Prospect Theory and Currency Returns *

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Abstract

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

JEL classification: $F31, G12, G15, G40$

Keywords: Foreign exchange, currency returns, prospect theory, limits to arbitrage

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1 Introduction

The foreign exchange (FX) market is known for its large trading volume, the dominance of sophisticated institutional investors, and the absence of short selling constraints. Prima facie, these institutional features imply that mispricing should be eliminated rapidly given the ease of arbitrage. Nevertheless, previous studies document rich evidence that exchange rates and macro-economic fundamentals are disconnected (Meese & Rogoff 1983, Engel & West 2005). Moreover, technical trading rules exploiting past price patterns are widely used and highly profitable in the FX market (Menkhoff & Taylor 2007, Hsu, Taylor & Wang 2016). Such striking and contrasting evidence against institutional features naturally motivate a comprehensive investigation from a behavioral finance perspective.

In this paper, we empirically examine the role of prospect theory in the cross-section of currency returns. Prospect theory are introduced by Kahneman & Tversky (1979) and Tversky & Kahneman (1992) and since Benartzi & Thaler (1995), many studies have considered of empirical applications of prospect theory in stock markets. Barberis, Mukherjee & Wang (2016) show that prospect theory values predict the cross-section of stock returns. The unique institutional features of currency markets provide a stringent condition to empirically analyze the impact of prospect theory on asset prices. The intuition as to why prospect theory may affect future currency returns is straightforward. Currencies with higher prospect theory values are those more attractive currencies, which investors are willing to hold. On the contrary, currencies with lower prospect theory values are those more unappealing, which investors are unwilling to hold. Therefore, such trading activities cause these appealing currencies to be overvalued, and hence earn lower expected returns later. Specifically, we expect that currencies with higher prospect theory values earn lower expected returns in the subsequent period.

Our findings lend strong empirical support for this prediction. We find that the prospect theory value, derived from historical distribution of exchange rate changes, negatively and significantly forecasts future currency excess returns. Furthermore, 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. The returns to this strategy – prospect theory premium (PTP) – has only moderate correlations with other currency risk factors, equity risk factors and hedge fund factors. Abnormal returns after controlling for currency risk factors is about 4.08% per annum and is statistically significant at 1% level. After controlling for equity market factors or hedge fund factors, alphas are 4.48% and 4.93% per annum respectively.

We do not find evidence that the excess returns driven by the exposures to PTP. While 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)), we show that betas to PTP are only marginally significant in explaining currency returns. The relation becomes insignificant, when lagged prospect theory value is included. Therefore, the profitability of the PTP strategy cannot be interpreted as conventional risk premia, including either due to noise trader risk of Long, Shleifer, Summers & Waldman (1990) or any other omitted risk factor that correlates with PTP returns.

We find, however, that the lag of the prospect theory value itself remain significant over the betas of traditional currency factors. This speaks in favor of existence of mispricing rather than systematic risk exposure. 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 is high and funding constraint is tight. Moreover, the predictive relation is 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 performance). 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 number 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 periods. Second, our prospect theory strategy returns remain economically significant after accounting for the bid-ask spreads. Third, we show that other behavioral indicators cannot explain the cross-sectional variation of our portfolios returns. Forth, our results are robust to alternative number of currencies and different pricing currencies.

The overall contribution of this paper is two-fold. Primarily, we enrich the research on cross-sectional currency return predictability by introducing a new cross-sectional return 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.[1] Different from existing studies, we propose one of the first currency portfolio strategies motivated by behavioral finance theory. Our study not only expands the scope of investment opportunity sets for practical currency portfolio managers, but also introduces a new set of test assets and provides new challenges for existing asset pricing models in the literature.

The paper also contributes to the asset pricing implications of prospect theory in general. 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.[2] Barberis et al. (2016) initially examine the cross-sectional return predictability of prospect theory value in individual stocks directly. Zhong & Wang (2018) study prospect theory in the cross-section of corporate bonds. We provide one of the first analysis of asset pricing implications of prospect theory in currency markets, an important asset class beyond equity. Hence, we offer an "out-of-sample" investigation of the role of prospect theory in explaining asset returns.

While we obtain similar conclusions to previous studies in equity markets, our paper is unique on at least three aspects. First, the success of our strategy in a market dominated by institutional investors implies that even sophisticated institutional investors may encounter severely cognitive bias and can trade speculatively. Second, the strength of our strategy even in highly liquid currency markets provide a challenge to the conventional

[1] 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 2017) etc. Throughout the paper, we only focus on carry, momentum, and value for their popularity and data availability considerations.

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

wisdom that arbitrage activities are easier when markets are more liquid.[3] Third, while Barberis et al. (2016) highlight the role of limits to rational arbitrage activities in the predictability, we provide evidence that the speculative trading activities of irrational traders (or attentions of retailer investors) also critically contribute to the predictability.

A closely related study is Chabi-Yo & Song (2012). These authors investigate the role of aggregate probability weighting of tail events to predict currency market return and price carry trade and momentum returns. Our paper is essentially different from them in several respects. First, while prospect theory and rank dependent utility (Quiggin 1993) are closely related, we provide arguably the first formal empirical investigation of prospect theory in currency markets, while Chabi-Yo and Song focus only on the probability weighting component. Second, we focus on the cross-sectional return predictability through portfolio construction; in contrast, these authors focus on aggregate time series predictability. Third, our measure is based on the 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 better fits our purpose of a comprehensive empirical investigation of the cross-sectional return predictability in currency markets.[4]

Our 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 impact of uncertainty aversion and heterogeneous beliefs respectively. A few studies consider the profitability in technical trading rules in FX markets (Taylor & Allen 1992, Menkhoff & Taylor 2007, Neely & Weller 2012, Hsu et al. 2016). These studies focus on bilateral exchange rates and use time series regressions. Instead, we adopt a cross-sectional asset pricing perspective, which is explicitly linked to a zero-cost long-short strategy. The economic gain of predictive power can be assessed directly and compared with other cur-

[3]Indeed, Avramov, Cheng & Hameed (2016) find that equity momentum profits are actually larger rather than smaller in high liquid states.

[4]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 relative short sample periods from 1997 afterwards. These practical issues may restrict the use of option-based measure in currency markets.

rency portfolio strategies. Burnside, Han, Hirshleifer & Wang (2011), Ilut (2012),and Yu (2012) consider overconfidence, ambiguity, and sentiment based interpretation of forward premium puzzle or carry trade with either theoretical models only or focusing only on the time series perspective. Instead, we focus on the cross-sectional currency return predictability motivated by prospect theory.

