Currency portfolios and global foreign exchange ambiguity*

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May 26, 2024

Abstract

This study investigates whether cross-sectional global foreign exchange (FX) ambiguity impacts currency portfolios. We observe that, in contrast to FX volatility, high FX ambiguity leads to high currency carry returns. We also reveal that FX ambiguity is weakly associated with the highest interest rate portfolio, but strongly related to the second highest interest rate portfolio. These results suggest that FX ambiguity captures elements of uncertainty that are not captured by FX volatility. In addition, FX ambiguity is not linked to returns on currency momentum and value portfolios.

Keywords: Currency Portfolio; Ambiguity; Carry Trades; FX Volatility
JEL Codes: F31, G11, G15

*The authors would like to thank Satoko Asano for her excellent research assistance. This research was financially supported by International Joint Research Center of Advanced Economic Research of KIER and the Grants-in-Aid for Scientific Research, JSPS (23K01468, 22H00846, 22K13430).

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1 Introduction

Currencies are important assets for both investors and corporations to generate profits and mitigate the effects of changes in currency prices. The literature proposes currency investment methods that generate high Sharpe ratios (e.g., Asness et al., 2013; Barroso and Santa-Clara, 2015). In particular, currency carry trades that exploit deviations of the uncovered interest rate parity have received attention in the literature (e.g., Lustig et al., 2011). The influential work of Menkhoff et al. (2012a) presents that the profits of carry trades are compensation for risk, which is captured by cross-sectional global foreign exchange (FX) volatility. Moreover, the literature presents that global FX volatility is a key variable to understand the fluctuation of currency carry trades. For instance, Bakshi and Panayotov (2013), Lu and Jacobsen (2016), and Nakagawa and Sakemoto (2023) adopt global FX volatility to predict the carry trade profits. Moreira and Muir (2017), Mulder and Tims (2018), and Dupuy (2021) propose approaches to enhance the performance of carry trades using global FX volatility. However, volatility focuses on one aspect of uncertainty,[1] and the literature on decision theory distinguishes ambiguity and risk (volatility), see Gilboa and Schmeidler (1989) and Schmeidler (1989) for pioneering works and Machina and Siniscalchi (2014) and Gilboa and Marinacci (2016) for surveys of axiomatic models and applications.

This study contributes to the literature by proposing cross-sectional global FX ambiguity. Estimating ambiguity has been considered challenging (e.g., Epstein and Schneider, 2008; Bianchi and Tallon, 2019), but recent studies by Brenner and Izhakian (2018) and Augustin and Izhakian (2020) introduce an empirical approach that examines ambiguity using stock market prices within a time series context.[2] They find that volatility and ambiguity have different impacts on equity returns. In the currency literature, Lustig et al. (2011) and Menkhoff et al. (2012a) demonstrate that currency carry portfolios are exposed to risks associated with currency and equity market volatility. Incorporating the methods of Menkhoff et al. (2012a)

[1]In this paper, uncertainty refers to all situations that are not deterministic.

[2]This empirical approach is also adopted by Luo et al. (2021) and Shust (2024).

and Brenner and Izhakian (2018), we explore whether ambiguity influences returns on currency carry portfolios. In contrast to the works of Brenner and Izhakian (2018) and Augustin and Izhakian (2020), which adopt high frequency time series data, we employ daily cross-sectional currency prices. This reduces the number of observations but allows us to investigate a longer period than these authors.

Our second contribution is the exploration of the relationships between ambiguity and various currency portfolios. Nucera et al. (2024) employ the information reduction methods proposed by Lettau and Pelger (2020) and Giglio and Xiu (2021) and find that pricing kernels can be mainly summarized into dollar, carry, and momentum factors. Moreover, Pojarliev and Levich (2010) report that many professional currency fund managers take exposures to carry, momentum, value, and volatility, and Barroso and Santa-Clara (2015) report that carry, momentum, and value generate high Sharpe ratios in the currency portfolios.[3] Therefore, our focus extends beyond carry portfolios to include momentum and value portfolios.

The rest of the paper is organized as follows. Section 2 describes the data and methodology, Section 3 presents the empirical results, and Section 4 concludes.

2 Data and methodology

2.1 Data

We employ one-month forward and spot exchange rates against the US dollar (USD) to construct currency portfolios. Our portfolios are rebalanced at a monthly frequency, and we obtain the end of the month values. We also adopt daily spot price data and estimate daily ambiguity values. All data are obtained from Datastream, which is widely used in the currency literature (e.g., Menkhoff et al., 2012a).[4] Following Lustig et al. (2011) and Menkhoff et al. (2012a), we construct G10 and all-country portfolios and provide the list of countries in Online Appendix. The number of currencies varies over time, and our data extend from December 1983 to

[3]Sakemoto (2018) demonstrates that carry, momentum, and value portfolios have heterogeneous exposures to other assets.

[4]In addition, we employ spot exchange rates against the British pound (GBP) and the Japanese yen (JPY) to estimate daily ambiguity values. See section 2.3 for further details.

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2.2 Currency portfolios

Following Lustig et al. (2011) and Menkhoff et al. (2012a), we calculate an excess return on currency i at $t+1$ as the difference between the log one-month forward price f_i at time t and a log spot price s_i at $t+1$:

$$re_{i,t+1} = f_{i,t} - s_{i,t+1}.$$

Note that $f_{i,t}$ is delivered at time $t+1$. We rank currencies based on the following characteristics: carry (e.g., Menkhoff et al., 2012a), momentum (e.g., Menkhoff et al., 2012b), and value (e.g., Asness et al., 2013).[5] Our holding period is one month and we employ an equal weight scheme in the portfolio. The portfolio is rebalanced at the end of each month and returns on carry, momentum, and value portfolios are calculated as the spread returns between the lowest rank (P1) and the highest rank (P5) portfolios (e.g., Menkhoff et al., 2012a).

2.3 Ambiguity estimation

This section describes the method used to estimate monthly cross-sectional FX ambiguity. Let r_d be the spot return on a currency pair on day d, on which K currency pairs are available.[6] In the following explanation, we omit the subscript d and simply write r. To estimate monthly global FX ambiguity using daily returns of K currency pairs, we consider the following framework. Suppose that all investors have an identical set of priors over the daily return distribution. Each prior in the set is represented by the observed daily returns on the K currency pairs (that is, we have one distribution of realized daily returns for each trading day, with K as the number of currency pairs), and the number of priors in the set depends on the number of

[5]Online Appendix provides methods to calculate scores for these three characteristics and summary statistics of all portfolios.

[6]We employ the daily spot price return (Menkhoff et al., 2012a). Brenner and Izhakian (2018) and Augustin and Izhakian (2020) adopt intraday data, whereas our employment of daily data enables us to explore a longer time period. For instance, many influential studies on currency portfolios start their investigations from the early 1980s (e.g., Lustig et al., 2011).

trading days in the month. Assuming that one month consists of 22 trading days, we have 22 distributions over this month, which is considered a set of investors' priors. If this set of priors consists of a single prior (distribution), then there is no ambiguity.

Based on Brenner and Izhakian (2018) and Augustin and Izhakian (2020), we estimate the degree of monthly cross-sectional FX ambiguity Amb_t at month t using the following equation:[7]

$$
\begin{aligned}
& Amb_t \\
= \; & \sum_{j=0}^{11} E[P(B^j)]\mathrm{Var}[P(B^j)] \\
= \; & E[\Phi(r^0;\mu,\sigma)]\mathrm{Var}[\Phi(r^0;\mu,\sigma)] \\
+ \; & \sum_{j=1}^{10} E[\Phi(r^j;\mu,\sigma)-\Phi(r^{j-1};\mu,\sigma)]\mathrm{Var}[\Phi(r^j;\mu,\sigma)-\Phi(r^{j-1};\mu,\sigma)] \\
+ \; & E[1-\Phi(r^{10};\mu,\sigma)]\mathrm{Var}[1-\Phi(r^{10};\mu,\sigma)].
\end{aligned} \tag{1}
$$

