

INTERMEDIARY ELASTICITY AND LIMITED RISK-BEARING CAPACITY

Yu An¹ Amy W. Huber²

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¹Johns Hopkins Carey

²The Wharton School

MOTIVATION

- A growing literature offers evidence that financial intermediaries matter for asset prices (e.g., [Haddad and Muir, 2021](#); [Du, Hébert, and Huber, 2022](#)).
- Intermediaries have limited risk-bearing capacity, leading to an upward-sloping “supply” curve.
 - [Du and Huber \(2024\)](#) show that CIP deviations increase in FX hedging demand.
- Therefore: customers’ trading demand shocks that are not motivated by or informative of fundamentals, could affect asset prices.
 - Magnitude depends on intermediaries’ risk-bearing capacity.
- **Q: Can we use trading data to quantify intermediaries’ risk-bearing capacity and its effect on asset prices?**

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- “Intermediary (inverse semi) elasticity”: price sensitivity to a marginal increase in risk induced by trading demand shocks.

$$\lambda = \frac{\Delta P/P}{\Delta \text{ quantity of risk (induced by trading)}}.$$

- Higher $\lambda \rightarrow$ higher price sensitivity to risk $\rightarrow$ lower risk-bearing capacity.

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- Compared to (unconditional) price of risk: λ measures change-on-change.
 - Quantifies risk-return trade-off for trading at the margin.
- Compared to IO (inverse) elasticity ($\frac{\Delta P/P}{\Delta Q/Q}$): λ defined w.r.t. risk.
 - Quantity of securities (Q) $\neq$ quantity of risk.
 - Consider an intermediary taking customer buy orders for two assets.
 - $\text{corr}(r_1, r_2) = -1$: positions offset, intermediary bears no risk $\rightarrow$ no price impact.

RISKS, QUANTITIES, AND THIS PAPER

- Theories long attribute the price effect of trading demand shocks to risks.
 - E.g., [Grossman and Miller \(1988\)](#); [Duffie \(2010\)](#); [Vayanos and Vila \(2021\)](#).
- This paper: measures trading-induced risks through risk factors.
 - Characterize risks at the security level is challenging: diversification.
 - Risk of a security = $\text{var}(\text{own return}) + \text{cov}(\text{with everything else})$.
 - We generalize portfolio theory (factors) ([Markowitz, 1952](#); [Ross, 1976](#)): isolate non-diversifiable trading-induced risks.
 - Convenient: risk of a factor = $\text{var}(\text{own return})$.
 - Relevant in FX: sophisticated intermediaries + deep inter-dealer market $\rightarrow$ strong factor structure in returns ([Lustig, Roussanov, and Verdelhan, 2011](#)).

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 - Relevant in FX: sophisticated intermediaries + deep inter-dealer market $\rightarrow$ strong factor structure in returns (Lustig, Roussanov, and Verdelhan, 2011).
- What we do:
 1. Identify Dollar, Carry, Euro-Yen as the 3 most important “traded risk factors” in FX by using trading return data *and* novel trading flow data.
 2. Quantify the rather low FX risk-bearing capacity by estimating “intermediary elasticity” of traded risk factors with instrumented trading demand shocks.
 3. Derive novel cross-currency and cross-asset-class elasticity by combining estimated risk-bearing capacity with exposure to traded risk factors.

MODEL SETUP

- Three-period N -foreign-currency model.
 - USD is the numeraire or home currency.
- r_n : eqm return of currency n from $t = 0$ to $t = 1$, with $\mathbf{r} = (r_1, r_2, \dots, r_N)^\top$.
- R_n : eqm return of ccy n from $t = 1$ to $t = 2$, with $\mathbf{R} = (R_1, R_2, \dots, R_N)^\top$.
 - Assume stationarity: $\text{var}(\mathbf{r}) = \text{var}(\mathbf{R})$ (can generalized to $\text{var}(\mathbf{r}) = L\text{var}(\mathbf{R})$).
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 - Key: measure trading-induced risks via factors.
 1. Identify the most important traded risk factors through eqm flow and return.
 - Key: link observed currency-level trading flows to implied factor-level flows.