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

2 Prospect Theory in Currency Markets

Expected utility theory (EU) is a building block for many classical models in financial economics. Experimental evidence, however, shows that real world investor behaviors tend to deviate from what expected utility theory predicts. Kahneman & Tversky (1979) introduced the prospect theory as an alternative and more realistic theoretical framework for decision making. Tversky & Kahneman (1992) propose a modified version of the theory termed cumulative prospect theory, which we focus on in this paper.

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, concave function of terminal wealth. The prospect theory value function is a function of gains and losses relative to a reference point, is kinked at zero, concave at gains but convex at losses. Second, while in the expected utility framework the relation between probabilities of events and weights is linear, the prospect theory introduces a non-linear probability weighting function. The function reflects the gambling preference of investors to overweight probabilities of extreme tail events. The prospect theory also models investors' perception of gain probabilities differently from probability of losses.

Using aforementioned properties of prospect theory value function and probability weighting function and following procedures in Barberis et al. (2016), we construct prospect theory value in currency markets. The empirical use of prospect theory requires two steps. First, investors need to form a mental *representation* of a risk. Second, investors need to *value* whether such a representation is appealing or not. Analogously to the stock market research in Barberis et al. (2016), we use the past distribution of exchange rate returns to form a mental representation of risk for currency investors. We then apply the Tversky & Kahneman (1992) formula to assess whether the mental representation is appealing. We provide more formal description of of prospect theory value in Section 3 below.

Our first hypothesis states the predictive relation between prospect theory value and subsequent currency return. Barberis et al. (2016) theoretically illustrate the negative relation between prospect theory value and future stock return and documented it empirically in the US stock market. We conjecture that currency investors may share a similar mental process to represent and evaluate risk. In practice, currency investors, like equity investors, use historical price information extensively when making investment decisions. Taylor & Allen (1992) document that over 90% of their survey respondents used technical analysis when trading currencies. This finding provides direct evidence that a significant proportion of currency investors use past price charts in their decision processes. Therefore, investors may naturally rely on the historical return distribution to mentally represent a currency. As a result, these investors are very likely to evaluate a currency based on its prospect theory value, and hence willing to buy high prospect theory value (and hence more attractive) currencies and to sell low prospect theory value (and hence less attractive) currencies. In the presence of a non-trivial proportion of this type of investors in the FX market, trading activities will cause appealing currencies to be overvalued, and hence these currencies will earn lower expected returns. Therefore our first hypothesis is:

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

Behavioral finance provide two main explanations on why the mispricing survives in the market and are not exploited by rational arbitrageurs. First, real markets arbitrage is limited due to presence of trading frictions and constrained capital (see Gromb & Vayanos (2010) for a survey on limits to arbitrage literature). Second, unpredictability of irrational investors sentiments generate additional risk called noise traders risk (see Long et al. (1990)). Arbitrageurs, being risk averse do not aggressively exploit existing mispricing because of fear that the mispricing gap widen in the nearest future. Based on those two behavioral explanations, we formulate our next hypotheses:

Hypothesis 2 (Risk): *The negative relation between the prospect theory value and the currency subsequent return is fully explained by the exposure to risk factors.*

Hypothesis 3 (Limits to Arbitrage and Speculative Demand): *The negative relation between the prospect theory value and the currency subsequent return is strengthen 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 daily frequency from November 1st 1983 to February 28th 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. 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.

Our main sample consists 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. These currencies or G10 (after the Euro introduction in 1999) are highly liquid and account for more than 67% of 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 carry trade performance using G10 currencies. Using these liquid and major currencies as test assets allows us to conduct sharper tests for our predictions based on prospect theory.[5]

3.2 Prospect Theory Value

We follow Barberis et al. (2016) to construct the empirical measure of prospect theory value tk_t for currency i at time t. To do so, we consider a series of K consecutive past returns r from $t-K+1$ 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 increasing order we re-denote them as:

$$r_{-m}, \frac{1}{K}; ...; r_{-1}, \frac{1}{K}; r_1, \frac{1}{K}; ...; r_n, \frac{1}{K}.$$

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

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

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 past exchange rate return distribution. In the robustness section, we also consider distributions of currency excess returns and forward discounts. Following the literature, we set $K = 60$, namely, we rely on past 5 years monthly exchange rate returns to construct a prospect theory value every month. We also consider different K values in robustness checks.

The functional form of the value and probability weighting functions are specified as

[5] In the robustness section, we also consider an extended list of countries.

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. We use 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) on individual stock returns. In the robustness and further analysis section, we consider decomposing total prospect theory value into different components with respective parameters (loss version (1,2.25,1,1), convexity/concavity(0.8,1,1,1), and probability weighting (1,1,0.61,0.69)).

3.3 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 $fd_t = (F_t - S_t)/S_t$. The first component, exchange rate return, is just the input variable we used to construct prospect theory value as described in Section 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.[6] 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 construct past three month cumulative return ($rx_{t-3,t}$) as in Menkhoff et al. (2012) and Della Corte, Ramadorai & Sarno (2016). We also collect monthly CPI data from the OECD main economic indicator database, in order to construct real exchange rate changes and form currency value strategies as in Asness et al. (2013) and Della Corte, Ramadorai & Sarno (2016).We use the change of real exchange rate over past five years to construct the signal to form currency value portfolios. Specifically, we define

$$\begin{aligned} rx_{t-3,t} &= \sum_{i=1}^{3} rx_{t-i}, \\ rx_{t-5y,t} &= \log\left(\frac{0.5(S_{t-4.5\times12} + S_{t-5.5\times12})}{S_t}\right) - \log\left((cpi_t^* - cpi_{t-5\times12}^*) - (cpi_t - cpi_{t-5\times12})\right), \end{aligned}$$

where cpi_t and cpi_t^* are the CPI in the US and foreign country. The detail construction of currency portfolios and risk factors as described in Appendix A

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

Table 1 about here

Currencies appreciate on average against the USD in our sample. The average excess return is 0.123% per month with the standard deviation of 3.015%. 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,

[6] 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).

the prospect theory value is positively correlated with contemporaneous excess returns and negatively correlated with the forward discount.

4 Empirical Findings

4.1 Cross-Sectional 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, and the currency-specific control variables X^i_t include the forward discount fd^i_t and past returns $rx_{t-3,t}$ and $rx_{t-5y,t}$. The standard errors are clustered by 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 1% level. The magnitude is economically large: one standard deviation increase in tk_t value decreases the future excess returns by about 0.34% per month (about 4.07% per annum). The effect is robust to inclusion of the control variables.

In order to assess economic value of prospect theory value in more details 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 a 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 portfolios. Currency excess returns drop monotonically from P_1 (low tk_t value) to P_5 (high tk_t value). The long-short strategy (PTP) buying P_1 and shorting P_5 produces statistically significant return spread of 5% per year and an annualized Sharpe ratio of 0.59.[7] The strategy also has positive skewness and moderate kurtosis, indicating that the strategy is unlikely to be affected by market crash risk. For exchange rate returns, we observe a similar monotonic decreasing pattern and significant return spreads, suggesting that tk_t has predictive power for spot exchange rate returns.

