Asymmetric Information Risk in FX Markets

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Motivation: Asymmetric Information Everywhere

Why Study Asymmetric Information in FX Trading?

- **Largest** financial **market** in the world ($6.6 trillion per day)
- OTC market, limited transparency, fragmentation and **heterogeneity** of market participants
- Recent **structural changes** including new regulations

Key Research Questions:

1. Is **asymmetric information** a deep-rooted issue in FX markets?
2. What is the **economic value** of **asymmetric information risk**?

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Contribution of This Paper

Heterogeneous Asymmetric Information

- Some agents in the **global FX market** are **systematically better informed** than others
- **Asymmetric information risk** is a deep-rooted issue across **market participants**, **time** and **currency pairs**

Asymmetric Information Premium

- A **new asset pricing factor** capturing the economic value of **asymmetric information risk** generates significant returns
- The **new** pricing factor is not subsumed by **existing risk factors** and withstands a battery of **robustness checks**

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Review of Related Literature

Market Microstructure:

- Glosten and Milgrom (1985) and Kyle (1985) on order flows conveying superior information across agents
- Bacchetta and van Wincoop (2006) and Evans and Lyons (2006) on asymmetric information in FX rate determination
- Hasbrouck (1988, 1991a,b) permanent price impact proxies asymmetric information
- Order flow impacts FX rates, e.g., Evans (2002), Payne (2003), Evans and Lyons (2008, 2012), Bjønnes and Rime (2005), Rime et al. (2010), Mancini et al. (2013)

FX Asset Pricing:

- Wang (1993, 1994), Easley et al. (2002), Gârleanu and Pedersen (2003) asset pricing with asymmetric information
- Lustig and Verdelhan (2007) first to build cross-sections of currency portfolios
- Lustig et al. (2011), Menkhoff et al. (2012, 2017), Aloosh and Bekaert (2017) currency factors and FX trading strategies based on excess returns
- Menkhoff et al. (2016), Gargano et al. (2018) order flow as dealers' "smart money" and the value of volume in FX markets

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Outline

Questions?

Dataset from CLS Group

FX Order Flow Data:

- **CLS** operates the world's largest multi-currency cash settlement system handling **50-60%** of global FX trading volume
- **Disaggregated hourly** FX **spot order flow**
- Customer groups include **price taker banks (BA)**, **corporates (CO)**, **funds (FD)**, **non-bank financial firms (NB)**, total **buy-side** (price takers) and **sell-side** (market makers)
- **Number of transactions** (trade count) and equivalent value in the **base currency** (trade volume)
- Unique dataset on high-frequency **disaggregated order flow** that has *not* been used for academic purposes before

Dataset Snapshot

Data Characteristics:

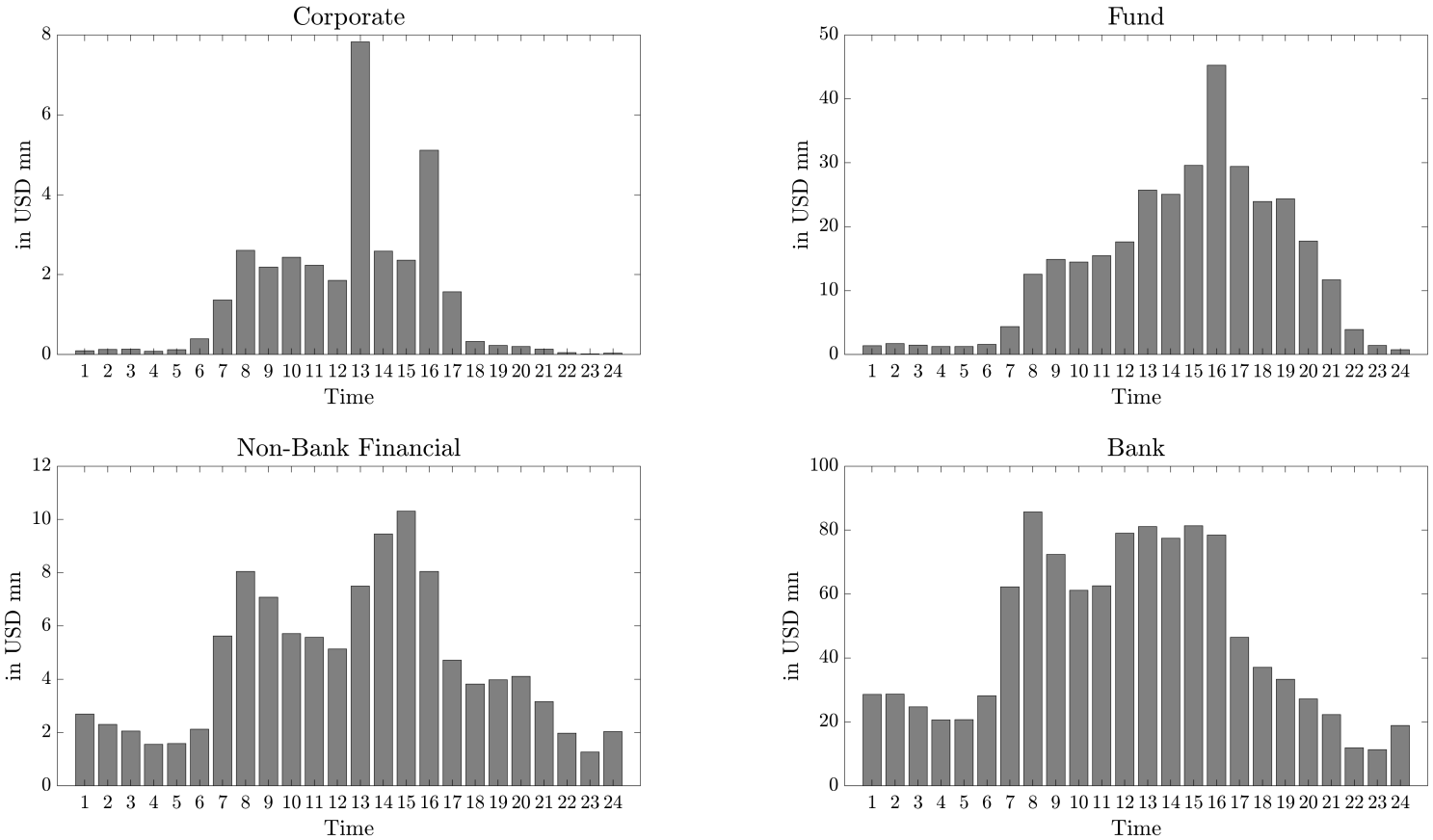
- **16 major currencies** and **30 currency pairs**: 15 USD-based, 9 EUR-based, 6 GBP-based, 3 AUD-based and the CADJPY.
- These **30 currency pairs** account for more than **90%** of the global **FX market turnover** (see BIS, 2019)
- FX spot quotes (bid, ask and mid) are retrieved from **Olsen**
- **Time-period**: Sep-2012 to Dec-2019
- Relative share of trading volume is in line with BIS (2019)
- Transactions between **two market-makers** or **two price-takers** are **excluded** from the dataset to avoid **double counting**

Sources of Asymmetric Information in FX Markets

What are the Origins of Asymmetric Information?

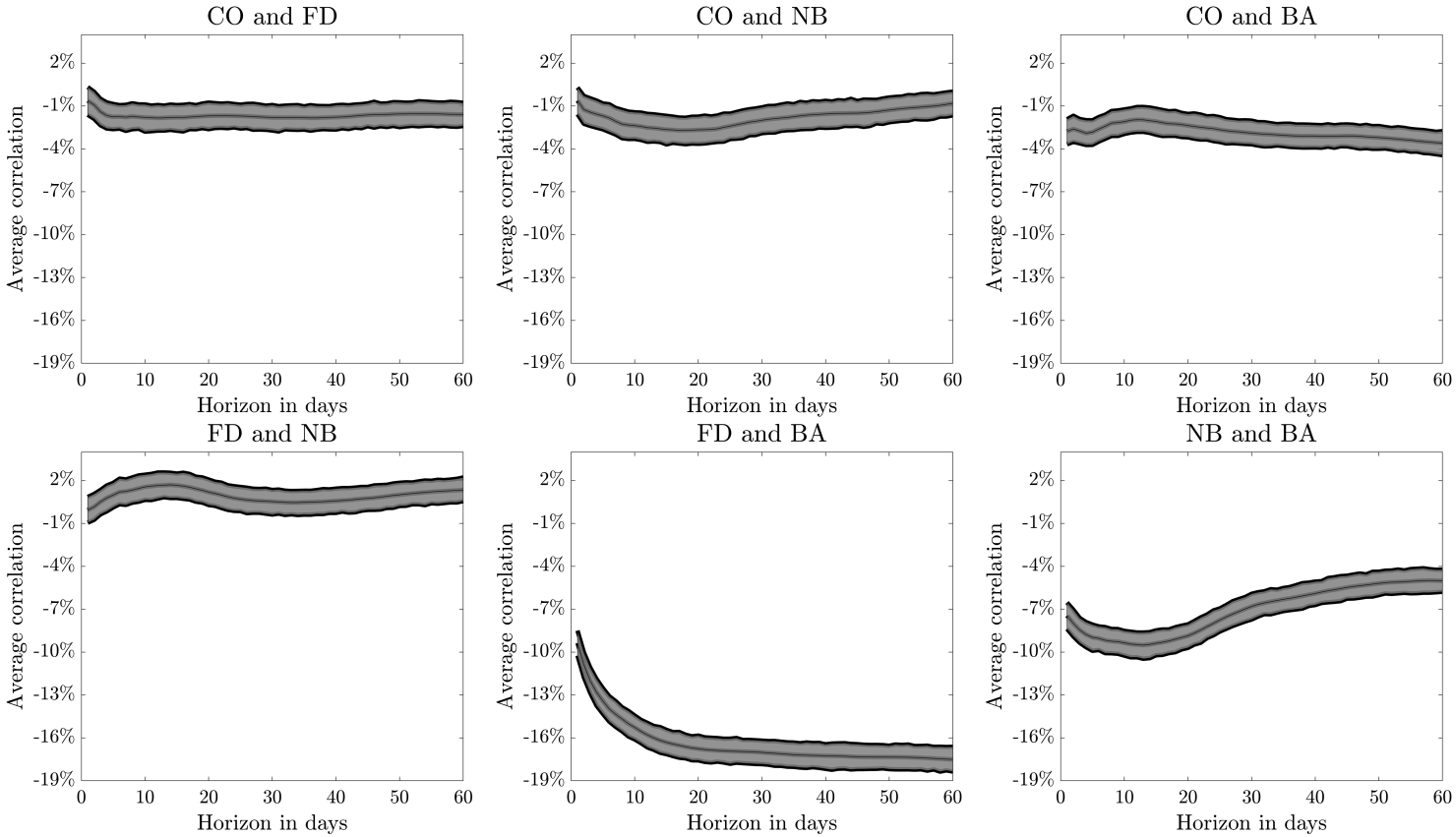
- **Decentralised** network (Babus and Kondor, 2018) and dealership (Liu and Wang, 2016) structure
- Individual investors have **private information** on **currency values** or **order flows** (Lyons, 1997, Evans and Lyons, 2006)
- Asymmetric information in **other asset classes** such as fixed income and equities (Hau and Rey, 2004)
- **Political uncertainty** (Pástor and Veronesi, 2013), **central bank decisions** (Mueller et al., 2017) or **monetary policy interventions** (Peiers, 1997)
- **Structural changes** (e.g. electronic and automated trading and settlement) exacerbate **market fragmentation** (BIS, 2018)

Figure 1: Distribution of Trading Volume Over a Day



Note: The average is computed across all trading days and currency pairs using the entire sample period. The numbers on the horizontal axis denote the closing time, e.g. the bar denoted 17 refers to volume between *4pm* and *5pm* (London time, GMT).

