Foreign Exchange Order Flow as a Risk Factor

Craig Burnside, Mario Cerrato, and Zhekai Zhang

Supplemental Material

Estimates of the DOL-HMLC Model

In Table 1 we present the decomposed betas for the DOL-CM model that are referred to in Section IV.

Estimates of the DOL-HMLC Model

In Table 2 we estimate a model based on the DOL and HMLC factors proposed by Lustig et al. (2011). Qualitatively, the results are in line with what has been documented in the existing literature. The SDF parameter (b) for the HMLC factor is positive, although only statistically significant at around the 12% level. The associated risk price (λ) is positive and statistically significant at the 7% or 1% level depending on the procedure used to compute standard errors. For the DOL factor both parameters are positive, but neither is statistically significant.

The cross-sectional fit of the model is modest, with an $R^2 = 0.39$. The modest fit of the model can also be seen in Figure 1 which plots the model-predicted expected returns against the sample average returns of the ten test assets. While the model does quite well in fitting the carry portfolios (C1–C5), it does rather poorly in explaining the momentum portfolios (M1–M5). In fact, it predicts that the M5 portfolio should have a lower expected return than the M1 portfolio. This is not puzzling: As we saw above, the M1 portfolio has a much larger exposure to HMLC risk than the M5 portfolio does.

While the model passes the Hansen-Jagannathan specification test (p-value of 0.16), it is rejected based on the Fama-MacBeth specification test (p-value of 0.01). The KP test strongly rejects the null of reduced rank.

Estimates of the DOL-DVOL Model

Table 3 shows results for a model similar to the one used by Menkhoff et al. (2012), which includes DOL and DVOL as factors. Qualitatively, the results are in line with what has been documented in the existing literature. The SDF parameter and the risk price of DVOL are both negative, indicating that portfolios with greater exposure to higher volatility (i.e. lower returns when volatility increases) have higher mean returns. However, neither $\hat{b}_{\text{DVOL}}$ nor $\hat{\lambda}_{\text{DVOL}}$ is statistically significant at conventional significance levels, except when we use the Fama-MacBeth method.

The cross-sectional fit of the model is slightly better than that of the DOL-HMLC model, because the model fits the momentum portfolios somewhat better, and the carry portfolios almost as well. This is illustrated in Figure 2.

While the model passes the Hansen-Jagannathan specification test (p-value of 0.30), it is rejected based on the Fama-MacBeth specification test (p-value of 0.02). On the other hand, the KP test only rejects the null hypothesis of reduced rank at the 24% level. This may reflect the degree of imprecision with which the betas are estimated for the DVOL factor.

Additional Currency Portfolios

In this section we consider several currency portfolios in addition to the ones we used as test assets in the main text.

Carry Related Portfolios

- HMLC "High-Minus-Low Carry". Similar in spirit to the factor created by Lustig et al. (2011), and, as described in Section II.1, this is the return to being long portfolio C5 and short portfolio C1.

- HMLC-Alt. Similar to HMLC, this is the return to being long 50-50 in C4 and C5, and short 50-50 in C1 and C2.

- EWC "Equally-Weighted Carry". As in Burnside et al. (2011), if there are N_t currencies available at time t, this portfolio goes long $1/N_t$ in each of the currencies with a positive forward discount and short $1/N_t$ in each of the currencies with a negative forward discount.

- DNC "Dollar-Neutral Carry". As in Daniel et al. (2017), this is formed in the same way as EWC except that the portfolio is long those currencies whose forward discount exceeds the median value in that time period, and short those whose forward discount is below the median value in that time period. This is similar to HMLC-Alt but doesn't exclude the currencies in C3, and is less leveraged (the sum of the absolute portfolio weights is 1 not 2).

- DDC "Dynamic Dollar Carry". As in Daniel et al. (2017), this portfolio goes long $1/N_t$ in every foreign currency if the median forward discount is positive, and short $1/N_t$ in every foreign currency if the median forward discount is negative.

- EWD "Equally Weighted Dollar Carry". As in Lustig et al. (2014), this portfolio goes long $1/N_t$ in every foreign currency if the median forward discount is positive, and short $1/N_t$ in every foreign currency if the median forward discount is negative.

Momentum Related Portfolios

- HMLM "High-Minus-Low Momentum". This is the return to being long portfolio M5 and short portfolio M1.

- HMLM-Alt. This is the return to being long 50-50 in M4 and M5, and short 50-50 in M1 and M2.

