Intermediary Elasticity and Limited Risk-Bearing Capacity

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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, i.e., uninformed trading flows, 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?**

Intermediary elasticity and risk-bearing capacity

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  - Should trading demand shocks affect prices, they do so by altering the amount of (non-diversifiable) risks that intermediaries bear.

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- "Intermediary (inverse semi) elasticity": price response to a marginal unit of risk induced by trading.

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

  - Higher $\lambda \rightarrow$ higher price impact from risk $\rightarrow$ lower risk-bearing capacity.

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  - Higher $\lambda \to$ higher price impact from risk $\to$ lower risk-bearing capacity.
- 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.
    - $\text{cov}(r_1, r_2) = -1$: positions offset, intermediary bears no risk $\to$ no price impact.
    - $\text{cov}(r_1, r_2) \neq -1$: intermediary exposed to non-diversifiable risk $\to$ requires comp.
  - Securities may be fungible. Risks are not: potentially simpler cross-substitution.

Risks, quantities, and this paper

- Trading affects asset prices, not just because of information (e.g., in FX: Evans and Lyons, 2002 vs. Froot and Ramadorai, 2008).
- Theories long attribute the effect to risks (e.g., Duffie, 2010; Vayanos and Vila, 2021).
- Abundant empirical work documenting reduced-form evidence in support.
- This paper:
  1. Identifies the most important "traded risk factors" in FX using novel trading flow data.
  2. Quantifies risk-bearing capacity through "intermediary elasticity" by instrumenting for trading demand shocks to traded risk factors.
  3. Combines exposure to traded risk factors and estimated risk-bearing capacity to derive cross-currency and cross-asset-class elasticity.

Road map and preview of results

- Conceptual framework:
  1. Define factor-level net trading demand.
  2. Identify traded risk factors.
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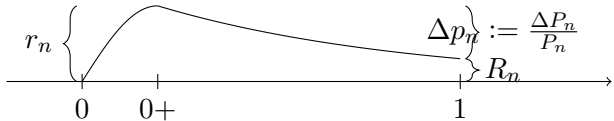
- Empirics:
  1. Traded FX factors.
     - Just 3 traded risk factors can jointly account for 90% of the non-diversifiable risks in FX trading.
     - Familiar factors, new results on customer flows to these factors.
  2. Intermediary elasticity of traded FX factors.
     - Intermediaries raise prices by 5 to 30 bps in response to $1 billion net trading demand shock to these traded FX factors.
     - Estimated using sovereign debt auction announcements as instruments.
  3. Mapping intermediary elasticity to cross-asset elasticity.
     - Quantifies cross-elasticity of 16 currencies and between 7 asset classes.
     - A literature first.

Model setup



- Two-period N-foreign-currency model.
  - USD is the numeraire or home currency.
- A unit mass of competitive intermediaries take customer FX trades.
- Time 1: currency n' fundamental returns R_n realized.
- Time 0+: equilibrium return r_n affected by customer trading demand shocks.
  - To induce the intermediaries to accommodate, price of n adjusts by ΔP_n.
- $\Delta p_n = \lambda \times \Delta$ risk induced by trading demand shock.
  - To estimate λ, need to quantify trading (shock) induced risk, which in turn requires identifying traded risk factors.

Factor-level net trading demand

- Define risk factors by vectors of portfolio weights, e.g., $\mathbf{b}_1 = (b_{1,1}, b_{2,1}, \ldots, b_{N,1})^\top$.
- Currency-level net trading demand: $\mathbf{f} = (f_1, f_2, \ldots, f_N)^\top$, where f_n is the net customer buying demand for currency n against USD.
- f_n exposes intermediary to a factor-level demand of size $f_n \beta_{n,1}$, where $\beta_{n,1} = \text{cov}(R_n, \mathbf{b}_1^\top \mathbf{R})/\text{var}(\mathbf{b}_1^\top \mathbf{R})$.
- Intermediaries can offset some trading demand across currencies, but are exposed to non-diversifiable factor-level trading demand of amount

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

Traded risk factors via modified PCA

- Objective: to identify most traded risk factors from net trading demand $\mathbf{f}$.
  - 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 $\mathbf{b}_2$:

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

- Compare: standard PCA constructs factors to maximally explain $\text{var}(\mathbf{b}_1^\top \mathbf{R})$.

Factor price and intermediary elasticity

- The unit mass of intermediaries have CARA preference with possibly factor-specific risk-aversion, γ_k.

