Banks, Dollar Liquidity, and Exchange Rates

by Bianchi (MPLS FED) Bigio (UCLA) Engel (UW)
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Intro

> Motivation

UIP Deviation

$$\mathcal{L} = \underbrace{\mathbb{E}\left[\frac{1+i^m}{1+\pi}\right]}_{\text{€ Exp Real Ret}} - \underbrace{\mathbb{E}\left[\frac{1+i^{*,m}}{1+\pi}\cdot\frac{e'}{e}\right]}_{\text{\$ Exp Real Ret}}$$

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* Why relevant?
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    - Alvarez-Atkeson-Kehoe

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* ...but what's behind $\mathcal{L}$?

> Contribution

* Literature: risk premium
  * habits: Verdelhan 2010
  * long-run risk: Colacito & Croce 2013
  * tail risk: Farhi & Gabaix 2016
  * information+behavioral: Bacchetta & van Wincoop '06 | Gourinchas & Tornell '04

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- Literature: financial frictions
  - segmented markets: Alavarez, Atkeson, Kehoe 2009 | Itskhoki & Mukhin 2019
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* Paper: settlement frictions
  * **$ deposits** are international medium of exchange
  * settlements frictions
  * **$ reserve** assets ease settlement friction
  * "scramble for dollars" rather than "flight to safety"

> Main Feature | UIP and FX

Deviations from UIP

$$\underbrace{\mathcal{L}\left(\mu, \mu^*, \Theta\right)}_{\$\ \text{LP}} = \mathbb{E}\left[\frac{1+i^m}{1+\pi}\right] - \mathbb{E}\left[\frac{1+i^{*,m}}{1+\pi} \cdot \frac{e'}{e}\right]$$

$$\begin{aligned} \mu &= \text{€ reserve asset/ € deposit ratio} \\ \mu^* &= \text{\$ reserve asset/ \$ deposit ratio} \\ \Theta &= \text{transactions, technology, policy shocks} \end{aligned}$$

* $\mathcal{L}$: encodes frictions

> Talk

- ⋆ Evidence
  - ∗ financial sector μ correlates w/ *e*
  - ∗ dispersion in interbank rates correlate w/ *e*

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- ⋆ Theory:
  - ∗ principle: interbank market unsecured
  - ∗ frictions $\Rrightarrow$ deviations UIP
  - ∗ FX determination

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  - ∗ FX determination
- ⋆ Fit regressions with shocks to:
  - ∗ payment (volatility)
  - ∗ US interest rate shocks

Empirical Evidence

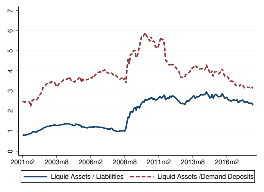
> Empirical Result: $\mathcal{L}$ and Fed Funds dispersion

* Exchange rates
  * G10 currencies, 2001:m1- 2018:m1
* Regression:
  * Δe vs. interest differential
  * $+$ bank liquid-asset/short-term fund ratio:

$$\text{Liquid Assets} \equiv \text{Reserves} + \text{US Treasury}$$

and

$$\text{Short-Term Fund} \equiv \text{Demand Desposits} + \text{Fin. Commercial Paper}$$



$ Liquidity Ratio

> Empirical Result: $\mathcal{L}$ and Liquidity Ratio

* Baseline regression

$$\Delta e_t = \alpha + \beta_1 \Delta\left(\mu_t^*\right) + \beta_2(\pi_t - \pi_t^*) + \beta_3 \mu_{t-1} + \epsilon_t$$

where

$$\mu \equiv \frac{\text{liquid assets}}{\text{short-term funds}}$$

Baseline Regression

	EU	AU	CA	JY	NZ	NK	SK	SW	UK
$\Delta\left(\mu_t\right)$	**0.23*** **	**0.24*** **	**0.13*** **	**-0.15*** **	**0.30*** **	**0.19*** **	**0.21*** **	**0.15*** **	**0.17*** **
$\pi_t - \pi_t^*$	-0.54***	-0.42**	-0.41*	0.01	-0.71***	-0.11	-0.49**	-0.67***	-0.39**
μ_{t-1}	0.01**	0.01	0.01	0.00	0.01	0.01*	0.01	0.01	0.01*
cons	-0.01***	-0.00	-0.01*	-0.00	-0.01**	-0.01*	-0.01**	-0.02***	-0.01
N	234	232	234	234	232	234	234	234	234
adj. R^2	0.11	0.05	0.03	0.03	0.10	0.03	0.05	0.04	0.04

