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Currency Carry, Momentum, and Global Interest Rate Volatility

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Abstract

Returns to currency carry and momentum compensate for the risk of global interest rate volatility (IRV), with risk exposures explaining 92% of the cross-sectional return variations. This unified explanation stems from its impact on foreign exchange intermediaries. An intermediary-based exchange rate model shows that a higher global IRV increases the uncertainty of future risk-taking and tightens current financial constraints. Position unwinding triggers loss of carry and momentum. Additional empirical results confirm this economic channel. Global IRV risk is also negatively priced in other currency strategies and momentum. The explanatory power is not driven by existing measures of uncertainty or intermediary constraints.

I. Introduction

I study why currency strategies are profitable. The carry trade buys currencies with high short-term interest rates and sells those with low short-term interest rates. The momentum strategy buys currencies that have recently appreciated and sells those that have recently depreciated. These two strategies are profitable and widely used by market practitioners to trade foreign exchange (FX) based on short-term information. Given that the FX market is very liquid, with low trading costs and easy access to short-selling, a reasonable explanation for such profitability is that their returns reflect risk compensation. However, little is known about the common risk sources underlying these two strategies (see the review by Burnside, Eichenbaum, and Rebelo (2011b)).

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This study provides a unified risk-based explanation for the returns to FX carry and momentum strategies. I find that innovations in global interest rate volatility (IRV) are negatively and significantly correlated with returns on carry trade and momentum. Risk exposure, measured as return sensitivities to the global IRV, accounts for strategy profitability. To construct this global measure of volatility, I start by computing the monthly realized variance of the government bond yields for each of the G10 currencies, where the global IRV is the cross-sectional average over the individual volatility. Asset pricing tests show that risk exposures to the global IRV explain the cross-sectional return variations of currency carry and momentum, with cross-sectional R^2 reaching 88% and 98%, respectively. More precisely, I find that the top carry and momentum portfolios have lower and negative exposures to the risk of the global IRV. By contrast, their peers at the bottom have higher and positive betas. The beta spreads are statistically significant and translate to negative and significant prices for global IRV risk. Test on the joint cross section of carry and momentum returns delivers similar results: the cross-sectional R^2 is 92% and the Shanken t-statistic for the price of risk is close to -3. The significant and negative price of risk is also documented in the asset pricing test after considering time-varying risk exposures, a test based on 48 individual currencies, tests that include other currency strategies, such as the value, long-term momentum, global imbalance, and the conditional dollar, and the test that accounts for omitted-variable bias and measurement errors.

The role of the global IRV differs from that of recent research linking monetary policy to currency risk premia. Mueller, Tahbaz-Salehi, and Vedolin (2017b) find that carry trade is more profitable on days with scheduled FOMC announcements. The authors interpret higher returns as compensation for the heightened U.S. monetary policy uncertainty. However, they do not study how carry trade is affected at a lower frequency (monthly frequency) or whether the joint cross section with currency momentum can be explained, which is the focus of my study. Mueller et al. (2017b) also reconcile their findings by demonstrating how monetary policy uncertainty can be priced in an intermediary asset-pricing model. While their model is consistent with some of my results, it does not consider the currency momentum effect. To gain a deeper understanding of how the IRV impacts currency momentum traders, I extend Gabaix and Maggiori (2015) by illustrating how the intermediary asset pricing model accounts for currency momentum. In another related work, Eriksen (2019) finds that the return dispersion of currency portfolios can explain currency momentum. The author then shows that when the U.S. monetary policy stance is expansive (restrictive), innovations to dispersion and currency momentum returns are both higher (lower). Nonetheless, Eriksen (2019) does not draw implications for the carry trade, and his explanation is based on shifts in the monetary stance (first-moment shock), whereas my explanation is based on a monetary policy uncertainty shock (second-moment shock). Consistently, I find that the pricing power of the global IRV risk is not diminished by the return dispersion factor.

Additionally, I carefully distinguish the global IRV risk from the global FX volatility risk proposed by Menkhoff, Sarno, Schmeling, and Schrimpf (2012a). First, while they document that global FX volatility explains returns to carry trade and momentum based on the long-term signal (past 12 months), I find that their factor does not explain currency momentum based on the short-term signal (past 3 months), which is consistent with results in Menkhoff, Sarno, Schmeling, and Schrimpf (2012b). Second, I show that the results do not change substantially when the monetary policy uncertainty index of Baker, Bloom, and Davis (2016) (BBD) is used to measure IRV, which is less related to global FX volatility. I find that the BBD MPU index still explains the joint cross section of FX carry and momentum, with a cross-sectional R^2 close to 80%.

To interpret these findings, I propose an intermediary-based exchange rate model in the spirit of Gabaix and Maggiori (2015) and Mueller et al. (2017b). In this model, exchange rates are determined when FX intermediaries (financiers) absorb the imbalance arising from the demand and supply of assets in different currencies. FX intermediaries are financially constrained and face two types of risks: the uncertainty associated with the imbalance and the uncertainty associated with future interest rates. Financiers' limited risk-bearing capacity would make those risks important determinants of the exchange rate. On the one hand, when there are differences in interest rates between currencies, in equilibrium, financiers would run carry trade by buying high-interest rate currencies and selling low-interest rate currencies. However, a higher global IRV increases the uncertainty of intermediaries' future risk-taking and tightens their current financial constraints, leading to position unwinding and carry trade losses. On the other hand, when the interest rate difference is small and the FX intermediary sector underreacts to information about future imbalance, exchange rates do not sufficiently adjust to reflect all relevant information. Consequently, financiers are willing to buy (sell) previously appreciated (depreciated) currencies because they tend to continue appreciating (depreciating). Higher global IRV reduces intermediaries' risk-bearing capacity and triggers position unwinding and momentum losses.

I document three-fold empirical support for the above economic channel. First, I find that global IRV risk negatively and significantly predicts the risk-bearing capacity of financial intermediaries, as measured by the intermediary's equity capital ratio proposed by He, Kelly, and Manela (2017). Second, consistent with the recent literature on intermediary asset pricing (e.g., Adrian, Etula, and Muir (2014), He et al. (2017), and Haddad and Muir (2021)), the risk of IRV is negatively and significantly priced among a wide range of asset classes beyond FX. Third, when using non-commercial traders' net demand for FX futures to measure intermediaries' speculative activity for carry and momentum, following, for example, Brunnermeier, Nagel, and Pedersen (2008) and Della Corte, Ramadorai, and Sarno (2016), I find that the speculative activity indeed increases with carry or momentum signal, yet the positive relation is adversely affected by the IRV risk. The effect is statistically significant and not related to alternative intermediary risk-appetite measures such as the VIX, global FX volatility, or the intermediary's equity capital ratio.

The intermediary channel also sheds light on the commonality of momentum returns across asset classes, as documented by, for example, Asness, Moskowitz, and Pedersen (2013). To the extent that international investors display return-chasing behavior by buying (selling) past high-performing (low-performing) assets, their trading may contribute to the momentum effect in various asset classes. Nonetheless, financial disruption in the FX market increases the cost of obtaining

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FX liquidity for international investors and dampens their trading activity. Hence, momentum returns are adversely affected by the IRV risk. Empirically, I find that most momentum strategies realize sizable losses when the global IRV risk is high, and that such an effect cannot be explained by other variables that have been used to explain the commonality of momentum returns. Asset pricing tests using all momentum portfolios (excluding FX portfolios) confirm the negative and significant risk prices of global IRV.

To corroborate the main findings, I conduct a battery of robustness checks. First, the results are invariant to the use of different testing procedures, such as GMM estimation. Second, the asset pricing results are robust under different subsamples, such as the pre- and post-crisis periods. Third, after controlling for conventional risk factors, I find that the unified pricing power of the global IRV risk is not affected. Performance is also robust under different arbitrage limits as measured by idiosyncratic volatility or skewness.

This article relates to a large strand of literature toward understanding the risk sources of high returns to currency strategies. Most previous papers focus on the cross section of carry trade. Lustig and Verdelhan (2007) interpret its returns as exposures to the risk of consumption growth, and Lustig, Roussanov, and Verdelhan (2011) further reconcile its profitability via the slope factor constructed from the carry trade portfolios. Based on the ICAPM argument, Menkhoff et al. (2012a) find that global FX volatility changes help explain the carry returns. Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011a) argue that the carry trade returns reflect a peso problem, whereas Dobrynskaya (2014) and Lettau, Maggiori, and Weber (2014) highlight the importance of downside risk. Recent literature starts to focus more on currency momentum. Burnside et al. (2011b) and Menkhoff et al. (2012b) find that the correlation between carry and momentum returns is small, and traditional risk factors cannot explain the cross section of momentum returns. Filippou, Gozluklu, and Taylor (2018) show that the global political risk can reconcile the momentum returns. The challenge of a unified resolution is well documented in Burnside et al. (2011b), and many papers show that the risk factor explaining carry (momentum) trade cannot explain the momentum (carry) (see, e.g., Menkhoff et al. (2012a), Berg and Mark (2018), Husted, Rogers, and Sun (2018), and Della Corte and Krecetovs (2024)).[1] My article is tightly linked with all these articles by showing empirically that the risk of global IRV can explain both currency carry and momentum strategies' returns.

This article also contributes to a fast-growing strand of literature relating intermediary frictions to asset prices. Following the theoretical research such as He and Krishnamurthy (2013) and Gabaix and Maggiori (2015), the literature documents a strong impact of intermediaries on asset prices (see, e.g., Adrian et al. (2014), Corte, Riddiough, and Sarno (2016), He et al. (2017), Fang and Liu (2021), Haddad and Muir (2021), and Du, Hébert, and Huber (2023)). Building on

[1]Other related papers on currency risk premia include Hassan (2013), Ready, Roussanov, and Ward (2017), Richmond (2019), Dahlquist and Hasseltoft (2020), Panayotov (2020), and Jiang (2022).

Gabaix and Maggiori (2015), Corte et al. (2016) find that a long-short currency portfolio that captures global imbalanced risk can explain several low-frequency risk premium anomalies. I show that the global imbalance risk cannot price the currency momentum based on short-term signal and does not drive away the explanatory power of global IRV. Furthermore, I show that the global IRV is significantly correlated with the intermediary constraint measured from intermediary fundamentals, and it outperforms other constraint measures in terms of pricing FX momentum returns.

The article is organized as follows: Section II describes data and measurement of the global IRV. Section III shows the main empirical results, and Section IV discusses the underlying mechanism. Section V includes additional results and robustness checks, and Section VI concludes.

II. Currency Data and Measures of IRV

A. Currency Carry and Momentum Portfolios

The data for spot exchange rates and one-month forward rates cover 48 countries and are obtained from Datastream (Barclays Bank International and Reuters). I remove the Eurozone currencies after the adoption of Euro, and also remove the periods for some currencies when there are large violations in the Covered Interest Rate Parities (CIP).[2] The sample period is from Jan. 1985 to Jan. 2019. I denote the mid-spot rate as S_t which represents the units of foreign currency per unit of the U.S. dollar, and one-month mid-forward rate as F_t. As a proxy for the interest rate differential between the foreign country and the USA, I follow the literature using the forward discount (e.g., Lustig et al. (2011)):

(1) $$i_t^* - i_t \approx f_t - s_t,$$

where the small letters represent the log terms. Then, the one-period log excess return rx_{t+1}:

(2) $$rx_{t+1} = i_t^* - i_t - \Delta s_{t+1} \approx f_t - s_{t+1}.$$

To form the carry trade portfolios, I first sort the forward discounts for all currencies at the end of each month. Then each currency is attributed to one of the quintile portfolios, where portfolio 1 (5) consists of currencies with the lowest (highest) interest rate differentials vis-à-vis the U.S. To construct the momentum portfolios, I sort past 3-month realized excess returns at the end of each month, and then form five portfolios, where portfolio 1 (5) contains currencies with the lowest (highest) realized excess returns. All portfolios are rebalanced monthly and their excess returns are computed using the equal-weighted scheme following Lustig et al. (2011) and Menkhoff et al. (2012a).

[2]Details are given in Section B of the Supplementary Material.

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TABLE 1

Statistics of Currency Carry and Momentum Portfolios

Table 1 reports the statistics for the currency carry and momentum portfolios. Carry portfolios are obtained by sorting on the forward discounts, and momentum portfolios are obtained by sorting on the realized excess returns over the previous 3 months. All portfolios are rebalanced monthly and the reported average annualized excess returns (in percentage) are net of transaction costs. Exposures to the risk of global IRV are computed from equation (4). t-statistics are in parentheses and based on Newey and West (1987) with optimal lag selection following Andrews (1991). The excess returns, betas to the dollar factor and the risk of IRV, and monthly Sharpe ratios (SR) of high-minus-low portfolios are also reported. The monotonicity of portfolio excess returns and IRV betas are tested via the monotonic relation (MR) test of Patton and Timmermann (2010), where the p-values are reported in parentheses based on all pair-wise comparisons. The null hypotheses for the tests are the monotonically increasing returns and decreasing betas respectively. The sample period is from Jan. 1985 to Jan. 2019.