FACTOR-LEVEL TRADING FLOW AND RISK

- We observe f_n : net customer buying flow for currency n against USD from $t = 0$ to $t = 1$, with $\mathbf{f} = (f_1, f_2, \dots, f_N)^\top$.
 - f_n is eqm flow, which can be pure trading demand shocks or informed.

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- Define risk factors by vectors of portfolio weights, $\mathbf{b}_1 = (b_{1,1}, b_{2,1}, \dots, b_{N,1})^\top$.
- The trading flow to factor is

$$q_1 = \sum_{n=1}^N f_n \beta_{n,1} = \text{cov}(\mathbf{f}^\top \mathbf{r}, \mathbf{b}_1^\top \mathbf{r}) \text{var}(\mathbf{b}_1^\top \mathbf{r})^{-1}$$

- Each f_n exposes intermediary to a factor-level flow of size $f_n \beta_{n,1}$, where $\beta_{n,1} = \frac{\text{cov}(r_n, \mathbf{b}_1^\top \mathbf{r})}{\text{var}(\mathbf{b}_1^\top \mathbf{r})}$.
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TRADED RISK FACTORS VIA MODIFIED PCA

- Objective: to identify the most important **traded** risk factors from observed trading flow $\mathbf{f}$.

- First factor $\mathbf{b}_1$:

$$\max_{\mathbf{b}_1} \frac{\text{var}(q_1 \text{var}(\mathbf{b}_1^\top \mathbf{r}))}{\text{var}(\mathbf{b}_1^\top \mathbf{r})} = \text{var}(q_1) \text{var}(\mathbf{b}_1^\top \mathbf{r}), \text{ where } q_1 = \text{cov}(\mathbf{f}^\top \mathbf{r}, \mathbf{b}_1^\top \mathbf{r}) \text{var}(\mathbf{b}_1^\top \mathbf{r})^{-1}.$$

- Second factor $\mathbf{b}_2$:

$$\begin{aligned} \max_{\mathbf{b}_2} \text{var}(q_2) \text{var}(\mathbf{b}_2^\top \mathbf{r}) \\ \text{s.t. } \text{cov}(\mathbf{b}_1^\top \mathbf{r}, \mathbf{b}_2^\top \mathbf{r}) = 0. \end{aligned}$$

- Compare: standard PCA constructs factors to maximally explain $\text{var}(\mathbf{b}_1^\top \mathbf{r})$.
- Property: invariant to factor scaling, sign reversal, and the choice of numeraire currency.

FACTOR PRICE AND INTERMEDIARY ELASTICITY

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- Consider hypothetical and marginal trading demand shocks $\hat{q}_1, \dots, \hat{q}_K$, which occur from $t = 0$ to $t = 1$ and are uninformed about currency prices at $t = 2$.
- The price of factor k at time 1 needs to adjust such that intermediaries find it optimal to absorb the trading demand shocks in equilibrium:

$$\Delta p_k := \frac{P_k(\hat{q}_1, \dots, \hat{q}_K) - P_k(0, \dots, 0)}{P_k(0, \dots, 0)} = \underbrace{\lambda_k}_{\text{int. elas.}} \cdot \underbrace{\hat{q}_k \text{var}(\mathbf{b}_k^\top \mathbf{r})}_{\text{risk}}, \text{ where } \lambda_k = \frac{\gamma_k}{\mu R_F}.$$

Optimization

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Optimization

- Equivalently,

$$\lambda_k = \frac{\Delta p_k}{\hat{q}_k \text{var}(\mathbf{b}_k^\top \mathbf{r})}.$$

- λ_k is invariant under factor scaling or sign reversal.
- Uncorrelated returns across factors: λ_k can be estimated factor by factor.
- Later: mapping intermediary elasticity to cross-elasticity of individual currencies.

DATA

- Daily FX trading flow data from CLS, largest single source of FX trades.
 - 16 foreign currencies + USD between Sep 2012 and Dec 2023.
 - All trades between Banks (dealers and hedge funds) and customers.
 - Three type of customers: Funds, Corporations, Non-Bank Financial.