- EWM "Equally-Weighted Momentum". If there are N_t currencies available at time t, this portfolio goes long $1/N_t$ in each of the currencies with positive momentum and short $1/N_t$ in each of the currencies with negative momentum.

Value Portfolios

- Following Asness et al. (2013), we form three "value" portfolios from the G9 currencies, based on the magnitude of the real exchange rate of each currency with respect to the USD, measured against a benchmark of 60 months prior. These portfolios are labeled V1, V2, and V3 and are arranged in order from undervalued to overvalued.

- The V1, V2, and V3 portfolios are based on real exchange rates measured with price indices. This is why they have to be benchmarked against historical values. An alternative is to form five portfolios based on the value of the Big Mac Index (BMI) in each country. The BMI measures the USD price of a Big Mac in different countries and therefore provides a real exchange rate (however narrowly defined) with a direct interpretation. This requires us to drop Slovakia from consideration as data for Slovakia's BMI are not available during our sample period. Our five portfolios, labeled B1, B2, ..., B5 are arranged in increasing order of BMI in the previous calendar year.
- HMLB "High-Minus-Low Big Mac". This is the return to being long portfolio B1 and short portfolio B5.
- HMLB-Alt. This is the return to being long 50-50 in B1 and B2, and short 50-50 in B4 and B5.

Currency Liquidity

- LIQ. As in Mancini et al. (2013) this portfolio is long in the two most illiquid and short in the two most liquid currencies, where liquidity is measured by the size of the big-ask spread.

We use the model estimated in Section V to compute the model-predicted expected return for each portfolio. This is formed as $\hat{\beta}_p \hat{\lambda}$ where $\hat{\beta}_p$ is the portfolio's 1×2 vector of betas with respect to our factors (DOL and CM) and $\hat{\lambda}$ is the 2×1 vector of estimated risk premia presented in Table 12. The model-predicted expected return is then compared to the sample average of the return on the portfolio.

References

Asness, C. S.; T. J. Moskowitz; and L. H. Pedersen. Value and Momentum Everywhere. *Journal of Finance*, 68 (2013), 929–985.

Burnside, C.; M. Eichenbaum; I. Kleshchelski; and S. Rebelo. Do Peso Problems Explain the Returns to the Carry Trade? *Review of Financial Studies*, 24 (2011), 853–891.

Daniel, K.; R. J. Hodrick; and Z. Lu. The carry trade: Risks and drawdowns. *Critical Finance Review*, 6 (2017), 1–62.

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

Lustig, H.; N. Roussanov; and A. Verdelhan. Countercyclical currency risk premia. *Journal of Financial Economics*, 111 (2014), 527–553.

Mancini, L.; A. Ranaldo; and J. Wrampelmeyer. Liquidity in the foreign exchange market: Measurement, commonality, and risk premiums. *Journal of Finance*, 68 (2013), 1805–1841.

Menkhoff, L.; L. Sarno; M. Schmeling; and A. Schrimpf. Carry trades and global foreign exchange volatility. *Journal of Finance*, 67 (2012), 681–718.

Table 1: Decomposed Betas for the DOL-CM Model

	(a) Currency Change				(b) Forward-Discount			
	α $\times 100$	β-DOL	β-CM	$\bar{R}^2$	α $\times 100$	β-DOL $\times 100$	β-CM $\times 100$	$\bar{R}^2$
C1	-0.01	0.60	-0.25	0.62	-0.03	0.03	-0.20	-0.003
	(0.02)	(0.04)	(0.10)		(0.00)	(0.09)	(0.41)	
C2	-0.01	0.94	0.09	0.82	0.00	0.05	0.03	-0.003
	(0.02)	(0.03)	(0.07)		(0.00)	(0.07)	(0.39)	
C3	-0.02	0.94	0.21	0.83	0.02	0.06	0.17	-0.002
	(0.02)	(0.03)	(0.08)		(0.00)	(0.08)	(0.44)	
C4	-0.06	1.16	0.28	0.77	0.06	0.04	0.20	-0.003
	(0.04)	(0.07)	(0.12)		(0.00)	(0.09)	(0.44)	
C5	-0.04	1.04	0.38	0.55	0.19	0.23	0.95	-0.001
	(0.06)	(0.09)	(0.20)		(0.01)	(0.26)	(1.28)	
M1	-0.09	0.98	-0.36	0.63	0.04	0.14	0.14	-0.003
	(0.04)	(0.07)	(0.15)		(0.01)	(0.28)	(1.08)	
M2	-0.01	1.00	0.13	0.78	0.03	0.03	0.74	-0.001
	(0.03)	(0.05)	(0.09)		(0.00)	(0.17)	(0.67)	
M3	-0.04	0.96	0.18	0.81	0.04	0.05	1.02	0.002
	(0.03)	(0.03)	(0.09)		(0.03)	(0.12)	(0.68)	
M4	0.00	0.89	0.34	0.76	0.05	0.02	0.00	-0.004
	(0.03)	(0.02)	(0.10)		(0.00)	(0.17)	(0.77)	
M5	0.03	0.80	0.64	0.57	0.11	0.31	-0.77	-0.002
	(0.04)	(0.05)	(0.16)		(0.01)	(0.35)	(1.57)	