	Carry			Momentum		
Quantile	$r^e(\%)$	β_{DOL}	β_{IRV}	$r^e(\%)$	β_{DOL}	β_{IRV}
L	−4.45	0.90	3.48	−2.55	1.04	3.40
	(−2.62)	(20.57)	(4.58)	(−1.32)	(13.96)	(5.14)
2	0.45	0.89	0.60	−0.59	0.99	1.32
	(0.36)	(25.15)	(1.20)	(−0.42)	(20.99)	(2.59)
3	1.95	1.01	−1.44	1.81	1.00	−1.08
	(1.40)	(34.09)	(−1.42)	(1.33)	(24.21)	(−1.10)
4	2.29	1.05	0.24	1.97	0.97	−0.84
	(1.55)	(31.54)	(0.37)	(1.42)	(26.11)	(−1.23)
H	4.18	1.15	−2.85	4.48	1.00	−2.88
	(2.07)	(18.94)	(−2.08)	(2.75)	(14.20)	(−2.91)
HML	8.63	0.25	−6.33	7.03	−0.04	−6.28
	(4.11)	(2.72)	(−3.56)	(4.02)	(−0.33)	(−4.45)
SR	0.90			0.69		
MR	[1.00]		[0.99]	[0.99]		[0.92]

The first column of each panel in Table 1 reports the average annualized excess returns of the carry and momentum portfolios after considering bid–ask spreads.[3] Consistent with the findings in the literature, strategy profitability is large and significant. The average monthly high-minus-low return spreads for carry and momentum are 8.63% and 7.03%, respectively. Figure A.1 in the Supplementary Material plots the cumulative returns of two strategies within the sample. Furthermore, the returns increase monotonically from the bottom to the top portfolios, revealing the substantial predictive power of interest rate differentials and realized currency returns on future returns. The monotonic order is also statistically supported by a test of monotonic relations following Patton and Timmermann (2010). In parentheses, I report the p-values of testing the null hypothesis that portfolio returns increase monotonically, which is based on all pairwise comparisons. Thus, the null hypothesis cannot be rejected at any conventional confidence level.

B. Measuring Global IRV

I consider two measures of global IRV. First, I focus on the universe of G10 currencies to construct a global measure, as they play a dominant role in FX markets. To estimate the IRV for each individual currency, I rely on their daily yields on 10-year government bonds denominated in local currency to obtain the monthly interest rate realized variance, similar to Cieslak and Povala (2016). The data of U.S. 10-year bond yields are from the Federal Reserve Economic Data

[3]The bid–ask data are also available from Reuters, and in the Supplementary Material I show how to account for transaction costs when computing portfolio returns. Note that the bid–ask spread data from Reuters are around twice the size of inter-dealer spreads, as documented by Lyons (2001).

(FREDSTART), and those of other currencies are from Bloomberg.[4] Table 2 tabulates the correlation matrix and output from the principal component analysis (PCA) on a panel of individual interest rate uncertainties. Overall, there are substantial co-movements across individual uncertainties. Thus, I take a simple cross-sectional average over all individual IRV to obtain the global IRV.

I also use the U.S. monetary policy uncertainty (MPU) index of Baker et al. (2016) to measure IRV. The BBD MPU index is based on a textual analysis of U.S. newspapers and hence has the advantage of being model-free and reflecting subjective uncertainty. It can be seen that although the index has the "U.S." name, it may still capture the global interest rate uncertainty as the keywords it searches include European Central Bank, Bank of England, and Bank of Japan. The BBD MPU index is available from Jan. 1985, which is the starting month for the analysis.

Figure 1 compares two measures of global IRV. Graph A plots their standardized levels, and Graph B plots the innovations by fitting an AR(1) model to each level series. Although these two measures are constructed from very different sources, they co-move significantly with each other, with a correlation level of 0.38. Both measures of global IRV capture sharp changes in international financial markets, such as Black Monday, the collapse of Long-Term Capital Management,

TABLE 2

Interest Rate Volatility of G10 Currencies

Panel A of Table 2 reports the correlation coefficients of interest rate volatility for G10 currencies. For each economy, the interest rate volatility is estimated as the monthly realized variance of 10-year government bonds, computed from daily bond yields. Panel B reports the output from the principal component analysis (PCA) on the correlation matrix of G10 interest rate volatility. The pre-crisis sample is from Jan. 1985 to June 2007, and the post-crisis sample ranges from May 2010 to Jan. 2019. Reported are the percentage of the total variance explained by each of the first three principal components.

Panel A. Correlation

	AUD	CAD	CHF	EUR	GBP	JPY	NOK	NZD	SEK	USD
AUD	1.00									
CAD	0.69	1.00								
CHF	0.75	0.79	1.00							
EUR	0.61	0.49	0.67	1.00						
GBP	0.62	0.63	0.67	0.66	1.00					
JPY	0.24	0.45	0.46	0.19	0.37	1.00				
NOK	0.72	0.67	0.65	0.77	0.65	0.32	1.00			
NZD	0.72	0.63	0.62	0.49	0.47	0.26	0.53	1.00		
SEK	0.77	0.74	0.73	0.83	0.77	0.31	0.80	0.64	1.00	
USD	0.75	0.53	0.78	0.60	0.49	0.24	0.61	0.61	0.69	1.00

Panel B. PCA

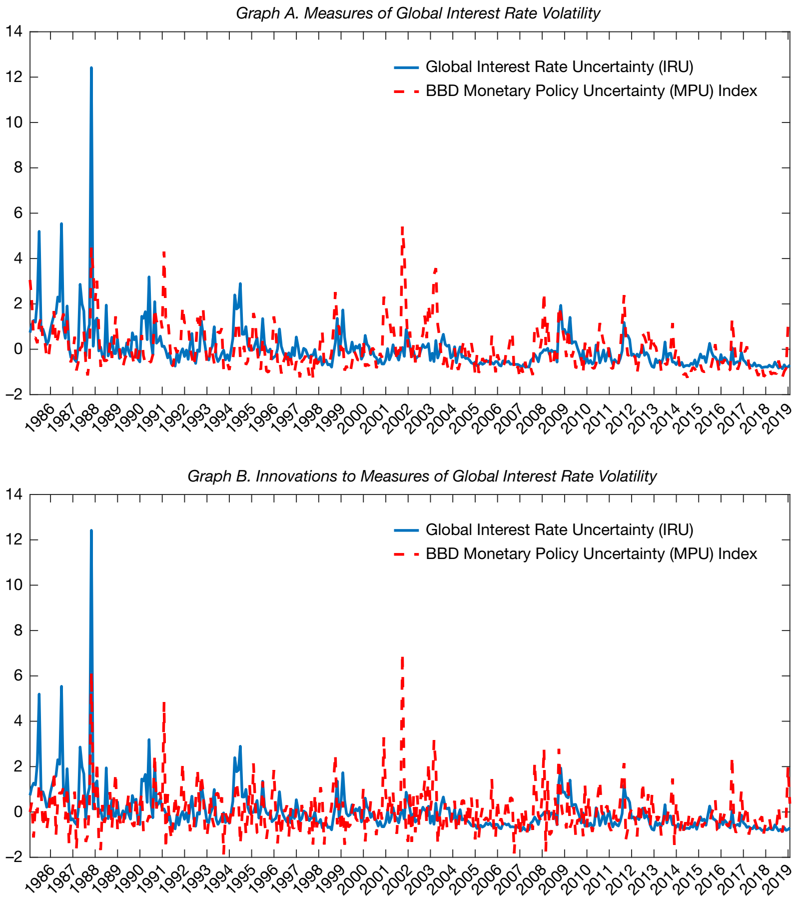
	Full Sample	Pre-crisis	Post-crisis
First	64.8	55.2	64.1
Second	9.8	12.1	9.7
Third	7.4	8.9	6.9
Total	82.0	76.3	80.8

[4]The focus on 10-year maturity is mainly due to the data availability issue as the data on other maturities are significantly shorter for many countries. The G10 currencies cover United States dollar (USD), Euro (EUR), Pound sterling (GBP), Japanese yen (JPY), Australian dollar (AUD), New Zealand dollar (NZD), Canadian dollar (CAD), Swiss franc (CHF), Norwegian krone (NOK), and Swedish krona (SEK). In particular, I use Germany 10-year bond yields as the interest rates for the Euro. The detail of data availability for each economy is in Section B of the Supplementary Material.

FIGURE 1

Measures of Global Interest Rate Volatility and Innovations

Figure 1 compares two measures of global interest rate volatility. The first measure is calculated as the equal-weighted realized variance of 10-year government bond yields of G10 currencies, and the second measure is the Monetary Policy Uncertainty (MPU) index of Baker et al. (2016). Graph A plots the standardized levels, and Graph B plots the standardized innovations obtained from fitting an AR(1) model to each level series. The sample period is from Jan. 1985 to Jan. 2019.



the recent global financial crisis, and the Euro-debt crisis. For the empirical tests, I primarily use the measure construed directly from government bonds.

Table 3 reports the correlation coefficients of innovations to measures of the global IRV with returns to carry, momentum, and conventional risk factors. These results are consistent with the usual findings in the literature that two strategy returns are weakly correlated with popular risk factors (e.g., Burnside et al. (2011b)). The correlation between the carry and momentum returns is close to zero, further highlighting the difficulty of establishing a unified explanation. Although carry returns are significantly correlated with VIX and global FX volatility (see, e.g., Brunnermeier et al. (2008), Menkhoff et al. (2012a)), neither are

TABLE 3

Correlation Analysis

Table 3 reports the correlation coefficients of returns to currency carry, momentum, innovations to the Monetary Policy Uncertainty (MPU) index of Baker et al. (2016), global IRV risk, and other risk factors. These risk factors include innovations to the VIX, TED spread, global FX volatility, U.S. consumption growth, NBER recession dummy, Fama–French small-minus-big (SMB), and high-minus-low (HML) factors. *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels. The sample period is from Jan. 1985 to Jan. 2019.

	VIX	TED	FXvol	Growth	Rec	SMB	HML	MPU	IRV	Carry	Mom
VIX	1.00										
TED	0.22***	1.00									
FXvol	0.35***	0.11**	1.00								
Growth	−0.02	−0.01	0.06	1.00							
Rec	0.12***	0.03	0.14***	−0.29***	1.00						
SMB	−0.21***	−0.06	0.01	0.09**	0.05	1.00					
HML	0.09**	0.08**	0.01	−0.08**	−0.07*	−0.27***	1.00				
MPU	0.32***	0.16***	0.17***	−0.06	0.15***	−0.15***	0.07*	1.00			
IRV	0.46***	0.19***	0.21***	0.06	0.07*	−0.10**	0.01	0.31***	1.00		
Carry	−0.25***	−0.05	−0.32***	−0.08**	−0.03	0.06	−0.07**	−0.18***	−0.19***	1.00	
Mom	−0.01	−0.09**	0.01	0.02	0.01	0.02	−0.06	−0.10**	−0.18***	0.06	1.00

significantly correlated with momentum returns. Interestingly, innovations in the global IRV are strongly and negatively related to both strategy returns at the 1% significance level, suggesting that both strategy returns decrease under large shocks to the global IRV. To evaluate the economic magnitude of the impact of the global IRV risk, I estimate the following time-series regression:

$$r_t = \alpha + \beta u_t^{\mathrm{IRV}} + \varepsilon_t, \tag{3}$$

where r_t denotes carry or momentum returns and u_t^{IRV} indicates innovations to the global IRV. The estimated slope coefficient is −7.39% (−5.62%) for carry (momentum) returns, which also represents the annualized loss of the carry (momentum) trade under a one standard deviation change of u_t^{IRV}. The effect is statistically significant with t-statistics of −4.44 and − 3.44, respectively.

III. Empirical Results

A. Cross-Sectional Asset Pricing Test

In this subsection, I test the pricing power of shocks to the global IRV for the cross section of carry and momentum portfolios. As the benchmark testing procedure, I use the usual 2-stage Fama–MacBeth regression. In the first stage, the return sensitivity to global IRV shocks for each portfolio i is estimated from a time-series regression:

$$rx_t^i = \alpha^i + \beta_{\mathrm{DOL}}^i \mathrm{DOL}_t + \beta_{\mathrm{IRV}}^i u_t^{\mathrm{IRV}} + \varepsilon_t^i, \tag{4}$$

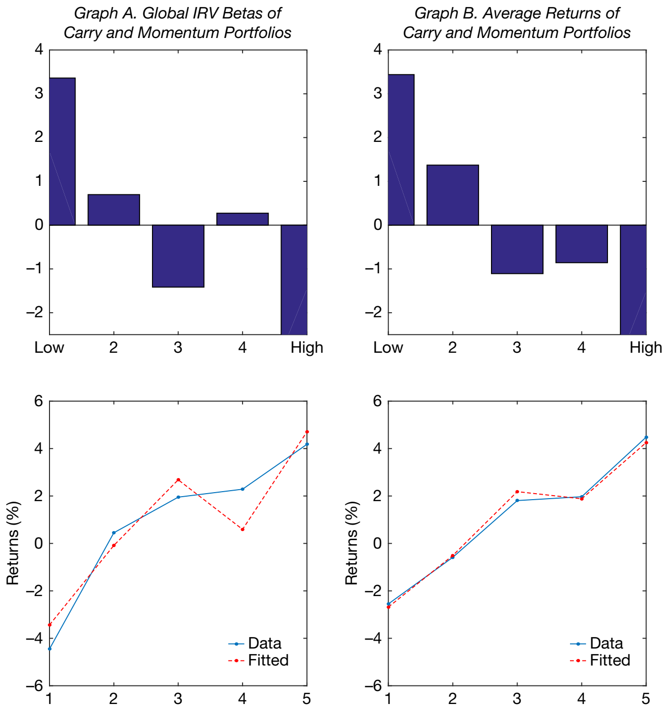
where DOL_t is the dollar factor constructed as the cross-sectional average of the excess returns of the five carry trade portfolios following Lustig et al. (2011): This can be treated analogously as a market factor in the FX market. In the second stage, I run the following cross-sectional regression:

$$\overline{rx}^i = \widehat{\beta}_{\mathrm{DOL}}^i \lambda_{\mathrm{DOL}} + \widehat{\beta}_{\mathrm{IRV}}^i \lambda_{\mathrm{IRV}} + \eta^i, \tag{5}$$

FIGURE 2

Global IRV Betas and Pricing Error Plots

Graph A of Figure 2 plots the sensitivities of carry and momentum portfolio returns to the risk of global uncertainty (IRV betas), which are estimated from equation (4). Graph B plots the portfolio mean returns and fitted returns from the asset pricing model containing the dollar factor and the global IRV risk, estimated over carry and momentum portfolio separately. The sample period is from Jan. 1985 to Jan. 2019.



where the left-hand side is the unconditional mean of portfolio excess returns and the first-stage estimated betas are used as the explanatory variables on the right-hand side. λ_{DOL} and λ_{IRV} are the risk prices per unit of dollar factor beta and IRV beta, respectively. Note that I do not add the intercept to the second-stage regression because of the dollar factor (see, e.g., Menkhoff et al. (2012a)).