Figure 2: Correlation of Customer Order Flows Over Longer Horizons



Note: Correlations are based on the average correlation across all currency pairs. A one day horizon corresponds to non-overlapping hourly observations. For longer horizons we sum over daily (overlapping) observations. Shaded areas correspond to bootstrapped 95% confidence bands.

Methodological Approach

Estimate a **bivariate VAR** model that picks up order flow dependence of up to 10 lags:

$$r_t = \zeta_{1,I} D_{I,t} + \sum_{i=1}^{10} \rho_i r_{t-i} + \sum_{j \in C} \left(\sum_{i=0}^{10} \beta_i^j T_{t-i}^j + \sum_{i=0}^{10} \phi_i^j \tilde{S}_{t-i}^j \right) + \tag{1}$$
$$+ \eta_1 \Delta s_{t;t-\tau} + \eta_2 \Delta s_{t;t-5\tau} + \epsilon_{r,t},$$
$$T_t = \zeta_{2,I} D_{I,t} + \sum_{i=1}^{10} \gamma_i r_{t-i} + \sum_{j \in C} \left(\sum_{i=1}^{10} \delta_i^j T_{t-i}^j + \sum_{i=1}^{10} \omega_i^j \tilde{S}_{t-i}^j \right) + \tag{2}$$
$$+ \epsilon_{T,t},$$

where $C = \{CO, FD, NB, BA\}$. Eqs. (1) and (2) are based on Hasbrouck (1988, 1991a) and Hendershott et al. (2011) and **decompose** the price moves into **trade-related** and **trade-unrelated** components

Regression Results

- **Order flow** coefficients (β_i^j) are **positive** and in line with market microstructure theory
- For some currency pairs **corporates** experience a **negative** contemporary price impact
  - Consistent with earlier work by Bjønnes et al. (2005), Lyons (2006), Evans and Lyons (2012) and Menkhoff et al. (2016)
- Lagged **return coefficients** (ρ_i) are **negative**: short-term mean reversion
- The coefficients in the order flow equation bear the expected sign: **order flow continuation** (δ_i^j)

Measuring Asymmetric Information

- Following Hasbrouck (1988) and Payne (2003), the permanent price impact of agent j, in currency pair k, is equal to the **sum of** the **asymmetric information coefficients** in Eq. (1)

$$\alpha_m^{j,k} = \sum_{t=0}^{m} \beta_t^{j,k}, \tag{3}$$

  where $m = 10$ indicates the number of lags.

- The **average permanent price impact** across agents captures **systematic superior information**

$$\bar{\alpha}_m^k = \frac{1}{|C|} \sum_{j \in C} \sum_{t=0}^{m} \beta_t^{j,k} = \frac{1}{|C|} \sum_{j \in C} \alpha_m^{j,k}. \tag{4}$$

Heterogeneous Asymmetric Information

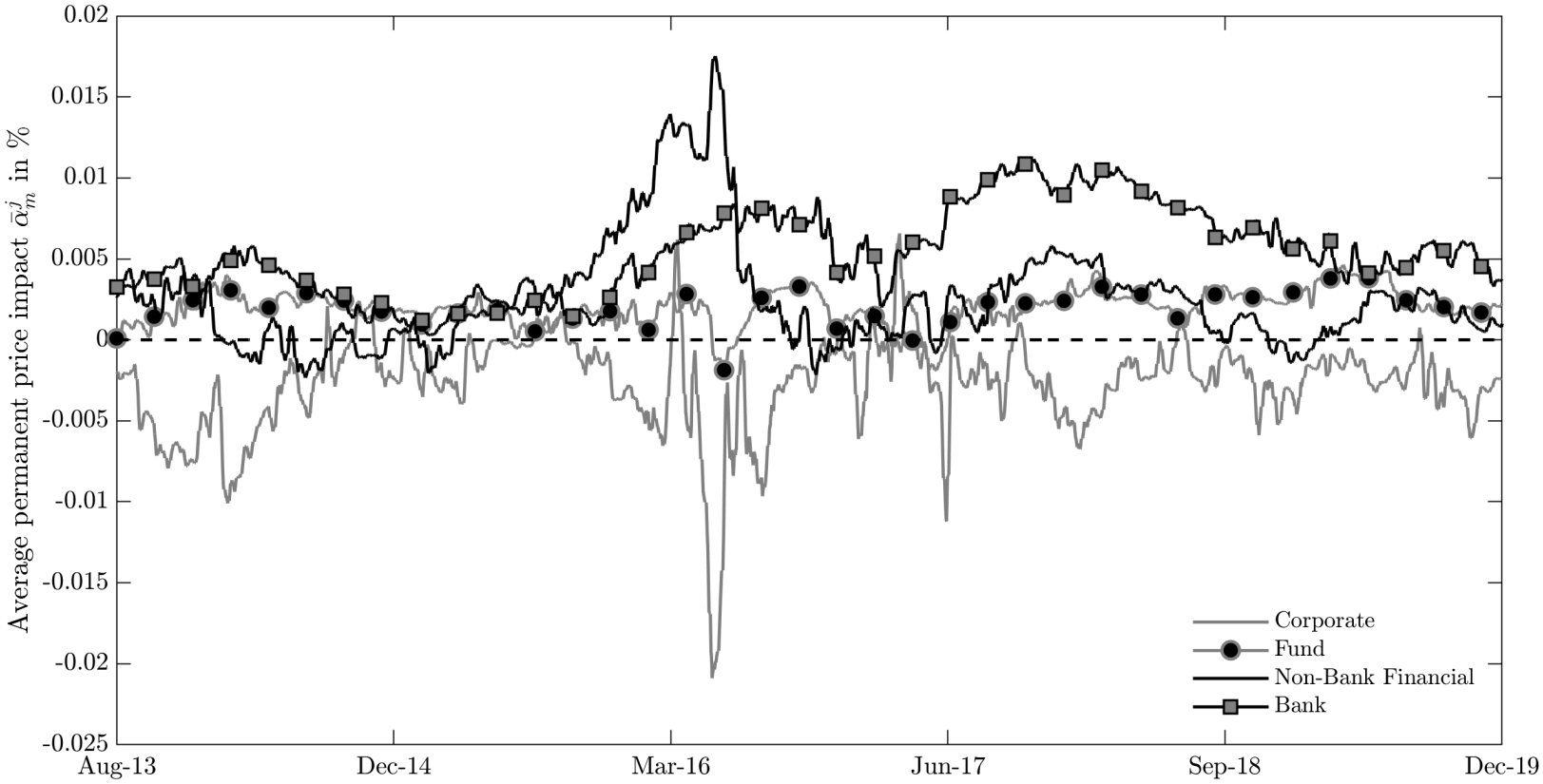
Permanent Price Impact Measures Asymmetric Information

1. Measures **adverse selection** and **asymmetric information risk**
2. Captures heterogeneity in **asymmetric** and **private information** on currency values (e.g. Evans and Lyons, 2006)
3. Accounts for the persistence in order flow and **feedback trading**

Strong Evidence of Asymmetric Information Dispersion

- **Traders**: banks and funds exhibit large permanent price impacts
- **Currencies**: market fragmentation
- **Time**: time variation based on rolling window estimation

Figure 3: Twelve Months Rolling Window Regression for $\bar{\alpha}_m^j$



Note: The cross-sectional five-day-moving-average permanent ($\bar{\alpha}_m^j$) price impact is calculated after removing any coefficients that are heavy outliers in terms of the median.

Questions?

Asymmetric Information Premium I

Intuition:

- **Asymmetric information hypothesis**: order flows of agents impounding a **persistent price impact** convey **superior information**
- Holding currencies with **higher informational asymmetries** requires a premium for taking the risk of **trading against informed investors**
- Empirically, currency pairs with a **large** (*small*) **permanent price impact** gain **positive** (*negative*) **excess returns**

Ingredients:

1. *Weighting*: **self-financing**, equally weighted long-short portfolio
2. *Rebalancing*: daily, weekly and **monthly**
3. *Transaction cost*: are implemented using quoted **bid and ask** rates

Asymmetric Information Premium II

4. *Signal Generation*:
   - Estimate Eq. (1) in a **twelve months** rolling window fashion at daily frequency based on **order flows** and **mid-quotes**
   - Extract the permanent price impact $\alpha_m^{j,k}$
   - **Sort** the systematic price impact $(\frac{1}{|C|}\sum_{j\in C}\alpha_m^{j,k})$ across currency pairs
   - Use yesterday's trading signals to create portfolio weights today
   - Form **tertile portfolios** and derive AIP_{HML} as $Q_3 - Q_1$
5. *Excess Returns*:
   - **Net** log excess return for going **long** in foreign currency X:

$$rx_{t+1}^{X/Y} = f_{t,t+1}^{USD/Y,b} - s_{t+1}^{USD/Y,a} - (f_{t,t+1}^{USD/X,a} - s_{t+1}^{USD/X,b}), \qquad (5)$$

   - f_t and s_t are both in units of the foreign currency per USD.