We divide the range of daily returns r, from -2% to $+2\%$, into ten intervals, each with a width of 0.4%, and add two intervals, $(-\infty,-2\%]$ and $(+2\%,\infty)$, which yields 12 intervals. We discretize the return distributions into 12 bins $B^j=(r^{j-1},r^j]$ of equal sizes for $j=0,1,\ldots,11$, $B^0=(r^{-1},r^0]=(-\infty,-2\%]$, $B^1=(r^0,r^1]=(-2\%,-1.6\%],\ldots,B^{11}=(r^{10},r^{11}]=(2\%,\infty)$. Next, we compute the mean and the variance of the probabilities for each interval $E[P(B^j)]$ and $\mathrm{Var}[P(B^j)]$ over a month t, $P(B^j)$ for $j=0,1,\ldots,11$. Similar to Brenner and Izhakian (2018) and Augustin and Izhakian (2020), we assume a normal distribution, $P^d[B^j]=[\Phi(r^j;\mu_d,\sigma_d)-\Phi(r^{j-1};\mu_d,\sigma_d)]$, where $\Phi(\cdot)$ denotes the cumulative normal distribution function and μ_d and σ_d denote the mean and variance of r at day d, respectively. The cross-sectional mean μ_d and the cross-sectional standard deviation σ_d are estimated at a daily frequency. Our approach is more sensitive to the number of K because cross-sectional FX volatility needs histograms. To assess this point, we calculate three types of ambiguity using spot returns against the USD for G10 countries, spot returns against the USD for all countries, and a combination of spot returns against the USD, GBP, and JPY for G10 countries. Following Menkhoff et al. (2012a), we

[7] Equation (1) is a discrete form of Equation (A-4) in Online Appendix.

obtain innovations of monthly ambiguity (ΔAmb_t) using an autoregressive order one, which is the standard approach in the currency literature.

3 Empirical results

3.1 Comparison among ambiguity

We begin with the estimation results for ambiguity in Equation (1). Figure 1 depicts three ambiguity values: G10 based on the USD (Amb_{G10}), all-countries based on the USD (Amb_{all}), and G10 based on the USD, GBP, and JPY (Amb_{3bc}). We find that the three values had spikes at the same time. Interestingly, we observe that these spikes did not occur during the situations of market turmoil, such as the Asian financial crisis in 1997, the Russian financial crisis in 1998, the global financial crisis in 2008, or the COVID-19 pandemic in 2020.

Insert Figure 1 here.

This feature contrasts with the cross-sectional global FX volatility results in Menkhoff et al. (2012a). Moreover, we observe that average values of Amb_{G10} and Amb_{all} were particularly larger in the 1980s because price data on some currencies were not available during this period. Equation (1) indicates that the ambiguity estimation depends on the mean and standard deviation of cross-sectional currency returns. Therefore, if the number of available currencies is small, these values tend to demonstrate significant fluctuations. This point is another important difference between global FX volatility and ambiguity.

3.2 Currency portfolios and ambiguity

Having found the substantial differences between global FX volatility and ambiguity, we investigate whether these differences impact on asset pricing models. We regress excess returns on carry, momentum, and value portfolios onto the innovations to global FX ambiguity (ΔAmb). These excess returns are calculated as the spread returns between the lowest rank portfolio (P1) and the highest rank portfolio (P5). We employ the dollar factor, which acts as a level factor in a time series context

(Lustig et al., 2011).[8]

Panels A, B, and C in Table 1 indicate that ΔAmb is associated with the carry return for the G10 portfolios, and these results are statistically significant at the 5% level. We also find that these results are economically meaningful. For instance, Panel A displays that an increase in the one standard deviation of ΔAmb causes an increase in the carry return by 0.27% per month ($8.93 \times 0.03 = 0.27$). Our results also indicate that the values of global FX ambiguity depend on the number of currencies, as in Equation (1), but this difference does not have a large impact. This is because the three ambiguity values demonstrate the same up–down trends. We observe that low ambiguity is linked to low carry returns because the average values of ambiguity decrease during periods of market stress. This is consistent with the stock market results of Brenner and Izhakian (2018), and our findings also complement those of Menkhoff et al. (2012a), who demonstrate that carry portfolio profits decline during periods of market stress. Furthermore, we find that the relationship is weak for the all-country portfolios, and we will investigate the reason for this in the next section. In addition, Table 1 demonstrates that the relationships between ambiguity and the other two currency portfolios are unclear. These results align with the findings of Menkhoff et al. (2012b) and Byrne and Sakemoto (2021), suggesting that FX volatility is weakly linked to momentum and value returns.

Insert Table 1 here.

3.3 Portfolio results

The previous section focused on spread returns (P5−P1), which may lose information between P2 and P4. This section repeats the same exercise using each sorted portfolio. We employ ΔAmb_{G10} for the G10 portfolios and ΔAmb_{all} for the all-country portfolios. The results in Panel A of Table 2 indicate that global FX ambiguity is not linked to the highest interest rate portfolio (P5) for both G10 and all-countries.[9] This is the substantial difference between volatility and ambiguity, demonstrating

[8]The dollar factor is calculated as: $DOL_t = (\sum_{i=1}^{K_t} re_{i,t})/K_t$, where K_t represents the number of currency pairs available at time t.

[9]Tables A5–A8 in Online Appendix provide summary statistics for each portfolio.

that ambiguity is not a simple variable that flips the sign of volatility. This difference may stem from investors' attitudes toward ambiguity. By considering ambiguity, Dow and Werlang (1992) theoretically explain the existence of the price range, in other words, portfolio inertia, in which an investor neither buys nor sells a stock (e.g., Epstein and Wang, 1994).[10] Therefore, ambiguity is more strongly associated with the more ambiguous portfolio (P4) than with the less ambiguous portfolio (P5).[11] In addition, Panels B and C of Table 2 demonstrate that ambiguity does not systematically impact portfolios sorted by momentum and value.

Insert Table 2 here.

3.4 Effects of transaction costs

In this section, we construct currency portfolios including bid–ask spreads (e.g., Lustig et al., 2011; Menkhoff et al., 2012a). Tables A1 and A2 present the same pattern as Tables 1 and 2, where an increase in ΔAmb yields high carry returns, and P5 is weakly associated with ΔAmb.

3.5 Subsample results

This section splits the data into two periods and repeats the same exercises with results presented in Tables 1 and 2. The first period extends from January 1984 to December 1996, and the second period covers January 1997 to May 2023. Data for most emerging countries are available for the second period, and the disparity between G10 and all-country portfolios is larger in this period. Tables A3 and A4 reveal that the relationship between ΔAmb and the carry portfolios became strong in the second period. This result is associated with the fact that carry trades generated high profitability in the 2000s. See, for instance, Ready et al. (2017).

[10] For further discussion of portfolio inertia, refer to Online Appendix.

[11] We observe that the most ambiguous portfolio in terms of interest rates (P3) does not relate to ΔAmb, indicating that the impacts of ambiguity are the opposite to those of volatility. This result is associated with the findings of Menkhoff et al. (2012a), who demonstrate that global FX volatility does not influence P3.

4 Conclusion

This study extends the global FX volatility of Menkhoff et al. (2012a) to global FX ambiguity using the approach of Brenner and Izhakian (2018) and Augustin and Izhakian (2020). The previous literature presents that returns on currency carry trades depend on global FX volatility, and high volatility causes low returns (Menkhoff et al., 2012a; Moreira and Muir, 2017; Mulder and Tims, 2018; Dupuy, 2021). In contrast, we find that high ambiguity leads to high carry trade returns. Moreover, we reveal that the relationship between the highest interest rate portfolio and ambiguity is weak. These results indicate that global FX ambiguity captures uncertainty that is not necessarily captured by global FX volatility.

Our results suggest that currency investors should control for exposures not only to volatility but also to ambiguity to achieve comprehensive risk management. Examining how to optimize volatility and ambiguity simultaneously and to construct portfolios is a topic for future research.