The remaining columns in Table 1 report the first-stage time series regression results. While both types of cross-sectional portfolios load similarly on the dollar factor, their exposure to u_t^{IRV} decreases almost monotonically from the bottom portfolio to the top portfolio. I plot these patterns in Graph A of Figure 2. The magnitudes of the high-minus-low beta spreads are similar and statistically significant at the 1% level. Obtaining a significant spread in betas is a pivotal check of whether the factor is priced, following Burnside (2011): The order of the betas is tested using the monotonicity test of Patton and Timmermann (2010), where the p-values are based on the null hypothesis that the betas are monotonically decreasing. The first-stage evidence sheds light on the potentially unified explanation of carry and momentum returns based on their exposure to the risk of the global IRV.

Then the cross-sectional regression (5) is estimated using OLS. I use three approaches to calculate the standard errors in order to test the significance of risk prices. The first approach (NW) follows Lustig and Verdelhan (2007) and calculates the asymptotic standard errors from the cross-sectional regression, which involves estimating the covariance of pricing errors using the method of Newey and West (1987) with optimal lag selection following Andrews (1991). However, this approach assumes known betas when running cross-sectional regressions. Given that IRV risk is a non-tradable factor and the estimation of betas might be noisy (see, e.g., Burnside (2011)), I use the second approach (NW-GMM) to adjust for the first-stage estimation error in betas via the GMM method discussed in Cochrane (2009) (see also Section I.B in Burnside (2011)). This approach sets up a GMM system that delivers the same point estimates for risk prices as the 2-stage Fama–MacBeth method, while accounting for the estimation error in betas and potentially heteroskedastic error terms. The third approach (Sh) uses the asymptotic adjustment following Shanken (1992) to account for estimation error in betas. It should be noted that the variance–covariance matrix of pricing errors is different under these three methods, which would translate to different results for the χ^2-test on testing the null of zero pricing errors. For instance, assuming betas are known would underestimate the variability of pricing errors relative to other two methods.

I use five carry and five momentum portfolios, separately or jointly, as testing assets. Panel A of Table 4 presents the results. The almost monotonically decreasing betas and increasing portfolio returns render negative prices for the global IRV risk, with cross-sectional R^2 of 88% and 98%, respectively. A large R^2 indicates that exposure to IRV risk goes a long way toward reconciling returns to FX carry and momentum. Meanwhile, the magnitudes of the risk prices are similar and significant for all types of t-statistics. The results are invariant under the joint cross section of carry and momentum returns, with an R^2 of 92%. To test for zero-pricing errors, I further report the p-values from the χ^2-test, as discussed in Cochrane (2009). The computation of χ^2 statistics is also based on the Newey–West $\left(\chi^2_{\text{NW-GMM}}\right)$ method with a GMM adjustment or Shanken $\left(\chi^2_{\text{Sh}}\right)$. The null hypothesis that all pricing errors are jointly zero cannot be rejected at the 5% level. This indicates a close distance between the average portfolio returns and the fitted returns from equation (5), as confirmed by Graph B of Figure 2.

However, the global IRV risk is a non-traded factor. To mitigate the concern of using such a factor in the asset pricing test, as widely discussed in, for example, Kan and Zhang (1999), I construct a factor-mimicking portfolio by projecting u_t^{IRV} onto 10 currency portfolios:

$$u_t^{\text{IRV}} = a + b' w_t + \varepsilon_t, \tag{6}$$

where w_t denotes the vector of the month-t excess returns on the five carry and five momentum portfolios. The correlation coefficient between the factor-mimicking portfolio returns $u_{\text{FMP},t}^{\text{IRV}}$ and u_t^{IRV} is 0.30. Given that $u_{\text{FMP},t}^{\text{IRV}}$ is now a traded factor, without undergoing any asset pricing test, the Sharpe ratio of the factor-mimicking portfolio reflects the market price of IRV risk. Its annual SR is −1.09, with a Newey–West t-statistic of −5.14. The magnitude of SR is even larger than that of the carry and momentum strategies, suggesting that the global IRV risk explains

TABLE 4

Cross-Sectional Asset Pricing Test

Panels A and B of Table 4 report the results of asset pricing test for the 2-factor model with the dollar factor and the risk of global interest rate volatility u_t^{IRV}, or its factor-mimicking portfolio returns $\left(u_{\mathrm{FMP},t}^{\mathrm{IRV}}\right)$. The testing assets are the carry, momentum, or their joint cross-sectional portfolios. The baseline global IRV is the cross-sectional average over G10 currencies' IRV calculated from their 10-year Treasury bonds. The factor-mimicking portfolio is constructed by projecting u_t^{IRV} on the return space of five carry and five momentum portfolios. The tests are implemented via the Fama–MacBeth regression, where I report the estimated risk prices and cross-sectional OLS R^2. The t-statistics are based on standard errors calculated from asymptotic Newey–West standard errors from the cross-sectional regression (NW), the method that further adjusts for first-stage estimation error in betas via GMM (NW-GMM), or the asymptotic adjustment standard errors following Shanken (1992) (Sh). The p-values of χ^2-test on the null hypothesis that the pricing errors are jointly zero are also reported. Panel C reports the results by using the Monetary Policy Uncertainty (MPU) index of Baker et al. (2016) to measure the global interest rate volatility. Panel D displays the test results using the baseline global IRV risk and the GMM estimation for the asset pricing model. I report the estimated factor loadings in the SDF model (7) by using the optimal weight matrix in the estimation. The Newey–West t-statistics are in parentheses. I also report the p-values from the χ^2-test, and the estimated Hansen-Jagannathan distances and their p-values, which are obtained via simulation following Jagannathan and Wang (1996). The sample period is from Jan. 1985 to Jan. 2019.

	Carry			Momentum			Carry + Momentum		
Panel A. Baseline Global IRV Risk									
	λ_{DOL}	λ_{IRV}	R^2	λ_{DOL}	λ_{IRV}	R^2	λ_{DOL}	λ_{IRV}	R^2
	0.07	−1.26	0.88	0.08	−1.10	0.98	0.08	−1.18	0.92
(NW)	(0.70)	(−4.06)		(0.80)	(−3.79)		(0.80)	(−4.37)	
(NW-GMM)	(0.53)	(−3.26)		(0.71)	(−2.87)		(0.65)	(−2.47)	
(Sh)	(0.70)	(−2.52)		(0.80)	(−2.56)		(0.80)	(−2.81)	
χ^2_{NW}	[0.04]			[0.93]			[0.01]		
$\chi^2_{\mathrm{NW-GMM}}$	[0.13]			[0.97]			[0.16]		
χ^2_{Sh}	[0.37]			[0.98]			[0.42]		
Panel B. Factor-Mimicking Portfolio									
	λ_{DOL}	λ_{FMP}	R^2	λ_{DOL}	λ_{FMP}	R^2	λ_{DOL}	λ_{FMP}	R^2
	0.07	−0.38	0.88	0.08	−0.33	0.98	0.08	−0.35	0.92
(NW)	(0.70)	(−5.43)		(0.10)	(−4.13)		(0.80)	(−5.83)	
(NW-GMM)	(0.58)	(−3.67)		(0.72)	(−3.89)		(0.68)	(−4.18)	
(Sh)	(0.70)	(−5.43)		(0.80)	(−4.13)		(0.80)	(−5.83)	
χ^2_{NW}	[0.05]			[0.93]			[0.01]		
$\chi^2_{\mathrm{NW-GMM}}$	[0.05]			[0.94]			[0.05]		
χ^2_{Sh}	[0.07]			[0.94]			[0.03]		
Panel C. BBD MPU Index									
	λ_{DOL}	λ_{MPU}	R^2	λ_{DOL}	λ_{MPU}	R^2	λ_{DOL}	λ_{MPU}	R^2
	0.07	−1.33	0.93	0.09	−2.97	0.78	0.08	−1.50	0.78
(NW)	(0.70)	(−3.50)		(0.90)	(−4.13)		(0.80)	(−4.05)	
(NW-GMM)	(0.54)	(−3.21)		(0.57)	(−2.32)		(0.62)	(−2.09)	
(Sh)	(0.70)	(−2.15)		(0.90)	(−2.01)		(0.80)	(−2.27)	
χ^2_{NW}	[0.30]			[0.06]			[0.07]		
$\chi^2_{\mathrm{NW-GMM}}$	[0.57]			[0.79]			[0.67]		
χ^2_{Sh}	[0.72]			[0.86]			[0.81]		
Panel D. GMM Estimation									
	b_{DOL}	b_{IRV}	R^2	b_{DOL}	b_{IRV}	R^2	b_{DOL}	b_{IRV}	R^2
Coef.	0.03	−1.34	0.87	0.03	−1.22	0.97	0.02	−1.51	0.84
(t)	(0.75)	(−2.73)		(0.75)	(−2.60)		(0.67)	(−3.87)	
χ^2-test	[0.18]			[0.99]			[0.10]		
HJ-dist	0.17			0.03			0.23		
	[0.10]			[0.95]			[0.17]		

the bulk of strategy returns. I then follow the previous exercises by running a cross-sectional asset pricing test using $u_{\mathrm{FMP},t}^{\mathrm{IRV}}$ as the risk factor. The results are in Panel B of Table 4. The main findings are robust with a large cross-sectional R^2, the risk prices have now become more significant. The Shanken t-statistic is as large as −5.83 when using the both currency portfolios are used as testing assets.

Now, I repeat the asset pricing test by using innovations to the MPU index of Baker et al. (2016) as a measure of shocks to global IRV.[5] Results are tabulated in Panel C of Table 4. Despite the lower cross-sectional R^2 for explaining the average momentum returns, the outcomes are similar to those of the baseline measure of the global IRV. The risk prices are negative and significant among carry or momentum returns and their joint cross sections. The results provide further support for the usefulness of IRV and alleviate concerns regarding spurious findings.

Finally, although the 2-stage method is easy to implement, the pre-estimation of IRV betas is unfavorable because it introduces an error-in-variable problem when running a cross-sectional test. Therefore, I employ the Generalized Method of Moments (GMM) to directly estimate the asset pricing model in one step. The estimation begins with a parametric form of the stochastic discount factor (SDF):

$$M_{t+1} = 1 - b_{\text{DOL}}(\text{DOL}_{t+1} - \mu_{\text{DOL}}) - b_{\text{IRV}} u_{t+1}^{\text{IRV}}. \tag{7}$$

The moment conditions are derived from the following Euler equations:

$$E\left(M_{t+1}\text{RX}_{t+1}^{i}\right) = 0, \tag{8}$$

where RX_{t+1}^{i} is the excess return of the testing asset i. Panel C of Table 4 reports the estimation results using the optimal weight matrices. To test for zero-pricing errors, I display the p-values from the χ^2-test. I also report the Hansen-Jagannathan distance of Hansen and Jagannathan (1997) to gauge model misspecification, where the simulation-based p-values following Jagannathan and Wang (1996) are in brackets. From the results, I find that the estimated factor loadings for IRV risk are negative and significant with a large cross-sectional R^2. Thus, the null hypothesis of a zero-pricing error cannot be rejected. In fact, the Hansen–Jagannathan distances are also small and not significantly different from zero.

B. Comparison with Closely Related Variables

My results differ from the recent literature that highlights the importance of uncertainty fluctuations in currency risk premia. Mueller et al. (2017b) find that carry trade is more profitable on days with scheduled FOMC announcements and they interpret higher return as compensation for heightened U.S. monetary policy uncertainty. However, they do not study how carry trade is affected at a lower frequency (monthly frequency) or whether the joint cross section of carry and momentum can be explained. The results in Table 4 suggest that a similar economic force goes a long way toward explaining the returns to carry and momentum. In another related study, Eriksen (2019) finds that the cross-sectional return dispersion of currency portfolios can explain currency momentum. His factor also measures some type of uncertainty risk in the FX market, but the author does not draw any

[5]Changes in the MPU index are highly correlated with changes in other category-specific BBD policy uncertainty indexes. To facilitate interpretation, these innovations are orthogonalized with respect to the category-specific indexes as described in Section B.3 of the Supplementary Material, following, for example, Della Corte and Krecetovs (2024).

implications for the carry trade. Panel A of Table 5 compares the results with the IRV risk. In the joint cross section of carry and momentum, the return dispersion factor is not significantly priced and does not drive out the impact of global IRV risk.[6] While the author shows that when the U.S. monetary policy stance is expansive (restrictive), both innovations to dispersion and currency momentum returns are higher (lower), his explanation is based on shifts in monetary stance (first-moment shock), whereas my explanation is based on a monetary policy uncertainty shock (second-moment shock). The results in Panel A also show that this factor does not drive the explanatory power of U.S. monetary policy uncertainty built by Baker et al. (2016).