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 - Re-constitute all flows relative to USD: if a customer buys EUR and sells JPY to a dealer, we record it as a positive EUR flow and a negative JPY flow.
 - We want total FX risk exposure: include all flows from FX spot, (discounted) FX forward, and (discounted) FX swaps.

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- Daily FX return data from Bloomberg.
 - Spot and forward rates at London closing.
 - Exchange rate: USD / FGN.
 - Currency return: $r_{t+1,n} = f_t - s_{t+1} = s_t - s_{t+1} + i^{CCY} - i^{USD} - x_t$.
- We aggregate both flow and return to weekly level for analysis.

TOP 3 TRADED FX FACTORS

Currency	Factor 1	Factor 2	Factor 3
AUD	-0.08	0.14	-0.08
CAD	-0.15	0.56	-0.87
CHF	-0.03	-0.07	-0.02
DKK	-0.01	0	0.02
EUR	-0.5	-0.43	1.16
GBP	-0.11	0.18	0.09
HKD	0	-0.01	0.02
ILS	0	0	0
JPY	-0.07	-0.49	-1
KRW	-0.01	0.01	-0.01
MXN	-0.01	0.02	-0.03
NOK	-0.01	0.02	-0.01
NZD	-0.01	0.02	-0.01
SEK	-0.01	0.01	-0.01
SGD	-0.01	0	0.02
ZAR	-0.01	0.01	-0.01
USD	1	0.03	0.74
Var explained	65%	16%	9%

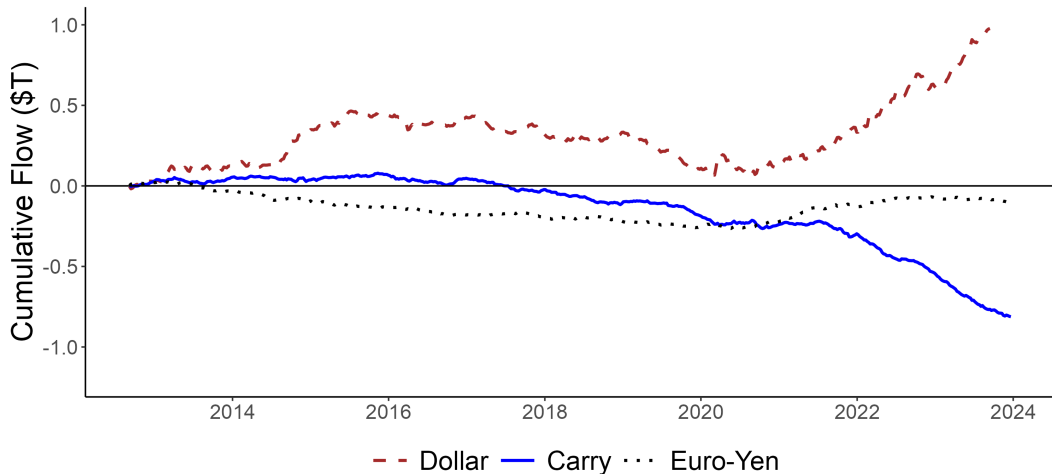
ECONOMIC RISK FACTORS

- Factor 1: Dollar factor.
 - -1/6 on AUD, CAD, CHF, EUR, GBP, JPY v.s. 1 on USD.
- Factor 2: Carry factor.
 - -1/3 on CHF, EUR, JPY vs. 1/3 on AUD, CAD, GBP.
- Factor 3: Euro-Yen factor.
 - -1 on JPY vs. 1 on EUR.
- Orthogonalized using the modified PCA procedure.

Correlation Between Economics Factors and PC Factors

	Factor 1	Factor 2	Factor 3
Return	0.98	0.95	0.92
Flow	1.00	0.99	0.95
Var explained by Econ Factors	63%	15%	8%

CUSTOMER FLOW TO TRADED FX FACTORS



- Intermediaries' exposures are the negative of customer'.
- Intermediaries have been providing Dollar and gaining exposure to Carry.