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Table 1: Time series regressions: Spread returns

Panel A: Amb_{G10}

	G10 countries					All countries			
	α	DOL	ΔAmb	Adj_R^2		α	DOL	ΔAmb	Adj_R^2
Carry	0.408***	0.149*	0.030**	2.38	Carry	0.965***	0.168*	0.011	1.73
	(0.130)	(0.089)	(0.013)			(0.205)	(0.097)	(0.012)	
Mom	0.287**	0.042	0.015	−0.09	Mom	0.672***	−0.116	−0.002	0.38
	(0.130)	(0.066)	(0.016)			(0.164)	(0.109)	(0.015)	
Value	0.269**	0.119	0.006	0.89	Value	0.583***	0.087	0.011	0.34
	(0.120)	(0.075)	(0.016)			(0.145)	(0.076)	(0.016)	

Panel B: Amb_{all}

	G10 countries					All countries			
	α	DOL	ΔAmb	Adj_R^2		α	DOL	ΔAmb	Adj_R^2
Carry	0.408***	0.147*	0.053**	2.42	Carry	0.965***	0.167*	0.005	1.61
	(0.133)	(0.087)	(0.023)			(0.199)	(0.096)	(0.023)	
Mom	0.287**	0.041	0.026	−0.08	Mom	0.672***	−0.116	0.005	0.38
	(0.130)	(0.066)	(0.026)			(0.154)	(0.106)	(0.024)	
Value	0.269**	0.118*	−0.006	0.86	Value	0.583***	0.086	0.005	0.19
	(0.119)	(0.071)	(0.031)			(0.126)	(0.066)	(0.028)	

Panel C: Amb_{3bc}

	G10 countries					All countries			
	α	DOL	ΔAmb	Adj_R^2		α	DOL	ΔAmb	Adj_R^2
Carry	0.408***	0.150*	0.058**	2.62	Carry	0.965***	0.168*	0.011	1.65
	(0.134)	(0.082)	(0.026)			(0.205)	(0.098)	(0.017)	
Mom	0.287**	0.042	0.022	−0.15	Mom	0.672***	−0.116	0.008	0.38
	(0.129)	(0.072)	(0.033)			(0.164)	(0.109)	(0.027)	
Value	0.269**	0.119	0.010	0.89	Value	0.583***	0.087	0.014	0.27
	(0.122)	(0.085)	(0.029)			(0.154)	(0.083)	(0.028)	

Notes: This table presents time series regressions of excess returns of the currency portfolios on a constant, the dollar factor, and innovations to global FX ambiguity. We employ carry, momentum, and value portfolios. The excess returns are calculated as the spread returns between P5 and P1. The standard errors are reported in parentheses and obtained by the Newey and West (1987) procedure. The adjusted R^2 (%) is also reported. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively. The sample period extends from January 1984 to May 2023.

Table 2: Time series regressions: Portfolio returns

Panel A: Carry									
	G10 countries					All countries			
	α	DOL	ΔAmb	Adj_R^2		α	DOL	ΔAmb	Adj_R^2
P1	−0.203**	0.982***	−0.025***	65.25	P1	−0.381***	0.963***	−0.019	67.99
	(0.087)	(0.058)	(0.009)			(0.099)	(0.057)	(0.017)	
P2	−0.066	0.972***	−0.006	71.23	P2	−0.155**	0.890***	−0.027*	70.86
	(0.070)	(0.039)	(0.012)			(0.065)	(0.051)	(0.014)	
P3	−0.024	0.876***	−0.008	67.89	P3	−0.014	0.992***	0.009	79.28
	(0.083)	(0.051)	(0.007)			(0.055)	(0.037)	(0.011)	
P4	0.087	1.040***	0.033***	73.45	P4	−0.034	1.024***	0.052***	73.11
	(0.068)	(0.057)	(0.005)			(0.082)	(0.061)	(0.015)	
P5	0.205***	1.131***	0.006	80.95	P5	0.584***	1.131***	−0.014	73.36
	(0.065)	(0.039)	(0.005)			(0.109)	(0.046)	(0.009)	
Panel B: Momentum									
	G10 countries					All countries			
	α	DOL	ΔAmb	Adj_R^2		α	DOL	ΔAmb	Adj_R^2
P1	−0.215***	0.924***	−0.010	61.87	P1	−0.241**	1.104***	−0.003	64.96
	(0.083)	(0.045)	(0.011)			(0.105)	(0.085)	(0.016)	
P2	0.210***	1.048***	−0.010*	73.42	P2	−0.179**	1.104***	0.009	77.13
	(0.066)	(0.041)	(0.006)			(0.080)	(0.046)	(0.013)	
P3	−0.095	1.087***	0.008	76.74	P3	−0.085	0.946***	−0.011	79.55
	(0.066)	(0.030)	(0.007)			(0.053)	(0.030)	(0.009)	
P4	0.038	0.991***	0.003	73.96	P4	0.078	0.986***	−0.012	75.41
	(0.060)	(0.036)	(0.005)			(0.065)	(0.043)	(0.012)	
P5	0.071	0.966***	0.005	70.64	P5	0.431***	0.988***	0.002	67.91
	(0.072)	(0.035)	(0.006)			(0.135)	(0.044)	(0.010)	
Panel C: Value									
	G10 countries					All countries			
	α	DOL	ΔAmb	Adj_R^2		α	DOL	ΔAmb	Adj_R^2
P1	−0.124	0.901***	−0.001	65.77	P1	−0.193***	0.989***	−0.005	73.51
	(0.076)	(0.048)	(0.010)			(0.067)	(0.045)	(0.018)	
P2	−0.059	1.063***	−0.012	75.25	P2	−0.137*	1.082***	−0.001	72.51
	(0.061)	(0.049)	(0.008)			(0.072)	(0.062)	(0.014)	
P3	−0.062	0.994***	0.012**	72.05	P3	−0.081	1.113***	−0.003	79.83
	(0.070)	(0.064)	(0.006)			(0.058)	(0.038)	(0.014)	
P4	0.044	1.053***	−0.002	72.41	P4	0.021	1.017***	−0.008	67.85
	(0.072)	(0.041)	(0.005)			(0.083)	(0.068)	(0.010)	
P5	0.145**	1.020***	0.005	75.86	P5	0.390***	1.075***	0.001	67.62
	(0.063)	(0.041)	(0.007)			(0.116)	(0.057)	(0.014)	

Notes: This table presents time series regressions of excess returns of the currency portfolio on a constant, the dollar factor and innovations to global FX ambiguity. We adopt ΔAmb_{G10} for G10 countries and ΔAmb_{all} for all-countries. We employ five currency portfolios sorted by carry, momentum, and value. The standard errors are reported in parentheses and obtained by the Newey and West (1987) procedure. The adjusted R^2 (%) is also reported. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

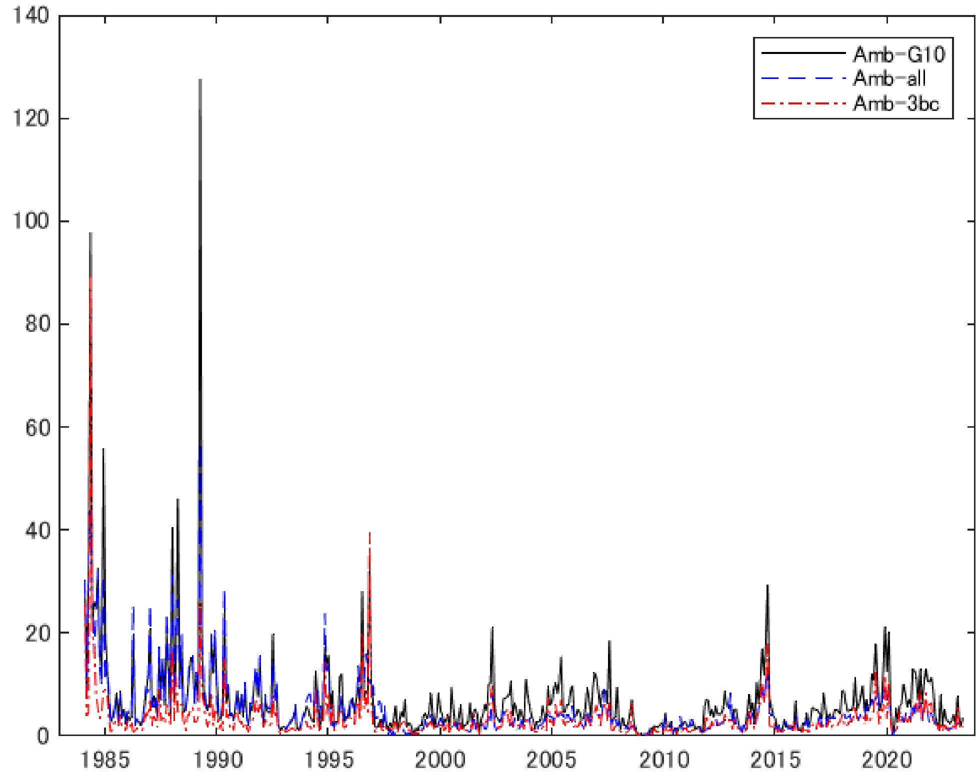

Figure 1. Global FX ambiguity

Notes: This figure demonstrates cross-sectional global FX ambiguity obtained by Equation (1). We report three types of ambiguity: G10 based on USD (Amb_{G10}), all-countries based on USD (Amb_{all}), and G10 based on USD, GBP, and JPY (Amb_{3bc}).