The IRV measure also differs from the global FX volatility constructed by Menkhoff et al. (2012a), which is a key risk factor for the carry trade. While the authors document the pricing power of global FX volatility on long-term momentum portfolios sorted by excess returns over the past 12 months, Menkhoff et al. (2012b) show that the same factor does not explain FX momentum based on the *short-term* signal, which is the key focus of my study. Panel B of Table 5 shows that

TABLE 5

Comparison with Closely Related Variables

Table 5 reports the results of asset pricing test for the three-factor model with the dollar factor, the risk of global interest rate volatility, and the cross-sectional return dispersion risk of Eriksen (2019) (Panel A) or the risk of global FX volatility of Menkhoff et al. (2012a) (Panel B). The testing assets are the joint cross section of carry and momentum portfolios. I also use the Monetary Policy Uncertainty (MPU) index of Baker et al. (2016) to measure the global interest rate volatility. The tests are implemented via the Fama–MacBeth regression, where I report the estimated risk prices and cross-sectional OLS R^2. The *t*-statistics are based on standard errors calculated from asymptotic Newey–West standard errors from the cross-sectional regression (NW), the method that further adjusts for first-stage estimation error in betas via GMM (NW-GMM), or the asymptotic adjustment standard errors following Shanken (1992) (Sh). The *p*-values of χ^2-test on the null hypothesis that the pricing errors are jointly zero are also reported. The sample period is from Jan. 1985 to Jan. 2019.

	Baseline Global IRV Risk Measure				BBD MPU Index			
Panel A. Return Dispersion								
	λ_{DOL}	λ_{CSV}	λ_{IRV}	R^2	λ_{DOL}	λ_{CSV}	λ_{MPU}	R^2
	0.08	−0.30	−1.21	0.92	0.08	0.58	−1.53	0.79
(NW)	(0.80)	(−1.02)	(−4.20)		(0.77)	(2.16)	(−3.89)	
(NW-GMM)	(0.66)	(−0.36)	(−2.44)		(0.62)	(0.94)	(−1.98)	
(Sh)	(0.80)	(−0.65)	(−2.70)		(0.77)	(1.11)	(−2.23)	
χ^2_{NW}	[0.01]				[0.47]			
$\chi^2_{NW\text{-}GMM}$	[0.12]				[0.90]			
χ^2_{Sh}	[0.34]				[0.97]			
Panel B. FX Volatility								
	λ_{DOL}	λ_{FXVOL}	λ_{IRV}	R^2	λ_{DOL}	λ_{FXVOL}	λ_{MPU}	R^2
	0.08	−0.42	−1.09	0.94	0.07	0.08	−2.30	0.86
(NW)	(0.79)	(−2.31)	(−4.22)		(0.71)	(0.39)	(−4.38)	
(NW-GMM)	(0.79)	(−1.89)	(−2.39)		(0.71)	(0.17)	(−2.03)	
(Sh)	(0.79)	(−1.58)	(−2.84)		(0.71)	(0.16)	(−2.21)	
χ^2_{NW}	[0.02]				[0.08]			
$\chi^2_{NW\text{-}GMM}$	[0.24]				[0.89]			
χ^2_{Sh}	[0.34]				[0.97]			

[6]Consistent with Eriksen (2019), unreported results show that his factor is significantly priced in momentum portfolios, but not carry portfolios.

after adding shocks to global FX volatility, the significant pricing power for carry and momentum by global IRV risk is not affected. Although the cross-sectional R^2 increases marginally, the risk prices of global FX volatility become insignificant.

C. Currency-Level Asset Pricing Tests

Recent literature (e.g., Lewellen, Nagel, and Shanken (2010), Ang, Liu, and Schwarz (2020)) raises the concern about data-snooping when using portfolios in asset pricing tests. The small number of testing assets usually used in currency asset pricing literature may yield spurious testing results and estimates of risk premia (Barroso, Kho, Rouxelin, and Yang (2018)). In this subsection, I test whether the risk of the global IRV remains negatively priced at the current level, with 48 currencies.

To better visualize the performance of the global IRV risk, I first estimate the risk exposures of G10 currencies using (4). Panel A of Table 6 compares the average excess returns with IRV betas together with their average forward discounts. Interestingly, the return-beta relation found from the portfolio-level analysis also translates to G10 currencies. On average, high interest-rate currencies such as AUD and NZD have the lowest IRV betas, whereas low interest-rate currencies such as JPY and CHF have the highest IRV betas.

TABLE 6

Currency-Level Asset Pricing

Table 6 reports the results of currency-level asset pricing. Panel A reports the monthly forward discounts (interest differentials) and excess returns, both in percentage, together with the IRV betas of G10 currencies. Panel B reports the estimated risk prices from the Fama–MacBeth regression by using the conditional currency excess returns of individual currencies. $C1$ is based on the conditional excess return that is defined as the raw excess return multiplied by the sign function of lagged interest rate differential or realized excess return, and $C2$ uses the sign function of the deviation from the cross-sectional median of lagged interest rate differential or realized excess return (detailed in equation (10)). The Newey–West HAC t-statistics are in parentheses and adjusted for the first-stage estimation error in betas. The sample period is from Jan. 1985 to Jan. 2019.

Panel A. G10 Currencies

	Forward Discount	Excess Return	IRV Beta
NZD	4.32	5.28	−4.32
AUD	2.64	2.28	−4.92
NOK	1.68	2.04	−0.12
GBP	1.68	2.04	0.84
SEK	1.56	1.44	0.72
CAD	0.72	0.72	−2.16
EUR	−0.24	−0.24	1.32
CHF	−1.32	1.44	2.76
JPY	−2.40	−0.12	5.16

Panel B. Conditional Currency Returns

	$C1$		$C2$	
	λ_{DOL}	λ_{IRV}	λ_{DOL}	λ_{IRV}
Carry	0.31	−0.24	0.56	−0.60
(t)	(2.48)	(−1.13)	(2.02)	(−2.15)
MOM	0.22	−0.27	−0.43	−0.36
(t)	(0.42)	(−1.62)	(−0.38)	(−1.72)
Carry + MOM	0.26	−0.39	0.41	−0.46
(t)	(1.77)	(−2.19)	(1.25)	(−2.23)

I then evaluate the pricing power of IRV risk for currency-level carry and momentum returns. Following Lustig et al. (2011) and Hassan and Mano (2019), the conditional currency excess return for currency i is defined as:

(9) $$crx_{t+1}^{i} = c_{t}^{i} rx_{t+1}^{i},$$

where two ways of incorporating the conditional information of carry and momentum are considered:

(10) $$c_{1,t}^{i} = \begin{cases} \text{sign}\left(f_{t}^{i} - s_{t}^{i}\right), \\ \text{sign}\left(rx_{t}^{i}\right). \end{cases} \quad c_{2,t}^{i} = \begin{cases} \text{sign}\left(f_{t}^{i} - s_{t}^{i} - \text{med}(f_{t} - s_{t})\right), \\ \text{sign}\left(rx_{t}^{i} - \text{med}(rx_{t})\right). \end{cases}$$

The first specification of the sign functions follows Burnside et al. (2011b) and Filippou et al. (2018), and the second follows Della Corte and Krecetovs (2024), which represents the sign of deviations from the cross-sectional median. These conditional returns are from the managed long-short strategies of *individual* currencies based on their carry or momentum signals. Given that the panel of currency-level data is unbalanced, I follow Della Corte and Krecetovs (2024) and use the Fama–MacBeth regression to estimate risk prices. The estimation is performed either separately or jointly on the individual carry and momentum returns. Panel B of Table 6 displays the results, with Newey–West t-statistics obtained based on the estimated series of risk prices and adjusted for the EIV problem of betas following Shanken (1992). In spite of less significant results from using the first specification of (10) on individual carry returns, the general outcomes are consistent with the portfolio-level tests and significant for other scenarios. Importantly, when examining a large universe combining currency-level carry and momentum returns, the estimated risk prices are negative and highly significant. Thus, results from currency-level test support the unified pricing of the global IRV risk, and the explanatory power is unlikely driven by the concern of portfolio-level analysis.

D. Broader Cross-Section of Currency Strategies

Given that the global IRV accounts for systematic risk in carry and momentum, it is natural to conjecture that the factor is priced in other cross sections of the currency portfolios. Thus, I expand 10 FX carry and momentum portfolios by including five currency portfolios in turn from the other currency strategies. These additional portfolios come from the currency value of Menkhoff, Sarno, Schmeling, and Schrimpf (2017), long-term momentum of Menkhoff et al. (2012a), global imbalance of Corte et al. (2016), and conditional dollar strategy of Verdelhan (2018). I estimate the price of the global IRV risk using the 2-pass Fama–MacBeth regression described in Section III.A and report the results in Table 7. I find that the results are weaker after adding more testing portfolios, with cross-sectional R^2 values ranging from 76% to 81%. However, the risk price remains negative and significant. The null hypothesis of jointly zero-pricing errors is rejected only when including the conditional dollar strategy. Finally, to implement a more powerful test, I include all 30 currency portfolios in the asset pricing test. While I am not arguing that the global IRV can price all currency strategies, the results indicate that

TABLE 7

Asset Pricing Tests with Additional Currency Strategies

Table 7 reports the results of asset pricing test for the 2-factor model with the dollar factor and the risk of global interest rate volatility u_t^{IRV}. The testing assets are the carry, momentum, and five portfolios in turn from the currency value, the long-term momentum, the global imbalance, and the conditional dollar. The final panel includes all 30 portfolios in the test. The table also reports the results from using all currency portfolios in the test. The tests are implemented via the Fama–MacBeth regression, where I report the estimated risk prices and cross-sectional OLS R^2. The t-statistics are based on standard errors calculated from asymptotic Newey–West standard errors from the cross-sectional regression (NW), the method that further adjusts for first-stage estimation error in betas via GMM (NW-GMM), or the asymptotic adjustment standard errors following Shanken (1992) (Sh). The p-values of χ^2-test on the null hypothesis that the pricing errors are jointly zero are also reported. The sample period is from Jan. 1985 to Jan. 2019.

	C + M + Value			C + M + Long-Term M			C + M + Imbalance		
	λ_{DOL}	λ_{IRV}	R^2	λ_{DOL}	λ_{IRV}	R^2	λ_{DOL}	λ_{IRV}	R^2
	0.11	−1.11	0.77	0.09	−0.94	0.80	0.12	−0.93	0.76
(NW)	(1.08)	(−4.16)		(0.91)	(−4.08)		(1.17)	(−3.94)	
(NW-GMM)	(0.93)	(−2.41)		(0.79)	(−2.81)		(1.04)	(−3.59)	
(Sh)	(1.04)	(−2.78)		(0.88)	(−2.99)		(1.16)	(−2.89)	
χ^2_{NW}	[0.00]			[0.00]			[0.00]		
$\chi^2_{NW\text{-}GMM}$	[0.12]			[0.13]			[0.06]		
χ^2_{Sh}	[0.22]			[0.19]			[0.19]		

	C + M + Conditional Dollar			All		
	λ_{DOL}	λ_{IRV}	R^2	λ_{DOL}	λ_{IRV}	R^2
	0.14	−1.12	0.80	0.13	−0.78	0.59
(NW)	(1.31)	(−4.06)		(1.29)	(−3.72)	
(NW-GMM)	(1.19)	(−3.60)		(1.13)	(−3.79)	
(Sh)	(1.30)	(−2.71)		(1.28)	(−2.93)	
χ^2_{NW}	[0.00]			[0.00]		
$\chi^2_{NW\text{-}GMM}$	[0.01]			[0.00]		
χ^2_{Sh}	[0.02]			[0.00]		

the dollar factor and global IRV risk account for 59% of the cross-sectional variations in mean returns, and the price of risk is significant. The evidence supports the global IRV risk as a systematic risk factor in the currency market.

E. Accounting for Omitted-Variable Bias and Measurement Errors

The global IRV risk is a nontradable risk factor and may suffer from the measurement error problem. Meanwhile, some relevant factors entering the pricing kernel could be omitted from the 2-stage Fama–MacBeth regression employed before, leading to the omitted variable bias. In this subsection, I tackle these two concerns by estimating the risk premium for the global IRV risk via the three-pass procedure proposed by Giglio and Xiu (2021), which is recently applied to the currency market by Nucera, Sarno, and Zinna (2023). The first step involves obtaining an optimal currency SDF by extracting important latent pricing factors from the panel of currency portfolio returns. The second step estimates the prices of risk for these latent factors via the cross-sectional regression, and the third step projects the global IRV risk onto the space spanned by the latent pricing factors. The risk premium estimate for the global IRV risk is then given by the linear combination of risk prices of the latent factors. To run the test, I utilize the currency portfolio data sourced from Nucera et al. (2023) that cover nine popular currency strategies. Table A2 in the Supplementary Material reports the estimate of the latent factor pricing kernel based on the sample from Jan. 1985 to Dec. 2017. The structure of the currency SDF is quantitatively similar to the results in Nucera et al. (2023) (see their Table 1). While the first factor (F_1) strongly explains variations in all currency portfolios and works as a "level" factor, the second and the third factor (F_2 and F_3) contribute more to the performance of cross-sectional asset pricing. Thus the optimal latent-factor currency SDF should consist of at least first three latent factors. As shown in Nucera et al. (2023), F_1 can be interpreted as the dollar factor, F_2 and F_3 are more correlated with carry and short-term momentum factor.