Figure 1 about here

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

Figure 2 about here

Figure 2 plots 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). See Appendix A for the construction of these factor strategies. It shows that the strategy dominates the value strategy and outperform the momentum strategy in the most of the time. The new strategy also performs comparable with carry strategy. 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 0.30 with VAL).

4.2 Asset Pricing Tests

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

[7] 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.

We consider whether the documented predictability can be rationalized by the compensations for existing known systematic risk factors. We empirically investigate this explanation from both time series and cross-sectional perspectives. Table 4 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 Appendix A. We regress the PTP factors to these three set of factors respectively using time series spanning regressions.

Table 4 about here

The returns to PTP strategy has positive exposures to carry and value factors, negative exposure to momentum factor, but has insignificant exposure to the dollar factor (see Panel A). We find that 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 explains the returns to PTP (see Panel C). In total, the currency factors explain 15.09% of variation in the PTP returns, the equity factors explain 6.13% and the hedge fund factors explain only about 1.58%. The abnormal returns of PTP drops to 0.340% per month (about 4.08% per year) in the case of currency risk factors, to 0.373% (about 4.48% per year) in the case of equity factors and to 0.411% (4.93% per year) in the case of hedge fund factors . In all three cases the alphas remain statistically significant at 1% level. Therefore, the PTP strategy cannot be fully spanned by the considered risk factor strategies.

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 presence of irrational investors in the market, e.g., noise traders risk), we should observe a risk-return trade-off.

To test this prediction, we apply Fama & MacBeth (1973) two stage regressions to conduct cross-sectional asset pricing tests. Different from existing studies mainly use currency portfolios as test assets, we focus on the individual currency-level asset pricing tests.[8] 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 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 carry factor (CAR), dollar (DOL), momentum (MOM), and value (VAL) as main risk factors. We also include the excess returns to PTP strategy in the specification.

In addition to inclusion of factor betas, we include tk_t to test if the cross-sectional predictability of prospect theory value survives after controlling for exposures to traditional risk factors. Besides, it allows us to answer the question whether risk exposure or currency-specific characteristic (or mispricing) mainly drive currency returns.[9]

Table 5 about here

Table 5 presents cross-sectional asset pricing results. Two main findings are worth mentioning. Firstly, we show that PTP is marginally priced in the cross-section of individual currency returns at the 10% significant level. Result holds true when other currency risk factors are considered. Therefore exposures to PTP may help to explain the cross-sectional variations of individual currency excess returns. Secondly and more

[8]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 particular severely in currency market 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*b*) and Kan & Zhang (1999*a*) argue that even "useless factors", which do not have significant betas, may have significant price of risk if test assets have a strong factor structure. Therefore, we consider the cross-section of individual currency excess returns as our main test assets.

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

importantly, we find the pricing power becomes insignificant once the currency characteristic tk_{t-1} is included. tk_{t-1} remains negatively and significantly predicts future currency excess returns cross-sectionally with and without including factor betas. In short, our results do not support our hypothesis 2 that prospect theory factor is a priced systematic risk factor. Instead, we suggest that currency-specific mispricing rather than factor exposure mainly drive the variations of currency excess returns.

4.3 Limits to Arbitrage, Sentiment, and Limited Attention

Our existing results show that risk-based explanations cannot 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) already 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 already link 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, arbitragers are more likely to stop or postpone their arbitrage activities when the FX market is volatile and illiquid, risk aversion is high, the funding constraint is tight, and financial stress is high. If limits to arbitrage enhance the predictive pattern, we expect that the interaction term ($tk_{t-1} \times la_{t-1}$) is negative and significant. Namely, it strengthens the negative predictive relation between tk and future returns.

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

$$rx^i_{t+1} = \gamma^i_t + \beta_0 tk^i_t + \beta_1 tk^i_t \times la_t + \beta_2 la_t + X^i_t + u^i_{t+1}, \tag{5}$$

where la denotes one of the aggregate limits to arbitrage proxy, X_t^i include currency-specific characteristics including forward discount, past return, and real exchange rate changes, γ_t^i contains currency and time fixed effects dummies. As a candidates for the limit to arbitrage proxy 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 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 Chicago Board of Option Exchange (CBOE). TED spread is the yield difference between 3-month US treasury bill and 3-month libor. FSI is the financial stress index issued by St. Louis Federal Reserve to measure the degree of financial stress in the markets. Except for TED spread, all other series are first differenced. Then we use the 12-month rolling window average of all series as our limits to arbitrage proxies, following Della Corte, Ramadorai & Sarno (2016). Standard errors are clustered at currency level.

Table 6 about here

Table 6 presents limits to arbitrage results. We show that tk_t is negatively and significantly related to future currency returns in all models as expected. Consistently with our hypothesis 3, the interaction term is negative and significant when FX volatility and TED spread are used as arbitrage risk proxies. Namely, the correction for mispricing by rational arbitragers is more difficult when FX market is more volatile and when the funding constraint is tight. Hence the negative predictive relation between tk and return persists. For other arbitrage risk proxies, the interaction term either has insignificant coefficient or has wrong sign. Therefore, 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 crucially on the choice of arbitrage risk measure.[10]

[10] In the appendix, we also consider currency-specific limits to arbitrage proxies such as currency-level illiquidity, idiosyncratic volatility, and covered interest rate (CIP) deviations using double sorted portfolios. While we do find that results are stronger for more volatile currencies. Results are unclear along the liquidity dimension, while CIP deviations do not explain the predictability.

Next we examine how speculative demand of irrational traders affect the predictability. Intuitively, the presumption for the tk to predict return is that prospect theory investors account for a significant proportion of all investors. Therefore, we expect that when the speculative demand for these irrational investors are high or the number of irrational investors in the economy increase, the tk-return predictive relation due to behavioral driven mispricing should be stronger. Empirically, it is difficult to measure the latent and speculative demand for 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 investor attention in our empirical analysis.

Previous studies (Baker & Wurgler 2006, Stambaugh, Yu & Yuan 2012, Antoniou, Doukas & Subrahmanyam 2013, Antoniou, Doukas & Subrahmanyam 2016) already extensively document the important role of investor sentiment in affecting the cross-section of asset returns. In the FX market, Yu (2012) provides a sentiment-based explanation for forward premium puzzle. We conjecture that irrational investors in the FX market are more likely to speculate or the proportion of irrational investors increases when the global investor sentiment is high. 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 up to 32 economies to construct a global measure of investor sentiment. We use the log return of each CCI to measure the growth rate of consumer confidence index. We then use the cross-sectional average to obtain a global measure of sentiment ($sent$). We estimate the following panel data regression:

$$rx_{t+1}^i = \gamma_t^i + \beta_0 tk_t^i + \beta_1 tk_t^i \times sent_t + \beta_2 sent_t + X_t^i + u_{t+1}^i, \tag{6}$$

where X_t^i include currency-specific characteristics including forward discount, past return, and real exchange rate changes, γ_t^i contains currency and time fixed effects dummies. We cluster standard errors by currency. Table 7 reports the estimation results.