Currency portfolios and global foreign exchange ambiguity

May 26, 2024

Online Supplement, Not for Publication

List of contents

A Currency portfolios

A.1 Carry

A currency carry trade exploits information on forward discounts. The literature shows that deviations from the uncovered interest rate parity and the carry trade generate positive profits (e.g., Lustig et al., 2011; Menkhoff et al. 2012). A forward discount $fd_{i,t}$ is computed as the difference between the one-month forward and spot rates at time t:

$$fd_{i,t} = f_{i,t} - s_{i,t} \tag{A-1}$$

where $f_{i,t}$ represents the log of the forward currency price i per one USD at time t, and $s_{i,t}$ indicates the log of the spot currency price i at time t. Investors go long (short) in the currency i when $fd_{i,t}$ displays a high (low) value. P5 indicates the highest interest rate currency portfolio based on covered interest rate parity (CIRP) (e.g., Akram et al., 2008). Du et al. (2018) report that CIRP is not observed after the global financial crisis, but we find that P5 constructed by forward discounts provides the highest risk and return.

A.2 Momentum

A currency momentum portfolio adopts information on past excess returns. Following Kroencke et al. (2014) and Barroso and Santa-Clara (2015), we deploy the past three months cumulative currency excess return as the momentum signal $smom_{i,t}$, which is calculated as:

$$smom_{i,t} = \Sigma_{j=0}^{m-1} re_{i,t-j}, \tag{A-2}$$

where $re_{i,t-j}$ represents the past currency excess return and m indicates the length of the formation period. We set m to 3. Investors go long (short) in the currency i when $smom_{i,t}$ demonstrates a high (low) value.

A.3 Value

A currency value portfolio deploys information on a fundamental value. The literature demonstrates that the value of the exchange rate has a mean-reversion property in the long-run (e.g. Taylor, 2002; Boudoukh et al., 2016). We calculate the fundamental value $sval_{i,t}$, computed as the cumulative five-year change of the real exchange rate, as follows:

$$sval_{i,t} = r_{i,t,t-h} + p_{i,t,t-h-3} - p_{US,t,t-h-3}, \tag{A-3}$$

where $r_{i,t,t-h}$ indicates the cumulative five-year change of the nominal exchange rate, $p_{i,t,t-h-3}$ denotes the cumulative five-year change of the consumer price index (CPI) in country i, and $p_{i,t,t-h-3}$ represents that in the US. We assume a three-month lag to obtain the CPI. Investors go long (short) in the currency i when $sval_{i,t}$ displays a high (low) value, which indicates that the currency experiences real depreciation against the USD.

B Definition of ambiguity

The importance of the distinction between risk and *uncertainty* is pointed out by Ellsberg (1961), who provides some evidence that people tend to prefer to act on known rather than unknown or vague probabilities. Ellsberg conjectures that individuals would prefer wagers with precise odds to those with imprecise odds. For example, consider a wager on pulling out a white ball from two urns. These two urns contain 200 balls. One urn contains 100 red balls and 100 white balls, whereas the other urn contains 200 red and white balls, but the precise number of balls of each color is not known. Ellsberg asserts that, in this situation, most individuals would prefer the first urn over the second because they are uncertain about the probabilities associated with the second urn. Therefore, individuals tend to be averse to uncertain situations. In other words, individuals are averse to ambiguity or uncertainty. In the literature on decision theory, uncertainty captured by a set of probability measures is called *ambiguity* (or *uncertainty*). On the other hand, uncertainty captured by a unique probability measure is referred to as *risk*.[1] Ambiguity or uncertainty can be analyzed using the maxmin expected utility (MMEU) framework. Axiomatized by Gilboa and Schmeidler (1989), MMEU states that if a certain set of axioms is satisfied, then individuals' beliefs are captured by a set of probability measures and their preferences are represented by the minimum of expected utilities over the set of probability measures.

Izhakian (2020) proposes a measure of ambiguity, $\mho^2$, which is defined as:

$$\mho^2[r] \equiv \int_X E[\varphi_r(x)]\mathrm{Var}[\varphi_r(x)]dx, \tag{A-4}$$

where $E[\varphi_r(x)] = \int_{\mathcal{P}} \varphi_r(x)d\xi$ denotes the expected marginal probability of $x \in X$ over $\mathcal{P}$ and $\mathrm{Var}[\varphi_r(x)] = \int_{\mathcal{P}}(\varphi_r(x) - E[\varphi_r(x)])^2 d\xi$ denotes the variance of the marginal probability of $x \in X$ over $\mathcal{P}$. Note that r is a random variable, X is an interval of outcomes in $\mathbb{R}$, $\mathcal{P}$ is a set of probability measures, $\varphi_r(x) = P(\{\omega \in \Omega | r(\omega) = x\})$ denotes the marginal probability, and Ω denotes the state space. From Equation (A-4), we know that the measure of ambiguity, $\mho^2(r)$, aggregates the variance of each outcome's probability $\mathrm{Var}[\varphi_r(x)]$ that is assigned a weight equal to the expectation of each outcome's probability $E[\varphi_r(x)]$. Because investors' priors are captured by a set of probability measures $\mathcal{P}$, and $\mathrm{Var}[\varphi_r(x)]$ measures the dispersion of the probabilities of each outcome x, $(\varphi_r(x) - E[\varphi_r(x)])^2$, $\mho^2(r)$ is zero for a unique prior.

[1] In this paper, as in the literature of finance, risk is captured by volatility.

C Portfolio inertia

In stock markets, we observe *portfolio inertia*, *i.e.*, a situation where some stocks are not traded or not priced for a few minutes or longer. This phenomenon can be necessarily accounted for by risk. Under the standard expected utility theory, Arrow (1965) demonstrates that an investor has the unique striking price, *i.e.*, a price above which he or she is willing to sell, and below which he or she is willing to buy. Portfolio inertia generically exists only if the striking prices for buying and selling have a spread. The standard expected utility theory does not account for the existence of the spread, except for a transaction cost. Under ambiguity, the existence of portfolio inertia is theoretically explained by Dow and Werlang (1992) and Epstein and Wang (1994).

D List of countries

G10 countries include the following countries: Australia, Canada, Switzerland, the United Kingdom, Japan, Norway, New Zealand, Sweden, the euro area.

All countries include the following countries: Australia, Canada, Denmark, Switzerland, the United Kingdom, Japan, Norway, New Zealand, Sweden, the euro area, the Czech Republic, Hungary, India, Indonesia, Malaysia, Mexico, the Philippines, Poland, Singapore, South Africa, South Korea, Taiwan, and Thailand.[2]

Emerging countries include the following countries: the Czech Republic, Hungary, India, Indonesia, Malaysia, Mexico, the Philippines, Poland, Singapore, South Africa, South Korea, Taiwan, and Thailand.