Is the global IRV risk related to these important latent factors? Nucera et al. (2023) find that existing currency risk factors tend to expose oppositely to F_2 and F_3 (see their Table 2), suggesting that a unified explanation for carry and momentum is challenging. Interestingly, Panel A of Table 8 shows that the global IRV risk is exposed negatively to both F_2 and F_3. Projecting u_t^{IRV} on these latent factors yields the slope coefficients for F_2 and F_3 that are negative and statistically significant. This is true for various specifications for the currency SDF that include the first three PCs ($\varphi(F_{1-3})$) or all six PCs ($\varphi(F_{1-6})$). The R^2 also increases after including the "momentum" factor (F_3) in the regression, indicating that the global IRV risk is correlated with the momentum after controlling for the correlation with carry factor. The R^2s from these regressions are generally low, suggesting the existence of measurement error in the global IRV. Panel B of Table 8 tabulates the estimated premium for the global IRV risk after applying the three-pass method of Giglio and Xiu (2021). I find that the global IRV risk continues to carry a significant and negative risk premium after accounting for omitted-variable bias

TABLE 8

Asset Pricing Tests Accounting for Omitted Variable Bias and Measurement Error

Table 8 reports the results after accounting for omitted variable and measurement errors using the three-pass method proposed by Giglio and Xiu (2021). Following Nucera et al. (2023), the latent factors governing the currency market stochastic discount factor (SDF) are extracted via the RP-PCA method proposed by Lettau and Pelger (2020). The table reports results under various specifications for the SDF that includes different number of latent factors (from the first two factors $\varphi(F_{1-2})$ to the first six factors $\varphi(F_{1-6})$). Panel A reports the exposures of global IRV risk to these latent factors. Panel B reports the estimated risk premium for the global IRV risk via the three-pass method. The Newey–West t-statistics are reported in parentheses. The p-values (p-val) of testing the null that the candidate risk factor is a weak factor are also reported. SR denotes the annualized Sharpe ratios from the projected factor, which is obtained from projecting nontradable IRV risk on latent factors underlying each SDF. The sample period is from Jan. 1985 to Dec. 2017.

	$\varphi(F_{1-2})$	$\varphi(F_{1-3})$	$\varphi(F_{1-4})$	$\varphi(F_{1-6})$
Panel A. Exposures to Latent Factors				
η_{F_1}	−0.07	−0.07	−0.07	−0.07
(t)	(−0.19)	(−0.20)	(−0.20)	(−0.20)
η_{F_2}	−5.75	−5.75	−5.75	−5.75
(t)	(−2.82)	(−2.86)	(−2.89)	(−2.94)
η_{F_3}		−4.14	−4.14	−4.14
(t)		(−2.06)	(−2.04)	(−2.15)
η_{F_4}			1.84	1.84
(t)			(0.64)	(0.70)
η_{F_5}				1.57
(t)				(0.62)
η_{F_6}				−6.39
(t)				(−2.28)
R^2 (%)	2.63	3.78	3.94	5.49
Panel B. Estimated Risk Premium				
λ	−0.69	−1.04	−0.98	−0.97
(t)	(−2.55)	(−2.67)	(−2.62)	(−2.60)
SR	1.22	1.52	1.42	1.20
p-val	0.02	0.01	0.03	0.03

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and measurement errors, under different specification for the currency SDF. The factor annualized Sharpe ratio ranges from 1.20 to 1.52, which is lower than but close to the maximal Sharpe ratio under each SDF shown in Table A2 in the Supplementary Material. The p-values also reject the null that the global IRV is a weak factor.[7] Overall, the evidence-based on significant factor exposures and risk premium estimate is consistent with the unified explanatory power for carry and momentum.

F. Impact of Time-Varying Betas

Previous empirical tests follow the literature by working with full-sample estimated exposures to risk factors, Verdelhan (2018) documents that the currency betas to the dollar factor are time-varying. Boguth, Carlson, Fisher, and Simutin (2011) find that working with betas that are not anticipated by investors may bias the results of asset pricing test. This subsection explores whether the results continue to hold in a conditional setting using conditional betas in the asset pricing test. As there are no obvious instruments for conditional betas, I follow Verdelhan (2018) by estimating (4) using a 60-month rolling window. After obtaining the conditional betas $\widehat{\beta}_{t-1}$ using the data between $t-60$ and $t-1$, for each carry or momentum portfolio, I estimate the following cross-sectional regression at the end of month t

$$rx_t^i = \widehat{\beta}^i_{\text{DOL},t-1}\lambda_{\text{DOL},t} + \widehat{\beta}^i_{\text{IRV},t-1}\lambda_{\text{IRV},t} + \eta_t^i. \tag{11}$$

I find that the average of $\lambda_{\text{IRV},t}$ is -0.29, with a t-statistic of -2.24, which implies that the results still hold in a conditional setting.

IV. Inspecting the Mechanism

In this section, I explore how the global IRV impact carry and momentum traders by proposing an exchange rate model in the spirit of Gabaix and Maggiori (2015) and Mueller et al. (2017b), which highlights the importance of FX intermediaries in exchange rate determination. In this model, exchange rates are determined when FX intermediaries (financiers) absorb the imbalance arising from the demand and supply of assets in different currencies. As my goal is to clarify the economic channel and derive further testable implications, the model is kept as parsimonious as possible.

A. Theoretical Framework

Consider an economy with two countries, denoted foreign and home, with four periods, $t=0,1,2,3$.[8] Each country is populated by a unit mass of investors with an exogenous demand for assets denominated in another currency. I denote ξ_t as the aggregate foreign demand for home assets (denominated in foreign currency) and ι_t as the aggregate home demand for foreign currency (denominated in the home

[7] This is the test proposed by Giglio and Xiu (2021) to evaluate whether an observable factor is only weakly reflected in the cross-section of asset returns.

[8] The framework extends the three-period model in Section III.A.1 of Gabaix and Maggiori (2015). While they assume exogenous changes in the intermediaries' risk-bearing capacity in the middle period, I add one more period to endogenously incorporate the impact of the global IRV.

currency). Without loss of generality, both ξ_t and ι_t are assumed to be positive. Investors in each country can also trade one-period, risk-free domestic bonds. I denote the foreign and home *gross* interest rates applied between t and $t+1$ as R_t^* and R_t. I denote the time-t exchange rate by e_t, denominated as the unit of the home currency per unit of foreign currency. In the economy, there is a unit mass of identical FX intermediaries (financiers) that absorb the excess supply of one currency against the other because of the imbalance $\xi_t e_t - \iota_t$. Financiers can trade bonds in both countries.

I denote the time-t demand of the representative financier for foreign currency against the home currency as q_t and assume that it unwinds the position at the end of period $t+1$, identical to the setting in Gabaix and Maggiori (2015) and Mueller et al. (2017b). The financier solves the following problem in period t by maximizing the expected profits (denominated in the home currency):

$$\max_{q_t} V_t = E_t\left[R_t^* \frac{e_{t+1}}{e_t} - R_t\right] q_t, \qquad (12)$$

$$\text{s.t.}\, V_t \geq \Gamma_t \frac{q_t^2}{e_t}.$$

Financial constraint (12) follows Gabaix and Maggiori (2015), and Γ_t is parameterized as

$$\Gamma_t = \gamma \text{var}_t(e_{t+1})^{\alpha}, \qquad (13)$$

with $\gamma, \alpha > 0$. Intuitively, this constraint ensures that the intermediary has sufficient funds to pay back creditors, and Γ_t captures (inversely) the risk-bearing capacity of financiers. Gabaix and Maggiori (2015) show that the constraint always binds so that intermediaries' aggregate optimal demand can be expressed as

$$Q_t = \frac{1}{\Gamma_t} E_t\left[\frac{R_t^*}{R_t} e_{t+1} - e_t\right].$$

The equilibrium exchange rate can be obtained by applying the following market-clearing condition for the foreign currency at each t (expressed as the value of the home currency):

$$\xi_t e_t - \iota_t + \text{R}Q_{t-1} - Q_t = 0. \qquad (14)$$

At $t=3$, financiers unwind all their positions and exit the economy so that $Q_3 = 0$.

Following Gabaix and Maggiori (2015), I normalize ξ_t to unity, and assume that ι_t is stochastic. For tractability, I further assume the following:

$$\iota_{t+1} = \iota_t + \sigma_t \varepsilon_{t+1}, \qquad (15)$$

where ε_{t+1} is standard normal innovation. Meanwhile, to study the impact of future interest rate uncertainty in a parsimonious manner, I assume that only the interest rates in the final period (R_2^* and R_2) are stochastic, and they only become known at the beginning of $t=2$. The interest rates in the other periods are deterministic and denoted by R^* and R. I follow the standard model of interest rate risk by assuming that the log of gross interest rates follows:

$$\text{(16)} \qquad \begin{aligned} \log R_2^* &= (1-\rho_r^*)\bar{r}^* + \rho_r^* \log R^* + \sigma_G \varepsilon_2^G + \sigma_r^* \varepsilon_2^*, \\ \log R_2 &= (1-\rho_r)\bar{r} + \rho_r \log R + \sigma_G \varepsilon_2^G + \sigma_r \varepsilon_2, \end{aligned}$$

with the uncorrelated standard normal innovations $\varepsilon_2^G, \varepsilon_2^*, \varepsilon_2$. The literature has established that bond yields across different currencies strongly comove, and the usual way to capture such commonalities is to introduce global factors for bond yields (see, e.g., Sarno, Schneider, and Wagner (2012), Jotikasthira, Le, and Lundblad (2015)). In system (16), ε_2^G captures the shock to the global bond yield factor, and σ_G represents global IRV.[9] Section A of the Supplementary Material provides the detailed steps for solving the model and proofs for subsequent propositions.

Now, suppose that at $t=1$ there is an unexpected change in the global IRV such that σ_G is higher, and the following proposition shows that this adversely affects the risk-bearing capacity of the FX intermediary.

Proposition 1. Γ_1 increases with σ_G.

Combining equations (13) and (14) indicates that Γ_1 is positively related to time-1 conditional volatility of ι_2 and Q_2, with the latter depending on R_2^* and R_2. A rising global IRV will increase the uncertainty surrounding future risk-taking Q_2 and reduce current risk-bearing capacity.

To understand the impact of IRV on carry traders, I solve out financiers' equilibrium demand at $t=0$

$$Q_0 = \frac{\left(\frac{R^*}{R} - 1\right)\iota_1 + \frac{R^*}{R} E_0 Q_1}{R^* + \Gamma_0 + 1}.$$

When the foreign interest rate is higher than the home interest rate $R^* > R$, financiers would run carry trades at $t=0$ by buying foreign currency and selling home currency. Furthermore, they invest more if i) $\frac{R^*}{R}$ is higher, ii) it expects more carry trade in the future ($E_0 Q_1$ is higher), and iii) Γ_0 is lower. However, if there is an unexpected shock to the global IRV at $t=1$, financiers would have to unwind their positions, leading to depreciated foreign currency at $t=1$ (lower e_1). Therefore, the carry trade implemented at $t=0$ will realize losses. This is summarized in the following proposition:

Proposition 2. If $\frac{R^*}{R} > 1$ and $E_0\left(\frac{R_2^*/R_2 - 1}{1+\Gamma_2+R_2^*}\right) > 0$,[10] then $Q_0 > 0$ and $\frac{\partial e_1}{\partial \sigma_G^2} < 0$.

[9]The global factor is an empirically important determinant. In my sample, the first principal component of government bond yields for G10 economies explain more than 90% of cross-sectional yield variations, for both short-term or long-term bonds, consistent with prior literature (see, e.g., Bauer and Diez de los Rios (2012)).

[10]The restriction on R_2^* and R_2 to ensure that FX intermediaries would not expect to take extreme short positions on foreign currency in the future, as it might lead them to short today. Given $R^* > R$ and the strong persistence of interest rates in many countries, this is not a strict condition.

I now discuss the momentum strategy, which involves sorting past realized currency appreciation. To endogenize realized exchange rate movements, I add one more period (denoted as period -1) before $t = 0$ so that realized appreciation between $t = -1$ and $t = 0$ is determined by the intermediaries' risk-taking. The trading arrangement is the same as before and financiers start trading at $t = 0$.

Given that the original model of Gabaix and Maggiori (2015) does not consider momentum, an equilibrium analysis of the impact of IRV on currency momentum is not feasible. Thus, I incorporate a simple setting in the spirit of Stein (2009) into my model so that the momentum effect may emerge in the model. Suppose that at $t = 0$, the representative financier receives advance information about $\imath_1$.[11] However, they process this information in a biased manner by underreacting.[12] In other words, they form expectations according to $E_0 \imath_1 = \delta \imath_1 + (1 - \delta)\imath_0$, where $\imath_0$ is the expectation of $\imath_1$ from (15). The degree of underreaction is given by $\delta \in (0, 1)$, and if δ is smaller, financiers underreact more to information for $\imath_1$ and their expectations are more anchored on $\imath_0$.

The intuition as to how such assumed underreaction leads to currency momentum is as follows: Consider advance information such that the foreign currency will appreciate against the home currency in the future. If $\delta = 1$, such information would be fully incorporated into the current exchange rate, the foreign currency would appreciate today, and there would not be subsequent appreciation. However, if $\delta < 1$, the exchange rate does not sufficiently adjust to reflect positive information and the appreciation of the foreign currency tends to continue, leading to a currency momentum effect.