- Intermediaries optimize their holdings of each factor. Price impact of trading demand shocks at time 0+ must induce them to sell exactly $q_1, q_2, \ldots, q_K$ to clear the market. Hence:

$$\Delta p_k := \frac{P_k(q_k) - P_k(0)}{P_k(0)} = \lambda_k q_k \text{var}(\mathbf{b}_k^\top \mathbf{R}), \text{ where } \lambda_k = \frac{\gamma_k}{R_{F,USD}}.$$

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- Equivalently, the intermediary elasticity is

$$\lambda_k = \frac{\Delta p_k}{q_k \text{var}(\mathbf{b}_k^\top \mathbf{R})}.$$

  - 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.

Optimization

Why FX market

- Think in terms of risks: (1) sophisticated, (2) inter-dealer market.
- Intermediary important to understand – marginal pricer, cross-market arbitrage.
- Availability of data.

Data

- Daily FX flow data from CLS, covering over 50% of global FX traded volumes between Sept 2012 and Dec 2023.
  - 16 foreign currencies + USD.
  - Broken down by type of customers: Funds, Corporations, Non-Bank Financial. All flows vis-à-vis Banks (dealers and hedge funds).

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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%

Robustness

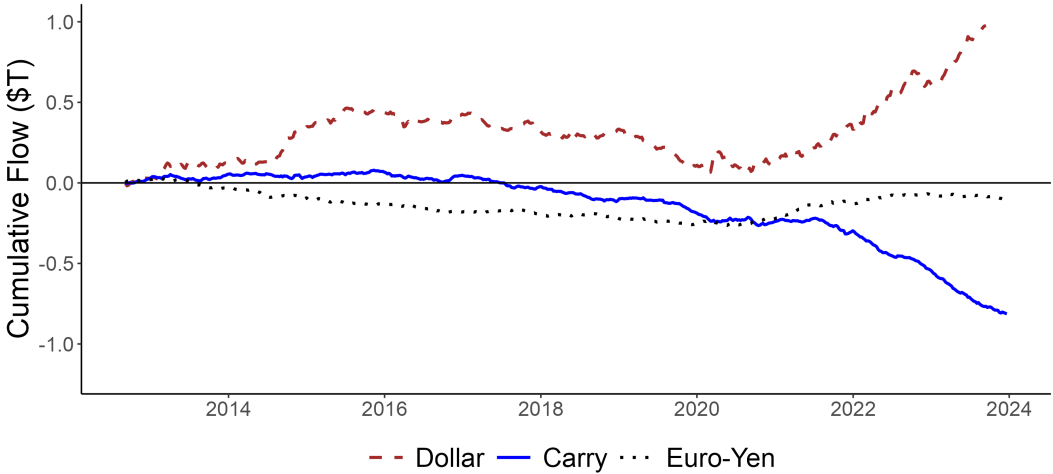
Economic risk factors

- 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 (Orthogonalized) 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%

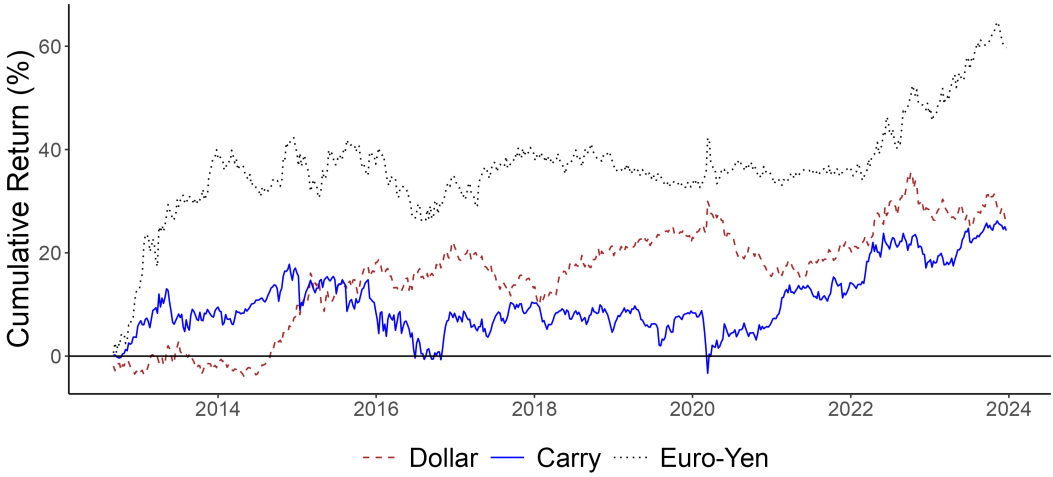
Customer flow to traded FX factors



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

By customer

Return of Traded FX factors



- Suggestive correlation between factor flow and factor return: more later.