t statistics in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

> Empirical Result: $\mathcal{L}$ and Settlement Frictions

* Evidence of settlement frictions

$$\Delta e_t = \alpha + \beta_1 \Delta(\sigma_t) + \beta_2(\pi_t - \pi_t^*) + \epsilon_t$$

where

$$\sigma_t \equiv \text{US LIBOR} \mid \text{Average Monthly Bid-Ask Spread}$$

Baseline Regression

	EU	AU	CA	JY	NZ	NK	SK	SW	UK
$\Delta(\sigma_t)$	**0.02****	**0.06*****	**0.03*****	**-0.03*****	**0.04*****	**0.04*****	**0.04*****	**0.01*****	**0.03*****
$\pi_t - \pi_t^*$	-0.38***	-0.11**	-0.12*	0.02	-0.38***	-0.05	-0.47**	-0.542***	-0.13**
cons	-0.01***	-0.00	-0.01*	-0.00	-0.01**	-0.01***	-0.01**	-0.02***	-0.01**
N	226	226	226	226	226	226	226	226	226

t statistics in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

> Remarks

- Additional Regressions:
  - add VIX index | effect still there
  - adding rates to regression
- Liquidity Ratio
  - endogenous as result from demand|supply
  - ...but correlated with e
  - model: changes payments risk drive correlation
- Regressions
  - quantity variable: not return vs. return

Dynamic Two-Currency World

> Features

* Open-economy model related to Bianchi-Bigio (2020) closed economy
    * stochastic GE, infinite horizon, discrete time
    * 2-country: Euro | US foreign

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  - 2-country: Euro | US foreign

- Action: "global banks"
  - assets: b real loans | m reserves in \$ and €
  - liabilities: d liabilities in \$ and €
  - payment shocks | settlement friction

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  - stochastic GE, infinite horizon, discrete time
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- Preferences & Tech
  - Microfoundation by design: static loan demand and deposit supply
  - firms: working capital loans
  - consume | work | CIA in two currencies | **risk neutral**
- Central bank
  - set policy rates | reserve supply | transfers
- Aggregate shocks
  - payment volatility
  - policy

> Environment

* Time: t, discrete, infinite horizon
* X_t vector of aggregate shocks

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* Time: t, discrete, infinite horizon
* X_t vector of aggregate shocks
* P_t denominated in €, P_t^* denominated in \$
  * dollar denominated
* One good (LOP)

$$P_t = P_t^* e_t$$

* Real Expected Returns:

$$R^x = \mathbb{E}\left[\frac{1+i^x}{1+\pi}\right], \; R^{*,x} = \mathbb{E}\left[\frac{1+i^{*,x}}{1+\pi^*}\right]$$

> Bank's Problem w/o Frictions

- Bank maximizes:

$$v(n, X) = \max_{\{\tilde{b}, \tilde{m}^*, \tilde{d}^*, \tilde{d}, \tilde{m}\} \geq 0} Div + \beta \mathbb{E}\left[v\left(n', X'\right) | X\right]$$

w/ budget

$$Div + b + m^* + m = n + d + d^*$$

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* No equity frictions so:

$$v(n, X) = n.$$

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* Expected net-worth:

$$\mathbb{E}\left[n'|X\right] = \underbrace{R^b b + R^m m + R^{m,*} m^* - R^d d - R^{*,d} d^*}_{\text{Expected Portfolio Returns}}$$

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* Without frictions

$$\frac{1}{\beta} = R^b = R^m = R^{m,*} = R^d = R^{*,d}$$

and

$$\mathcal{L} = 0$$

> Bank's Problem w/ Settlement Frictions

* Net-worth

$$\mathbb{E}\left[n'|X\right] = \underbrace{R^b b + R^m m + R^{m,*} m^* - R^d d - R^{*,d} d^*}_{\text{Expected Portfolio Returns}}$$

$$+ \underbrace{\mathbb{E}\left[\chi^*(s^*|\theta^*)\right] + \mathbb{E}\left[\chi(s|\theta)\right]}_{\text{Expected Settlement Costs}}$$