As the interest rates of high-momentum currencies do not differ systematically from those of low-momentum currencies in the data (see Section 4.4 of Menkhoff et al. (2012b)), I assume negligeable interest rate difference when studying currency momentum. The model implications for momentum are summarized in the following proposition:

Proposition 3. If $\frac{R^*}{R} = 1$ and $E_0\left(\frac{R_2^*/R_2 - 1}{1 + \Gamma_2 + R_2^*}\right) = 0$, then

i) When the underreaction is strong enough such that $\delta < \overline{\delta}$, the currency momentum effect exists $\text{cov}(e_2 - e_1, e_1 - e_0) > 0$, with the expression for $\overline{\delta}$ given by equation (IA.8) in the Supplementary Material.
ii) Financiers' aggregate foreign currency holding at $t = 0$ increases with its appreciation: $\text{cov}(Q_0, e_0 - e_{-1}) > 0$. Moreover, when the currency appreciation is sufficiently strong, $Q_0 > 0$ and $\frac{\partial e_1}{\partial \sigma_G^2} < 0$.

Obtaining implication (ii) is because financiers trade in the direction of advance information. In this setting, financiers implement the momentum strategy

[11]This setting is plausible because the FX market is a highly intermediated OTC market and FX intermediaries are arguably sophisticated FX traders that could be more informative than other investors (see, e.g., Haddad and Muir (2021)). The assumption that financiers can observe $\imath_1$ simplifies the analysis significantly. A more general setting is to assume that financiers learn from the noisy signals of $\imath_1$. However, this will not change the qualitative implications of the model if the signal is not too noisy.

[12]The assumed underreaction may appear to be ad hoc, but it can be micro-founded following Hong and Stein (1999). See more discussions in the next subsection.

at $t = 0$. Thus, similar to the impact on carry trade, shocks to the global IRV reduce the intermediary's risk-bearing capacity and trigger momentum losses.

The model provides several predictions, which will be tested in Section IV.C. First, based on Proposition 1, the global IRV risk negatively affects the risk-bearing capacity of financial intermediaries. Second, based on Propositions 2 and 3, controlling for realized appreciation (interest rate difference), intermediaries' holdings positively correlate with the interest rate difference (realized appreciation). In other words, FX intermediaries' speculative activity increases with carry and momentum signals. However, a higher global IRV negatively affects their speculation.

B. Caveats

The stylized model presented above aims to reconcile primary empirical evidence and generate additional predictions. However, it does have limitations associated with its assumptions. First, the model-implied currency momentum effect relies on the assumption of FX intermediaries underreacting to news. Microfounding this assumption within the framework of Gabaix and Maggiori (2015) is not trivial and would possibly deliver novel insights on how exchange rate responds to news. One potential solution is to incorporate the framework of Hong and Stein (1999). In their context, FX intermediaries serve as "news-watchers," each with access to private information not immediately inferred by others from observed exchange rates. As long as private information diffuses slowly across the intermediary sector, FX intermediaries will appear to underreact to news. Second, the model treats carry and momentum separately, essentially assuming they are uncorrelated. This assumption aligns with the observed low correlations between carry and momentum in empirical data (as also noted in, e.g., Menkhoff et al. (2012b), Nucera et al. (2023)). Investigating endogenous mechanisms within the framework of Gabaix and Maggiori (2015) that explain this low correlation could be an interesting topic for future research. A possible explanation from the current model is that the low correlation might stem from momentum profitability relying on intermediaries' underreaction to news, while this key factor does not contribute to the profitability of carry trade.

C. Impact on Intermediary Constraints and Risk-Taking in Carry and Momentum

To test whether shocks to the global IRV affect intermediary's risk-bearing capacity, I study the co-movements between the global IRV and the intermediary capital ratio from He et al. (2017), where intermediaries are identified as primary dealers and the authors construct the equity capital ratio from balance sheets. Specifically, I project innovations to the intermediary equity capital ratio of He et al. (2017), u_t^{HKM} on contemporaneous and lagged innovations to the global IRV. Panel A of Table 9 presents the results.[13] I find that the global IRV risk correlates negatively and significantly with intermediary financial constraints. Shocks to the

[13] I only report the comparison with the intermediary measure of He et al. (2017), as it is available at the monthly frequency. The results are similar when I use the quarterly measure of Adrian et al. (2014). The results are available from the author.

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TABLE 9

Impact of IRV on Intermediary Constraints

Panel A of Table 9 reports the results of regressing innovations to intermediary equity capital ratio of He et al. (2017) u_t^{HKM} on the contemporaneous (column 1) and lagged (column 2) innovations to the global IRV. I also report the results of regressing returns to currency carry (r_t^C) and momentum (r_t^M) on u_t^{HKM} and u_t^{IRV}. Panel B reports the results of asset pricing test for the factor model with the market factor, the innovations to intermediary equity capital ratio of He et al. (2017), and the risk of global interest rate volatility. The testing portfolios are 112 portfolios used in He et al. (2017), excluding currency portfolios. I report the estimated risk prices and cross-sectional OLS R^2. The GMM-t statistics are in parentheses and calculated following He et al. (2017), which adjust for cross-sectional correlation and estimation errors in betas. The sample period is from Jan. 1985 to Nov. 2018.

Panel A. Relation with Equity Capital Ratio

	u_t^{HKM}	u_{t+1}^{HKM}	r_t^C	r_t^M
	1	2	3	4
u_t^{IRV}	−0.16	−0.10	−4.92	−6.72
(t)	(−3.02)	(−2.61)	(−3.09)	(−4.21)
u_t^{HKM}			6.84	−2.16
(t)			(4.36)	(−0.90)
R^2 (%)	2.61	1.70	7.36	3.57

Panel B. Test Using Other Asset Classes

	λ_{MKT}	λ_{HKM}		R^2
	0.54	1.41		0.36
(t)	(1.06)	(1.25)		
	λ_{MKT}	λ_{IRV}		
	0.51	−0.51		0.49
(t)	(1.13)	(−3.05)		
	λ_{MKT}	λ_{HKM}	λ_{IRV}	
	0.51	1.17	−0.49	0.49
(t)	(1.07)	(0.69)	(−3.05)	

global IRV also predict a significantly lower subsequent equity capital ratio (tightened constraints).

In addition, I test whether the explanatory power for currency carry and momentum by global IRV risk is driven away by the intermediary capital ratio. I regress the returns on the currency carry $\left(r_t^C\right)$ and momentum $\left(r_t^M\right)$ on u_t^{HKM} and u_t^{IRV}. I find that although the intermediary's equity capital ratio explains carry returns, it does not explain currency momentum. Interestingly, the global IRV risk maintains significant explanatory power for both carry and momentum returns. While the effect of global IRV risk on carry returns is partly subsumed by the intermediary capital ratio, the risk of global IRV still significantly and negatively affects carry returns. However, the explanatory power of momentum is not driven by the intermediary capital ratio. Overall, exposure to the risk of the global IRV provides incremental information relative to the existing intermediary constraint measure when explaining currency return anomalies.

Another important dimension of the intermediary channel is whether the global IRV risk also prices other asset classes because financial intermediaries are likely to be marginal investors in different financial markets (see, e.g., Adrian et al. (2014), He et al. (2017)). To this end, I test whether the global IRV risk is *negatively* priced in a large cross section of returns beyond currency returns. I include 112 testing portfolios that cover Fama–French 25 portfolios sorted by size and book-to-market, 10 portfolios of U.S. government bonds, 10 portfolios of U.S. corporate bonds, 6 portfolios of sovereign bonds, 18 portfolios of S&P 500 index options, 23 commodity portfolios, and 20 portfolios of corporate CDS.

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The return data of these portfolios are taken directly from He et al. (2017), and following their testing procedure, I add a constant in the second-stage cross-sectional regression to account for the non-zero beta rate. Panel B of Table 9 reports the test results, where I compare the IRV risk with intermediary equity capital ratio shocks. Consistent with He et al. (2017), the price of this factor is positive, albeit insignificant within the sample.[14] Importantly, I find that the price for global IRV risk is negative and significant, and the result is not driven by shocks to the intermediary equity capital ratio. Thus, the evidence supports the economic channel through which shocks to IRV affect the intermediary constraints.

Next, I investigate whether IRV directly affects financiers' risk-taking in terms of the FX carry and momentum. However, measuring financiers' arbitrage activity is challenging. I follow Brunnermeier et al. (2008) and Della Corte et al. (2016) and use futures position data from the Commodity Futures Trading Commission (CFTC). For each currency i and month t, I construct the variable $\text{NET\_DEMAND}_{i,t}$ which measures the trading activity of non-commercial traders (who trade FX for speculative reasons) as their month-t long minus short futures positions divided by their total open interest. The data range from Jan. 1986 to Jan. 2019 and cover 13 economies: Australia, Brazil, Canada, Euro, France, Germany, Japan, Mexico, New Zealand, Russia, South Africa, Switzerland, and the United Kingdom.

Two panel regressions are estimated for each currency strategy:

$$\text{(17)} \qquad \text{NET\_DEMAND}_{i,t+1} = a + b \times \text{SIGNAL}_{i,t} + \varepsilon_{i,t+1},$$

$$\text{(18)} \quad \text{NET\_DEMAND}_{i,t+1} = a + a_{\text{IRV}} u_{t+1}^{\text{IRV}} + \left(b + b_{\text{IRV}} u_{t+1}^{\text{IRV}}\right) \times \text{SIGNAL}_{i,t} + \varepsilon_{i,t+1},$$

where $\text{SIGNAL}_{i,t}$ refers to either a carry or momentum signal for currency i. The first equation tests the prediction from Propositions 2 and 3 that financiers' speculation of a currency increases with its interest rate difference or the past appreciation against the USD. The second equation tests the adverse impact of global IRV on financiers' risk-taking on carry and momentum. The theoretical model predicts $b > 0$ but $b_{\text{IRV}} < 0$.

I estimate the panel regression by adding the currency fixed effect. Table 10 reports the regression results with standard errors clustered by currency and time. Empirical estimates strongly support the theoretical predictions. Although the speculation by non-commercial traders increases with past carry or momentum signals, it is substantially reduced facing a higher risk of global IRV. I then investigate whether this impact is driven by the existing risk measures for intermediaries proposed in the literature by running a panel regression.

$$\text{(19)} \qquad \text{NET\_DEMAND}_{i,t+1} = a u_{t+1}^{\text{IRV}} + a_X u_{t+1}^{X} + \left(b + b_{\text{IRV}} u_{t+1}^{\text{IRV}} + b_X u_{t+1}^{X}\right) \times \text{SIGNAL}_{i,t} + \varepsilon_{i,t+1}.$$

[14]The results are significant if the analysis is based on their original sample from Jan. 1970 to Dec. 2012.

TABLE 10

Impact of IRV on Net Demand for FX Futures

Panels A and B of Table 10 report the estimation results of panel regressions (17) and (18), respectively. The signal is either the momentum (past 3-month currency appreciation against the USD) or the carry (past month interest rate difference against the USD). The interaction term is constructed by using shocks to IRV, VIX, global FX volatility, or the intermediary equity capital ratio. The panel regression is estimated by adding currency fixed effect. *t*-statistics are in parentheses and based on standard errors that cluster by both currency and time. The sample period is from Jan. 1986 to Jan. 2019.

	1	2	3	4	5
Panel A. Momentum					
$\text{MOM}_{i,t-1}$	1.02	1.03	1.06	1.04	1.01
	(3.22)	(3.55)	(3.84)	(3.46)	(3.55)
$u_t^{\text{IRV}} \times \text{MOM}_{i,t-1}$		−0.45	−0.44	−0.47	−0.47
		(−2.05)	(−2.30)	(−2.40)	(−2.10)
$u_t^{\text{VIX}} \times \text{MOM}_{i,t-1}$			0.10		
			(1.03)		
$u_t^{\text{FXVOL}} \times \text{MOM}_{i,t-1}$				0.09	
				(0.58)	
$(-u_t^{\text{HKM}}) \times \text{MOM}_{i,t-1}$					−0.05
					(−0.79)
Panel B. Carry					
$\text{CARRY}_{i,t-1}$	1.81	1.43	1.59	1.37	1.02
	(2.19)	(1.72)	(1.80)	(1.95)	(1.25)
$u_t^{\text{IRV}} \times \text{CARRY}_{i,t-1}$		−3.17	−3.12	−2.16	−3.20
		(−2.85)	(−2.60)	(−1.95)	(−2.58)
$u_t^{\text{VIX}} \times \text{CARRY}_{i,t-1}$			−0.99		
			(−2.29)		
$u_t^{\text{FXVOL}} \times \text{CARRY}_{i,t-1}$				−2.06	
				(−2.73)	
$(-u_t^{\text{HKM}}) \times \text{CARRY}_{i,t-1}$					−1.58
					(−2.54)

For the choice of X I include the VIX, global FX volatility, and the (minus) intermediary equity capital ratio from Brunnermeier et al. (2008), Menkhoff et al. (2012a), and He et al. (2017), where u_t^X denotes innovation to X. Results are displayed in Table 10. I find that, while alternative intermediary risk measures also negatively affect carry trade activity, their impact on trading momentum is mostly positive (except for the intermediary equity capital ratio). This is consistent with the fact that these measures fail to explain the cross section of momentum. Importantly, the effect of the global IRV risk is not driven by any of these risk measures.