Instrument for elasticity

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

$$r_{k,t}/\text{var}(r_{k,t}) = \lambda_k \hat{q}_{k,t} + \epsilon_{k,t}, \text{ where}$$
$$q_{k,t} = \theta z_{k,t} + e_{k,t},$$
$$\text{cov}(z_{k,t}, \epsilon_{k,t}) = 0.$$

- We need instruments for factor-level trading demand $q_{k,t}$.
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- Candidate instruments: the *announcements* of the *offering* amount at upcoming sovereign bond auctions.
  - Relevance: foreigners participate in sovereign bond auctions and need to exchange for local currency.
  - Exclusion: auction offering amount typically forward-guided and contains limited information on demand.
- Estimation sample: weekly observations from Sep 2012 to Dec 2023 excluding the first half of 2020 (COVID).

Estimated intermediary elasticity

	Dollar		Carry		Euro-Yen	
	OLS	IV	OLS	IV	OLS	IV
Factor flow	0.072***	0.107***	0.132***	0.138**	0.139***	0.335*
	(0.009)	(0.037)	(0.018)	(0.064)	(0.021)	(0.195)
1st stage F-stat		24.8		6.5		3.8
Anderson-Rubin CI				(0.01, 2.39)		(0.09, 1.91)
Observations	590	386	590	228	590	560

- Instruments:
  - Dollar factor: UST in week t
  - Carry factor: Australian, Canadian, British, and Japanese in week t.
  - Euro-Yen factor: Euro-Area (German+French+Italian) in week $t-1$ and t.

Time-varying IE

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Economic magnitude of intermediary elasticity

	Int. elasticity (IV) λ_k	Return volatility $\sigma(r_{k,t})$	Price impact per \$B flow $\lambda_k \sigma^2(r_{k,t})$
Dollar	0.11	6.9%	5.0 bps
Carry	0.14	8.2%	9.3 bps
Euro-Yen	0.34	9.4%	29.3 bps

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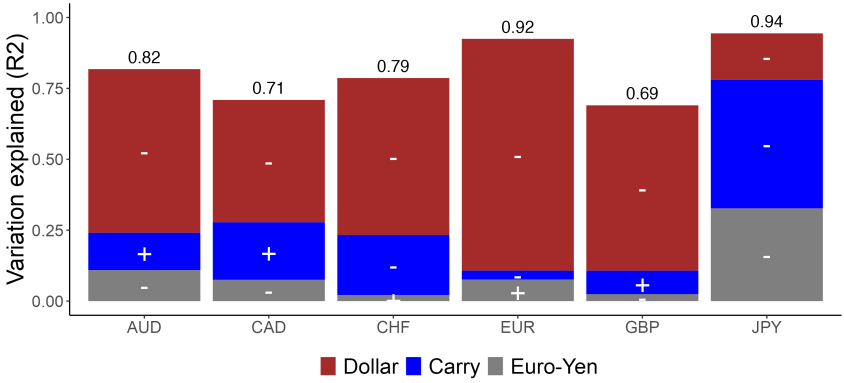
- Higher price response when risks are not substitutible / diveresifiable.
- Higher price response in FX possibly due to more limited FX arbitrage capital.

Traded FX factors matter for currency returns



- Traded FX factors constructed to explain trading-induced risks. But also explain total 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.

Flow loading
Cond vs. uncond risk

Currency cross-elasticity through factor exposure

$$\frac{\partial \text{ ccy-}n \text{ price}}{\partial \text{ ccy-}m \text{ demand}} = \sum_{k=1}^{K} \frac{\partial \text{ factor-}k \text{ demand}}{\partial \text{ ccy-}m \text{ demand}} \times \frac{\partial \text{ factor-}k \text{ price}}{\partial \text{ factor-}k \text{ demand}} \times \frac{\partial \text{ ccy-}n \text{ price}}{\partial \text{ factor-}k \text{ price}}$$

$$= \sum_{k=1}^{K} \beta_{m,k} \times \lambda_k \text{var}(r_{k,t}) \times \beta_{n,k}$$

- 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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- Key features:
  - 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 $1 billion demand shock

	AUD	CAD	GBP	CHF	EUR	JPY	MXN	HKD
AUD	12.0	7.9	9.0	2.1	2.8	5.9	7.8	0.2
CAD		5.3	5.9	0.7	1.6	2.6	5.3	0.1
GBP			7.4	3.1	4.0	3.2	6.2	0.1
CHF				8.6	7.3	4.1	1.1	0.0
EUR					7.4	0.2	2.5	0.1
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- Low cross-elasticity between EUR and JPY because of Euro-Yen factor.
- MXN and HKD as sanity check.