> Bank's Problem w/ Settlement Frictions

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* Background: b is illiquid | d circulates | m settles
* Settlement balance:

$$s = \begin{cases} m + \delta d \text{ pr. } 1/2 \\ m - \delta d \text{ pr. } 1/2 \end{cases} \text{ and } s^* = \begin{cases} m + \delta d \text{ pr. } 1/2 \\ m - \delta d \text{ pr. } 1/2 \end{cases}.$$

* χ capture settlement costs

> Bank's Problem

* Replace b from budget constraint:

$$\begin{aligned} \mathbb{E}\left[n'|X\right] &= R^b\left(n - Div\right) \\ &+ \underbrace{\left(R^b - R^d\right)d - \left(R^b - R^m\right)m + \mathbb{E}\left[\chi(s|\theta)\right]}_{\text{€ return}} \\ &+ \underbrace{\left(R^b - R^{*,d}\right)d^* - \left(R^b - R^{*,m}\right)m^* + \mathbb{E}\left[\chi(s^*|\theta)\right]}_{\text{\$ return}} \end{aligned}$$

> Portfolio w/ Settlement Frictions

Portfolio Separation

* Indeterminate *Div*
* $R^b = 1/\beta =$ Return on Equity
* Portfolio: $\{m, d\}$ and $\{m^*, d^*\}$ solved separately

> Portfolio w/ Settlement Frictions

* Bank Objective

$$\Pi = \max_{\{m,d\}} \underbrace{\left(R^b - R^d\right)}_{\text{Arbitrage}} \cdot d - \underbrace{\left(R^b - R^m\right)}_{\text{Liq. Insurance}} \cdot m + \underbrace{\mathbb{E}\left[\chi(s)|\theta\right]}_{\text{Settlement Cost}}$$

* Settlement balance:

$$s = \begin{cases} m + \delta d \text{ pr. } 1/2 \\ m - \delta d \text{ pr. } 1/2 \end{cases}$$

* χ average settlement cost
    * source of curvature

> Microfoundation - Intermediation Cost

* Bianchi and Bigio (17): OTC Fed Funds
  * Alfonso and Lagos ('15) + Atkeson et al. ('15)
  * Dynamic search for reserves:

$$\theta \equiv \frac{S^-}{S^+} = \underbrace{-\frac{\delta - \mu}{\delta + \mu}}_{\text{Tightness}}$$

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* Matching:
  * borrow: probability $\psi^-(\theta)$, else discount window
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* Clearing:

$$\psi^{-}(\theta) \cdot S^{-} = \psi^{+}(\theta) \cdot S^{+}$$

> Microfoundation - Intermediation Cost

Liquidity Yields

Penalty

$$\Delta R \equiv \underbrace{R^{dw}}_{\text{penalty}} - R^{m}$$

average liquidity yields:

$$\chi^{+} \equiv \psi^{+}(\bar{R} - R^{m}) \text{ and } \chi^{-} \equiv \psi^{-}(\bar{R} \text{-} R^{m}) + \Delta \mathrm{R}\left(1 - \psi^{-}\right)$$

and

$$\bar{R} \equiv \text{endogenous interbank rate} = f(\theta)\,.$$

* Function χ

$$\chi(s) = \begin{cases} \chi^{-} \cdot s & \text{if } s \leq 0 \\ \chi^{+} \cdot s & \text{if } s > 0 \end{cases}$$

> Portfolio w/ Settlement Frictions

* Simplified Objective

$$\Pi = \max_{\{m,d\}} \underbrace{\left(R^b - R^d\right) \cdot d}_{\text{Arbitrage}} - \underbrace{\left(R^b - R^m\right) \cdot m}_{\text{Liq. Insurance}} + \underbrace{\mathbb{E}\left[\chi(m,d)|\theta\right]}_{\substack{\text{Settlement}\\ \text{Cost}}}$$

$$\chi(m,d) = \begin{cases} \chi^- \cdot (m - \delta d) & \text{pr. } 1/2 \\ \chi^+ \cdot (m + \delta d) & \text{pr. } 1/2 \end{cases}$$