V. Additional Implications and Robustness Checks

A. Momentum Everywhere and the Impact of Global IRV

The intermediary channel also sheds light on the commonality of momentum returns across different asset classes, another puzzling yet important characteristic of momentum (see, e.g., Asness et al. (2013)).[15] To understand how financial disruptions in the FX market can impact momentum in other asset markets, let me consider an internationally tradable asset class, such as U.S. equities. Recent foreign currency appreciation against the USD makes U.S. equities attractive to

[15]However, explanations for carry trade could differ substantially across different asset classes. Koijen, Moskowitz, Pedersen, and Vrugt (2018) document that crash risk theories, which serve as an explanation for currency carry return, cannot explain carry returns in other asset classes.

foreign investors.[16] Hence, the U.S. stock market experiences net inflows from foreign countries. These flows may chase recent high-performing U.S. stocks because of the return-chasing behavior of international investors (see, e.g., Bohn and Tesar (1996)), and contribute to the momentum effect in the U.S. stock market. Importantly, to make these investments, foreign investors would need to convert their currency to USD, resulting in an excess supply of foreign currency against the USD. According to Proposition 3, FX intermediaries can absorb this supply when they anticipate a further appreciation of the foreign currency. However, shocks to the global IRV would make them unwilling to do so, and it is more costly to obtain FX liquidity for international equity investors. Hence, a decrease in foreign demand for U.S. equities triggers a momentum loss in the U.S. stock market. Similar insights can be applied to other asset classes and I may observe the commonality of momentum returns.

Empirical test of the above mechanism can be challenging, given that capital flow data for many asset classes are not publicly available. Thus, I focus on testing whether the global IRV risk is negatively related to momentum returns in different asset markets.[17] Specifically, I consider seven asset classes (excluding FX) covered by Asness et al. (2013): the U.S. equities, U.K. equities, Europe equities, Japan equities, equity indices, fixed income, and commodities. I also consider the global momentum strategy returns in Asness et al. (2013), which is calculated as the cross-sectional weighted average of momentum returns across all asset classes.[18] For each momentum strategy return, I first run a time-series regression (3). Panel A of Table 11 shows that although momentum strategies earn positive returns in most markets, the slope coefficients of the global IRV risk are unambiguously negative, and many of them are statistically significant. In terms of economic magnitudes, for example, a one standard deviation change in the global IRV risk lowers monthly momentum returns in the commodity market by 6.24%. I then add the TED spread as a funding liquidity risk measure into the regression, following Asness et al. (2013). The results indicate that the impact of funding liquidity risk does not drive away the explanatory power of global IRV.

The performance in explaining momentum returns also distinguishes the global IRV from other uncertainty measures, such as FX or equity volatility. Menkhoff et al. (2012b) show that FX volatility risk cannot explain FX momentum, and Daniel and Moskowitz (2016) find that the equity volatility risk captured by the VIX cannot explain equity momentum returns. Panel B of Table 11 reports the coefficient estimates from the time-series regression of projecting momentum returns on innovations to global FX volatility or VIX. Nearly all momentum returns display an insignificant relationship with equity or FX volatility risk. Moreover, the relationship flips signs for many asset classes. The results clearly suggest that the pricing power of the global IRV is unrelated to other measures of uncertainty or risk

[16]Foreign investors' realized return from investing in the U.S. equity (denominated in foreign currency) is lower and expected return tends to be higher.

[17]Section C of the Supplementary Material provides flow-based evidence for the U.S. bond and equity markets by using the data from the Treasury International Capital (TIC). The results confirm that foreign currency appreciation against the USD will predict inflows to the U.S. bond and equity markets, yet such a relationship is adversely affected by the global IRV risk.

[18]The data are obtained from the website of AQR Capital.

TABLE 11

Momentum Everywhere and Global IRV Risk

Panel A of Table 11 reports the mean returns and t-statistics of momentum strategies in different asset classes, and the results of time-series regression (3) by projecting these momentum returns on the global IRV risk. As a control, I also include the funding liquidity risk proxied by the innovations to the TED spread following Asness et al. (2013). Panel B reports the results of projecting momentum returns on the innovations to either the VIX or the global FX volatility. All t-statistics are reported in the parentheses. The sample period is from Jan. 1985 to Jan. 2019.

	Panel A. Impact of IRV				*Panel B. Other Uncertainty*	
	r^{MOM}(%)	β_{IRV}(%)	β_{TED}(%)	β_{IRV}(%)	β_{VIX}(%)	β_{FXVOL}(%)
U.S. equities	3.60	−4.08	−3.01	−4.56	1.44	−0.48
	(1.35)	(−2.04)	(−1.22)	(−2.35)	(0.41)	(−0.19)
U.K. equities	7.80	−4.56	−4.68	−3.72	3.84	3.12
	(2.71)	(−2.41)	(−1.78)	(−1.74)	(0.93)	(0.87)
Europe equities	5.04	−0.96	−3.48	−0.60	7.44	2.16
	(1.96)	(−0.59)	(−1.76)	(−0.35)	(2.17)	(0.73)
Japan equities	1.68	−3.96	1.68	−4.56	6.36	6.48
	(0.47)	(−2.19)	(0.57)	(−1.92)	(1.76)	(1.50)
Equity indices	5.64	−5.16	−0.96	−6.24	−0.72	−0.24
	(3.13)	(−1.50)	(−0.50)	(−1.96)	(−0.17)	(−0.09)
Fixed income	−0.10	−0.12	−0.48	−0.72	−0.84	−1.08
	(−0.01)	(−0.03)	(−0.44)	(−0.65)	(−0.78)	(−1.01)
Commodities	8.28	−6.24	0.72	−7.44	−3.00	−5.28
	(2.61)	(−2.48)	(0.19)	(−2.53)	(−0.95)	(−1.74)
Global Mom	7.08	−6.48	−2.16	−6.02	−0.12	0.12
	(4.02)	(−4.51)	(−1.22)	(−3.81)	(−0.04)	(0.05)

aversion. Finally, I run a 2-stage cross-sectional asset pricing test over these momentum portfolios, where I consider a 2-factor model consisting of the market factor (CAPM) and global IRV risk. Table 12 reports portfolio returns, estimated CAPM and global IRV betas. The high-minus-low spreads in IRV betas are negative, and many of them are significant. The lower right corner of Table 12 displays the estimated price for global IRV risk by pooling 21 momentum portfolios. The risk price is negative and statistically significant with a large cross-sectional R^2.

B. Controlling for Alternative Risk Factors

To show that my findings are unrelated to existing explanations, I test whether the inclusion of other risk factors can attenuate the explanatory power of IRV risk by running an asset-pricing test with the dollar factor, global IRV risk, and innovations to one of the control variables. Based on the relevance of the economic channels, I consider three classes of control. The first class contains other measures of financial constraints or liquidity, such as the TED spread (Brunnermeier et al. (2008)), bond liquidity premia (Fontaine and Garcia (2012)), betting against the beta factor (Frazzini and Pedersen (2014)), intermediary's equity capital ratio (He et al. (2017)), and average currency bid–ask spread. The second class includes measures that capture different aspects of uncertainty. These include the VIX (Brunnermeier et al. (2008), global FX correlation (Mueller, Stathopoulos, and Vedolin (2017a), Economic Policy Uncertainty (Baker et al. (2016)), and factor-based estimates of U.S. macro-and financial uncertainty (Jurado, Ludvigson, and Ng (2015)). The third class includes currency risk factors proposed in the literature: U.S. consumption growth (Lustig and Verdelhan (2007), downside risk (Lettau et al. (2014)), global imbalance factor (Corte et al. (2016)), and the slope factors

TABLE 12

Pricing Momentum Returns Across Asset Classes

Table 12 reports the results of cross-sectional asset pricing test using the asset pricing model with the market factor and the global IRV risk. The test is done via the Fama–MacBeth regression, where I report the first-stage estimated betas for each asset class, and the second-stage estimated risk price by pooling 21 momentum portfolios together. I also report the cross-sectional OLS R^2, and the t-statistics that account for first-stage estimation error in betas are reported in parentheses. They are calculated by using the heteroskedastic and autocorrelation consistent standard errors based on Newey and West (1987) and with GMM adjustment (NW-GMM), or by using Shanken-adjusted standard errors following Shanken (1992) (Sh). The p-values of χ^2-test on the null hypothesis that the pricing errors are jointly zero are also reported. I impose zero intercept in the second-stage regression. The sample period is from Jan. 1985 to Jan. 2019.

	L	M	H	HML	L	M	H	HML
	U.S. Equities				U.K. Equities			
Return (%)	6.84	7.68	10.44	3.60	2.52	9.48	10.32	7.80
	(2.16)	(3.18)	(3.60)	(1.35)	(0.62)	(3.27)	(3.03)	(2.71)
CAPM beta	1.06	0.87	0.99	−0.07	0.99	0.73	0.78	−0.21
	(14.50)	(20.79)	(15.91)	(−1.29)	(15.29)	(20.21)	(18.55)	(−2.98)
IRV beta	4.44	−0.72	−0.48	−4.92	−0.36	−3.72	−7.20	−6.84
	(2.84)	(−1.18)	(−0.44)	(−2.01)	(−0.12)	(−1.42)	(−2.57)	(−2.71)
	Europe Equities				Japan Equities			
Return (%)	6.84	9.72	11.88	5.04	2.76	3.00	4.44	1.68
	(1.78)	(3.13)	(3.59)	(1.96)	(0.65)	(0.84)	(1.13)	(0.47)
CAPM beta	1.00	0.79	0.79	−0.21	0.61	0.53	0.49	−0.12
	(10.16)	(12.97)	(13.49)	(−2.44)	(10.72)	(11.80)	(9.31)	(−1.42)
IRV beta	−1.68	−2.28	−4.80	−3.12	6.84	1.44	1.56	−5.28
	(−0.55)	(−0.89)	(−1.88)	(−1.45)	(1.89)	(0.38)	(0.48)	(−2.58)
	Equity Indices				Fixed Income			
Return (%)	3.60	7.44	9.24	5.64	3.72	2.76	3.62	−0.10
	(1.16)	(2.59)	(3.05)	(3.13)	(3.79)	(2.84)	(3.64)	(−0.01)
CAPM beta	0.82	0.79	0.77	−0.05	−0.01	−0.01	−0.01	0.00
	(12.65)	(20.67)	(18.29)	(−0.75)	(0.23)	(0.02)	(0.56)	(0.44)
IRV beta	−3.60	−2.16	−9.24	−5.64	−0.22	−0.72	−0.12	0.10
	(−1.70)	(−1.40)	(−4.55)	(−1.72)	(−0.08)	(−0.64)	(−0.04)	(0.09)
	Commodities				Pricing Test with 21 Portfolios			
Return (%)	−0.48	1.08	7.80	8.28	Risk price			−0.53
	(−0.16)	(0.39)	(2.50)	(2.61)	(NW-GMM)			(−2.17)
CAPM beta	0.23	0.22	0.19	−0.04	(Sh)			(−2.39)
	(4.38)	(3.78)	(2.18)	(−0.87)	R^2			0.59
IRV beta	2.64	1.44	−4.08	−6.70	$\chi^2_{\text{NW-GMM}}$			[0.00]
	(1.08)	(0.75)	(−1.54)	(−2.52)	χ^2_{Sh}			[0.00]

(high-minus-low returns) from carry (Lustig et al. (2011)) and momentum portfolios (Menkhoff et al. (2012b)). Table 13 reports the results of the asset pricing test via the Fama–MacBeth regression, using both carry and momentum portfolios as testing assets. For comparison, I also display the outcomes from a model without the IRV risk. While these competing risk factors fail to jointly reconcile carry and momentum returns, as manifested by the low R^2, the explanatory power of the global IRV risk is unaffected after adding these controls. Moreover, despite the significant risk prices for some control variables, partly because of their success in explaining carry returns, the magnitudes of their risk prices decrease substantially after adding to the global IRV risk. Thus, the evidence eliminates the concern that information in the global IRV risk is subsumed by other risk factors.

C. Subsample Analysis

I assess the performance under a variety of subsamples over time and countries, the results of which are shown in Table 14. First, I examine the performance of

TABLE 13

Robustness: Pricing Power of IRV Risk Under Controls

Table 13 reports the results of asset pricing test on the joint cross-section of currency carry and momentum portfolios, by including other control variables in addition to the global IRV risk. Panel A contains the controls measuring the financial constraints or liquidity: TED spread of Brunnermeier et al. (2008) and Gabaix and Maggiori (2015), the bond liquidity factor of Fontaine and Garcia (2012), betting against the beta factor of Frazzini and Pedersen (2014), intermediary's equity capital ratio of He et al. (2017), and the average FX bid–ask spread. Panel B contains alternative measures of uncertainty, including the VIX, FX correlation of Mueller et al. (2017a), index of Economic Policy Uncertainty of Baker et al. (2016), factor-based estimates of macro and financial uncertainty of Jurado et al. (2015). Panel C contains the commonly used currency risk factors: U.S. consumption growth of Lustig and Verdelhan (2007), downside risk of Lettau et al. (2014), global imbalance factor of Corte et al. (2016), high-minus-low returns of carry portfolios in Lustig et al. (2011), high-minus-low returns of momentum portfolios in Menkhoff et al. (2012b). The test is done via Fama–MacBeth regression, where I report the estimated risk prices and cross-sectional OLS R^2. The *t*-statistics are based on standard errors calculated from asymptotic Newey–West standard errors from the cross-sectional regression (NW), the method that further adjusts for first-stage estimation error in betas via GMM (NW-GMM), or the asymptotic adjustment standard errors following Shanken (1992) (Sh). The *p*-values of χ^2-test on the null hypothesis that the pricing errors are jointly zero are also reported. The detailed sample period for each comparison, due to data availability of alternative factors, is listed in the Data Appendix in the Supplementary Material.