Table 7 about here

The prospect theory value variable tk_t remains negative and significant as before. The interaction term $tk_t \times sent_t$ is negative and highly significant. Therefore, our evidence shows that the negative predictive relation between tk_t and future return is strengthened when the global investor sentiment is high, as more irrational investors trade speculatively and enlarge the mispricing captured by the prospect theory value.

In our next text we consider the effects of limited attention on the predictability. Existing studies (Peng & Xiong 2006, Barber & Odean 2008, Da, Engelberg & Gao 2011) analyze the role of attention in affecting asset prices. Recently, Bali, Hirshleifer, Peng & Tang (2019) show that the attention of retailer investors is a driving force for the lottery-demand related phenomena. As previous studies, we use the first difference in log of Google searching volume (gsv) around the world from Google Trend to measure attention.[11] We focus on the Google searching volume of six terms related to either foreign exchange or macro-fundamental variables: "FX", "GDP", "Inflation", "Unemployment", "Interest rate" and "Central bank". The intuition is as follows. Since investors have limited attention, when they pay more attention to macro-fundamentals, they are less likely to trade speculative and less likely to rely on past performance and technical trading rules. Therefore, we expect that an increase of macro-fundamental searching volumes is expected to be associated with declines of the predictive power. Hence, we expect the interaction term between tk and gsv is positive and significant.

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

where gsv_t is the first difference in log of Google searching volume corresponding to one of the attention proxies, X^i_t include currency-specific characteristics including forward discount, past return, and real exchange rate changes, γ^i_t contains currency and time fixed effects dummies. We cluster standard errors by currency. Table 8 reports the estimation results.

TABLE 8 ABOUT HERE

The coefficient on tk^i_t remains negative and significant at 1% level. The interaction term $tk^i_t \times gsv_t$ corresponding to "FX", "Inflation", "Unemployment", "Interest rate", and

[11] 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.

"Central bank" are also positive and significant. Our results suggest that the tk-return relation is weaken when investors pay more attention to macroeconomic fundamentals, which is consistent with our conjecture. Therefore, our findings provide evidence to support the speculative demand-based explanation for the predictability.

In summary, both investor sentiment and limited attention results support that the speculative demand of irrational traders play an important role in 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 further analysis reported in Tables A1 to A9 in the Appendix. First, we consider alternative measures of prospect theory value (Table A1). The main results are qualitatively unchanged when different formation periods and currency excess returns are used to construct prospect theory value. We also show that allowing for exponential decaying of returns destroys the predictive relation. Replacing prospect theory value by expected utility value does not reproduce the predictive pattern.

Second, we investigate the performance of our strategy for different sub-sample periods (Table A2). Results are generally stable across different periods and again stronger for developed economies. The variable tk_t is significant in non-recession periods, while it is insignificant but still outperforms others in recession periods. Furthermore, tk_t remains significant both before and after financial crises and in both low and high investor sentiment states.

Moreover, we also show that the strategy performance remains when we control for transaction costs (Table A3). All prospect theory value components matter (Table A4). Results are qualitatively unchanged when we consider 10 and 20 currencies (Table A5). Using 48 currencies turns the return spread to insignificant but the negative relation retains. Our strategy remains profitable when controlling for other factors motivated by behavioral theories (Table A6). Changing to different pricing currencies (other than USD) does not qualitatively affect our main findings (Table A7).

We also provide further analysis results about currency-specific limits to arbitrage analysis in Table A8, and the effects of central bank intervention on the PTP in Table A9.

In summary, our main conclusions remain valid when different robustness checks and further analysis 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 prospect theory value at individual currency level. Our empirical evidence supports currency-level prospect theory value negatively and significantly predicts the subsequent month currency excess returns, even controlling for other currency-level characteristics. Moreover, a long-short strategy based prospect theory values earns statistically significant and economically large profits.

We then explore several alternative explanations for the predictability. We show that the predictability cannot be interpreted as conventional risk premia, nor can it be attributed to systematic risk exposure for a prospect theory factor. Instead, the predictability is in line with the mispricing at currency-specific characteristic level. We find that both limits to arbitrage and speculative demands of irrational investors contribute to the predictive relation. Our main results remain strong after comprehensive robustness checks.

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

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Tables and Figures

Table 1: Summary statistics

This table reports summary statistics of currency excess returns and characteristics (Panel A) and the correlations among the variables (Panel B). The sample is from January 1990 to February 2018 for the set 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 sum over the previous three months, $rx_{t-5y,t}$ is the past five years real exchange rate changes.

Panel A: Currency Excess Returns

	Mean	Std.dev	Min	Max	Nr.obs.
rx_t	0.123	3.015	-15.71	16.90	3,735
fd_t	0.066	0.257	-2.804	2.208	3,740
tk_t	-2.554	0.912	-5.164	-0.023	3,740

Panel B: Correlations

	rx_{t+1}	fd_t	$rx_{t-3,t}$	$rx_{t-5y,t}$	tk_t
fd_t	0.074	1			
$rx_{t-3m,t}$	0.590	0.124	1		
$rx_{t-5y,t}$	0.467	0.337	0.283	1	
tk_t	0.094	-0.185	0.183	-0.266	1
rx_t	0.069	0.098	0.631	0.023	0.111

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 is the currency i excess return, 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, past three month cumulative returns $rx_{t-3,t}$ and past five years real exchange rate changes $rx_{t-5y,t}$. t-statistics (reported in brackets) are based on standard errors clustered by currency. The sample runs from January 1990 to December 2018.