> Yields Equilibrium Rates

Liquidity Premia

For reserves

$$R^b = R^m + \underbrace{\frac{1}{2}\left[\chi^+ + \chi^-\right]}_{\text{reserve-LP}}$$

For liabilities

$$R^b = R^d + \frac{\delta}{2}\underbrace{\left(\chi^- - \chi^+\right)}_{\text{dep-LP}}$$

> Yields Equilibrium Rates

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$$R^b = R^m + \underbrace{\frac{1}{2}\left[\chi^+ + \chi^-\right]}_{\text{reserve-LP}}$$

For liabilities

$$R^b = R^d + \frac{\delta}{2}\underbrace{\left(\chi^- - \chi^+\right)}_{\text{dep-LP}}$$

Across currencies:

$$R^m + \underbrace{\frac{1}{2}\left[\chi^+ + \chi^-\right]}_{\text{reserve-LP}} = R^{*,m} + \underbrace{\frac{1}{2}\left[\chi^{*,+} + \chi^{*,-}\right]}_{\text{reserve-LP}}$$

* Liquidity premia: like "risk" premia
  * **NOT:** risk aversion | not limited equity
  * **YES:** currency payment size | settlement technology | monetary policy

> Global Asset Demand System

Asset Demand System

Deposit supply:

$$
\begin{aligned}
D &= \Theta_t^D \left(R_{t+1}^D \right)^{\epsilon^D} \\
D^* &= \Theta_t^{D,*} \left(R_{t+1}^{D,*} \right)^{\epsilon^{D,*}}
\end{aligned}
$$

Real loan demand:

$$B^* = \Theta_t^{B,*} \left(R_{t+1}^{B,*} \right)^{\epsilon^{B,*}}$$

> Central Bank

* Instrument:

$$i^m \to R^m \equiv \frac{1+i^m}{1+\pi}$$

* Instrument:

$$M$$

> Central Bank

- Instrument:

$$i^m \to R^m \equiv \frac{1+i^m}{1+\pi}$$

- Instrument:

$$M$$

- CB budget:

$$T + \text{Discount Window} = M(1+i^m) - M'$$

- T residual transfers

Theoretical Results

> Equilibrium Determination

FX Determination

Reserve Tightness:

$$\theta \equiv \frac{\delta - \mu}{\delta + \mu} \text{ and } \theta^* = \frac{\delta^* - \mu^*}{\mu^* + \delta^*}$$

UIP deviation:

$$\mathcal{L} = \frac{1}{2}\left(\chi^- + \chi^+\right) - \frac{1}{2}\left(\chi^{*,-} + \chi^{*,+}\right) = \mathbb{E}\left[\frac{1 + i^m}{1 + \pi}\right] - \mathbb{E}\left[\frac{1 + i^{*,m}}{1 + \pi} \cdot \frac{e'}{e}\right]$$

> Equilibrium Determination

FX Determination

Reserve Tightness:

$$\theta \quad \equiv \quad \frac{\delta - \mu}{\delta + \mu} \text{ and } \theta^* = \frac{\delta^* - \mu^*}{\mu^* + \delta^*}$$

UIP deviation:

$$\mathcal{L} = \frac{1}{2}\left(\chi^- + \chi^+\right) - \frac{1}{2}\left(\chi^{*,-} + \chi^{*,+}\right) \quad = \quad \mathbb{E}\left[\frac{1+i^m}{1+\pi}\right] - \mathbb{E}\left[\frac{1+i^{*,m}}{1+\pi} \cdot \frac{e'}{e}\right]$$

Price Determination (like Lucas 78, not quite)

$$M^*/P^* \quad = \quad \underbrace{\mu^* \; D^*\left(\mu^*\right)}_{\text{Real Deposits}}$$

and

$$e \equiv \frac{P}{P^*}$$

> Theorems | Special Case

- Following Propositions
  - deposit supplies perfectly inelastic
  - i.i.d shocks
- Then simulations

> Volatility

Dollar Payment Volatility

Let, δ_t^* be i.i.d. random variable

$$\omega^* = \begin{cases} \delta_t^* & \text{w prob.} 1/2 \\ -\delta_t^* & \text{w/ prob.} 1/2 \end{cases}$$

Then

$$\frac{d \log e}{d\delta^*} = \frac{d\log \mu^*}{d\delta^*} \geq 0$$

and

$$\frac{d \log(\mathcal{L})}{d\delta^*} > 0.$$

and same direction if random walk.