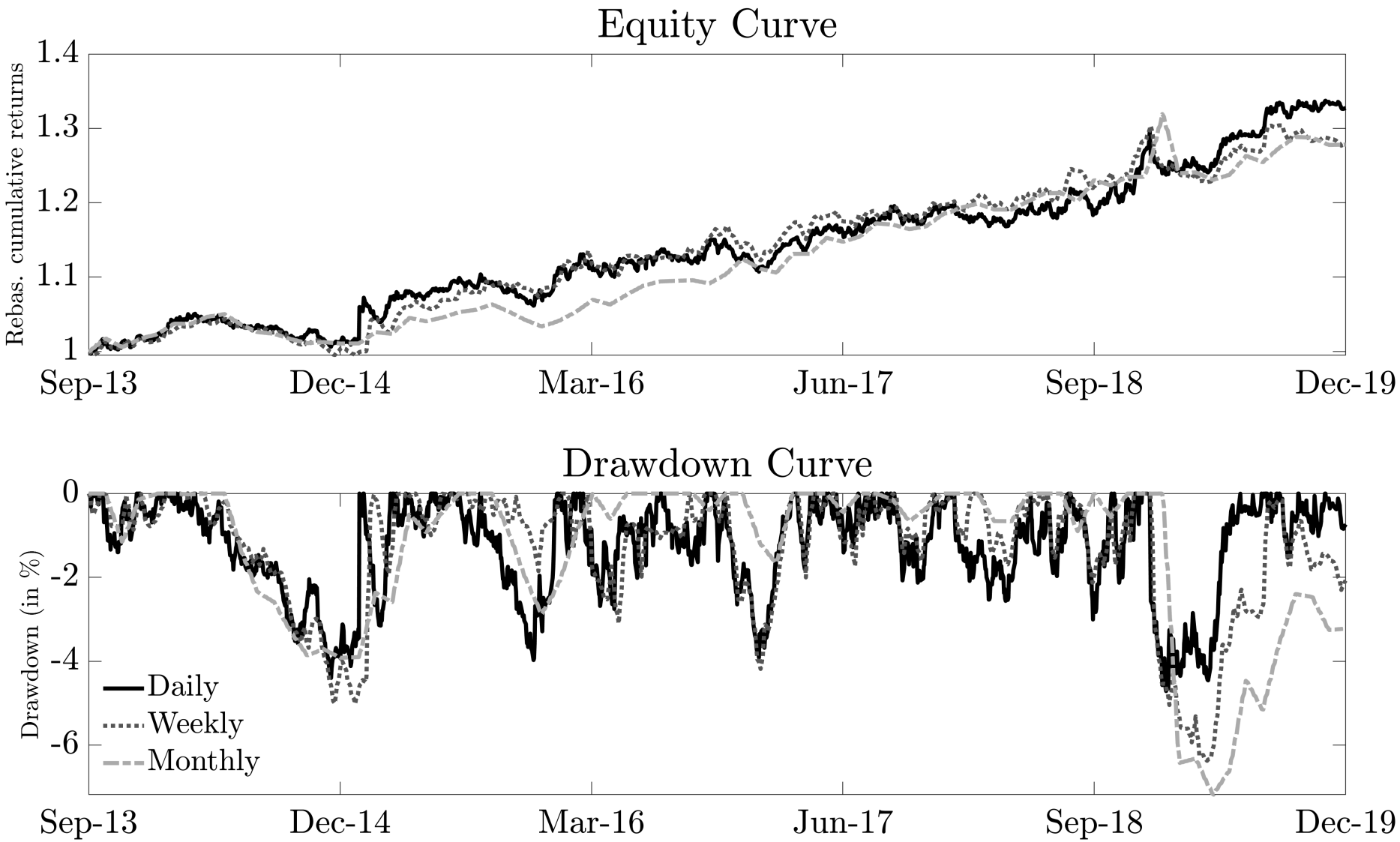
Trading Performance

*Table 1: Performance Benchmarking Based on Monthly **Gross** Excess Returns*

	DOL	RER_{HML}	RER	MOM_{HML}	CAR_{HML}	BMS	VOL_{LMH}	Q_1	Q_3	AIP_{HML}
SR	−0.11	−0.22	−0.22	−0.13	0.05	0.68	−0.54	*0.65	0.23	**0.83
	[0.33]	[0.53]	[0.58]	[0.32]	[0.16]	[1.49]	[1.25]	[1.84]	[0.59]	[2.35]
Mean in %	−0.33	−1.08	−0.71	−0.91	0.39	2.79	−3.20	**3.01	1.04	***4.05
	[0.33]	[0.52]	[0.58]	[0.31]	[0.16]	[1.48]	[1.24]	[1.97]	[0.58]	[3.01]
MDD in %	6.48	14.26	10.14	28.56	19.31	8.30	29.30	8.05	11.24	7.19
Scaled MDD	7.40	9.40	10.22	12.19	8.34	6.71	15.00	5.78	8.23	4.95
Θ in %	−0.41	−1.32	−0.81	−1.41	−0.14	2.62	−3.55	2.79	0.84	3.81
Skewness	0.56	0.12	−0.02	−0.30	−0.70	0.16	0.11	−0.10	0.69	0.15
Kurtosis-3	1.55	−0.40	0.16	0.88	0.81	−0.31	−0.10	1.66	1.17	9.45

Note: The t-stats are based on HAC errors. Stars (*/ **/ ***) denote significance at the 90%/ 95%/ 99% levels, respectively.

*Figure 4: Equity and Drawdown Curves **Prior** Transaction Cost*



Exposure Regression

*Table 2: Exposure Regression Based on Monthly **Gross** Excess Returns*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept (α) in %	***4.05	***4.22	**4.20	***4.14	**4.29	***4.39	**4.47	**4.11	***4.66
	[3.09]	[2.65]	[2.55]	[2.68]	[2.57]	[2.99]	[2.55]	[2.52]	[2.79]
DOL		−0.13	−0.13	0.03	−0.12	−0.08	−0.13	0.00	0.09
		[1.03]	[0.96]	[0.25]	[1.07]	[0.67]	[1.02]	[0.01]	[0.73]
RER_{HML}			−0.02						
			[0.15]						
RER				**−0.31					**−0.33
				[2.27]					[2.41]
MOM_{HML}					0.16				
					[1.28]				
CAR_{HML}						**−0.34			**−0.35
						[1.96]			[2.11]
BMS							−0.07		−0.10
							[0.50]		[0.81]
VOL_{LMH}								−0.15	
								[0.92]	
R^2 in %	N/A	12.97	12.99	19.35	15.46	22.47	13.41	13.50	29.90
IR	0.24	0.27	0.27	0.27	0.28	0.30	0.28	0.26	0.33
#Obs	75	75	75	75	75	75	75	75	75

Note: The intercept (α) has been annualised ($\times 12$). The t-stats are based on HAC errors and stars (*/ **/ ***) denote significance at the 90%/ 95%/ 99% levels, respectively. All results hold after controlling for relative changes in the VIX index, the North American credit default swap index (CDX), the TED spread as well as risk aversion (Bekaert et al., 2013).

Explaining the Asymmetric Information Premium

Table 3: Economic Drivers of AIP_{HML}

	(1)	(2)	(3)	(4)
Intercept (α)	***0.05	***0.05	**0.04	***0.05
	[2.86]	[2.95]	[2.48]	[2.84]
VIX	***0.01			
	[8.58]			
AAA Bond yields		*−0.01		
		[1.65]		
Top FX dealers			***−0.06	
			[10.42]	
CDX				***0.03
				[11.95]
MSCI return		***−0.12		
		[11.51]		
BGBI return	**0.06	**0.06	**0.06	***0.07
	[2.51]	[2.36]	[2.48]	[2.83]
R^2 in %	4.78	9.03	6.77	8.78
Adj. R^2 in %	4.66	8.86	6.65	8.61
#Obs	1564	1564	1564	1564
VIF	1.05	1.14	1.07	1.10

Note: This table shows results from multivariate regressions of daily gross AIP_{HML} returns on its potential drivers, $AIP_{HML,t} = \alpha + \beta' f_t + \epsilon_t$, where f_t denotes demand- and supply-side sources as well as a set of market conditions. The intercept (α) has been annualised ($\times 252$). *VIF* is the *maximum* variance inflation factor. The t-stats are based on HAC errors and stars (*/ **/ ***) denote significance at the 90%/ 95%/ 99% levels, respectively.

Robustness Checks

Rolling One-year Returns

- Performance is robust to the length of investment period
- Returns remain high after first dissemination of the working paper

Subsampling Currencies

- Balanced exposure across currencies and over time
- Results hold for various subsamples of currency pairs

Risk Aversion

- Similar results for restricting order flow to the main stock market trading hours (i.e. 7 *am* to 9 *pm* GMT, 'London hours')
- Robust to controlling for (time varying) risk aversion (Bekaert et al., 2013)

Rebalancing at Different Times

- Implement at different Bloomberg fixing times (i.e. 12 *am* to 8 *pm*)
- Evidence that strategy is profitable at any time of the day

Asymmetric Information Risk in FX Markets

Summary

- **Asymmetric information** is **systematically** present in the global FX market, where **some agents** are **always more informed** than others
- Empirical evidence of **asymmetric information risk** being deep-rooted across **market participants**, **time** and **currencies**
- A **new asymmetric information risk factor** generates significant returns and is not subsumed by existing FX risk factors

Questions?

Appendix I: Controlling for Order Size

$\tilde{S}_t$: order size variable to account for the positive relation between order size and price impact:

- Logarithms of the net volume (z_t) control for presumed non-linearities between order size and quote revisions:

$$v_t = \begin{cases} +log(z_t) & \text{if } z_t > 0 \\ 0 & \text{if } z_t = 0 \\ -log(-z_t) & \text{if } z_t < 0 \end{cases}. \tag{6}$$

- v_t is regressed against current and lagged values of T_t
- $\tilde{S}_t$ denotes the residuals of this regression (uncorrelated with T_t)

Appendix II: Notation and Assumptions

Notation:

- $D_{l,t}$: dummy variable matrix with $l = 24$ columns and $t = n$ rows to control for time of the day fixed effects
- $T_{k,t}$: buy-sell indicator for trade t in currency k ($+1$, buys; -1, sells)
- $r_{k,t}$: log-return in the mid-quote of currency pair k
- $\tilde{S}_{k,t}$: order size variable to account for the positive relation between order size and price impact (see Appendix 1)
- $\Delta s_{k,t;t-\tau}$, $\Delta s_{k,t;t-5\tau}$: return over previous day/ week where $\tau = 24$ and t is measured at hourly frequency

Assumptions:

- Since we include contemporaneous T_t in Eq. 1, the VAR is exactly identified and hence the error terms shall have zero mean and be jointly and serially uncorrelated:

$$\begin{aligned} &E(\epsilon_{T,t}) = E(\epsilon_{r,t}) = 0 \\ &E(\epsilon_{T,t}\epsilon_{T,s}) = E(\epsilon_{r,t}\epsilon_{r,s}) = E(\epsilon_{T,t}\epsilon_{r,s}) = 0, \text{ for } s \neq t \end{aligned} \tag{7}$$