By customer

INSTRUMENT FOR ELASTICITY

- We want to identify λ_k associated with Δ quantity of risk, as induced by trading demand shocks.

$$r_{k,t}/\text{var}(r_{k,t}) = \lambda_k \hat{q}_{k,t} + \epsilon_{k,t}, \text{ where}$$

$$q_{k,t} = \theta z_{k,t} + e_{k,t},$$

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- Candidate instruments: the *announcements* of the offering amount at upcoming sovereign bond auctions.
 - Relevance: foreigners exchange for local currency to participate in auctions.
 - Exogeneity/Exclusion: auction offering amount exhibits fiscal cyclicalities $\rightarrow$ heavily anticipated.
- Estimation sample: weekly observations from Sep 2012 to Dec 2023 excluding the first half of 2020 (COVID).

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ECONOMIC MAGNITUDE OF INTERMEDIARY ELASTICITY

	Int. elasticity (IV)	Return volatility	Price impact per \$B shock
	λ_k	$\sigma(r_{k,t})$	$\lambda_k \sigma^2(r_{k,t})$
Dollar	0.11	6.9%	5.0 bps
Carry	0.14	8.2%	9.3 bps
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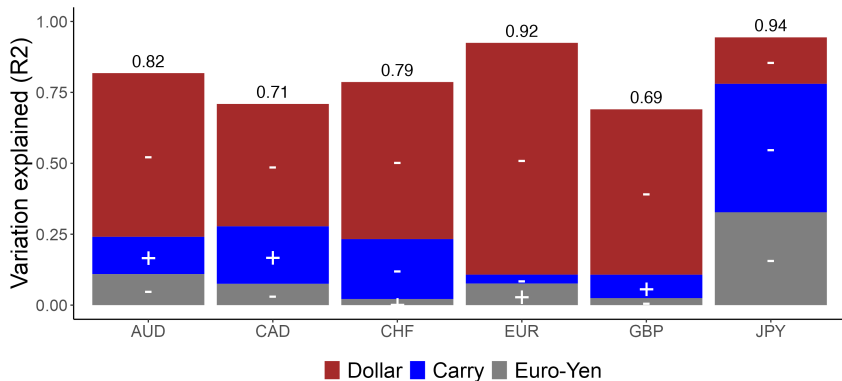
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- High price sensitivity $\Leftrightarrow$ limited risk-bearing capacity.
 - Possibly limited FX arbitrage capital.
 - Nature: specialized intermediaries.
 - Estimation: weekly vs. monthly in equity.

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 - Estimation: weekly vs. monthly in equity.
 - Available arb capital may be even less for less traded factors.
 - Volatility of flows: \$85B in Dollar, \$34B in Carry, \$22B in Euro-Yen.

TRADED FX FACTORS MATTER FOR CURRENCY RETURNS



- Traded FX factors constructed to explain trading-induced risks. But also explain unconditional risk (Lustig, Roussanov, and Verdelhan, 2011).
- Important: if trading demand shocks affect price of traded FX factors, will also affect the price of currency through exposure.

CURRENCY CROSS-ELASTICITY THROUGH FACTOR EXPOSURE

$$\begin{aligned}\frac{\partial \text{ccy-}n \text{ price}}{\partial \text{ccy-}m \text{ demand}} &= \sum_{k=1}^K \frac{\partial \text{factor-}k \text{ demand}}{\partial \text{ccy-}m \text{ demand}} \times \frac{\partial \text{factor-}k \text{ price}}{\partial \text{factor-}k \text{ demand}} \times \frac{\partial \text{ccy-}n \text{ price}}{\partial \text{factor-}k \text{ price}} \\ &= \sum_{k=1}^K \beta_{m,k} \times \lambda_k \text{var}(r_{k,t}) \times \beta_{n,k}\end{aligned}$$

- The impact of a trading demand shock to currency m on the price of currency n , while holding the trading demand shocks of all other currencies constant.

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 - Many covariance parameters.
 - “Poor data”: likely correlated currency-level trading demand shocks.

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- Typical IO approach: impose structure on unobserved latent demand.