Panel A. Measures of Financial Constraints or Liquidity

	TED		Bond Liquidity		BAB		Equity Capital Ratio		FX Bid–Ask Spread	
λ_X	−1.60	0.21	−0.71	0.88	1.53	−0.66	0.78	1.05	−0.73	−0.18
(NW)	(−4.10)	(0.43)	(−1.45)	(2.05)	(2.83)	(−1.29)	(2.89)	(1.42)	(−1.89)	(−0.52)
(NW-GMM)	(−2.01)	(0.32)	(−0.98)	(1.14)	(0.89)	(−0.35)	(2.26)	(1.42)	(−1.46)	(−0.20)
(Sh)	(−2.16)	(0.27)	(−1.18)	(1.22)	(1.72)	(−0.89)	(2.29)	(0.78)	(−1.66)	(−0.35)
λ_{IRV}		−1.18		−0.77		−1.14		−1.16		−1.17
(NW)		(−4.54)		(−3.35)		(−4.22)		(−4.30)		(−4.12)
(NW-GMM)		(−2.77)		(−2.32)		(−2.42)		(−2.82)		(−2.47)
(Sh)		(−2.74)		(−2.08)		(−2.48)		(−2.42)		(−2.81)
R^2	0.41	0.92	0.08	0.91	0.15	0.95	0.31	0.95	0.14	0.92
χ^2_{NW}	[0.02]	[0.05]	[0.00]	[0.04]	[0.00]	[0.06]	[0.00]	[0.03]	[0.00]	[0.03]
$\chi^2_{NW\text{-}GMM}$	[0.04]	[0.21]	[0.00]	[0.16]	[0.00]	[0.26]	[0.03]	[0.17]	[0.01]	[0.14]
χ^2_{Sh}	[0.03]	[0.57]	[0.00]	[0.33]	[0.01]	[0.47]	[0.01]	[0.46]	[0.00]	[0.32]

Panel B. Measures of Uncertainty

	VIX		FX Corr		EPU		Macro Uncertainty		Financial Uncertainty	
λ_X	−0.96	−0.63	−0.82	0.25	−1.91	−0.83	−0.32	−0.25	−1.05	−0.49
(NW)	(−3.84)	(−2.86)	(−1.82)	(0.52)	(−3.41)	(−1.80)	(−0.74)	(−0.58)	(−2.84)	(−1.40)
(NW-GMM)	(−2.34)	(−1.90)	(−1.51)	(0.43)	(−2.22)	(−1.30)	(−0.66)	(−0.51)	(−2.13)	(−1.21)
(Sh)	(−2.74)	(−1.91)	(−1.41)	(0.33)	(−1.58)	(−1.11)	(−0.71)	(−0.38)	(−1.98)	(−0.91)
λ_{IRV}		−1.10		−1.19		−1.13		−1.17		−1.17
(NW)		(−4.78)		(−4.25)		(−4.35)		(−4.33)		(−4.33)
(NW-GMM)		(−2.57)		(−2.88)		(−2.58)		(−2.62)		(−2.63)
(Sh)		(−3.14)		(−2.70)		(−2.69)		(−2.79)		(−2.78)
R^2	0.44	0.91	0.09	0.93	0.51	0.96	0.04	0.92	0.28	0.92
χ^2_{NW}	[0.00]	[0.06]	[0.00]	[0.04]	[0.01]	[0.08]	[0.00]	[0.05]	[0.00]	[0.06]
$\chi^2_{NW\text{-}GMM}$	[0.04]	[0.23]	[0.00]	[0.14]	[0.05]	[0.28]	[0.00]	[0.20]	[0.02]	[0.23]
χ^2_{Sh}	[0.04]	[0.57]	[0.00]	[0.35]	[0.06]	[0.44]	[0.00]	[0.35]	[0.02]	[0.38]

Panel C. Currency Risk Factors

	Consumption Growth		Downside Risk		Imbalance		HML_{CARRY}		HML_{MOM}	
λ_X	−1.60	0.15	2.54	−0.78	0.37	0.21	0.24	0.25	0.22	0.20
(NW)	(−2.42)	(0.26)	(3.97)	(−1.15)	(2.85)	(1.62)	(4.80)	(5.00)	(4.40)	(4.00)
(NW-GMM)	(−1.66)	(0.21)	(2.50)	(−1.11)	(2.45)	(1.11)	(3.87)	(2.72)	(4.19)	(3.34)
(Sh)	(−1.28)	(0.16)	(2.38)	(−1.32)	(2.64)	(1.31)	(4.80)	(4.17)	(4.40)	(4.00)
λ_{IRV}		−1.17		−1.17		−0.88		−1.07		−1.22
(NW)		(−4.33)		(−4.88)		(−3.14)		(−3.69)		(−3.59)
(NW-GMM)		(−2.21)		(−2.45)		(−2.32)		(−2.65)		(−2.61)
(Sh)		(−2.79)		(−3.22)		(−2.44)		(−2.49)		(−2.26)
R^2	0.14	0.92	0.41	0.96	0.33	0.90	0.49	0.93	0.52	0.92
χ^2_{NW}	[0.00]	[0.05]	[0.00]	[0.07]	[0.00]	[0.05]	[0.00]	[0.02]	[0.00]	[0.02]
$\chi^2_{NW\text{-}GMM}$	[0.00]	[0.27]	[0.04]	[0.31]	[0.03]	[0.21]	[0.02]	[0.17]	[0.01]	[0.14]
χ^2_{Sh}	[0.00]	[0.45]	[0.04]	[0.59]	[0.03]	[0.55]	[0.00]	[0.40]	[0.00]	[0.35]

global IRV risk over two subsamples separated by the 2008 global financial crisis. The carry and momentum strategies are profitable in the pre-crisis sample with annualized excess returns of 10.07% and 9.39%, respectively. However, the performances of both strategies deteriorate substantially after the global financial

TABLE 14

Robustness: Subsample Analysis

Table 14 reports mean returns to carry and momentum strategies and their *t*-statistics, and results of asset pricing test under different subsamples for the joint cross section of carry and momentum portfolios. For the subsample that only includes 21 developed economies, all currencies are sorted into four groups and results are reported separately for carry and momentum strategies. The test is done via the Fama–MacBeth cross-sectional regression, where I report the estimated risk prices and cross-sectional OLS R^2. The *t*-statistics are based on standard errors calculated from asymptotic Newey–West standard errors from the cross-sectional regression (NW), the method that further adjusts for first-stage estimation error in betas via GMM (NW-GMM), or the asymptotic adjustment standard errors following Shanken (1992) (Sh). The *p*-values of χ^2-test on the null hypothesis that the pricing errors are jointly zero are also reported in brackets. The sample period is from Jan. 1985 to Jan. 2019.

	r^{CARRY} (%)	r^{MOM} (%)	λ_{DOL}	λ_{IRV}	R^2	χ^2_{NW}	$\chi^2_{\text{NW-GMM}}$	χ^2_{Sh}
Pre-crisis (Jan. 1985 to Dec. 2006)	10.07	9.39	0.24	−0.73	0.83	[0.02]	[0.19]	[0.22]
(NW)	(4.46)	(4.21)	(1.96)	(−3.23)				
(NW-GMM)			(1.78)	(−2.03)				
(Sh)			(1.96)	(−2.36)				
Post-crisis (Jan. 2007 to Jan. 2019)	6.58	2.87	−0.22	−1.30	0.65	[0.11]	[0.59]	[0.24]
(NW)	(2.25)	(1.07)	(−1.23)	(−2.98)				
(NW-GMM)			(−1.02)	(−2.05)				
(Sh)			(−1.23)	(−2.18)				
Developed economies (carry)	3.72		0.13	−0.55	0.82	[0.45]	[0.61]	[0.57]
(NW)	(2.07)		(1.08)	(−1.77)				
(NW-GMM)			(1.06)	(−1.43)				
(Sh)			(1.08)	(−1.57)				
Developed economies (momentum)		2.64	0.14	−0.32	0.62	[0.52]	[0.68]	[0.57]
(NW)		(1.38)	(1.17)	(−1.19)				
(NW-GMM)			(1.12)	(−1.05)				
(Sh)			(1.17)	(−1.10)				
Excl. periods of Asian financial crisis	9.60	6.96	0.12	−1.16	0.90	[0.01]	[0.14]	[0.38]
(NW)	(4.71)	(4.14)						
(NW-GMM)			(1.12)	(−3.14)				
(Sh)			(1.20)	(−3.05)				
Excl. periods of 08 global financial crisis	8.76	6.96	0.08	−1.00	0.87	[0.01]	[0.12]	[0.28]
(NW)	(4.06)	(3.87)						
(NW-GMM)			(0.77)	(−2.51)				
(Sh)			(0.73)	(−2.44)				
Excl. periods of Euro-debt crisis	8.88	7.68	0.08	−1.24	0.92	[0.02]	[0.15]	[0.48]
(NW)	(4.11)	(4.27)						
(NW-GMM)			(0.75)	(−3.13)				
(Sh)			(0.80)	(−2.82)				

crisis.[19] Importantly, I find that the explanatory power of the global IRV risk is similar in both subsamples, with the cross-sectional R^2 reaching 83% and 65%, respectively. The risk prices are also negative and statistically significant, and the null hypothesis of zero pricing errors cannot be rejected.

Existing studies typically find that momentum trade is unprofitable in developed countries (see, e.g., Karnaukh (2016), Filippou et al. (2018)). Thus, I study how pricing performance varies over carry and momentum returns by restricting the sample to 21 developed economies.[20] Although the profitability of the carry trade remains significant, the profit from the momentum strategy is insignificant. Conforming to this fact, the pricing power of the global IRV risk persists among carry portfolios, and the feeble momentum returns are naturally accompanied by a weaker price for the global IRV risk and smaller cross-sectional R^2.

[19]Table A3 in the Supplementary Material reports statistics of carry and momentum portfolios in both subsamples.

[20]The detailed classification is in Section B of the Supplementary Material.

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Finally, I construct different subsamples by excluding periods of extreme market events that may be important to the FX market, such as the 1997 Asian financial crisis, 2008 global financial crisis, and Euro debt crisis. The pricing power of global IRV risk is barely affected by these samples. Figure A.2 in the Supplementary Material plots the estimated IRV betas for all the subsamples above for both the carry and momentum portfolios. It is clear that these betas still decline almost monotonically within the cross section of the carry and momentum portfolios.

D. Additional Robustness Exercises

In the Supplementary Material, I report more results covering other aspects of robustness. First, I evaluate the asset pricing performance on the momentum portfolios formed over different window sizes, or formed by sorting on realized changes in log spot rates instead of excess returns. The latter exercise is an important check since Menkhoff et al. (2012b) show that there is a carry component within the momentum portfolios when sorting on excess returns instead of currency appreciations. Table A4 in the Supplementary Material shows that although the performance is slightly weaker for one-month momentum, with the joint cross-sectional R^2 now reducing to 75%, the main conclusions are largely unchanged: the high-minus-low beta spreads are significant and the global IRV risk carries significant and negative prices of risk.

Since the currency momentum may be tightly linked to the limits to arbitrage (e.g., Menkhoff et al. (2012b)), I test whether the role of IRV risk may be different for currencies with different limits to arbitrage. Following Filippou et al. (2018), at each month and for each currency, I compute the idiosyncratic volatility (idvol) and skewness (idskew) that serve as two measures for the limits to arbitrage. Then I run double sort by first forming two groups of currencies based on their idiosyncratic volatility or skewness, and within each group, I form three momentum portfolios. Table A5 in the Supplementary Material reports the IRV betas of these portfolios. Whereas the profitability of FX momentum is generally higher among the currencies with stronger limits to arbitrage, the high-minus-low spreads in IRV betas are significant across these two groups of momentum portfolios. Therefore, the main empirical findings in this article are unlikely driven by the limits to arbitrage.

VI. Conclusion

This study documents that the risk of global IRV explains cross-sectional variations in currency carry and momentum returns. I show that the return sensitivities of currency carry and momentum portfolios to global IRV shocks decrease almost monotonically from the bottom to the top portfolios. The high-minus-low beta spreads are negative and statistically significant. These risk exposures explain 88% and 98% of the cross-sectional variations in the mean returns of the carry and momentum portfolios, respectively. The results are similar when the BBD MPU index is used to measure the global IRV. The explanatory power remains significant under various settings and robustness checks, and is not driven by alternative measures of uncertainty, such as the global FX volatility, or financial constraint measures, such as the intermediary capital ratio.

The channel behind the new empirical evidence is the strong effect of the global IRV on FX intermediary constraints. An intermediary-based exchange rate model shows that a higher global IRV increases the uncertainty of intermediaries' future risk-taking and tightens their current financial constraints. Position unwinding triggers loss of carry and momentum. Empirically, I show that the global IRV risk is negatively correlated with, and can predict, the intermediary capital ratio of He et al. (2017). Furthermore, the intermediary capital ratio does not subsume its impact on currency return anomalies. The evidence from currency futures trading suggests that while the speculative activity of non-commercial FX traders increases with carry or momentum signal, the activity is adversely and significantly affected by the IRV risk. Finally, in line with the intermediary asset pricing literature, the global IRV risk is negatively and significantly priced among many other asset classes and different momentum strategies.

Supplementary material

To view supplementary material for this article, please visit http://doi.org/10.1017/S0022109023001485.

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