Table 4: Summary Statistics for Hourly Spot Returns

in BPS	AUDJPY	AUDNZD	AUDUSD	CADJPY	EURAUD	EURCAD
Mean(Δ_r)	0.00	−0.04	−0.08	0.02	0.07	0.04
Std(Δ_r)	15.38	9.34	12.53	14.11	12.16	11.14
Avg. Spread	4.00	4.33	3.25	4.10	3.50	3.48
in BPS	EURCHF	EURDKK	EURGBP	EURJPY	EURNOK	EURSEK
Mean(Δ_r)	−0.02	0.00	0.02	0.06	0.07	0.06
Std(Δ_r)	9.96	0.52	10.60	12.69	10.47	8.57
Avg. Spread	2.71	2.61	3.24	3.10	6.00	5.30
in BPS	EURUSD	GBPAUD	GBPCAD	GBPCHF	GBPJPY	GBPUSD
Mean(Δ_r)	−0.02	0.05	0.03	−0.03	0.05	−0.03
Std(Δ_r)	10.26	12.87	11.95	13.76	14.98	11.18
Avg. Spread	2.27	4.16	3.96	4.15	3.79	2.66
in BPS	NZDUSD	USDCAD	USDCHF	USDDKK	USDHKD	USDILS
Mean(Δ_r)	−0.03	0.07	0.01	0.03	0.00	−0.03
Std(Δ_r)	13.71	9.64	12.72	10.25	0.84	9.54
Avg. Spread	3.95	2.62	3.11	2.88	1.69	24.72
in BPS	USDJPY	USDMXP	USDNOK	USDSEK	USDSGD	USDZAR
Mean(Δ_r)	0.08	0.09	0.10	0.09	0.02	0.14
Std(Δ_r)	11.46	15.41	13.79	12.65	6.26	20.41
Avg. Spread	2.51	5.82	6.85	6.00	3.47	11.11

Table 5: Summary Statistics for Hourly Absolute (Net) Volume

in USD mn	CO	FD	NB	BA	in USD mn	CO	FD	NB	BA
AUDJPY	0.04	1.01	1.32	14.66	GBPCHF	0.02	1.56	0.73	5.75
AUDNZD	0.00	0.89	1.35	12.82	GBPJPY	0.09	1.80	2.55	16.45
AUDUSD	0.89	27.15	9.90	87.93	GBPUSD	4.06	47.29	15.20	131.13
CADJPY	0.02	0.31	0.57	5.06	NZDUSD	0.04	8.89	3.46	34.26
EURAUD	0.09	2.85	2.09	16.36	USDCAD	1.19	32.93	12.32	182.73
EURCAD	1.01	2.34	1.74	12.64	USDCHF	1.57	12.47	9.82	64.51
EURCHF	0.88	7.85	4.04	35.13	USDDKK	0.69	3.53	0.14	7.71
EURDKK	0.20	4.48	0.54	17.85	USDHKD	0.10	12.99	1.14	42.39
EURGBP	3.33	17.44	4.21	47.27	USDILS	0.04	1.16	0.22	10.63
EURJPY	1.39	7.08	7.22	38.67	USDJPY	3.70	50.49	18.57	164.32
EURNOK	0.95	5.20	2.31	19.50	USDMXP	0.31	10.29	2.36	31.44
EURSEK	2.30	8.22	2.45	23.81	USDNOK	0.21	5.18	1.53	18.53
EURUSD	19.32	121.36	27.37	264.84	USDSEK	0.59	7.83	1.68	22.35
GBPAUD	0.02	1.52	1.14	7.67	USDSGD	0.25	5.85	1.24	35.01
GBPCAD	0.21	0.97	0.83	6.13	USDZAR	0.07	5.62	1.32	21.53

Table 6: Return Equation Coefficients

Eq. (1)	ρ_1	β_0^{CO}	β_0^{FD}	β_0^{NB}	β_0^{BA}	$\bar{R}^2$ in %	Eq. (1)	ρ_1	β_0^{CO}	β_0^{FD}	β_0^{NB}	β_0^{BA}	$\bar{R}^2$ in %
AUDJPY	***−8.597	−0.018	***0.009	***0.007	***0.014	9.517	GBPCHF	***−11.915	**−0.033	−0.002	***0.008	***−0.004	9.915
	[7.005]	[1.621]	[3.213]	[5.251]	[17.868]			[4.078]	[2.533]	[1.031]	[3.396]	[5.937]	
AUDNZD	***−11.602	−0.006	−0.002	***−0.003	***−0.002	8.588	GBPJPY	***−7.688	−0.008	**0.003	***0.004	***0.010	9.793
	[17.792]	[0.276]	[0.933]	[4.666]	[5.176]			[4.117]	[0.915]	[2.050]	[4.034]	[10.430]	
AUDUSD	***−8.202	***−0.013	***0.004	***0.010	***0.003	9.358	GBPUSD	***−6.598	***−0.014	***0.004	***0.007	***0.005	9.485
	[11.634]	[2.602]	[5.377]	[16.976]	[5.513]			[5.484]	[5.155]	[5.168]	[11.177]	[9.580]	
CADJPY	***−7.497	0.002	−0.001	0.002	***0.004	8.353	NZDUSD	***−9.579	**−0.039	***0.007	***0.006	***0.006	8.601
	[6.129]	[0.129]	[0.435]	[1.506]	[5.515]			[14.234]	[2.544]	[6.788]	[8.402]	[8.771]	
EURAUD	***−6.910	**−0.015	**0.002	**0.002	***0.003	8.280	USDCAD	***−8.680	***−0.024	***0.003	***0.004	***0.002	9.213
	[6.617]	[2.358]	[2.180]	[2.386]	[6.023]			[10.932]	[5.493]	[4.152]	[8.924]	[5.230]	
EURCAD	***−7.980	***−0.028	0.001	***0.005	***−0.002	8.883	USDCHF	***−12.859	***−0.012	**0.002	***0.010	**0.001	10.595
	[7.430]	[6.152]	[0.961]	[5.581]	[3.641]			[3.532]	[4.120]	[1.999]	[14.811]	[2.374]	
EURCHF	***−11.741	***−0.012	0.002	0.000	***−0.005	10.359	USDDKK	***−6.728	***−0.042	−0.001	***0.007	***−0.002	8.248
	[2.939]	[5.023]	[1.542]	[0.477]	[6.002]			[7.463]	[5.676]	[1.205]	[2.643]	[2.896]	
EURDKK	***−28.951	0.000	***0.000	0.000	***0.000	15.163	USDHKD	***−20.058	0.000	***0.000	0.000	***0.000	12.558
	[18.486]	[1.306]	[3.646]	[0.865]	[4.289]			[11.718]	[0.279]	[5.398]	[0.948]	[3.540]	
EURGBP	***−9.385	***−0.012	**0.002	***0.002	***−0.003	8.682	USDILS	***−21.784	−0.001	***0.003	***−0.010	***0.002	12.746
	[12.004]	[5.639]	[2.565]	[3.345]	[5.942]			[26.444]	[0.128]	[2.882]	[7.185]	[3.878]	
EURJPY	***−7.433	***−0.019	**−0.002	***0.004	**−0.001	8.816	USDJPY	***−7.362	***−0.006	***0.005	***0.008	***0.005	9.457
	[5.935]	[6.317]	[1.960]	[6.144]	[2.390]			[7.059]	[3.346]	[6.709]	[14.995]	[8.725]	
EURNOK	***−9.768	***−0.019	***0.008	0.002	***0.002	9.494	USDMXP	**−6.609	*−0.015	0.002	***−0.008	0.000	8.404
	[10.742]	[5.174]	[6.775]	[1.570]	[4.211]			[2.278]	[1.826]	[1.528]	[6.410]	[0.141]	
EURSEK	***−9.996	***−0.010	***0.004	**0.002	***0.002	8.549	USDNOK	***−9.614	***−0.034	***0.004	***0.005	***0.004	9.271
	[12.360]	[4.961]	[5.101]	[2.379]	[4.143]			[10.544]	[3.104]	[3.459]	[4.140]	[5.170]	
EURUSD	***−6.685	***−0.015	0.000	***0.006	−0.001	9.475	USDSEK	***−8.518	***−0.023	***0.004	***0.004	***0.003	8.471
	[7.261]	[12.389]	[0.337]	[11.522]	[1.342]			[10.176]	[4.560]	[4.353]	[3.637]	[5.206]	
GBPAUD	***−7.873	0.026	***0.004	0.001	***0.003	8.624	USDSGD	***−10.698	***−0.013	***0.002	***0.002	***−0.001	9.577
	[9.974]	[1.620]	[2.703]	[1.266]	[5.525]			[15.594]	[4.712]	[4.259]	[4.071]	[4.468]	
GBPCAD	***−9.137	**−0.035	0.001	**0.003	0.000	8.392	USDZAR	***−9.591	*−0.030	***0.006	0.003	***0.007	9.695
	[11.353]	[2.436]	[0.594]	[2.500]	[0.780]			[10.749]	[1.934]	[3.417]	[1.433]	[6.707]	
Expected sign	-	+	+	+	+		Expected sign	-	+	+	+	+	

Note: All coefficients are in %. Regression coefficients are estimated by OLS on the full sample. The t-stats are based on HAC errors and stars (*/ **/ ***) denote significance at the 90%/ 95%/ 99% levels, respectively.