CURRENCY CROSS-ELASTICITY THROUGH FACTOR EXPOSURE

$$\begin{aligned}\frac{\partial \text{ccy-}n \text{ price}}{\partial \text{ccy-}m \text{ demand}} &= \sum_{k=1}^K \frac{\partial \text{factor-}k \text{ demand}}{\partial \text{ccy-}m \text{ demand}} \times \frac{\partial \text{factor-}k \text{ price}}{\partial \text{factor-}k \text{ demand}} \times \frac{\partial \text{ccy-}n \text{ price}}{\partial \text{factor-}k \text{ price}} \\ &= \sum_{k=1}^K \beta_{m,k} \times \lambda_k \text{var}(r_{k,t}) \times \beta_{n,k}\end{aligned}$$

- The impact of a trading demand shock to currency m on the price of currency n , while holding the trading demand shocks of all other currencies constant.
- Estimating cross-elasticity for a whole panel of currencies is challenging:
 - Many covariance parameters.
 - “Poor data”: likely correlated currency-level trading demand shocks.
- Typical IO approach: impose structure on unobserved latent demand.
- Our approach: derive structure from observed common risk exposure.
 - Complementarity: cross-elasticity is low when $\beta_{m,k}\beta_{n,k} < 0$.
 - Symmetry: n on m is the same as m on n .

PRICE IMPACT (IN BPS) PER \$1B TRADING DEMAND SHOCK

	AUD	CAD	GBP	CHF	EUR	JPY	HKD
AUD	12.0	7.9	9.0	2.1	2.8	5.9	0.2
CAD		5.3	5.9	0.7	1.6	2.6	0.1
GBP			7.4	3.1	4.0	3.2	0.1
CHF				8.6	7.3	4.1	0.0
EUR					7.4	0.2	0.1
JPY						16.2	0.0
HKD							0.0

- All positive because loading on Dollar factors.

PRICE IMPACT (IN BPS) PER \$1B TRADING DEMAND SHOCK

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- Low cross-elasticity between long and short Carry legs (complementarity).

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- Low cross-elasticity between long and short Carry legs (complementarity).
- Low cross-elasticity between EUR and JPY because of Euro-Yen factor.

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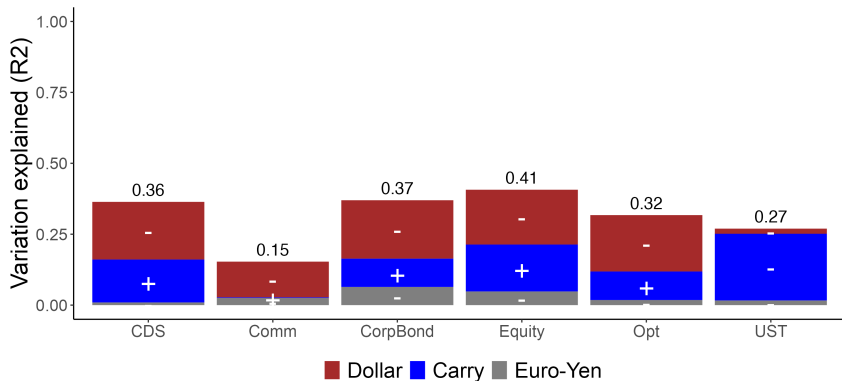
- All positive because loading on Dollar factors.
- Low cross-elasticity between long and short Carry legs (complementarity).
- Low cross-elasticity between EUR and JPY because of Euro-Yen factor.
- HKD as sanity check.

CROSS-ELASTICITY BETWEEN ASSET CLASSES

$$\begin{aligned}\frac{\partial \text{asset-}n \text{ price}}{\partial \text{asset-}m \text{ demand}} &= \sum_{k=1}^K \frac{\partial \text{factor-}k \text{ demand}}{\partial \text{asset-}m \text{ demand}} \times \frac{\partial \text{factor-}k \text{ price}}{\partial \text{factor-}k \text{ demand}} \times \frac{\partial \text{asset-}n \text{ price}}{\partial \text{factor-}k \text{ price}} \\ &= \sum_{k=1}^K \beta_{m,k} \times \lambda_k \text{var}(r_{k,t}) \times \beta_{n,k}\end{aligned}$$

- Can apply cross-elasticity formula to non-FX assets if other asset classes also load on the FX factors.
 - Trading demand shocks in one asset increase non-diversifiable risks captured in traded FX factors, affecting factor prices and asset prices.

