	[-2.98]	[-3.03]	[-3.05]	[-2.89]
$tk_{t-1} \times gsv_{t-1}$	1.60	0.06	0.70	0.86	2.06	2.03
	[2.57]	[0.25]	[1.37]	[4.09]	[3.96]	[2.42]
gsv	0.05	0.00	0.01	0.01	0.03	0.04
	[3.59]	[0.16]	[1.44]	[2.61]	[3.08]	[2.51]
fd	0.75	0.74	0.74	0.75	0.77	0.76
	[5.31]	[5.26]	[5.16]	[5.48]	[5.17]	[5.42]
$rx_{t-3m,t}$	-0.01	0.00	-0.01	-0.01	-0.01	-0.01
	[-0.45[	[0.39]	[-0.39]	[-0.71]	[-0.92]	[-0.54]
$rx_{t-5y,t}$	0.00	0.00	0.00	0.00	0.00	0.00
	[0.32]	[0.26]	[0.20]	[0.24]	[0.02]	[0.31]
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Curr FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	Currency	Currency	Currency	Currency	Currency	Currency
Nr.Obs	3,081	3,081	3,081	3,081	3,081	3,081
R^2	6.09%	5.84%	5.97%	5.94%	6.53%	6.24%

Table A14: PTP Beta Sorted Portfolios

This table reports returns and characteristics of portfolios sorted by prospect theory premium (PTP) betas for the sample of 15 currencies for developed economies. A rolling window of 36 month is used to estimate factor betas. The sample period is from January 1993 to February 2018. $B1$ to $B5$ are prospect theory premium beta sorted portfolios from low to high. AVG and H/L are average portfolio returns and returns of a strategy buying high beta currencies and shorting low beta currencies. Returns are not adjusted for transaction costs. Monthly average returns and standard deviations are reported in percentage points. Skewness, kurtosis, monthly Sharpe ratios, pre-formation betas, post-formation betas, and average prospect theory value (tk) are also reported. Figures in brackets are t-statistics based on Newey and West (1987) standard errors with optimal lag by Andrews (1991). We consider both currency excess return (Panel A) and the exchange rate return component (Panel B).

	$B1$	$B2$	$B3$	$B4$	$B5$	AVG	H/L
			Currency Excess Returns				
$Mean$	-0.06	0.12	-0.02	0.11	0.34	0.10	0.40
	[-0.39]	[0.78]	[-0.14]	[0.67]	[2.10]	[0.67]	[2.64]
Std	2.27	2.62	2.68	2.86	2.82	2.28	2.54
$Skew$	-0.62	-0.04	-0.26	0.12	0.01	-0.08	0.42
$Kurt$	6.86	4.42	3.73	3.63	3.77	3.77	5.66
SR	-0.03	0.05	-0.01	0.04	0.12	0.04	0.16
β_{pre}	-0.13	0.17	0.34	0.46	0.74		
β_{post}	0.04	0.29	0.39	0.42	0.59		
TK	-0.17	-0.20	-0.21	-0.23	-0.27		

Table A15: Limits to arbitrage: individual currency measures

This table reports limits to arbitrage results using double sorting. We first sort all currencies into two portfolios according to limits to arbitrage proxies, and hence within each portfolio, we sort according to prospect theory value to three portfolios. PTP is the long-short strategy buying the tk_{Low} portfolio and shorting the tk_{High} portfolio. We consider idiosyncratic volatility ($ivol$), illiquidity (bas), and covered interest rate parity deviation (cip) as limits to arbitrage proxies. The sample consists of developed currencies from January 1990 to February 2018. For cip, only G10 currencies are used due to data availability.

Panel A: Idiosyncratic volatility ($ivol$)

	tk_{Low}	tk_{Med}	tk_{High}	PTP
$ivol_{Low}$	0.15	0.26	0.08	0.07
	[1.48]	[1.15]	[0.79]	[0.77]
$ivol_{High}$	0.25	0.10	0.01	0.23
	[1.10]	[1.10]	[0.08]	[1.72]

Panel B: Illiquidity (bas)

	tk_{Low}	tk_{Med}	tk_{High}	PTP
bas_{Low}	0.15	0.40	0.17	-0.02
	[0.87]	[2.15]	[1.07]	[-0.21]
bas_{High}	0.10	-0.05	0.00	0.10
	[0.60]	[-0.34]	[0.03]	[0.68]

Panel C: Covered interest rate parity deviation (cip)

	tk_{Low}	tk_{Med}	tk_{High}	PTP
cip_{Low}	0.43	0.28	0.04	0.39
	[1.58]	[1.15]	[0.24]	[2.12]
cip_{High}	0.11	-0.25	-0.20	0.31
	[0.48]	[-1.32]	[-1.05]	[1.93]