Table 7: Order Flow Equation Coefficients

Eq. (2)	γ_1	δ_1^{CO}	δ_1^{FD}	δ_1^{NB}	δ_1^{BA}	$\bar{R}^2$ in %	Eq. (2)	γ_1	δ_1^{CO}	δ_1^{FD}	δ_1^{NB}	δ_1^{BA}	$\bar{R}^2$ in %
AUDJPY	***34.453	−0.014	***0.041	0.001	***0.061	1.672	GBPCHF	***−28.160	**0.145	0.001	0.006	***0.023	0.377
	[8.661]	[0.208]	[2.694]	[0.107]	[12.407]			[4.300]	[2.029]	[0.121]	[0.612]	[4.671]	
AUDNZD	***−35.226	0.124	0.009	0.001	***0.051	0.585	GBPJPY	***42.777	−0.001	***0.029	0.006	***0.054	1.389
	[6.714]	[0.690]	[0.490]	[0.216]	[10.712]			[6.283]	[0.024]	[2.679]	[0.891]	[10.653]	
AUDUSD	**−8.763	0.010	0.008	***0.020	***0.039	0.507	GBPUSD	**−10.448	0.018	0.008	0.005	***0.048	0.836
	[2.276]	[0.328]	[1.426]	[4.102]	[8.036]			[2.525]	[1.142]	[1.350]	[0.894]	[9.976]	
CADJPY	−2.469	0.036	0.007	0.008	***0.030	0.209	NZDUSD	***−15.227	−0.059	**0.015	0.004	***0.056	0.694
	[0.718]	[0.395]	[0.328]	[0.828]	[6.156]			[4.343]	[0.896]	[2.039]	[0.819]	[11.678]	
EURAUD	***−14.415	0.023	0.003	0.003	***0.022	0.226	USDCAD	1.868	0.005	0.009	0.003	***0.054	1.117
	[3.626]	[0.493]	[0.306]	[0.458]	[4.523]			[0.383]	[0.177]	[1.377]	[0.557]	[11.158]	
EURCAD	***−27.702	***0.146	−0.005	**0.018	***0.037	0.620	USDCHF	***−15.953	***0.076	***0.025	0.001	***0.041	0.551
	[6.512]	[4.850]	[0.578]	[2.464]	[7.529]			[3.741]	[3.205]	[3.730]	[0.161]	[8.454]	
EURCHF	*−41.130	***0.079	***0.028	0.004	***0.064	1.791	USDDKK	**−8.360	0.008	*0.014	0.004	***0.020	0.543
	[1.739]	[3.636]	[3.609]	[0.537]	[12.341]			[1.967]	[0.199]	[1.669]	[0.196]	[3.528]	
EURDKK	133.740	−0.036	***0.026	***0.082	***0.074	1.070	USDHKD	***−301.884	**0.232	**0.015	0.021	***0.058	0.749
	[1.578]	[0.946]	[2.641]	[2.812]	[13.460]			[4.764]	[2.228]	[2.461]	[1.215]	[11.823]	
EURGBP	***−37.084	**0.029	***0.022	−0.004	***0.045	1.035	USDILS	4.110	0.165	***0.028	0.007	***0.075	1.369
	[8.007]	[1.972]	[3.366]	[0.630]	[9.419]			[0.917]	[1.419]	[2.592]	[0.495]	[13.396]	
EURJPY	0.970	0.004	**0.018	***0.025	***0.039	0.993	USDJPY	−2.790	*0.023	***0.027	***0.016	***0.028	0.503
	[0.261]	[0.190]	[2.178]	[4.777]	[8.076]			[0.681]	[1.698]	[4.699]	[3.235]	[5.819]	
EURNOK	***−38.956	***0.053	***0.038	***0.034	***0.075	1.376	USDMXP	***−24.825	*0.067	0.007	**0.014	***0.048	0.530
	[7.544]	[2.836]	[4.524]	[4.492]	[15.042]			[6.273]	[1.884]	[0.917]	[2.115]	[9.791]	
EURSEK	***−44.468	***0.054	***0.035	***0.024	***0.081	1.392	USDNOK	***8.968	0.079	***0.021	0.005	***0.071	0.924
	[8.165]	[3.875]	[4.707]	[3.149]	[16.525]			[2.670]	[1.541]	[2.663]	[0.616]	[14.005]	
EURUSD	***−35.157	0.010	***0.030	0.001	***0.051	1.815	USDSEK	**−7.691	***0.090	***0.026	0.006	***0.048	0.557
	[7.576]	[1.179]	[5.421]	[0.270]	[10.439]			[2.080]	[3.351]	[3.648]	[0.822]	[9.833]	
GBPAUD	−5.831	−0.191	0.016	0.012	***0.022	0.128	USDSGD	***−73.324	−0.014	0.011	−0.005	***0.049	0.705
	[1.576]	[1.022]	[1.605]	[1.533]	[4.616]			[9.593]	[0.310]	[1.547]	[0.557]	[10.229]	
GBPCAD	***13.404	**0.224	0.008	***0.028	***0.034	0.258	USDZAR	***−16.545	0.032	***0.022	**−0.016	***0.050	0.679
	[3.102]	[2.123]	[0.739]	[3.211]	[6.852]			[6.707]	[0.785]	[2.828]	[2.171]	[10.238]	
Expected sign	-	+	+	+	+		Expected sign	-	+	+	+	+	

Note: The t-stats are based on HAC errors and stars (*/ **/ ***) denote significance at the 90%/ 95%/ 99% levels, respectively.

Table 8: Permanent Price Impact Across Agents - Joint F-test

in BPS	α_m^{CO}	α_m^{FD}	α_m^{NB}	α_m^{BA}	in BPS	α_m^{CO}	α_m^{FD}	α_m^{NB}	α_m^{BA}
AUDJPY	−5.467	1.003	***0.472	***1.755	GBPCHF	−1.312	0.861	*0.740	***0.236
	[1.216]	[1.889]	[4.114]	[31.727]		[1.268]	[1.130]	[2.305]	[4.686]
AUDNZD	**1.919	1.536	**−0.267	***0.465	GBPJPY	−0.066	0.795	***−0.659	***1.431
	[2.438]	[1.313]	[2.826]	[5.483]		[0.770]	[1.447]	[3.618]	[19.415]
AUDUSD	1.011	***0.500	***0.945	***0.848	GBPUSD	***−1.729	***0.515	***0.484	***1.630
	[1.482]	[3.545]	[26.899]	[3.765]		[3.262]	[3.379]	[12.913]	[12.300]
CADJPY	2.708	0.688	0.204	***−0.135	NZDUSD	−1.411	***0.749	***1.300	***0.931
	[0.575]	[0.640]	[0.979]	[4.805]		[1.926]	[4.378]	[8.118]	[7.616]
EURAUD	−1.868	0.577	−0.214	***0.711	USDCAD	***−2.228	***0.447	***0.356	***0.576
	[1.186]	[1.317]	[1.327]	[4.387]		[3.680]	[2.878]	[8.262]	[3.536]
EURCAD	***−0.867	0.555	***0.545	***0.425	USDCHF	***−1.054	0.686	***0.458	0.700
	[4.268]	[0.976]	[4.000]	[3.469]		[3.217]	[1.316]	[22.676]	[2.076]
EURCHF	***−0.541	0.004	−0.001	***0.084	USDDKK	***−2.216	0.113	0.635	−0.247
	[3.443]	[0.830]	[1.267]	[13.305]		[4.832]	[1.916]	[1.684]	[1.910]
EURDKK	0.068	**0.040	0.092	***0.015	USDHKD	−0.258	***0.036	0.028	***0.026
	[1.690]	[2.553]	[1.989]	[3.238]		[1.287]	[4.034]	[0.467]	[3.267]
EURGBP	***−0.726	0.346	***0.047	***0.691	USDILS	−0.015	0.905	***−1.310	0.507
	[3.795]	[1.334]	[3.458]	[7.808]		[1.224]	[1.997]	[5.934]	[1.905]
EURJPY	***−0.384	−0.682	***0.156	0.551	USDJPY	0.063	***0.513	***−0.135	***0.852
	[4.483]	[1.248]	[6.206]	[1.997]		[2.241]	[5.039]	[25.859]	[7.555]
EURNOK	***−1.756	***0.928	**0.149	***0.691	USDMXP	2.221	−0.073	***−0.567	0.856
	[3.167]	[6.124]	[2.512]	[3.562]		[1.001]	[0.991]	[5.490]	[1.915]
EURSEK	***−0.704	***1.130	0.538	**0.601	USDNOK	−0.981	*1.086	***0.920	***0.143
	[3.133]	[9.860]	[2.161]	[2.825]		[1.725]	[2.309]	[3.220]	[4.145]
EURUSD	***−1.096	0.507	***0.076	***0.977	USDSEK	*−2.378	***1.770	***1.123	***0.364
	[14.863]	[1.579]	[13.739]	[4.462]		[2.307]	[4.952]	[3.382]	[3.598]
GBPAUD	5.925	0.468	0.619	***1.341	USDSGD	***−0.600	**0.119	**0.302	***−0.078
	[1.059]	[1.215]	[1.750]	[5.328]		[3.193]	[2.829]	[2.838]	[3.049]
GBPCAD	*−0.119	0.702	1.436	0.427	USDZAR	−7.323	0.562	0.738	***3.494
	[2.397]	[1.110]	[1.563]	[0.747]		[0.890]	[1.346]	[1.840]	[11.147]

Note: The numbers in brackets correspond to the test statistic for a joint F-test that the parameters in Eq. (3) are jointly different from zero. Stars (*/ **/ ***) denote significance at the global 90%/ 95%/ 99% levels (α_g), respectively. For each individual test a Bonferroni correction is applied such that the local significance level is $\frac{\alpha_g}{m}$, where m is the number of multiple tests in the joint hypothesis. All regression coefficients are in BPS.

Table 9: Heterogeneous Permanent Price Impact Across Agents

	CO	FD	NB	CO	FD	NB	CO	FD	NB	CO	FD	NB	CO	FD	NB
FD	***0.00	-	**AUDJPY**	***0.00	-	**AUDNZD**	***0.00	-	**AUDUSD**	***0.00	-	**CADJPY**	***0.00	-	**EURAUD**
NB	***0.00	***0.00	-	***0.00	***0.00	-	***0.00	***0.00	-	***0.00	0.03	-	***0.00	0.04	-
BA	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	0.09	***0.00	***0.00	***0.00	***0.00	***0.00	0.07	***0.00
FD	***0.00	-	**EURCAD**	***0.00	-	**EURCHF**	***0.00	-	**EURDKK**	***0.00	-	**EURGBP**	***0.00	-	**EURJPY**
NB	***0.00	***0.00	-	***0.00	0.01	-	***0.00	***0.00	-	***0.00	**0.00	-	***0.00	***0.00	-
BA	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	*0.00	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00
FD	***0.00	-	**EURNOK**	***0.00	-	**EURSEK**	***0.00	-	**EURUSD**	***0.00	-	**GBPAUD**	***0.00	-	**GBPCAD**
NB	***0.00	***0.00	-	***0.00	***0.00	-	***0.00	***0.00	-	***0.00	0.04	-	***0.00	0.02	-
BA	***0.00	***0.00	***0.00	***0.00	***0.00	0.01	***0.00	**0.00	***0.00	***0.00	0.01	***0.00	***0.00	0.01	**0.00
FD	***0.00	-	**GBPCHF**	***0.00	-	**GBPJPY**	***0.00	-	**GBPUSD**	***0.00	-	**NZDUSD**	***0.00	-	**USDCAD**
NB	***0.00	***0.00	-	***0.00	***0.00	-	***0.00	***0.00	-	***0.00	0.12	-	***0.00	***0.00	-
BA	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	0.44	0.37	***0.00	**0.00	***0.00
FD	***0.00	-	**USDCHF**	***0.00	-	**USDDKK**	***0.00	-	**USDHKD**	***0.00	-	**USDILS**	***0.00	-	**USDJPY**
NB	***0.00	***0.00	-	***0.00	***0.00	-	***0.00	***0.00	-	***0.00	***0.00	-	***0.00	***0.00	-
BA	***0.00	0.18	***0.00	***0.00	0.07	***0.00	***0.00	***0.00	***0.00	***0.00	0.04	***0.00	***0.00	0.22	***0.00
FD	***0.00	-	**USDMXP**	***0.00	-	**USDNOK**	***0.00	-	**USDSEK**	***0.00	-	**USDSGD**	***0.00	-	**USDZAR**
NB	***0.00	***0.00	-	***0.00	0.03	-	***0.00	***0.00	-	***0.00	0.02	-	***0.00	0.03	-
BA	***0.00	***0.00	***0.00	***0.00	0.00	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00

Note: The numbers correspond to p-values associated with the test statistic of a joint pairwise F-test: $F = (R^i\hat{\theta}^k_Q - R^j\hat{\theta}^k_Q)^\top [R^i(\hat{V}_Q/Q)(R^i)^\top]^{-1}(R^i\hat{\theta}^k_Q - R^j\hat{\theta}^k_Q)$, where $\hat{\theta}^k$ is a vector of parameter estimates with $||R^i\hat{\theta}^k||_1 = \sum_{l=0}^{10} |\hat{\beta}^{i,k}_l|$ and $||R^j\hat{\theta}^k||_1 = \sum_{l=0}^{10} |\hat{\beta}^{j,k}_l|$. F converges to a χ^2_Q distribution. R^i and R^j are $Q \times L$ matrices, where Q is the number of hypotheses being tested and L the number of coefficients. Let $\hat{V}_Q$ be an estimator of the covariance matrix. For each pairwise test, $i \neq j$ and $k \in$ [currency pairs] must hold. Asterisks *, ** and *** denote significance at the global 90%, 95% and 99% levels (α_g), respectively.