OTHER ASSET CLASSES LOAD ON TRADED FX FACTORS



- All negative on Dollar factor.
- UST negative on Carry factor, but other assets load positively.
- CorpBond and Equity load on Euro-Yen.
- Note: our cross-elasticity captures what is *channeled via traded FX factors*.

CROSS ELASTICITY BETWEEN ASSET CLASSES DUE TO TRADED FX FACTORS

	CDS	Comm	CorpBond	Equity	Option	UST
CDS	2.4	3.5	3.2	5.8	4.7	-0.5
Comm		8.9	6.0	9.5	7.7	0.7
CorpBond			4.8	8.3	6.5	-0.2
Equity				14.6	11.4	-0.9
Opt					9.3	-0.6
UST						0.7

- UST: “safe-haven asset” $\leftrightarrow$ only asset class that loads negatively on Carry.
- UST: deepest market $\leftrightarrow$ smallest own price impact to trading demand shocks.

CONCLUSION AND CONNECTIONS TO THE LITERATURE

- This paper investigates trading-induced risks borne by representative intermediary (review by [He and Krishnamurthy, 2017](#)) through factors ([Markowitz, 1952](#); [Ross, 1976](#)).
 - Modified PCA on flow and return data to identify Dollar, Carry, Euro-Yen: account for 90% of the non-diversifiable risks in FX trading.
- This paper links trading quantities to asset prices (e.g., [Froot and Ramadorai, 2008](#); [Koijen and Yogo, 2019](#)) through *risks*.
 - IV analysis finds low risk-bearing capacity: price must rise by 5 to 30 bps for intermediaries to absorb \$1B trading demand shock to traded FX factors.
- This paper uses common factor exposure to derive novel cross-asset dynamics across currencies (e.g. [Lustig, Roussanov, and Verdelhan, 2011](#)) and asset classes (e.g. [Haddad and Muir, 2021](#)).
 - Quantifies cross-elasticity of 16 currencies and 7 asset classes: a literature first.
- Overall, our findings highlight an integrated-market and a portfolio (rather than asset-by-asset) view when studying intermediaries' risk-bearing capacity.

Supplementary materials

ELASTICITY IN KOIJEN AND YOGO (2019)

$$\underbrace{\frac{w_{i,t}(n)}{w_{i,t}(0)}}_{\text{Quantity}} = \exp\left\{\underbrace{\beta_{0,i,t}me_t(n)}_{\text{Price}} + \underbrace{\sum_{k=1}^{K-1} \beta_{k,i,t}x_{k,t}(n)}_{\text{Risk}} + \beta_{K,i,t}\right\} \underbrace{\epsilon_{i,t}(n)}_{\text{Latent demand}} \quad (10)$$

- $\beta_{0,i,t}$: quantity elasticity to price at stock level.
- $\beta_{k,i,t}$: quantity elasticity to the stock's characteristics (factor risk exposures).
- Our λ_k : price elasticity to risk induced by quantity change at factor level.

DETAILS OF INTERMEDIARY OPTIMIZATION

- The equilibrium price impacts Δp_k are set such that each intermediary finds it optimal to buy $y_k = -\hat{q}_k/\mu$ dollars of factor k .

$$\{-\hat{q}_1/\mu, \dots, -\hat{q}_K/\mu\} = \arg \max_{\{y_1, \dots, y_K\}} \mathbb{E} \left[-\exp \left(-\sum_{k=1}^K \gamma_k (y_k \mathbf{b}_k^\top \mathbf{R} - y_k R_F (1 + \Delta p_k)) \right) \right].$$

- Note: λ_k is not a function of intermediaries' pre-existing holdings at time 1, as we do not model nonlinear constraints (e.g., position limits).
 - Also because of CARA utility, though we can re-cast the absolute risk aversion as a function of intermediary wealth to mimic a CRRA preference.