Note: We present estimates of the time series regressions

$$w_{it} = \alpha_i + z_t'\beta_i + \epsilon_{it}, \qquad t = 1, \ldots, T,$$

where w_{it} is one of two component of r_{it}^e, the excess return of portfolio i at time t, and z_t is a vector of the two risk factors, DOL and CM. In part (a) w_{it} is the component of the excess return due to the changing values of the spot rates of the constituent currencies. In part (b) w_{it} is the component of the excess return due to the forward discounts of the constituent currencies. The portfolios are C1—C5 and M1—M5, described in the main text. Standard errors are reported in parentheses. We use weekly data, from the third week of January 2002 to the fourth week of March 2012.

Table 2: Estimates of the DOL-HMLC Model

GMM Estimates				
	DOL	HMLC	R^2	HJ
b	3.85	5.93	0.39	11.73
	(4.00)	(3.78)		[0.16]
λ	0.10	0.18		
	(0.06)	(0.10)		
Fama-MacBeth Estimates				
	DOL	HMLC	R^2	χ^2_{SH}
λ	0.10	0.18	0.39	19.26
	(0.06)	(0.07)		[0.01]
KP Rank Tests				
	Stat.	d.f.	p-value	
Rank(0)	273.6	20	0.00	
Rank(1)	206.0	9	[0.00]	

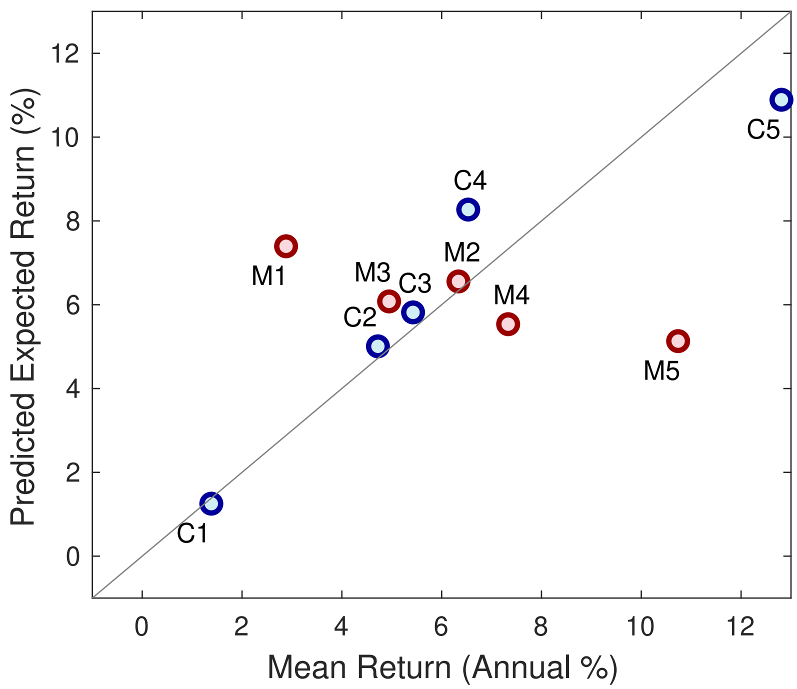
Note: We present estimates of the SDF and beta representations of the DOL-HMLC model, as well as KP reduced-rank tests. The test assets are C1 to C5, the five portfolios sorted on interest rate, and M1 to M5, the five portfolios sorted on momentum. The first panel shows the estimates of the SDF coefficients, b, from first stage GMM, corresponding risk prices, λ, the cross-sectional R^2 and Hansen-Jagannathan distance (HJ). Estimates of λ are scaled by 100. The second panel shows estimates of λ obtained using the Fama-MacBeth method with no intercept. A χ^2 measure of fit is also reported. The third panel reports KP rank tests. In all panels, standard errors are reported in parentheses, and p-values in square brackets. The Shanken correction is used for the Fama-MacBeth standard errors. We use weekly data, from the last week of November 2001 to the fourth week of March 2012.