Table 10: Heterogeneous Permanent Price Impact Across Currency Pairs - CO & FD

CO	AUDJPY	AUDNZD	EURCHF	EURGBP	EURNOK	EURUSD	GBPCHF	GBPUSD	USDCHF
AUDNZD	***0.00								
EURCHF	***0.00	***0.00							
EURGBP	***0.00	***0.00	0.38						
EURNOK	***0.00	***0.00	0.07	0.53					
EURUSD	***0.00	***0.00	0.00	0.27	0.09				
GBPCHF	0.02	***0.00	***0.00	***0.00	***0.00	***0.00			
GBPUSD	***0.00	***0.00	0.02	0.07	0.17	0.00	***0.00		
USDCHF	***0.00	***0.00	**0.00	***0.00	***0.00	***0.00	***0.00	***0.00	
USDSEK	***0.00	***0.00	0.00	0.00	0.86	***0.00	*0.00	0.13	***0.00
FD	AUDJPY	AUDNZD	EURCHF	EURGBP	EURNOK	EURUSD	GBPCHF	GBPUSD	USDCHF
AUDNZD	***0.00								
EURCHF	***0.00	***0.00							
EURGBP	***0.00	***0.00	0.05						
EURNOK	**0.00	***0.00	***0.00	***0.00					
EURUSD	***0.00	***0.00	0.00	0.04	***0.00				
GBPCHF	***0.00	0.00	***0.00	***0.00	***0.00	***0.00			
GBPUSD	***0.00	***0.00	*0.00	0.01	***0.00	***0.00	***0.00		
USDCHF	***0.00	***0.00	0.02	0.25	***0.00	0.27	**0.00	0.01	
USDSEK	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	**0.00

Note: The numbers correspond to p-values associated with the test statistic of a joint pairwise F-test: $F = R^i\hat{\theta}^k_Q - R^i\hat{\theta}^q_Q)^\top [R^i(\hat{V}_Q/Q)(R^i)^\top]^{-1}(R^i\hat{\theta}^k_Q - R^i\hat{\theta}^q_Q)$, where $\hat{\theta}^k$ and $\hat{\theta}^q$ are vectors of parameter estimates with $||R^i\hat{\theta}^k||_1 = \sum_{l=0}^{10} |\hat{\beta}^{i,k}_l|$ and $||R^i\hat{\theta}^q||_1 = \sum_{l=0}^{10} |\hat{\beta}^{i,q}_l|$. F converges to a χ^2_Q distribution. R^i is a $Q \times L$ matrix, where Q is the number of hypotheses being tested and L the number of coefficients. Let $\hat{V}_Q$ be an estimator of the covariance matrix. For each test, $k \neq q$ and $k \in$ [currency pairs] must hold. Asterisks *, ** and *** denote significance at the global 90%, 95% and 99% levels (α_g), respectively.

Table 11: Heterogeneous Permanent Price Impact Across Currency Pairs - NB & BA

NB	AUDJPY	AUDNZD	EURCHF	EURGBP	EURNOK	EURUSD	GBPCHF	GBPUSD	USDCHF
AUDNZD	***0.00								
EURCHF	***0.00	0.00							
EURGBP	***0.00	***0.00	***0.00						
EURNOK	0.00	***0.00	***0.00	0.01					
EURUSD	***0.00	***0.00	***0.00	***0.00	***0.00				
GBPCHF	0.21	***0.00	***0.00	***0.00	***0.00	***0.00			
GBPUSD	0.00	***0.00	***0.00	***0.00	***0.00	0.09	0.01		
USDCHF	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	*0.00	***0.00	
USDSEK	0.00	***0.00	***0.00	*0.00	0.00	***0.00	0.00	***0.00	***0.00
BA	AUDJPY	AUDNZD	EURCHF	EURGBP	EURNOK	EURUSD	GBPCHF	GBPUSD	USDCHF
AUDNZD	***0.00								
EURCHF	***0.00	*0.00							
EURGBP	***0.00	0.08	0.00						
EURNOK	***0.00	***0.00	***0.00	***0.00					
EURUSD	***0.00	**0.00	***0.00	***0.00	***0.00				
GBPCHF	***0.00	0.01	0.04	0.01	***0.00	***0.00			
GBPUSD	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00		
USDCHF	***0.00	***0.00	***0.00	***0.00	0.09	**0.00	***0.00	***0.00	
USDSEK	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00	***0.00

Note: The numbers correspond to p-values associated with the test statistic of a joint pairwise F-test: $F = R^i\hat{\theta}^k_Q - R^i\hat{\theta}^q_Q)^\top [R^i(\hat{V}_Q/Q)(R^i)^\top]^{-1}(R^i\hat{\theta}^k_Q - R^i\hat{\theta}^q_Q)$, where $\hat{\theta}^k$ and $\hat{\theta}^q$ are vectors of parameter estimates with $||R^i\hat{\theta}^k||_1 = \sum_{l=0}^{10} |\hat{\beta}^{i,k}_l|$ and $||R^i\hat{\theta}^q||_1 = \sum_{l=0}^{10} |\hat{\beta}^{i,q}_l|$. F converges to a χ^2_Q distribution. R^i is a $Q \times L$ matrix, where Q is the number of hypotheses being tested and L the number of coefficients. Let $\hat{V}_Q$ be an estimator of the covariance matrix. For each test, $k \neq q$ and $k \in$ [currency pairs] must hold. Asterisks *, ** and *** denote significance at the global 90%, 95% and 99% levels (α_g), respectively.

Appendix III: Diagnostic Tests

Table 12: Diagnostic Tests

Test	H_0	Return Equation	Order Flow Equation
Ljung-Box	Independent distribution	✓	✗
Durbin-Watson	No First Order Autocorrelation	✗	✗
White	Homoscedasticity	✓	✗
Kwiatkowski-Phillips-Schmidt-Shin	(Covariance) Stationarity	✗	✗
Dickey-Fuller	Unit root	✓	✓

Note: For all tests we apply a significance level of 5%, except for the Durbin-Watson (DW) test, where the difference between the DW test statistic and its critical value 2 is ≤ 0.001 for the entire cross-section. Check/Cross-marks are based on applicability to at least 85% of all currency pairs. A check-mark indicates that the null hypothesis (H_0) is rejected.

Appendix IV: Trading Performance

Table 13: Performance Benchmarking Based on Monthly ***Net*** *Excess Returns*

	DOL	RER_{HML}	RER	MOM_{HML}	CAR_{HML}	BMS	VOL_{LMH}	Q_1	Q_3	AIP_{HML}
SR	−0.24	−0.38	−0.38	−0.24	−0.07	0.47	−0.69	0.55	0.13	**0.65
	[0.69]	[0.91]	[1.02]	[0.61]	[0.19]	[1.04]	[1.59]	[1.59]	[0.33]	[1.96]
Mean in %	−0.70	−1.88	−1.24	−1.74	−0.48	1.95	−4.10	*2.57	0.59	**3.16
	[0.70]	[0.92]	[1.02]	[0.60]	[0.19]	[1.03]	[1.58]	[1.69]	[0.33]	[2.35]
MDD in %	7.67	17.51	12.01	31.57	21.24	10.19	35.65	8.58	12.35	7.57
Scaled MDD	8.71	11.38	12.03	13.29	9.07	8.20	17.83	6.13	9.01	5.18
Θ in %	−0.78	−2.12	−1.34	−2.24	−1.01	1.78	−4.45	2.36	0.39	2.92
Skewness	0.56	0.10	−0.03	−0.31	−0.70	0.14	0.09	−0.13	0.68	0.10
Kurtosis-3	1.53	−0.38	0.16	0.91	0.81	−0.34	−0.10	1.71	1.15	9.46

Note: The t-stats are based on HAC errors. Stars (*/ **/ ***) denote significance at the 90%/ 95%/ 99% levels, respectively.