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PCA OF TRADING FLOWS

Currency	PC 1	PC 2	PC 3
AUD	-0.03	0.03	0.12
CAD	-0.04	1.00	-0.06
CHF	-0.01	-0.02	-0.06
DKK	-0.00	-0.00	0.01
EUR	-1.00	-0.03	0.03
GBP	-0.02	-0.01	0.26
HKD	-0.00	-0.02	-0.00
ILS	-0.00	-0.01	-0.00
JPY	-0.04	-0.06	-0.95
KRW	-0.00	0.01	-0.00
MXN	-0.01	0.01	-0.00
NOK	0.00	0.01	0.01
NZD	-0.01	0.01	0.01
SEK	0.01	0.00	0.00
SGD	-0.01	-0.01	0.01
ZAR	-0.01	0.00	0.01
USD	1.17	-0.92	0.62
Flow Var explained	46%	21%	12%

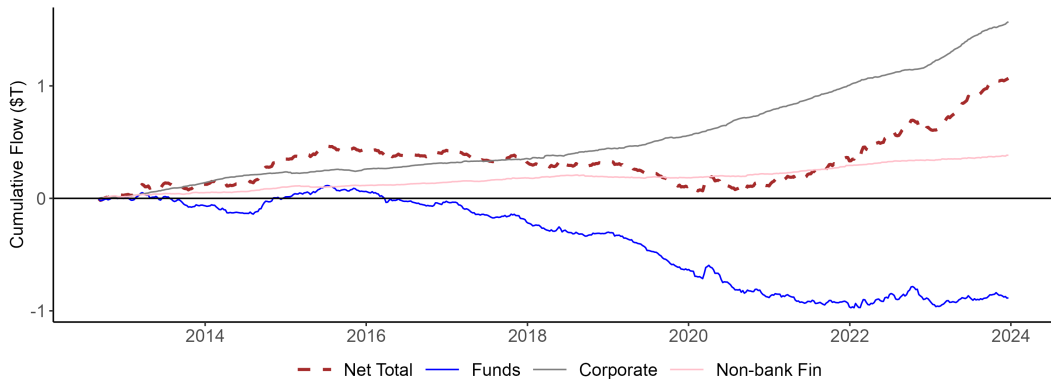
ROBUSTNESS OF FX FACTORS

		Factor 1	Factor 2	Factor 3
Return	Pre 2020	0.97	0.83	0.83
	Post 2020	1.00	0.97	0.89
Flow	Pre 2020	0.98	0.82	0.81
	Post 2020	0.99	0.96	0.81

- The underlying data are well-behaved.
- In particular, the flow and return covariance structures are rather stable over time.

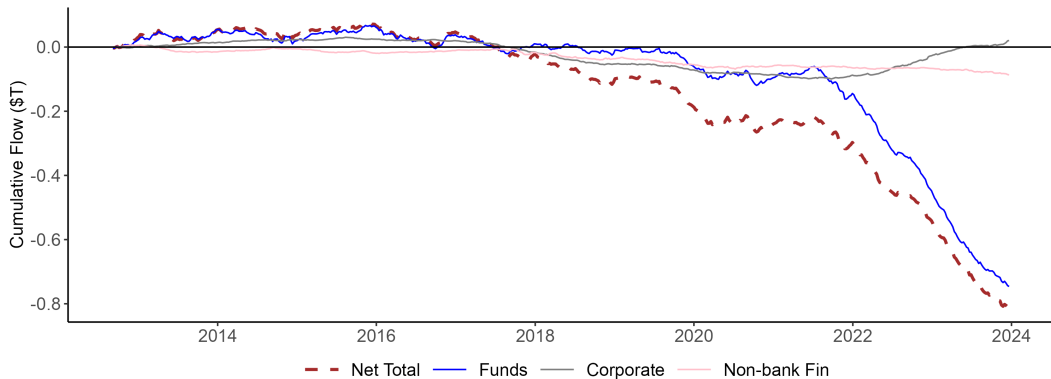
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FLOW TO DOLLAR FACTORS