- Takeaway:
  - volatility: increases demand for dollars and appreciates FX

> Interest Rate

Effects of Policy Rates

Let, ΔR be fixed and i_t^m be i.i.d. Then,

$$\frac{d \log e}{d \log\left(1+i^{*,m}\right)} = \frac{d \log \mu^*}{d \log\left(1+i^{*,m}\right)} \in (0,1)$$

and

$$\frac{d \log\left(\mathcal{L}\right)}{d \log\left(1+i^{*,m}\right)} < 0.$$

and same direction if random walk.

* Policy effect: tighter US policy
    * appreciates dollar
    * Fama puzzle

> Other Theoretical results...

- Size:
  - i.i.d increase in \$ deposit demand: appreciates dollar, increase \$ liquidity premium and \$ dollar liquidity ratio
  - permanent shock: appreciates dollar, but irrelevant for premia
- Policy:
  - OMO different instruments than rates
  - FX Intervention interesting effects depending on country size
  - sterilized interventions

Producing the Data

> Calibration of Parameters

Calibration: match ratio levels and spreads

Exogenous Parameters

Parameter	Description	Target
Fixed Parameters		
$i_t^m = 2.14\%$	EU Safe Asset Rate	data
M^* / M	Relative Supplies of Reserves	normalized to match average e
$\Theta^{d,*} = \Theta^d = 40$	Deposit Demand Scales	Liquidity ratio of 20%
$\varsigma^* = \varsigma = 35$	Deposit Demand elasticity	[?]
$\sigma = 4\%$	EU withdrawal risk	$R^b - R^d = 2\%$
$\lambda^* = \lambda = 3.1$	US interbank market matching efficiency	$\mathcal{EBP} = R^b - R^{*,m} = 1\%$

> Moment Fit

Calibration: payment volatility process, to match FX

Calibrated Processes

Statistic	Data/Target	Model
Process for US withdrawal volatility (AR(1) process)		
$\mathbb{E}\left(\sigma_t^*\right) = 4\%$	average US withdrawal risk	empirical average $\mathcal{LP}$
$std\left(\sigma_t^*\right) = 0.12\%$	standard deviation	empirical std of $log\left(e\right)$
$\rho\left(\sigma_t^*\right) = 0.98$	mean reversion coefficient	empirical auto-correlation of $log\left(e\right)$
Process for US policy rate $i^{m,*}$ (AR(1) process)		
$\mathbb{E}\left(i_t^{*,m}\right) = 1.95\%$	average annual US policy rate	data
$std\left(i_t^{*,m}\right) = 2.1652\%$	std annual US policy rate	data
$\rho\left(i_t^{*,m}\right)$=0.99	auto-correlation annual US policy rate	data

> Moment Fit

Model and Data Moments

Statistic	Data/Target	Model
Targets		
$std(\log e)$	0.15	0.154
$\rho(\log e)$	0.98	0.99
$\mathbb{E}(\mathcal{LP})$	20bps	19.8bps
$\mathbb{E}(\mathcal{EBP})$	100bps	100.1bps
Non-Targeted		
$std(\log \mu^*)$	0.42	0.068
$\rho(\log \mu)$	0.99	0.99
$std(\pi_{eu} - \pi_{us})$	1.3	1.8
$\rho(\pi_{eu} - \pi_{us})$	0.93	0.98

> Model Regressions

Regression Coefficients with Simulated Data

	δ^*−shocks only	$i^{*,m}$−shocks only	both shocks
$\Delta(\text{LiqRat}_t)$	2.2**	1.1***	2.0***
(LiqRat_{t-1})	-0.001	-0.001	-0.004
$\Delta(i_t^m - i_t^{*,m})$		-42.5***	-14.5***
constant	-0.0	-0.02	-0.04
adj. R^2	0.99	0.99	0.99

t statistics in parentheses.

*** $p < 0.01$

Conclusion

> Conclusions

- Recent work: convenience yield | liquidity yields | specialness of $
  - source of convenience yield: liquidity of financial institutions
  - model: links liquidity | payment frictions | FX
  - empirically: evidence of correlation
- Comments welcome!