*Figure 5: Equity and Drawdown Curves **After** Transaction Cost*

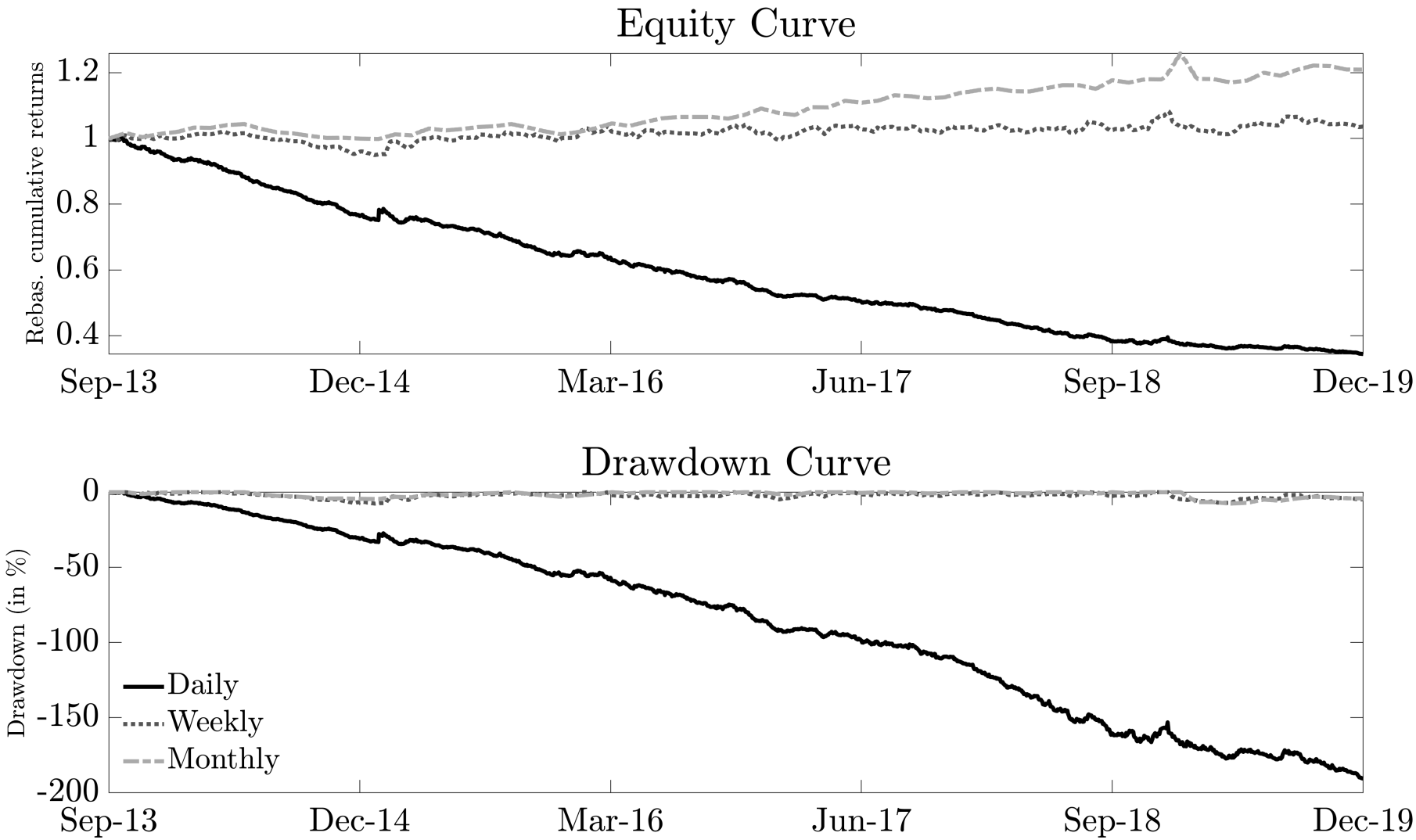
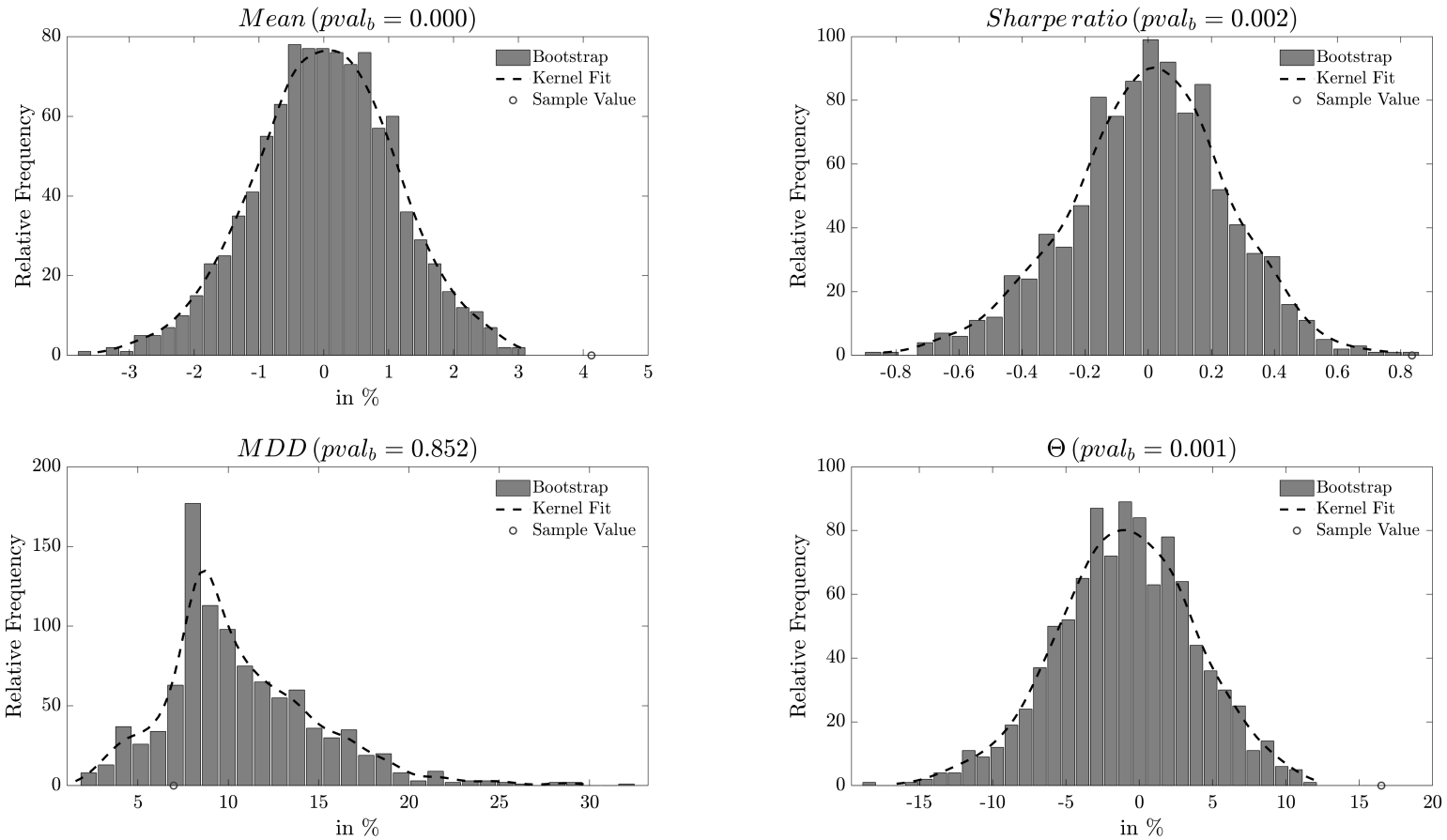
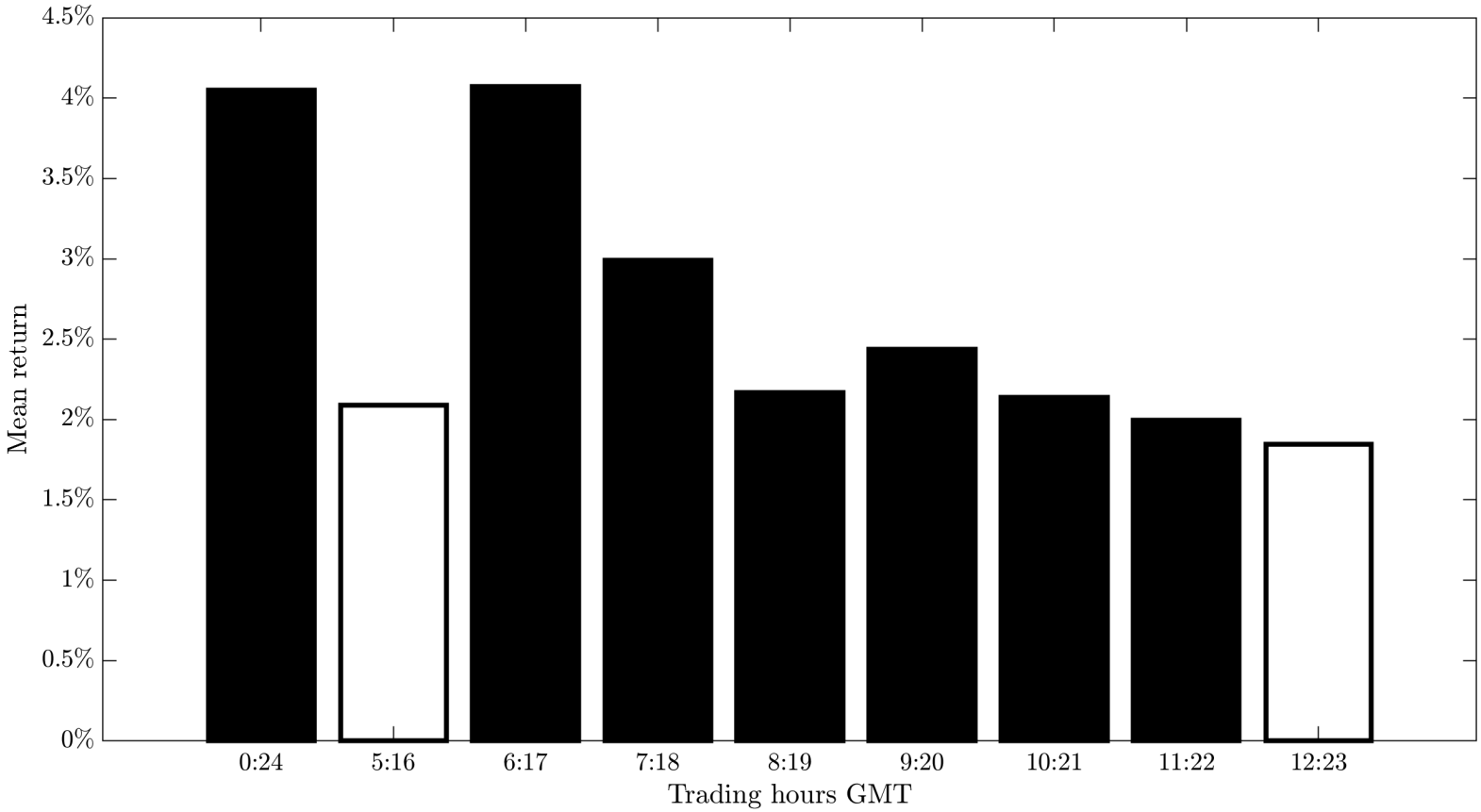


Figure 6: Bootstrapped Economic Performance of AIP_{HML}



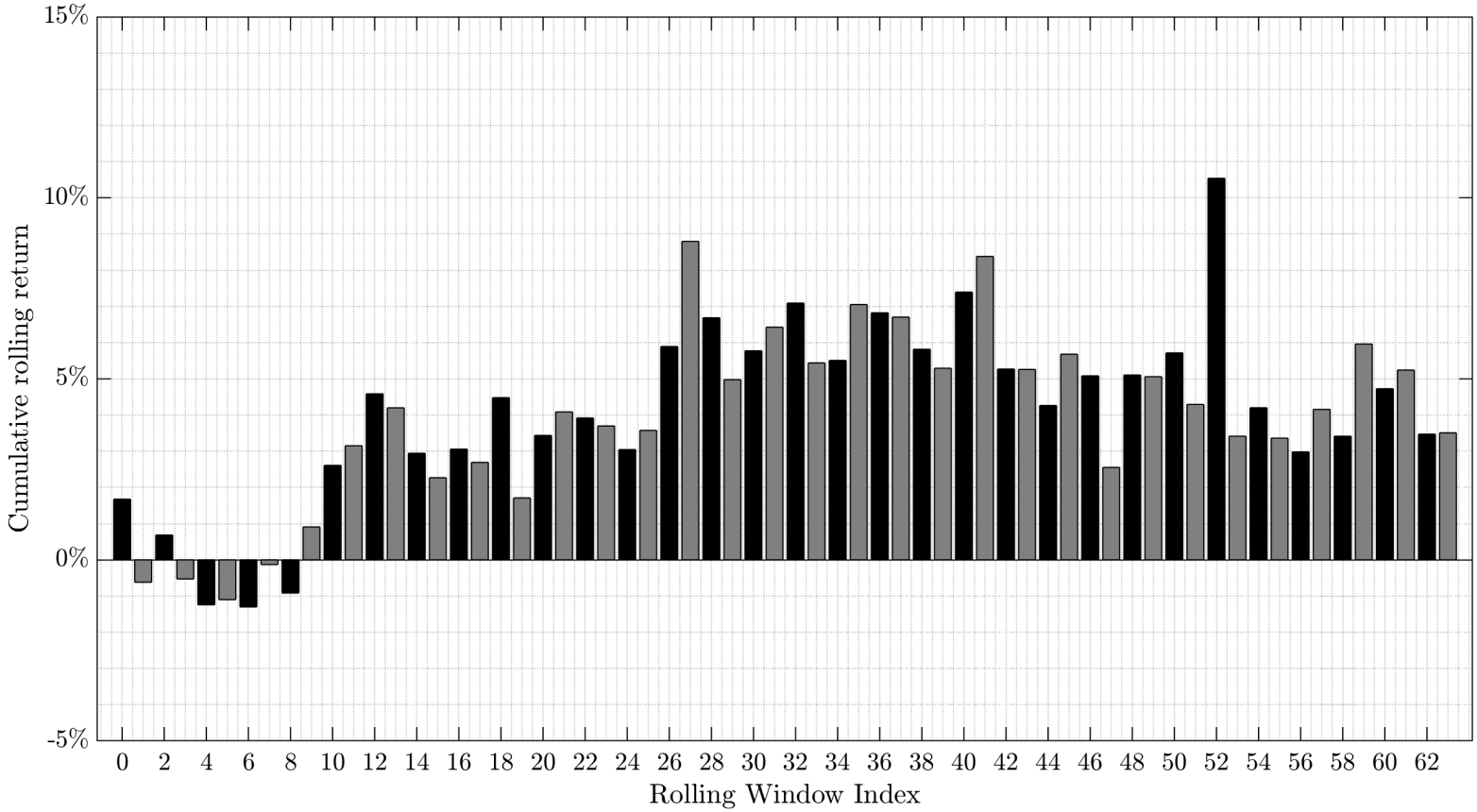
Note: These figures depict bootstrapped *p*-values using 1000 bootstrap repetitions for AIP_{HML} prior transaction cost, respectively. The upper-left plot displays the annualised mean excess return (*Mean*), the upper-right plot displays the annualised Sharpe ratio, the lower-left plot displays the maximum drawdown (*MDD*) and the lower-right plot displays the Θ performance measure of Goetzmann et al. (2007) based on monthly rebalancing. The bootstrapped *p*-values ($pval_b$) are reported in parentheses in the titles.