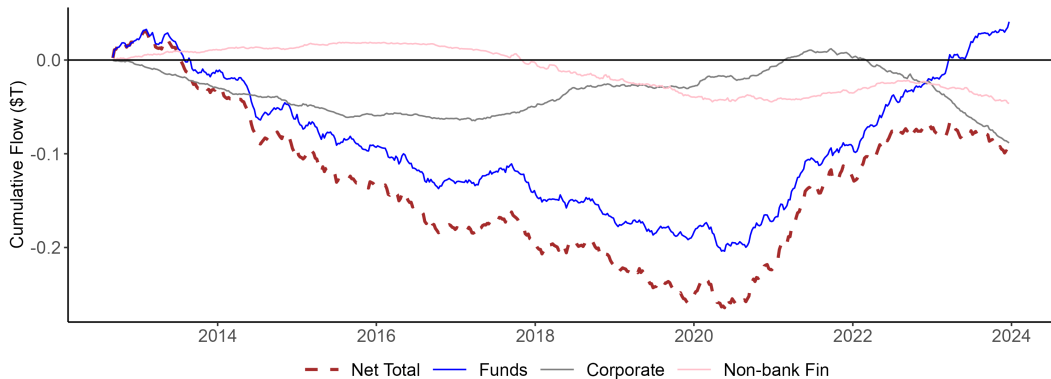
- Funds are persistently selling Dollars, whereas Corporates are buying.
- In recent years, intermediaries have been be net sellers of the Dollar factor.

FLOW TO CARRY FACTORS



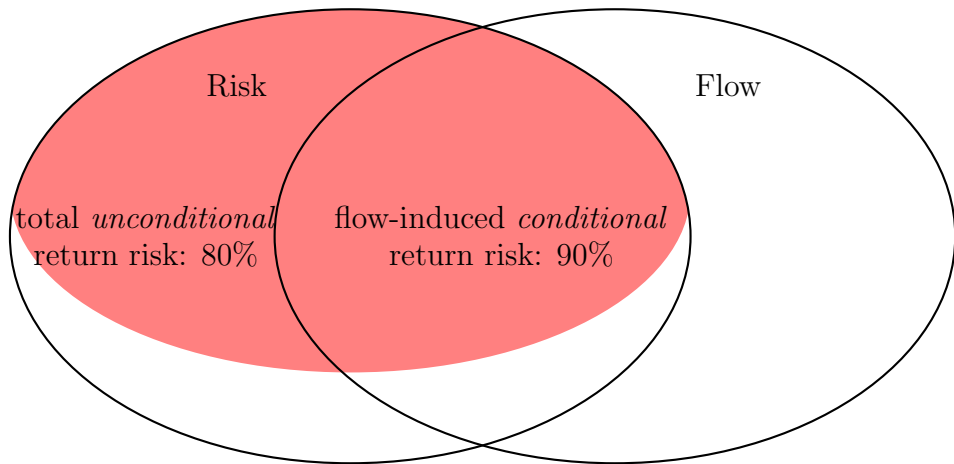
- Since 2022, Funds have strongly sold off the Carry factor.
- The Carry trade exposure borne by Banks (dealers and hedge funds), accumulated to \$0.8 trillion between 2012 and 2023.

FLOW TO EURO-YEN FACTORS



- Sold by both Corporate and Funds right up to around the Covid-19 Crisis.
- Since then, Funds have bought back all of their short position to approximately neutral, while Corporate continued to sell the Euro-Yen factor.

UNCONDITIONAL V.S. CONDITIONAL RISK: % EXPLAINED



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TIME-VARYING λ FOR THE DOLLAR FACTOR

	Baseline (1)	Int. equity wealth (2)	CIP deviation (3)	Swap line usage (4)
Factor flow	0.107*** (0.037)	0.114*** (0.033)	0.160* (0.092)	0.106*** (0.029)
Flow $\times$ Int. wealth		-0.016 (0.031)		
Int. equity wealth		0.018 (0.130)		
Flow $\times$ CIP dev			0.063 (0.130)	
CIP deviation			0.172 (0.178)	
Flow $\times$ swap line				-0.056* (0.034)
Swap line usage				-0.449** (0.217)
Observations	386	383	386	385

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