	(1)	(2)	(3)	(4)	(5)
tk_{t-1}	-0.372	-0.374	-0.388	-0.386	-0.400
	[-4.64]	[-4.65]	[-4.42]	[-5.03]	[-4.85]
fd_{t-1}		-0.098			-0.106
		[-0.42]			[-0.40]
$rx_{t-3,t}$			0.009		0.006
			[0.85]		[0.56]
$rx_{t-5y,t}$				0.012	0.010
				[1.26]	[1.06]
Year FE	Yes	Yes	Yes	Yes	Yes
Curr FE	Yes	Yes	Yes	Yes	Yes
Nr.Obs	3,639	3,639	3,639	3,588	3,588
R^2	6.03%	6.03%	6.05%	6.10%	6.12%

Table 3: Prospect theory value sorted portfolios

This table reports returns and characteristics of prospect theory value sorted portfolios from January 1990 to February 2018 for the developed economies sample. 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). Annualized returns are reported in percentage points and are not adjusted for transaction costs. 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						
$Mean$	4.44	2.24	1.12	-0.21	-0.58	1.40	5.03
	[2.02]	[1.11]	[0.53]	[-0.14]	[-0.38]	[0.82]	[3.14]
$Std.dev$	10.52	9.90	9.76	8.66	7.43	8.06	8.46
$Skew$	-0.136	-0.054	-0.164	-0.274	-0.263	-0.185	0.229
$Kurt$	5.060	3.328	3.232	4.641	5.773	3.788	4.488
SR	0.42	0.23	0.12	-0.03	-0.08	0.17	0.59
$AR(1)$	0.09	0.03	0.09	0.01	0.11	0.09	0.10
p	(0.142)	(0.586)	(0.085)	(0.896)	(0.091)	(0.114)	(0.124)
	Panel B: Exchange Rate Returns						
$Mean$	2.77	1.39	0.61	-0.38	-0.92	0.69	3.69
	[1.28]	[0.71]	[0.29]	[-0.24]	[-0.60]	[0.41]	[2.29]
$Std.dev$	10.05	9.85	9.77	8.67	7.40	8.03	8.46
$Skew$	-0.184	-0.068	-0.192	-0.365	-0.215	-0.218	0.162
$Kurt$	5.149	3.346	3.324	4.917	5.816	3.858	4.602
SR	0.264	0.141	0.062	-0.043	-0.125	0.086	0.436
$AR(1)$	0.085	0.022	0.089	0.015	0.109	0.085	0.106
p	(0.163)	(0.701)	(0.109)	(0.834)	(0.107)	(0.143)	(0.096)

Table 4: 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 developed economies sample. The dependent variable is the 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. Returns are annualized and are not adjusted for transaction costs.

Panel A: Currency Factors

α	β_{DOL}	β_{CAR}	β_{MOM}	β_{VAL}	$\bar{R}^2$
0.340	0.057	0.130	-0.207	0.378	15.09%
[2.79]	[0.87]	[2.68]	[-3.58]	[4.19]	

Panel B: Equity Factors

α	β_{MKT}	β_{HML}	β_{SMB}	β_{WML}	$\bar{R}^2$
0.373	0.094	0.061	0.074	-0.072	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}	$\bar{R}^2$
0.411	-0.011	0.005	-0.031	0.036	-0.006	0.515	0.467	1.58%
[2.99]	[-0.87]	[0.65]	[-2.57]	[0.69]	[-0.13]	[0.54]	[0.26]	

Table 5: Asset pricing: cross-sectional tests

This table reports currency level asset pricing results for the developed economies sample. We use Fama-MacBeth two stage regression to estimate price of risk. The dependent variable is the one-period ahead 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.

	(1)	(2)	(3)	(4)
β_{PTP}	0.003 [1.73]	0.004 [1.88]	-0.002 [-0.95]	-0.000 [-0.11]
β_{DOL}		0.003 [0.60]		-0.001 [-0.29]
β_{CAR}		-0.000 [-0.09]		0.001 [0.91]
β_{MOM}		-0.000 [-0.00]		0.001 [0.36]
β_{VAL}		0.005 [1.77]		0.003 [0.07]
tk_{t-1}			-0.174 [-3.43]	-0.114 [-2.61]
$Const$	-0.000 [-0.39]	-0.000 [0.09]	-0.002 [-2.56]	-0.001 [-1.58]
R^2	16.4%	51.3%	27.4%	57.4%

Table 6: 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 is the currency i excess return, 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, past three month cumulative returns $rx^i_{t-3,t}$ and past five years real exchange rate changes $rx^i_{t-5y,t}$. 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). t-statistics (reported in brackets) are based on standard errors clustered by currency. The sample runs from January 1990 to December 2018.

	vol^{FX}	bas^{FX}	ted	fsi	vix
tk_{t-1}	-0.375 [-4.83]	-0.407 [-5.54]	-0.367 [-4.86]	-0.388 [-5.38]	-0.487 [-7.83]
$tk_{t-1} \times la_{t-1}$	-10.48 [-2.86]	9.450 [4.35]	-15.51 [-1.79]	0.712 [0.78]	0.111 [0.78]
la_{t-1}	-0.206 [-1.93]	0.260 [3.40]	0.006 [0.02]	0.062 [2.32]	-0.005 [-1.38]
fd_{t-1}	-0.165 [-0.77]	-0.154 [-0.66]	-0.142 [-0.63]	-0.127 [-0.56]	-0.127 [-0.53]
$rx_{t-3,t}$	0.003 [0.24]	-0.004 [-0.29]	0.005 [0.41]	-0.002 [-0.14]	-0.119 [-0.67]
$rx_{t-5y,t}$	0.002 [0.17]	0.001 [0.11]	0.003 [0.23]	0.003 [0.25]	0.003 [0.29]
Curr FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Cluster	Currency	Currency	Currency	Currency	Currency
Nr.Obs	2,859	2,850	2,850	2,850	2,850
R^2	6.91%	4.71%	7.47%	7.30%	7.27%

Table 7: 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 is the currency i excess return, 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, past three month cumulative returns $rx^i_{t-3,t}$ and past five years real exchange rate changes $rx^i_{t-5y,t}$. The investor sentiment variable $sent_t$ is defined as the cross-sectional average of consumer confidence index growth rate across 32 economies. t-statistics (reported in brackets) are based on standard errors clustered by currency. The sample runs from January 1990 to December 2018.

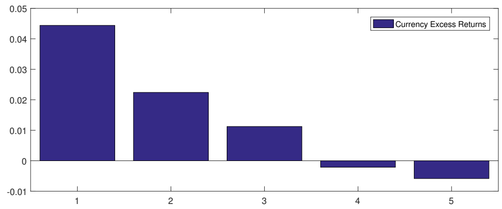
tk	-0.384	-0.414
	[-4.46]	[-4.87]
$tk \times sent$	-56.01	-76.64
	[-2.69]	[-4.64]
$sent$	-1.649	-1.093
	[-2.95]	[-2.60]
fd		-0.043
		[-0.16]
$rx_{t-3,t}$		0.005
		[0.49]
$rx_{t-5y,t}$		0.009
		[0.84]
Year FE	Yes	Yes
Curr FE	Yes	Yes
Cluster	Currency	Currency
Nr.Obs	3,529	3,480
R^2	6.20%	6.20%

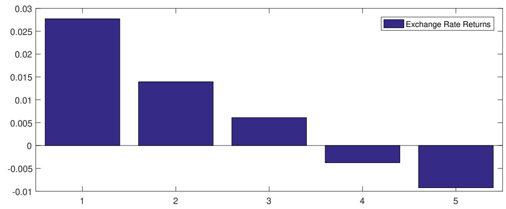
Table 8: Limited attention

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 currency i excess return, 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, past three month cumulative returns $rx^i_{t-3,t}$ and past five years real exchange rate changes $rx^i_{t-5y,t}$. The limited attention variable gsv_t corresponds to the growth in 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 1990 to December 2018.