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Table A1: Time series regressions: Spread returns with bid-ask spreads

Panel A: Amb_{G10}									
G10 Countries					All Countries				
	α	DOL	ΔAmb	Adj_R^2		α	DOL	ΔAmb	Adj_R^2
Carry	0.196	0.138	0.029**	1.96	Carry	0.633***	0.151	0.012	1.42
	(0.133)	(0.095)	(0.013)			(0.195)	(0.100)	(0.012)	
Mom	0.085	0.013	0.014	−0.22	Mom	0.357**	−0151	0.000	0.96
	(0.126)	(0.069)	(0.017)			(0.146)	(0.098)	(0.014)	
Value	0.077	0.114	0.004	0.77	Value	0.321**	0.071	0.011	0.15
	(0.122)	(0.079)	(0.017)			(0.141)	(0.075)	(0.016)	
Panel B: Amb_{all}									
G10 Countries					All Countries				
	α	DOL	ΔAmb	Adj_R^2		α	DOL	ΔAmb	Adj_R^2
Carry	0.196	0.136	0.047**	1.87	Carry	0.633***	0.150	0.006	1.28
	(0.134)	(0.093)	(0.023)			(0.186)	(0.097)	(0.022)	
Mom	0.085	0.012	0.021	−0.26	Mom	0.357**	−0.151	0.003	0.96
	(0.126)	(0.071)	(0.032)			(0.164)	(0.110)	(0.023)	
Value	0.077	0.113	−0.011	0.80	Value	0.321**	0.070	0.004	−0.00
	(0.121)	(0.075)	(0.031)			(0.130)	(0.069)	(0.029)	
Panel C: Amb_{3bc}									
G10 Countries					All Countries				
	α	DOL	ΔAmb	Adj_R^2		α	DOL	ΔAmb	Adj_R^2
Carry	0.197	0.017	0.022	0.46	Carry	0.633***	0.151	0.013	1.33
	(0.136)	(0.018)	(0.034)			(0.190)	(0.099)	(0.017)	
Mom	0.085	0.012	0.004	−0.23	Mom	0.357**	−0150	0.008	0.98
	(0.128)	(0.027)	(0.046)			(0.151)	(0.105)	(0.027)	
Value	0.077	0.114	0.008	0.80	Value	0.321**	0.071	0.014	0.08
	(0.124)	(0.086)	(0.029)			(0.150)	(0.082)	(0.029)	

Notes: This table presents time series regressions of excess returns of the currency portfolios on a constant, the dollar factor, and innovations to global FX ambiguity. We employ the bid and ask prices and calculate the excess returns. We use carry, momentum, and value portfolios. The excess returns are calculated as the spread returns between P5 and P1. The standard errors are reported in parentheses and obtained by the Newey and West (1987) procedure. The adjusted R^2 (%) is also reported. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A2: Time series regressions: Portfolio returns with bid-ask spreads

	G10 countries					All countries			
Panel A: Carry									
	α	DOL	ΔAmb	Adj_R^2		α	DOL	ΔAmb	Adj_R^2
P1	−0.030	0.992***	−0.023**	64.89	P1	−0.165*	0.970***	−0.018	68.57
	(0.090)	(0.062)	(0.010)			(0.097)	(0.060)	(0.017)	
P2	−0.150**	0.966***	−0.009	71.14	P2	−0.182***	0.889***	−0.029**	71.13
	(0.071)	(0.041)	(0.012)			(0.062)	(0.048)	(0.014)	
P3	−0.054	0.876***	−0.008	68.38	P3	−0.037	0.992***	0.008	79.47
	(0.078)	(0.050)	(0.007)			(0.054)	(0.038)	(0.011)	
P4	0.068	1.036***	0.033***	73.29	P4	−0.083	1.028***	0.051***	72.90
	(0.068)	(0.057)	(0.005)			(0.083)	(0.065)	(0.015)	
P5	0.166***	1.130***	0.006	80.98	P5	0.467***	1.120***	−0.012	73.96
	(0.064)	(0.040)	(0.005)			(0.102)	(0.046)	(0.009)	
Panel B: Momentum									
	G10 countries					All countries			
	α	DOL	ΔAmb	Adj_R^2		α	DOL	ΔAmb	Adj_R^2
P1	−0.081	0.940***	−0.007	62.54	P1	−0.036	1.132***	−0.002	65.57
	(0.083)	(0.048)	(0.013)			(0.095)	(0.086)	(0.016)	
P2	0.144**	1.069***	−0.010	73.51	P2	−0.213***	1.065***	−0.020	77.29
	(0.067)	(0.051)	(0.008)			(0.066)	(0.045)	(0.010)	
P3	−0.125*	1.038***	0.001	75.50	P3	−0.083	0.958***	−0.005	78.82
	(0.065)	(0.031)	(0.006)			(0.057)	(0.033)	(0.009)	
P4	−0.005	0.996***	0.003	74.92	P4	0.005	0.952***	−0.011	73.29
	(0.060)	(0.036)	(0.004)			(0.060)	(0.046)	(0.012)	
P5	0.004	0.953***	0.007	70.39	P5	0.322**	0.981***	0.001	69.34
	(0.070)	(0.036)	(0.006)			(0.133)	(0.040)	(0.010)	
Panel C: Value									
	G10 countries					All countries			
	α	DOL	ΔAmb	Adj_R^2		α	DOL	ΔAmb	Adj_R^2
P1	0.049	0.901***	0.001	65.53	P1	−0.006	0.989***	−0.003	73.41
	(0.079)	(0.050)	(0.010)			(0.068)	(0.046)	(0.018)	
P2	−0.126	1.060***	−0.014	75.17	P2	−0.149**	1.084***	−0.004	72.86
	(0.063)	(0.049)	(0.008)			(0.072)	(0.062)	(0.014)	
P3	−0.099	0.993***	0.012**	72.07	P3	−0.091	1.113***	−0.006	80.03
	(0.071)	(0.063)	(0.006)			(0.058)	(0.038)	(0.014)	
P4	0.020	1.050***	−0.002	72.33	P4	−0.015	1.012***	−0.009	67.77
	(0.071)	(0.042)	(0.005)			(0.083)	(0.069)	(0.010)	
P5	0.125***	1.014***	0.006	75.72	P5	0.315***	1.060***	0.001	67.64
	(0.062)	(0.043)	(0.007)			(0.114)	(0.058)	(0.014)	

Notes: This table presents time series regressions of excess returns of the currency portfolio on a constant, the dollar factor, and innovations to global FX ambiguity. We employ the bid and ask prices and calculate the excess returns. We adopt ΔAmb_{G10} for G10 countries and ΔAmb_{all} for all-countries. We use five currency portfolios sorted by carry, momentum, and value. The standard errors are reported in parentheses and obtained by the Newey and West (1987) procedure. The adjusted R^2 (%) is also reported. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A3: Sub-sample results: G10 countries

Panel A:Carry									
	Period 1					Period 2			
	α	DOL	ΔAmb	Adj_R^2		α	DOL	ΔAmb	Adj_R^2
P1	−0.358*	1.231***	−0.017	71.00	P1	−0.179***	0.849***	−0.029	63.43
	(0.196)	(0.091)	(0.011)			(0.068)	(0.050)	(0.020)	
P2	−0.117	1.126***	−0.001	69.69	P2	−0.087	0.889***	−0.019	74.18
	(0.159)	(0.085)	(0.014)			(0.058)	(0.046)	(0.016)	
P3	0.056	0.677***	−0.012	48.06	P3	−0.036	0.985***	−0.014	78.97
	(0.162)	(0.091)	(0.008)			(0.060)	(0.028)	(0.017)	
P4	0.206	0.929***	0.029***	62.96	P4	0.047	1.098***	0.030	78.74
	(0.161)	(0.112)	(0.007)			(0.069)	(0.056)	(0.020)	
P5	0.213*	1.037***	0.001	78.90	P5	0.255***	1.180***	0.033*	82.20
	(0.125)	(0.076)	(0.005)			(0.070)	(0.036)	(0.019)	
Carry	0.571*	−0.193	0.018	2.61	Carry	0.434***	0.331***	0.062*	10.33
	(0.305)	(0.160)	(0.014)			(0.122)	(0.076)	(0.033)	
Panel B:Momentum									
	Period 1					Period 2			
	α	DOL	ΔAmb	Adj_R^2		α	DOL	ΔAmb	Adj_R^2
P1	−0.548***	0.837***	−0.008	48.88	P1	−0.010	0.980***	0.014	70.87
	(0.191)	(0.104)	(0.014)			(0.069)	(0.035)	(0.015)	
P2	0.303*	1.092***	−0.014**	67.77	P2	0.192***	1.017***	0.014	77.47
	(0.156)	(0.103)	(0.007)			(0.069)	(0.036)	(0.020)	
P3	−0.010	1.188***	0.006	76.47	P3	−0.124*	1.025***	0.029	77.34
	(0.147)	(0.050)	(0.007)			(0.074)	(0.029)	(0.024)	
P4	0.128	0.967***	0.004	66.98	P4	−0.044	1.005***	−0.029*	77.92
	(0.145)	(0.074)	(0.005)			(0.062)	(0.034)	(0.017)	
P5	0.170	0.976***	0.006	74.96	P5	−0.013	0.960***	−0.021	68.17
	(0.110)	(0.064)	(0.006)			(0.081)	(0.047)	(0.024)	
Mom	0.719***	0.139	0.014	0.25	Mom	−0.002	−0.020	−0.035	−0.38
	(0.265)	(0.141)	(0.019)			(0.134)	(0.051)	(0.034)	

Notes: See the next page.