Table 3: Estimates of the Volatility (DOL-DVOL) Model

GMM Estimates				
	DOL	DVOL	R^2	HJ
b	0.58	-0.98	0.50	9.54
	(5.31)	(0.90)		[0.30]
λ	0.10	-24.61		
	(0.11)	(22.47)		
Fama-MacBeth Estimates				
	DOL	DVOL	R^2	χ^2
λ	0.10	-24.61	0.50	18.67
	(0.06)	(10.25)		[0.02]
KP Rank Tests				
	Stat.	d.f.	p-value	
Rank(0)	375.4	20	0.00	
Rank(1)	11.6	9	[0.24]	

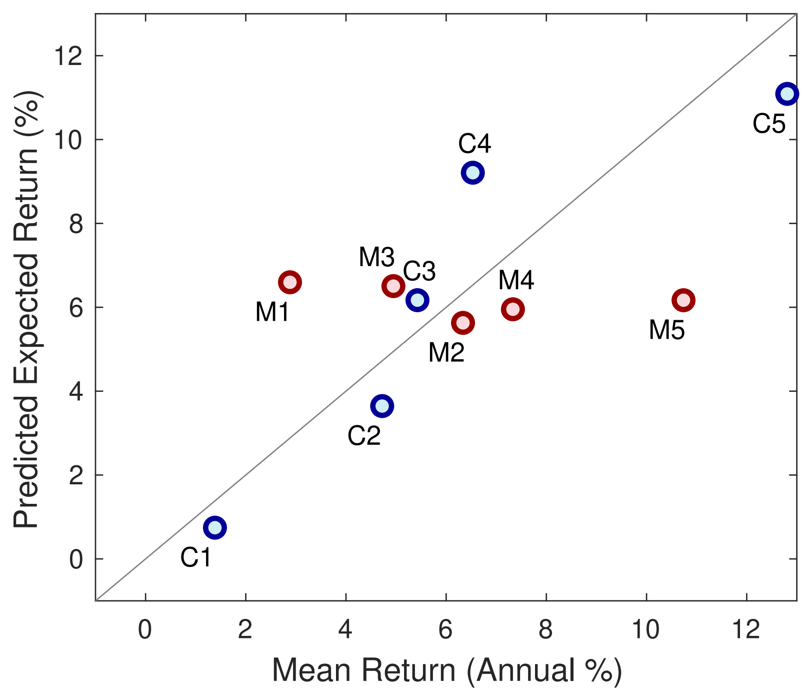
Note: We present SDF and beta representation estimates for the DOL-DVOL model, as well as KP reduced-rank tests. The test assets are C1 to C5, the five portfolios sorted on interest rate, and M1 to M5, the five portfolios sorted on momentum. The first panel shows the estimates of the SDF coefficients, b, from first stage GMM, corresponding risk prices, λ, the cross-sectional R^2 and Hansen-Jagannathan distance (HJ). Estimates of λ are scaled by 100. The second panel shows estimates of λ obtained using the Fama-MacBeth method with no intercept. A χ^2 measure of fit is also reported. The third panel reports KP rank tests. In all panels, standard errors are reported in parentheses, and p-values in square brackets. The Shanken correction is used for the Fama-MacBeth standard errors. We use weekly data, from the last week of November 2001 to the fourth week of March 2012.

Figure 1: Cross-Sectional Fit of the DOL-HMLC Model



Note: This figure illustrates the cross-sectional fit of the DOL-HMLC model (see Table 2). The model-predicted expected return is plotted against the mean annualized excess returns of the ten currency portfolios (C1–C5 in blue, and M1–M5 in red).

Figure 2: Cross-Sectional Fit of the DOL-DVOL Model



Note: This figure illustrates the cross-sectional fit of the DOL-DVOL model (see Table 3). The model-predicted expected return is plotted against the mean annualized excess returns of the ten currency portfolios (C1–C5 in blue, and M1–M5 in red).