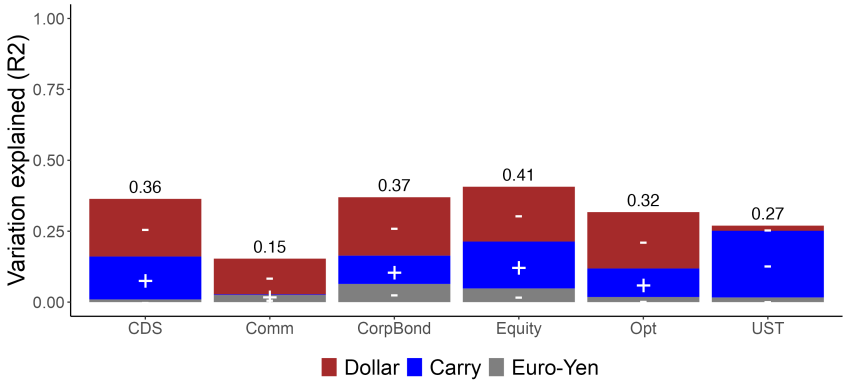
Cross-elasticity between asset classes

$$\frac{\partial \text{ asset-}n \text{ price}}{\partial \text{ asset-}m \text{ demand}} = \sum_{k=1}^{K} \frac{\partial \text{ factor-}k \text{ demand}}{\partial \text{ asset-}m \text{ demand}} \times \frac{\partial \text{ factor-}k \text{ price}}{\partial \text{ factor-}k \text{ demand}} \times \frac{\partial \text{ asset-}n \text{ price}}{\partial \text{ factor-}k \text{ price}}$$

$$= \sum_{k=1}^{K} \beta_{m,k} \times \lambda_k \text{var}(r_{k,t}) \times \beta_{n,k}$$

- Can apply cross-elasticity formula to non-FX assets if other asset classes also load on the FX factors.
  - Common exposure could arise from intermediaries hedge risks across markets.
  - 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*.

Asset elasticity to traded FX factors

	CDS	Comm	CorpBond	Equity	Option	UST
Dollar	-2.0	-5.0	-2.8	-4.4	-4.4	-0.5
Carry	3.7	1.6	3.7	7.9	6.1	-2.3
Euro-Yen	-2.5	-10.3	-7.3	-10.8	-6.6	-1.6

- Dollar: modest impact although most asset classes load heavily on the factor.
  - Dollar is the most elastic among the 3 factors.
- Carry and Euro-Yen: stronger price responses.
  - But recall: magnitude of flow shocks to these are about 1/3 of Dollar's.
- Price impact from FX shocks: depends on direction and magnitude of currencies' loading on traded FX factors.
  - Δ currency $\neq \Delta$ risk: not all shocks are created equal.

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 after trading demand shocks.

Conclusion and connections to the literature

- This paper extends priced non-diversifiable risks (Ross, 1976) to representative intermediary (review by He and Krishnamurthy, 2017).
  - Identifies 3 traded risk factors that account for 90% of the non-diversifiable risks borne by intermediaries when accommodating FX trading.

- This paper links trading quantities to asset prices (e.g., Froot and Ramadorai, 2008; Koijen and Yogo, 2019) through *risks*, in contrast to IO models.
  - IV analysis finds that intermediaries raise prices by 5 to 30 bps in response to $1 billion net 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 the cross-elasticity of the whole panel of currencies and across 7 major 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

Unconditional risk factors via standard PCA

- The standard PCA identifies risk factors as those that maximally explain the variance of the (unconditional) returns $\mathbf{R}$.
- The first factor is defined by a vector of N-currency portfolio weights $\mathbf{b}_1 = (b_{1,1}, b_{2,1}, \ldots, b_{N,1})^\top$ that maximizes $\text{var}(\mathbf{b}_1^\top \mathbf{R})$.
- The second factor $\mathbf{b}_2$, conditional on being uncorrelated with the first factor, i.e., $\text{cov}(\mathbf{b}_1^\top \mathbf{R}, \mathbf{b}_2^\top \mathbf{R}) = 0$, again aims to maximize $\text{var}(\mathbf{b}_2^\top \mathbf{R})$, and so on.
- Ross (1976) APT: these factors price unconditional expected returns in the cross-section.