Table A3: Continued

Panel C:Value									
	Period 1					Period 2			
	α	DOL	ΔAmb	Adj_R^2		α	DOL	ΔAmb	Adj_R^2
P1	0.204	1.116***	0.002	72.52	P1	−0.061	0.774***	0.004	62.45
	(0.174)	(0.084)	(0.010)			(0.070)	(0.056)	(0.019)	
P2	−0.274	1.094***	−0.013	72.61	P2	−0.044	1.045***	0.005	76.74
	(0.167)	(0.100)	(0.007)			(0.060)	(0.040)	(0.017)	
P3	−0.157	0.988***	0.015**	67.09	P3	−0.106	1.000***	−0.013	74.84
	(0.157)	(0.112)	(0.006)			(0.067)	(0.086)	(0.022)	
P4	−0.043	0.967***	−0.004	58.13	P4	0.087	1.093***	0.016	80.65
	(0.167)	(0.097)	(0.006)			(0.067)	(0.038)	(0.020)	
P5	0.197	0.957***	0.005	70.88	P5	0.086	1.046***	−0.006	78.09
	(0.140)	(0.099)	(0.008)			(0.071)	(0.042)	(0.020)	
Value	−0.007	−0.159	0.003	0.76	Value	0.147	0.271***	−0.010	6.70
	(0.284)	(0.176)	(0.018)			(0.123)	(0.074)	(0.033)	

Notes: This table presents time series regressions of excess returns of the currency portfolio on a constant, the dollar factor and innovations to global FX ambiguity. We focus on G10 countries and adopt ΔAmb_{G10}. Period 1 extends from January 1984 to December 1996 and Period 2 covers January 1997 to May 2023. The standard errors are reported in parentheses and obtained by the Newey and West (1987) procedure. The adjusted R^2 (%) is also reported. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A4: Sub-sample results: All countries

	α	DOL	ΔAmb	Adj_R^2
Panel A:Carry				
Period 2				
P1	−0.569***	0.901***	−0.141***	64.24
	(0.124)	(0.063)	(0.046)	
P2	−0.254***	0.903***	−0.047	79.13
	(0.056)	(0.046)	(0.037)	
P3	−0.074	0.967***	−0.025	85.59
	(0.058)	(0.036)	(0.027)	
P4	−0.015	1.062***	0.135***	73.19
	(0.068)	(0.084)	(0.047)	
P5	0.912***	1.167***	0.078	70.30
	(0.158)	(0.067)	(0.050)	
Carry	1.481***	0.265**	0.219**	5.78
	(0.224)	(0.111)	(0.088)	
Panel B:Momentum				
Period 2				
	α	DOL	ΔAmb	Adj_R^2
P1	−0.185	1.203***	0.041	63.96
	(0.133)	(0.122)	(0.048)	
P2	−0.202**	1.012***	0.001	75.29
	(0.083)	(0.054)	(0.044)	
P3	−0.128**	0.864***	0.007	79.06
	(0.055)	(0.040)	(0.027)	
P4	−0.006	0.903***	−0.033	75.75
	(0.073)	(0.045)	(0.034)	
P5	0.536***	1.037***	−0.026	67.26
	(0.193)	(0.069)	(0.058)	
Momentum	0.720***	−0.166	−0.067	0.96
	(0.177)	(0.137)	(0.089)	

Notes: See the next page.

Table A4: Continued

Panel C:Value				
Period 2				
	α	DOL	ΔAmb	Adj_R^2
P1	−0.231***	0.945***	−0.016	75.41
	(0.064)	(0.066)	(0.042)	
P2	−0.185**	1.087***	−0.038	75.72
	(0.078)	(0.074)	(0.039)	
P3	−0.128**	1.118***	−0.036	77.17
	(0.059)	(0.051)	(0.043)	
P4	0.015	0.987***	−0.036	69.51
	(0.086)	(0.093)	(0.046)	
P5	0.575***	1.119***	0.053	64.03
	(0.143)	(0.075)	(0.062)	
Value	0.806***	0.174**	0.069	2.11
	(0.168)	(0.083)	(0.086)	

Notes: This table presents time series regressions of excess returns of the currency portfolio on a constant, the dollar factor, and innovations to global FX ambiguity. We focus on all countries and adopt ΔAmb_{all}. The sample difference between G10 and all countries is marginal in Period 1. We focus on Period 2, which extends from January 1997 to May 2023. The standard errors are reported in parentheses and obtained by the Newey and West (1987) procedure. The adjusted R^2 (%) is also reported. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A5: Summary statistics: G10 countries

Panel A: Carry							
	Mean	Std.dev	Skew	Kurt	Max	Min	SR
Carry	4.97	9.20	−0.62	5.52	10.48	−11.73	0.54
P1	−1.92	10.28	0.10	3.90	10.93	−11.08	−0.19
P2	−0.28	9.68	0.09	3.75	11.28	−9.07	−0.03
P3	0.17	8.94	−0.27	3.83	7.53	−11.84	0.02
P4	1.59	10.22	−0.64	5.64	8.44	−14.51	0.16
P5	3.06	10.56	−0.18	4.16	10.22	−12.75	0.29
Panel B: Momentum							
	Mean	Std.dev	Skew	Kurt	Max	Min	SR
Mom	3.46	9.68	0.09	3.75	11.28	−9.07	0.36
P1	−2.10	9.88	−0.37	5.38	9.23	−14.5	−0.21
P2	3.07	10.29	0.12	4.24	14.05	−10.98	0.30
P3	−0.57	10.41	−0.31	4.61	10.93	−11.64	−0.05
P4	0.98	9.67	−0.10	3.55	8.50	−10.4	0.10
P5	1.36	9.65	−0.14	3.77	10.22	−8.80	0.14
Panel C: Value							
	Mean	Std.dev	Skew	Kurt	Max	Min	SR
Value	3.29	8.80	−0.20	3.46	7.79	−8.93	0.37
P1	−1.01	9.33	−0.03	4.67	10.23	−11.38	−0.11
P2	−0.31	10.38	−0.07	3.48	11.08	−9.38	−0.03
P3	−0.35	9.87	−0.04	4.03	9.64	−10.10	−0.04
P4	0.99	10.44	−0.46	5.67	8.54	−15.38	0.09
P5	2.28	9.83	−0.29	4.79	10.14	−12.60	0.23

Notes: This table reports annualized mean (Mean), annualized standard deviation (Std.dev), skewness (Skew), kurtosis (Kurt), maximum value (Max), minimum value (Min) and annualized Sharpe ratio (SR). The excess returns on carry, momentum, and value are calculated as the spread returns between P5 and P1. We employ G10 countries. The sample period extends from January 1984 to May 2023.

Table A6: Summary statistics: All-countries

Panel A: Carry							
	Mean	Std.dev	Skew	Kurt	Max	Min	SR
Carry	11.85	9.38	0.11	4.89	12.95	−9.96	1.26
P1	−3.03	9.32	−0.10	3.99	7.21	−10.44	−0.33
P2	−0.43	8.45	0.07	3.48	8.28	−7.37	−0.05
P3	1.42	8.87	−0.53	5.70	8.72	−12.60	0.16
P4	1.23	9.58	−1.14	9.18	7.87	−17.90	0.13
P5	8.82	10.52	−0.65	5.40	10.14	−14.47	0.84
Panel B: Momentum							
	Mean	Std.dev	Skew	Kurt	Max	Min	SR
Mom	7.88	10.35	0.55	8.36	19.36	−14.68	0.76
P1	−1.13	10.90	−0.88	10.15	15.33	−20.95	−0.10
P2	−0.39	10.01	−0.40	5.21	9.64	−13.21	−0.04
P3	0.49	8.45	−0.21	4.21	7.40	−10.29	0.06
P4	2.52	9.05	−0.42	5.95	7.57	−15.38	0.28
P5	6.75	9.54	−0.12	3.88	8.50	−9.15	0.71
Panel C: Value							
	Mean	Std.dev	Skew	Kurt	Max	Min	SR
Value	7.13	8.77	0.05	3.98	8.48	−8.81	0.81
P1	−0.74	9.19	−0.17	4.27	8.98	−11.08	−0.08
P2	0.09	10.11	−0.23	4.53	9.64	−11.26	0.01
P3	0.89	9.99	−0.04	3.10	7.67	−8.65	0.09
P4	1.83	9.83	−0.53	7.62	14.05	−15.38	0.19
P5	6.40	10.40	−0.32	4.68	9.73	−12.60	0.62

Notes: This table reports annualized mean (Mean), annualized standard deviation (Std.dev), skewness (Skew), kurtosis (Kurt), maximum value (Max), minimum value (Min) and annualized Sharpe ratio (SR). The excess returns on carry, momentum, and value are calculated as the spread returns between P5 and P1. We employ all-countries. The sample period extends from January 1984 to May 2023.