	"FX"	"GDP"	"Infl."	"Unempl."	"Interest Rate"	"Central Bank"
tk_{t-1}	-0.454	-0.495	-0.478	-0.496	-0.447	-0.452
	[-3.75]	[-4.07]	[-3.94]	[-4.00]	[-3.73]	[-3.84]
$tk_{t-1} \times gsv_{t-1}$	2.569	0.534	2.068	1.044	4.297	4.508
	[4.64]	[1.29]	[6.94]	[3.16]	[6.66]	[9.72]
gsv	0.049	0.004	0.035	0.011	0.069	0.087
	[3.77]	[0.63]	[4.19]	[1.42]	[4.08]	[5.25]
fd	-1.011	-0.920	-0.982	-0.869	-0.932	-1.021
	[-1.34]	[-1.28]	[-1.43]	[-1.21]	[-1.36]	[-1.44]
$rx_{t-5y,t}$	0.018	0.021	0.023	0.013	0.004	0.015
	[1.67]	[2.00]	[2.13]	[1.10]	[0.44]	[1.50]
$rx_{t-5y,t}$	-0.021	-0.023	-0.273	-0.018	-0.020	-0.020
	[-1.26]	[-1.34]	[-1.57]	[-1.06]	[-1.19]	[-1.17]
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	1,672	1,672	1,672	1,672	1,672	1,672
R^2	5.34%	5.17%	5.73%	5.17%	6.95%	6.20%

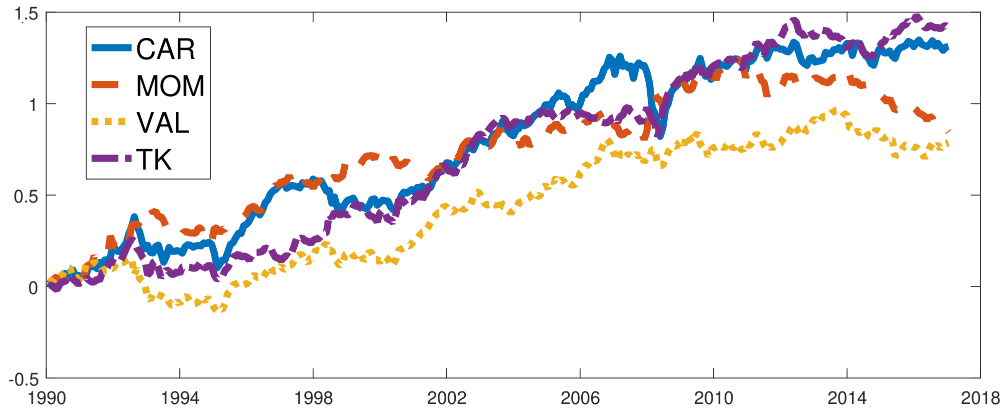
Figure 1: Currency portfolio returns sorted by prospect theory values





The figure illustrates currency excess returns and exchange rate returns for portfolios sorted by prospect theory values.

Figure 2: 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.

Internet appendix to

“Prospect Theory and Currency Returns”

(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 3.2. 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 return ($rx_{t-3,t}$). 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 past five years changes of real exchange rates ($rx_{t-5y,t}$). VAL is the zero-cost return spread of a strategy longing the lowest $rx_{t-5y,t}$ (undervalued) currencies and shorting the highest $rx_{t-5y,t}$ (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 returns of prospect theory value sorted portfolios from January 1990 to February 2018 for developed economies samples of currencies 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). Annualized returns are reported in percentage points and are not adjusted for transaction costs. 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							
$f = 36$	0.026	0.023	0.015	0.004	0.003	0.014	0.023
	[1.20]	[1.18]	[0.74]	[0.26]	[0.22]	[0.85]	[1.47]
$f = 48$	0.036	0.026	0.012	0.010	-0.010	0.015	0.046
	[1.64]	[1.26]	[0.65]	[0.61]	[-0.63]	[0.89]	[2.98]
$f = 72$	0.035	0.026	0.013	0.006	-0.005	0.015	0.040
	[1.55]	[1.31]	[0.65]	[0.33]	[-0.34]	[0.87]	[2.22]
Panel B: Different Variables							
rx	0.044	0.008	0.015	0.001	-0.004	0.013	0.049
	[2.29]	[0.37]	[0.71]	[0.05]	[-0.28]	[0.75]	[3.08]
fd	0.002	0.012	0.020	0.004	0.034	0.014	-0.032
	[0.10]	[0.63]	[1.12]	[0.20]	[1.56]	[0.85]	[-1.74]
Panel C: Different Functions: Exponential Decaying							
$\rho = 1$	0.044	0.022	0.011	-0.002	-0.006	0.014	0.050
	[2.02]	[1.11]	[0.53]	[-0.14]	[-0.38]	[0.82]	[3.14]
$\rho = 0.95$	0.030	0.014	0.010	0.010	0.012	0.015	0.018
	[1.48]	[0.63]	[0.50]	[0.57]	[0.78]	[0.89]	[1.18]
$\rho = 0.9$	0.025	0.017	0.013	0.009	0.011	0.015	0.014
	[1.23]	[0.76]	[0.66]	[0.51]	[0.71]	[0.90]	[0.82]
$\rho = 0.85$	0.024	0.011	0.025	0.001	0.015	0.015	0.009
	[1.14]	[0.55]	[1.13]	[0.08]	[1.00]	[0.90]	[0.50]
Panel D: Different Functions: Expected Utility							
$\lambda = 10$	0.023	0.029	0.028	0.004	-0.010	0.015	0.033
	[1.25]	[1.41]	[1.48]	[0.20]	[-0.56]	[0.87]	[1.91]
$\lambda = 5$	0.024	0.031	0.011	0.009	-0.003	0.015	0.027
	[1.41]	[1.54]	[0.59]	[0.45]	[-0.15]	[0.86]	[1.60]
$\lambda = 3$	0.025	0.027	0.005	0.010	-0.001	0.013	0.026
	[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 under different sub-sample periods. We consider NBER recession and non-recession periods, before (January 1990 to December 2006) and after (January 2007 to February 2018) financial crisis, and high (above and equal MSCI median) and low (below MSCI median) sentiment periods. We report return and characteristics. 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			
$Mean$	-0.047	0.080	0.062	0.092	0.057	0.024	0.024	0.046
	[-0.40]	[1.02]	[1.17]	[1.18]	[3.29]	[1.47]	[1.50]	[2.88]
Std	0.151	0.122	0.091	0.121	0.090	0.089	0.077	0.079
$Skew$	-0.458	1.235	-1.065	0.046	-0.415	0.147	-0.640	0.224
$Kurt$	4.310	5.165	5.114	3.428	3.501	4.218	4.483	4.346
SR	-0.309	0.654	0.683	0.762	0.637	0.274	0.314	0.574
Panel B: Financial Crisis								
	Before Crisis				After Crisis			
$Mean$	0.064	0.054	0.040	0.054	0.021	-0.007	0.009	0.045
	[2.88]	[2.86]	[2.03]	[2.67]	[0.56]	[-0.24]	[0.38]	[1.69]
Std	0.084	0.088	0.074	0.081	0.115	0.099	0.084	0.089
$Skew$	-0.524	0.499	-0.508	0.181	-0.504	0.441	-0.836	0.294
$Kurt$	3.851	4.601	4.423	4.904	4.704	5.171	4.513	3.986
SR	0.752	0.617	0.547	0.663	0.182	-0.072	0.104	0.500
Panel C: Investor Sentiment								
	High Sentiment				Low Sentiment			
$Mean$	0.049	0.017	0.031	0.045	0.044	0.043	0.025	0.055
	[2.15]	[0.79]	[1.52]	[2.32]	[1.40]	[1.61]	[1.17]	[2.29]
Std	0.082	0.083	0.074	0.074	0.112	0.102	0.082	0.094
$Skew$	-0.640	-0.008	-0.666	0.780	-0.528	0.624	-0.703	-0.062
$Kurt$	4.036	3.588	4.796	5.269	4.647	5.121	4.392	3.890
SR	0.598	0.206	0.418	0.612	0.396	0.419	0.301	0.588