Details of intermediary optimization

- A unit mass of competitive intermediaries collectively hold a total of $\$S_k$ in factor k and absorb the trading demand shock q_k, which changes the factor-k price from $P_k(0)$ to $P_k(q_k)$.
- By market clearing, the intermediaries sell $\$q_k$ and retain $\$S_k - q_k$ of factor k after accommodating the trading demand shock.
- The equilibrium price $P_k(q_k)$ is set such that it is optimal for intermediaries to sell $y_k = q_k$ dollars or $y_k/P_k(0)$ units of factor k at the new price $P_k(q_k)$,

$$\{q_1, \ldots, q_K\} = \arg \max_{\{y_1, \ldots, y_K\}} \mathbb{E}\left[-\exp\left(-\sum_{k=1}^{K} \gamma_k ((S_k - y_k)\mathbf{b}_k^\top \mathbf{R} + R_{F,USD} P_k(q_k) y_k / P_k(0)) \right) \right]$$

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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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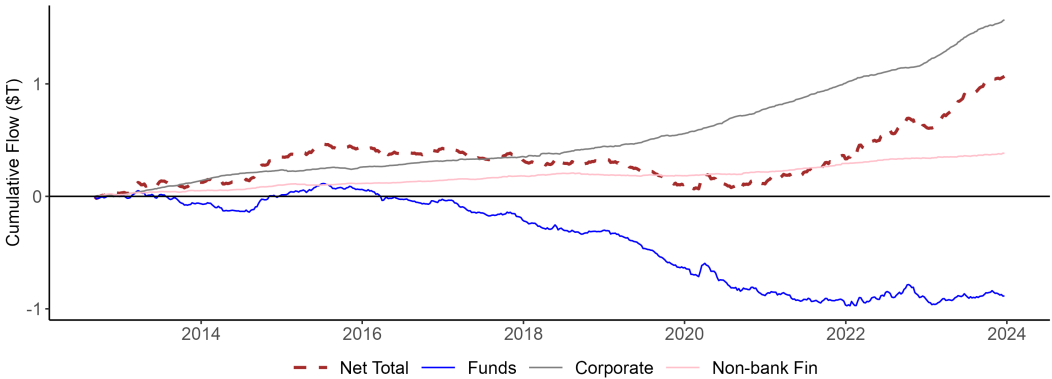
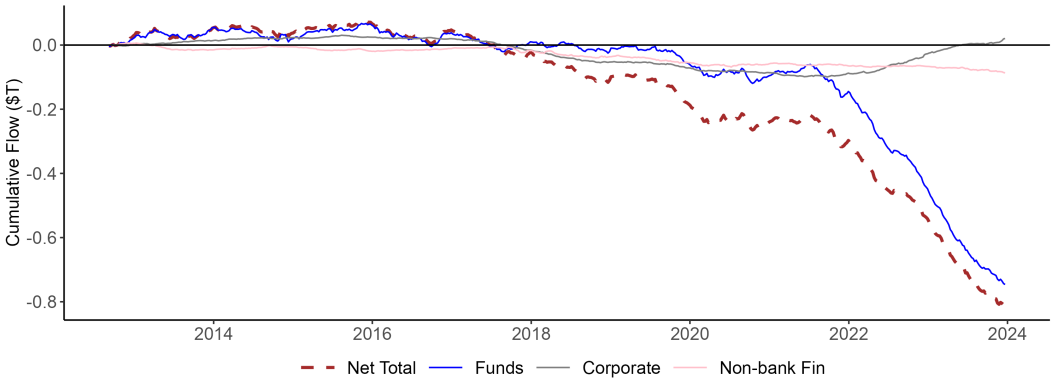
Flow to Dollar factors