Table A7: Summary statistics: G10 countries with bid-ask spreads

	Mean	Std.dev	Skew	Kurt	Max	Min	SR
Panel A: Carry							
	Mean	Std.dev	Skew	Kurt	Max	Min	SR
Carry	2.36	9.32	−0.58	5.66	10.29	−11.99	0.25
P1	−0.24	10.43	0.02	4.30	11.04	−12.96	−0.02
P2	−1.68	9.66	0.11	3.89	9.48	−11.15	−0.17
P3	−0.54	8.93	−0.30	3.84	7.51	−11.89	−0.06
P4	0.94	10.22	−0.65	5.65	8.32	−14.60	0.09
P5	2.13	10.57	−0.18	4.16	10.14	−12.86	0.20
Panel B: Momentum							
	Mean	Std.dev	Skew	Kurt	Max	Min	SR
Mom	1.02	9.65	0.09	3.76	11.12	−9.17	0.11
P1	−0.85	10.02	−0.30	5.15	9.44	−14.41	−0.08
P2	1.85	10.52	0.14	4.261	13.90	−11.16	0.18
P3	−1.37	10.06	−0.37	4.62	10.83	−11.70	−0.14
P4	0.07	9.69	−0.28	3.73	8.91	−10.96	0.01
P5	0.17	9.56	−0.09	3.78	10.14	−8.96	0.02
Panel C: Value							
	Mean	Std.dev	Skew	Kurt	Max	Min	SR
Value	0.93	8.82	−0.22	3.47	7.58	−9.28	0.11
P1	0.70	9.36	0.03	4.64	10.33	−11.22	0.07
P2	−1.51	10.37	−0.10	3.47	11.01	−9.49	−0.15
P3	−1.20	9.88	−0.06	4.01	9.48	−10.16	−0.12
P4	0.27	10.44	−0.47	5.70	8.47	−15.51	0.03
P5	1.63	9.81	−0.30	4.82	10.08	−12.66	0.17

Notes: This table reports annualized mean (Mean), annualized standard deviation (Std.dev), skewness (Skew), kurtosis (Kurt), maximum value (Max), minimum value (Min) and annualized Sharpe ratio (SR). The excess returns on carry, momentum, and value are calculated as the spread returns between P5 and P1. We employ G10 countries with bid-ask spreads. The sample period extends from January 1984 to May 2023.

Table A8: Summary statistics: All-countries with bid-ask spreads

Panel A: Carry							
	Mean	Std.dev	Skew	Kurt	Max	Min	SR
Carry	7.73	9.21	−0.08	4.86	11.43	−10.60	0.84
P1	−1.09	9.36	−0.15	3.99	7.47	−10.17	−0.12
P2	−1.36	8.44	0.05	3.46	8.16	−7.44	−0.16
P3	0.48	8.88	−0.53	5.68	8.76	−12.66	0.05
P4	−0.05	9.66	−1.24	9.90	7.80	−18.73	−0.01
P5	6.64	10.40	−0.75	5.66	10.08	−14.81	0.64
Panel B: Momentum							
	Mean	Std.dev	Skew	Kurt	Max	Min	SR
Mom	4.15	10.23	0.52	9.11	18.32	−15.83	0.41
P1	0.62	11.15	−0.75	10.08	16.39	−20.00	0.06
P2	−1.57	9.68	−0.55	5.25	8.76	−13.33	−0.16
P3	−0.11	8.62	−0.23	4.32	7.38	−10.89	−0.01
P4	0.94	8.87	−0.54	6.16	7.25	−15.51	0.11
P5	4.76	9.40	−0.18	3.97	8.16	−9.39	0.51
Panel C: Value							
	Mean	Std.dev	Skew	Kurt	Max	Min	SR
Value	3.92	8.69	−0.03	3.96	7.77	−8.95	0.45
P1	0.84	9.21	−0.11	4.25	9.11	−10.97	0.09
P2	−0.79	10.13	−0.25	4.55	9.48	−11.32	−0.08
P3	0.02	10.00	−0.05	3.11	7.59	−8.73	0.00
P4	0.70	9.82	−0.54	7.66	13.90	−15.51	0.07
P5	4.76	10.28	−0.39	4.73	9.11	−12.66	0.46

Notes: This table reports annualized mean (Mean), annualized standard deviation (Std.dev), skewness (Skew), kurtosis (Kurt), maximum value (Max), minimum value (Min) and annualized Sharpe ratio (SR). The excess returns on carry, momentum, and value are calculated as the spread returns between P5 and P1. We employ all-countries with bid-ask spreads. The sample period extends from January 1984 to May 2023.

Table A9: Summary statistics: global FX ambiguity

	Mean	Std.dev	Skew	Kurt	Max	Min
Panel A: Level						
	Mean	Std.dev	Skew	Kurt	Max	Min
Amb_G10	6.95	9.39	7.28	79.51	127.55	0.12
Amb_all	5.07	6.12	3.64	21.31	56.98	0.02
Amb_3bc	3.33	5.30	10.32	152.48	89.11	0.07
Panel B: Innovations						
	Mean	Std.dev	Skew	Kurt	Max	Min
Amb_G10	0.00	8.93	7.67	89.34	120.58	−27.97
Amb_all	0.00	5.13	3.93	29.85	50.96	−13.91
Amb_3bc	0.00	5.13	11.12	170.71	85.53	−5.31

Notes: This table reports mean (Mean), standard deviation (Std.dev), skewness (Skew), kurtosis (Kurt), maximum value (Max), and minimum value (Min) for global FX ambiguity and innovations to global FX ambiguity. The sample period extends from January 1984 to May 2023.

Table A10 Controlling for volatility effects

	G10 Countries						All Countries				
	α	DOL	ΔAmb	ΔVOL	Adj_R^2		α	DOL	ΔAmb	ΔVOL	Adj_R^2
Carry	0.408***	0.154*	0.026**	−0.167*	3.37	Carry	0.966***	0.161*	−0.005	−0.271***	3.51
	(0.130)	(0.090)	(0.012)	(0.100)			(0.202)	(0.094)	(0.022)	(0.075)	
P1	−0.203**	0.978***	−0.021**	0.140**	65.85	P1	−0.382***	0.967***	−0.013	0.166***	68.72
	(0.086)	(0.057)	(0.008)	(0.056)			(0.099)	(0.057)	(0.017)	(0.044)	
P2	−0.066	0.971***	−0.006	0.008	71.17	P2	−0.155**	0.891***	−0.026*	0.030	70.83
	(0.068)	(0.036)	(0.012)	(0.045)			(0.067)	(0.051)	(0.014)	(0.046)	
P3	−0.024	0.877***	−0.008	−0.027	67.86	P3	−0.014	0.993***	0.011	0.043	79.29
	(0.082)	(0.050)	(0.008)	(0.043)			(0.055)	(0.037)	(0.011)	(0.038)	
P4	0.087	1.042***	0.030***	−0.094**	73.70	P4	−0.034	1.021***	0.046***	−0.132*	73.53
	(0.064)	(0.060)	(0.004)	(0.042)			(0.080)	(0.058)	(0.015)	(0.078)	
P5	0.205***	1.132***	0.005	−0.027	80.93	P5	0.584***	1.128***	−0.018**	−0.106**	73.55
	(0.065)	(0.040)	(0.005)	(0.056)			(0.097)	(0.043)	(0.009)	(0.048)	

Notes: This table presents time series regressions of excess returns of the currency portfolio on a constant, the dollar factor, innovations to global FX ambiguity, and innovations to global FX volatility (Menkhoff et al., 2012a). We focus on carry portfolios. The standard errors are reported in parentheses and obtained by the Newey and West (1987) procedure. The adjusted R^2 (%) is also reported. The sample period extends from January 1984 to May 2023. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A11: Emerging currency results