Table A3: Transaction costs adjusted portfolio returns

This table reports returns and characteristics of prospect theory value sorted portfolios from January 1990 to February 2018 for both developed economies sample. 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). Annualized returns are reported in percentage points and are adjusted for transaction costs. 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							
$Mean$	0.044	0.021	0.009	-0.005	-0.004	0.013	0.049
	[2.01]	[1.03]	[0.44]	[-0.31]	[-0.29]	[0.76]	[3.05]
Std	0.105	0.099	0.098	0.087	0.074	0.081	0.085
$Skew$	-0.144	-0.062	-0.177	-0.276	-0.259	-0.193	0.223
$Kurt$	5.067	3.334	3.252	4.642	5.737	3.797	4.466
SR	0.422	0.212	0.096	-0.057	-0.060	0.162	0.577
$AR(1)$	0.093	0.037	0.100	0.012	0.117	0.097	0.098
p	(0.119)	(0.508)	(0.068)	(0.857)	(0.081)	(0.090)	(0.122)
Panel B: Exchange Rate Returns							
$Mean$	0.028	0.013	0.005	-0.006	-0.008	0.006	0.036
	[1.28]	[0.66]	[0.24]	[-0.37]	[-0.53]	[0.37]	[2.23]
Std	0.105	0.098	0.098	0.087	0.074	0.080	0.085
$Skew$	-0.195	-0.076	-0.205	-0.368	-0.214	-0.228	0.156
$Kurt$	5.163	3.352	3.346	4.924	5.801	3.870	4.585
SR	0.265	0.133	0.051	-0.069	-0.110	0.079	0.425
$AR(1)$	0.090	0.028	0.095	0.017	0.114	0.092	0.107
p	(0.139)	(0.623)	(0.090)	(0.815)	(0.095)	(0.116)	(0.095)

Table A4: Explanatory power of prospect theory value components

This table reports returns prospect theory value component sorted portfolios from 1990 to 2018 for developed economies sample using prospect theory value components. 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). Annualized returns are reported in percentage points and are not adjusted for transaction costs. 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	0.044	0.022	0.011	-0.002	-0.006	0.014	0.050
	[2.02]	[1.11]	[0.53]	[-0.14]	[-0.38]	[0.82]	[3.14]
la	0.031	0.025	0.015	0.007	-0.009	0.014	0.040
	[1.56]	[1.27]	[0.69]	[0.38]	[-0.61]	[0.80]	[2.64]
cc	0.032	0.022	0.011	0.015	-0.010	0.014	0.042
	[1.83]	[1.03]	[0.58]	[0.82]	[-0.52]	[0.82]	[2.43]
pw	0.031	0.032	0.018	0.010	-0.019	0.014	0.050
	[1.68]	[1.52]	[0.89]	[0.60]	[-1.08]	[0.84]	[3.07]
			Panel B: Exchange Rate Returns				
tk	0.028	0.014	0.006	-0.004	-0.009	0.007	0.037
	[1.28]	[0.71]	[0.29]	[-0.24]	[-0.60]	[0.41]	[2.29]
la	0.022	0.020	0.006	-0.001	-0.016	0.006	0.038
	[1.16]	[1.00]	[0.29]	[-0.04]	[-1.03]	[0.38]	[2.47]
cc	0.025	0.013	0.003	0.008	-0.018	0.006	0.042
	[1.48]	[0.60]	[0.19]	[0.46]	[-0.91]	[0.38]	[2.55]
pw	0.018	0.022	0.008	0.001	-0.015	0.007	0.033
	[1.02]	[1.08]	[0.42]	[0.04]	[-0.88]	[0.40]	[2.10]

Table A5: 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 48, 20, and 10 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). Annualized returns are reported in percentage points and are not adjusted for transaction costs. 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				
$Mean$	0.031	0.039	0.012	0.007	0.008	0.020	0.023
	[1.02]	[2.13]	[0.63]	[0.56]	[1.14]	[1.29]	[0.82]
Std	0.110	0.088	0.092	0.064	0.030	0.067	0.099
$Skew$	0.286	-0.217	-0.346	-0.609	-0.301	-0.369	0.498
$Kurt$	4.540	3.858	4.077	5.901	7.174	4.352	4.910
SR	0.283	0.450	0.133	0.117	0.254	0.293	0.238
			Panel B: 20 Currencies				
$Mean$	0.061	0.033	0.003	0.005	-0.007	0.019	0.068
	[1.98]	[1.68]	[0.16]	[0.35]	[-0.77]	[1.18]	[2.40]
Std	0.116	0.096	0.091	0.077	0.043	0.073	0.098
$Skew$	0.155	-0.100	-0.239	-0.142	-0.607	-0.218	0.527
$Kurt$	4.615	3.495	3.440	6.769	6.438	3.969	4.654
SR	0.528	0.341	0.033	0.069	-0.154	0.261	0.692
			Panel C: 10 Currencies				
$Mean$	0.040	0.023	0.004	0.006	-0.007	0.013	0.048
	[1.86]	[1.12]	[0.19]	[0.42]	[-0.46]	[0.78]	[2.91]
Std	0.107	0.098	0.102	0.084	0.076	0.079	0.089
$Skew$	-0.082	-0.051	-0.395	-0.085	-0.205	-0.158	0.323
$Kurt$	5.001	3.318	4.120	4.540	5.694	3.770	4.974
SR	0.377	0.233	0.040	0.075	-0.097	0.168	0.538

Table A6: Alternative behavioral factors

This table reports returns and characteristics of alternative behavioral indicators sorted portfolios from January 1990 to February 2018. We consider $SKEW$, MAX, MIN, PTH, and 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). Annualized returns are reported in percentage points and are not adjusted for transaction costs. 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.