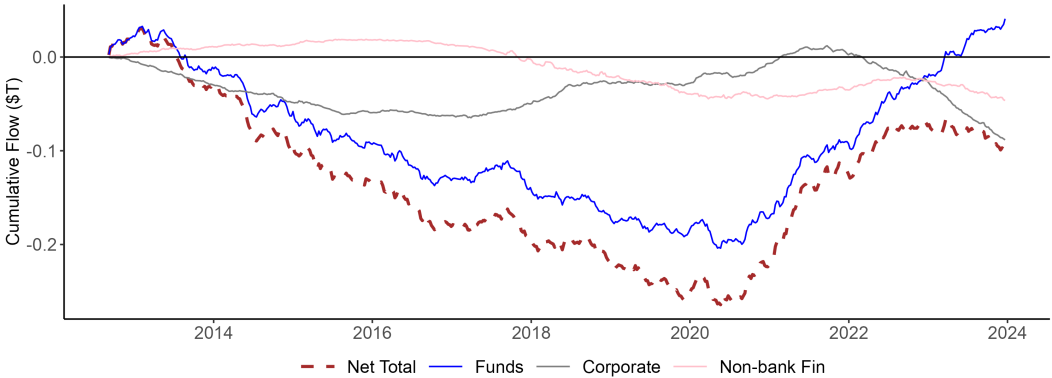
- Funds are persistently selling Dollars, whereas Corporates are buying.
- In recent years, intermediaries have been be net sellers of the Dollar factor.

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.

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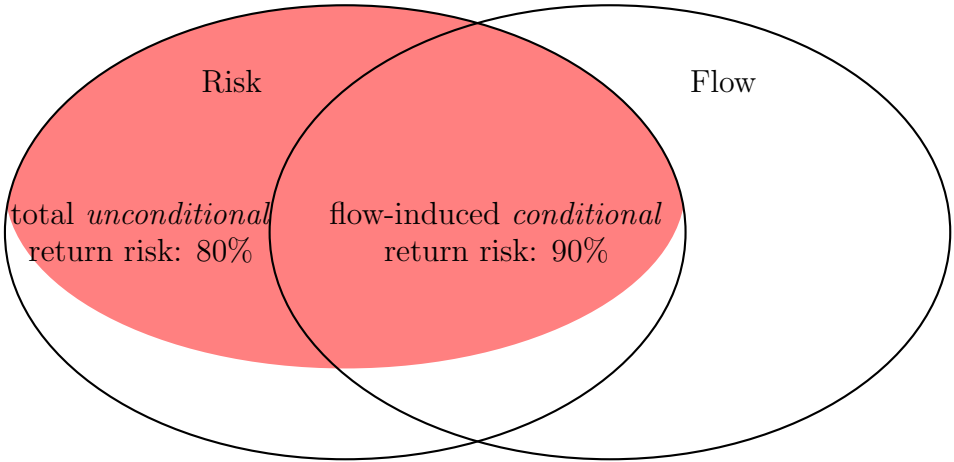
Unconditional v.s. Conditional Risk: % Explained



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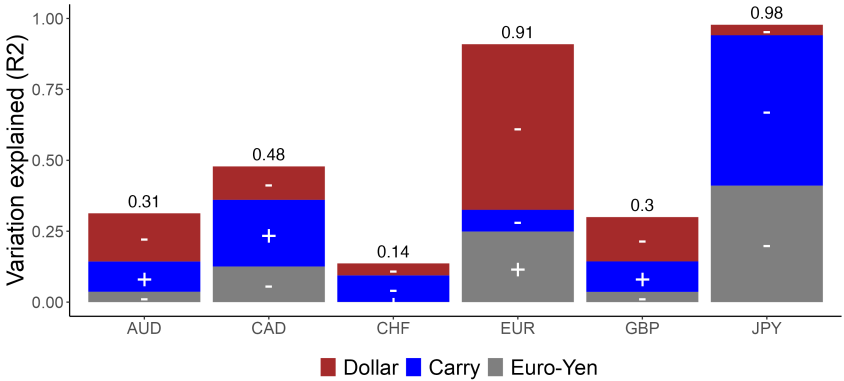
Flow Variation Explained by FX factors



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Time-varying λ for the Dollar factor

	Baseline	CIP deviation	Swap line usage
Factor flow	0.107***	0.160*	0.106***
	(0.037)	(0.092)	(0.029)
Flow × CIP dev		0.063	
		(0.130)	
CIP deviation		0.172	
		(0.178)	
Flow × swap line			-0.056*
			(0.034)
Swap line usage			-0.449**
			(0.217)
Observations	386	386	385

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