	α	DOL	ΔAmb	Adj_R^2
Panel A: Ambiguity obtained from emerging countries				
	α	DOL	ΔAmb	Adj_R^2
Carry	1.848***	0.285**	0.041	2.59
	(0.221)	(0.095)	(0.059)	
P1	−0.640***	0.989***	−0.058*	52.90
	(0.122)	(0.053)	(0.033)	
P2	−0.216***	0.811***	0.010	68.10
	(0.074)	(0.032)	(0.020)	
P3	−0.299***	1.027***	0.020	60.40
	(0.110)	(0.048)	(0.030)	
P4	−0.054	0.899***	0.044	55.50
	(0.108)	(0.047)	(0.029)	
P5	1.209***	1.275***	−0.017	59.10
	(0.140)	(0.060)	(0.037)	
Panel B: Ambiguity obtained from all countries				
	α	DOL	ΔAmb	Adj_R^2
Carry	1.814***	0.261***	0.253*	3.45
	(0.217)	(0.096)	(0.140)	
P1	−0.639***	1.001***	−0.193**	53.30
	(0.120)	(0.053)	(0.077)	
P2	−0.211***	0.811***	0.019	68.10
	(0.073)	(0.032)	(0.047)	
P3	−0.297***	1.024***	0.061	60.50
	(0.109)	(0.048)	(0.070)	
P4	−0.027	0.903***	0.053	55.20
	(0.107)	(0.047)	(0.069)	
P5	1.175***	1.262***	0.060	59.10
	(0.140)	(0.061)	(0.089)	

Notes: This table presents time series regressions of excess returns of the currency portfolio on a constant, the dollar factor, and innovations to global FX ambiguity. Portfolio returns are calculated using the following emerging countries: the Czech Republic, Hungary, India, Indonesia, Malaysia, Mexico, the Philippines, Poland, Singapore, South Africa, South Korea, Taiwan, and Thailand. Panel A adopts global FX ambiguity using emerging countries and Panel B employs that using all countries. The standard errors are reported in parentheses and obtained by the Newey and West (1987) procedure. The adjusted R^2 (%) is also reported. The sample period extends from January 1997 to May 2023. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table A12: Different bin size

	G10 countries					All countries			
	α	DOL	ΔAmb	Adj_R^2		α	DOL	ΔAmb	Adj_R^2
Carry	0.408***	0.148	0.172**	2.60	Carry	0.965***	0.167*	0.015	1.60
	(0.129)	(0.095)	(0.077)			(0.216)	(0.100)	(0.100)	
P1	−0.203**	0.983***	−0.140***	65.40	P1	−0.381***	0.964***	−0.091	68.00
	(0.083)	(0.062)	(0.050)			(0.109)	(0.065)	(0.076)	
P2	−0.066	0.972***	−0.020	71.20	P2	−0.155**	0.890***	−0.088	70.70
	(0.080)	(0.050)	(0.055)			(0.066)	(0.051)	(0.067)	
P3	−0.024	0.876***	−0.040	67.90	P3	−0.014	0.992***	0.049	79.30
	(0.067)	(0.040)	(0.038)			(0.055)	(0.041)	(0.044)	
P4	0.087	1.038***	0.167***	73.50	P4	−0.034	1.023***	0.205***	73.00
	(0.071)	(0.053)	(0.032)			(0.083)	(0.062)	(0.064)	
P5	0.205***	1.131***	0.032	81.00	P5	0.584***	1.131***	−0.076*	73.40
	(0.064)	(0.042)	(0.032)			(0.103)	(0.045)	(0.039)	

Notes: This table presents time series regressions of excess returns of the currency portfolio on a constant, the dollar factor, and innovations to global FX ambiguity. We discretize the return distributions into 7 bins, which are smaller than those of our baseline results (12 bins). We focus on carry portfolios. The standard errors are reported in parentheses and obtained by the Newey and West (1987) procedure. The adjusted R^2 (%) is also reported. The sample period extends from January 1984 to May 2023. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

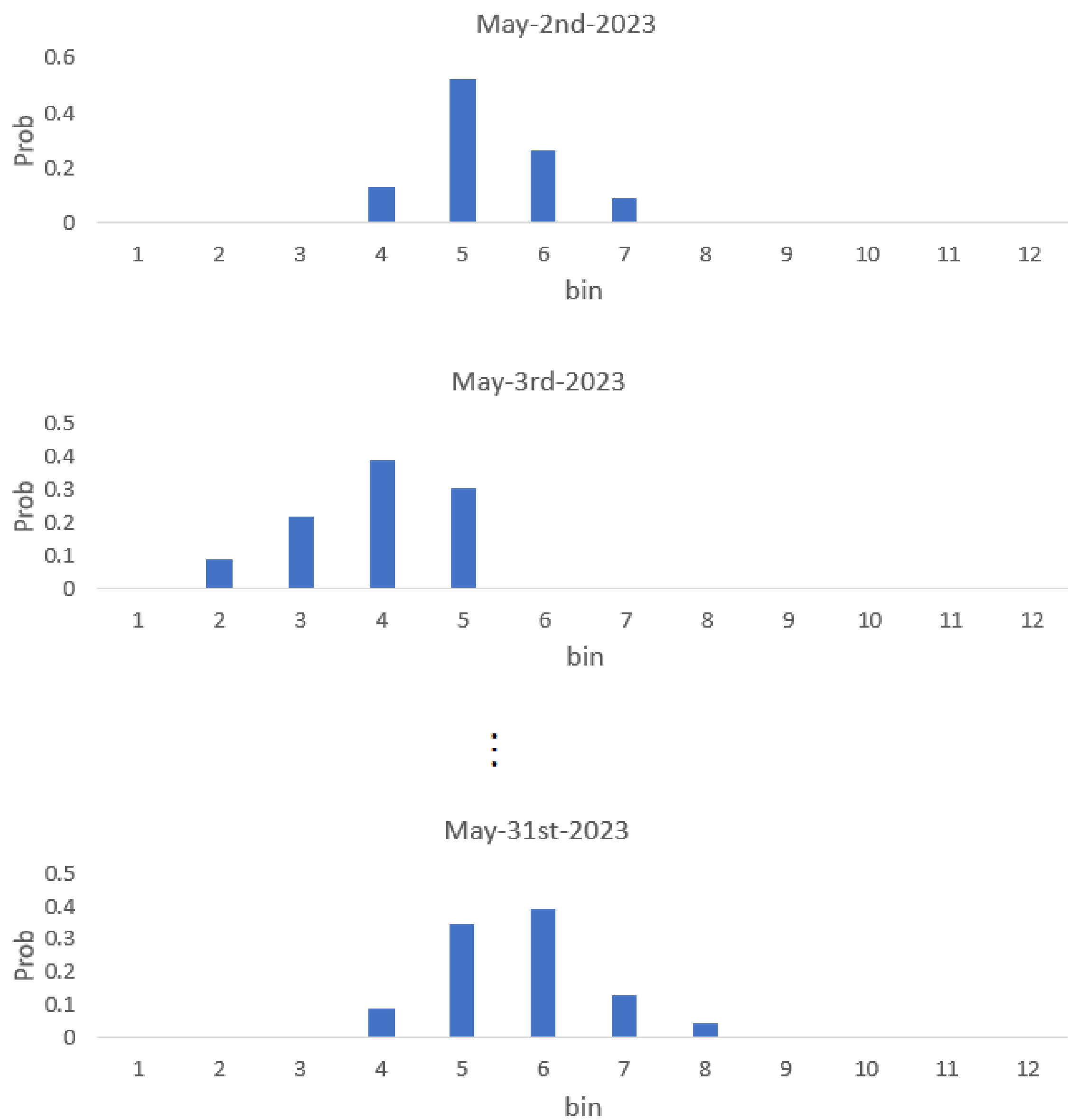

Figure A1. Daily global ambiguity histograms

Notes: This figure demonstrates daily global ambiguity histograms of up to 9 (G10), 23 (all-countries), and 27 (G10 based on the USD, GBP, and JPY) daily returns. Assuming one month consists of 22 trading days, we obtain 22 histograms in each month. The height of the histogram for a particular bin indicates the probability of that particular bin outcome.