Panel A: Currency Excess Returns

	$P1$	$P2$	$P3$	$P4$	$P5$	AVG	H/L
$SKEW$	0.000	0.020	0.016	0.025	0.013	0.015	0.013
	[0.03]	[1.06]	[0.76]	[1.39]	[0.72]	[0.88]	[0.83]
MAX	-0.002	0.008	0.015	0.023	0.027	0.014	0.029
	[-0.13]	[0.41]	[0.77]	[1.22]	[1.28]	[0.84]	[1.81]
MIN	0.014	0.008	0.022	0.011	0.014	0.014	0.000
	[0.86]	[0.46]	[1.17]	[0.58]	[0.60]	[0.81]	[-0.01]
PTH	-0.006	0.023	0.017	0.023	0.010	0.013	0.016
	[-0.28]	[1.18]	[0.86]	[1.31]	[0.64]	[0.79]	[0.93]
PTL	0.013	0.014	0.011	0.020	0.019	0.015	0.006
	[0.69]	[0.75]	[0.50]	[0.96]	[0.98]	[0.89]	[0.38]

Panel B: Correlations with PTP

	$SKEW$	MAX	MIN	PTH	PTL
$Corr_{TK}$	0.003	-0.343	-0.379	0.495	0.009

Panel C: Explaining PTP with Alternative Behavioral Factors

	α	$SKEW$	MAX	MIN	PTH	PTL	$\bar{R}^2$
	0.004	-0.028	0.147	0.128	-0.397	0.086	0.306
	[4.06]	[-0.41]	[2.08]	[1.60]	[-5.52]	[1.21]	

Table A7: Alternative pricing currencies

This table reports returns and characteristics of prospect theory value sorted portfolios from January 1990 to February 2018 using different base 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 portfolio (P_5) and longing low prospect theory value portfolio (P_1). Annualized returns are reported in percentage points and are not adjusted for transaction costs. 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 pricing currencies (other than USD).

	$P1$	$P2$	$P3$	$P4$	$P5$	AVG	PTP
Panel A: GBP As the Pricing Currency							
$Mean$	0.029	0.018	-0.011	-0.003	-0.011	0.004	0.040
	[1.46]	[1.09]	[-0.81]	[-0.17]	[-0.98]	[0.34]	[2.23]
Std	0.102	0.086	0.084	0.082	0.052	0.067	0.087
$Skew$	0.627	1.390	0.528	0.935	0.435	1.098	0.165
$Kurt$	5.240	10.24	5.716	6.211	7.537	7.734	4.394
SR	0.288	0.206	-0.136	-0.035	-0.202	0.066	0.456
Panel B: CHF As the Pricing Currency							
$Mean$	0.026	-0.001	0.014	0.001	-0.006	0.007	0.031
	[1.38]	[-0.07]	[1.05]	[0.11]	[-0.81]	[0.63]	[1.83]
Std	0.100	0.089	0.079	0.066	0.042	0.060	0.090
$Skew$	-0.227	-0.819	-0.954	-0.907	-0.518	-0.994	-0.145
$Kurt$	4.088	5.666	8.977	8.024	9.005	7.703	4.223
SR	0.255	-0.014	0.175	0.018	-0.141	0.111	0.350
Panel C: JPY As the Pricing Currency							
$Mean$	0.043	0.046	0.016	0.020	0.014	0.028	0.030
	[1.70]	[1.84]	[0.65]	[0.91]	[1.08]	[1.36]	[1.62]
Std	0.126	0.126	0.126	0.115	0.068	0.104	0.090
$Skew$	-0.619	-0.555	-0.733	-0.714	-0.841	-0.722	-0.449
$Kurt$	5.923	5.088	4.768	4.983	4.957	5.404	6.328
SR	0.344	0.365	0.130	0.177	0.201	0.270	0.329

Table A8: 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. 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.

Panel A: Idiosyncratic volatility (*ivol*)

	tk_{Low}	tk_{Med}	tk_{High}	HML
$ivol_{Low}$	0.018	0.032	0.009	-0.009
	[1.48]	[1.15]	[0.79]	[-0.77]
$ivol_{High}$	0.030	0.012	0.002	-0.028
	[1.10]	[1.10]	[0.08]	[-1.72]

Panel B: Illiquidity *bas*

	tk_{Low}	tk_{Med}	tk_{High}	HML
$ILIQ_{Low}$	0.018	0.048	0.021	0.003
	[0.87]	[2.15]	[1.07]	[0.22]
$ILIQ_{High}$	0.012	-0.006	0.000	-0.012
	[0.599]	[-0.34]	[0.03]	[-0.68]

Panel C: Covered interest rate parity deviation (*cip*)

	tk_{Low}	tk_{Med}	tk_{High}	HML
cip_{Low}	0.052	0.034	0.005	-0.046
	[1.58]	[1.15]	[0.24]	[-2.12]
cip_{High}	0.013	-0.030	-0.024	-0.037

Table A9: The impact of Central Bank intervention

This table reports the impact of central bank intervention on prospect theory value strategy profits. We focus on three central bank interventions by US (April 1991 to December 2003), Japan (April 1991 to February 2018), and Swiss (April 1991 to March 2001). The intervention data is obtained from Fed St Louis website. We report summary statistics of prospect theory value strategy for both the original sample and the sample after removing the intervention periods. We also consider the difference of average return and t-statistics with null hypothesis of zero difference.

	US		Japan		Swiss	
	Orignal	*Removal*	*Orignal*	*Removal*	*Orignal*	*Removal*
Mean	0.066	0.064	0.051	0.034	0.040	0.040
	[2.58]	[2.48]	[3.04]	[2.13]	[1.37]	[1.45]
Std	0.088	0.088	0.086	0.076	0.087	0.085
Skew	0.124	0.138	0.226	0.483	0.357	0.445
Kurt	4.551	4.661	4.433	6.116	5.171	5.593
SR	0.749	0.729	0.592	0.452	0.457	0.468
AR	0.081	0.092	0.098	0.145	0.164	0.123
p	(0.332)	(0.277)	(0.128)	(0.042)	(0.066)	(0.171)
Diff		0.002		0.017		0.000
		[0.93]		[1.88]		[0.02]