Figure 7: Performance of AIP_{HML}: Pruned Order Flow



Note: This figure depicts the annualised mean return of AIP_{HML} based on pruned daily order flows. For instance, the bar at '7 : 18' indicates that daily customer order flows have been calculated solely based on the order flows between 7 *am* and 6 *pm* GMT. Black shaded bars are significant at the 10% level. The first bar '0 : 24' is the benchmark case that is based on unrestricted order flows around the clock.

*Figure 8: Cumulative Rolling **Gross** Returns*



Note: Rolling window *gross* returns for monthly rebalancing and one year investment horizon.

Appendix V: Correlation with Common Risk Factors

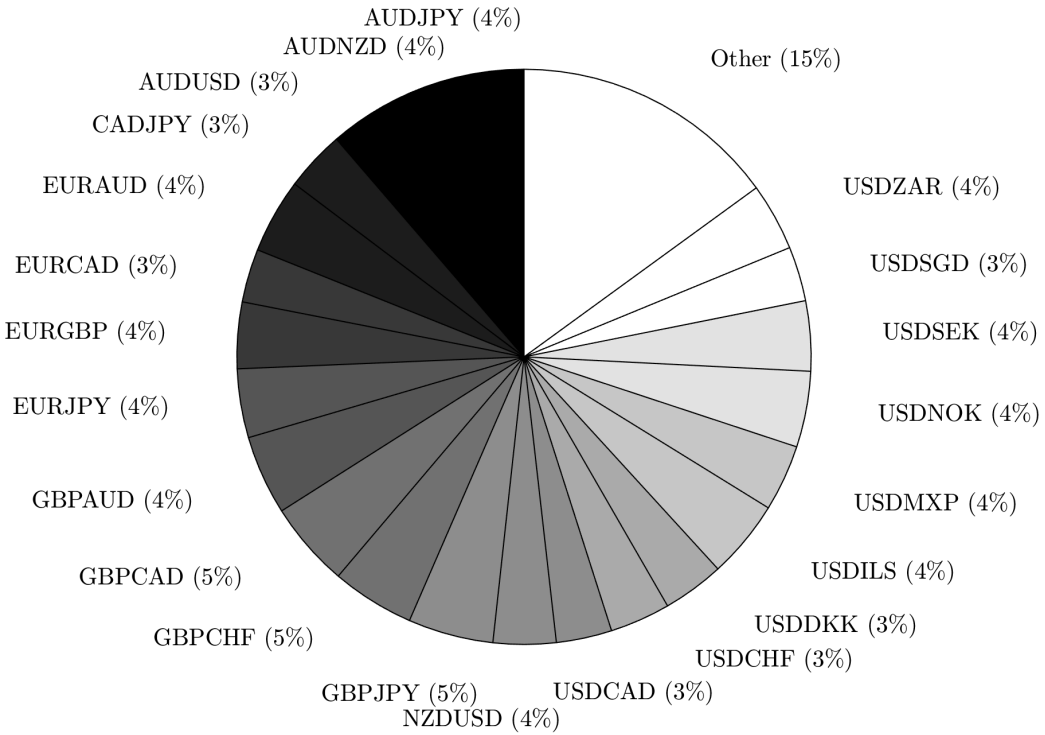
Table 14: Correlation with Common FX Risk Factors in %

	ΔVIX	ΔCDX	ΔTED	DOL	RER_{HML}	RER	MOM_{HML}	CAR_{HML}	BMS	VOL_{LMH}
ΔCDX	***71.41									
ΔTED	8.16	9.03								
DOL	−5.50	**−24.39	7.72							
RER_{HML}	6.08	−7.25	9.99	*21.89						
RER	−3.61	*−19.67	3.22	***59.26	***61.99					
MOM_{HML}	7.77	7.89	−0.72	−12.05	−6.13	−7.47				
CAR_{HML}	−11.72	−9.01	−7.32	*21.13	***−39.90	17.02	−17.25			
BMS	−7.47	−3.95	12.76	−6.47	−17.55	−16.60	*22.57	−8.13		
VOL_{LMH}	4.90	−14.00	−1.88	***87.59	**28.91	***63.53	−8.69	*19.45	−3.97	
AIP_{HML}	2.45	7.19	−9.62	**−24.75	−7.37	***−36.99	*20.96	***−43.60	1.08	**−25.09

Note: Significant correlations at the 90%/ 95%/ 99% levels are represented by asterisks (*/ **/ ***), respectively.

Appendix VI: Currency Exposure

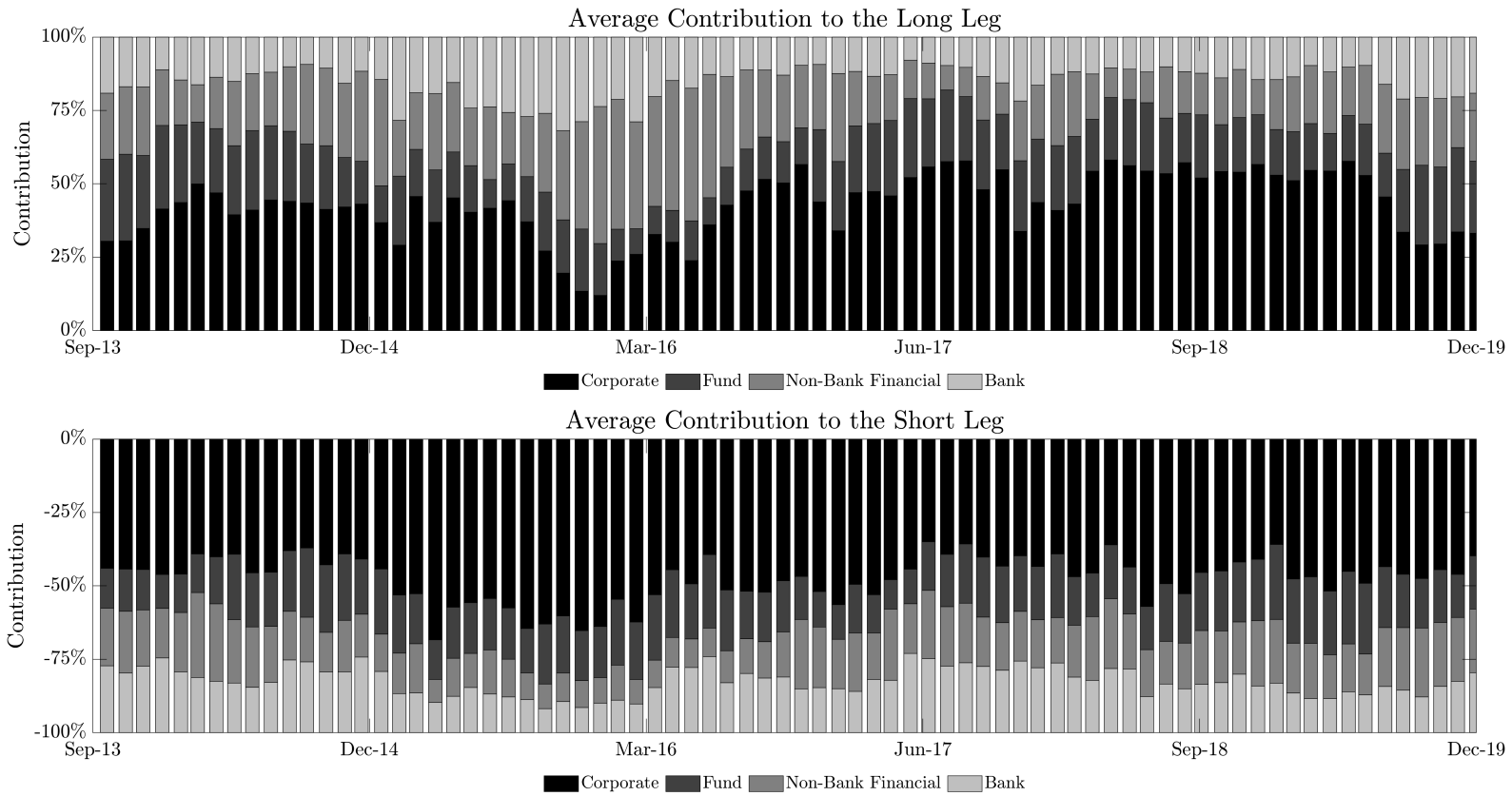
Figure 9: Distribution of Absolute Currency Exposure



Note: This figure shows the time-series average (absolute) relative weight of every currency pair normalised to one. 'Other' comprise currency pairs with a relative share $\leq$ 3%: EURCHF, EURDKK, EURNOK, EURSEK, EURUSD, GBPUSD, USDCAD, USDHKD and USDJPY.

Appendix VII: Decomposition of Long/ Short Leg

Figure 10: Average Contribution to the Long and Short Leg



Note: For every currency pair k, the relative share of each agent's $\alpha_m^{j,k}$ to the average $\bar{\alpha}_m^k$ is computed, and eventually the mean is calculated across all currency pairs.

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