Banks, Dollar Liquidity, and Exchange Rates

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- Recent literature has focused on the regularity that the dollar appreciates in times of global volatility and uncertainty
- This makes the dollar a good hedge, and so dollar assets earn a low expected return

But why does the dollar appreciate when there is global volatility?

- It’s too late to buy insurance once the fire starts. We contribute one possible reason why demand for dollars increases.
- We build a model and present evidence that it is a demand for liquidity that drives the dollar.
    - A “scramble for dollars” rather than, or in addition to, a “flight to safety”.
- We locate this demand for liquidity in the financial intermediation sector. Increase in liquid assets/short-term funding a key indicator.

- Globally, short-term non-deposit funding to banks is heavily skewed toward dollars.
- When uncertainty increases, banks respond by increasing demand for dollar liquid assets. In the U.S. this includes reserves, and in all countries includes short term Treasury obligations.
- This increase in demand for liquid dollar assets leads to an appreciation of the dollar.

(For convenience, we call the financial intermediation sector “banks”. We call short-term liquid assets “reserves”, but these include assets such as U.S. government bills held by financial intermediaries outside the U.S.)

I’ll present some evidence to motivate our theory.
Then present a model that microfounds the demand for liquidity.
Then show that the model can account for the data.

Empirical Motivation

- We consider the behavior of the dollar/euro exchange rate, 2001:1-2018:1.
- We start with a conventional regression in which monetary policy (interest rates, inflation rates) drive exchange rate changes
- Add change in liquid asset/short-term funding (in dollars) ratio
  - Data only available in U.S. Assume same forces drive this ratio in non-U.S. banks
  - Liquid assets = reserves + U.S. Treasury assets held by banks
  - Short-term funding = demand deposits + financial commercial paper

$$\Delta e_t = \alpha + \beta_1 \Delta\left(DepLiqRat_t\right) + \beta_2 \Delta\left(i_t - i_t^*\right) + \beta_3\left(\pi_t - \pi_t^*\right) + \beta_4 DepLiqRat_{t-1} + \varepsilon_t$$

"Home" is Europe, "Foreign" is U.S., *e* is euros/dollar

$\beta_1 > 0$, $\beta_2 < 0$, $\beta_3 < 0$

Table 1: Relationship of change of exchange rates and measures of banking liquidity

	01M2-18M1	01M2-18M1	05M1-18M1	05M1-18M1
$\Delta(\text{LiqRat}_t)$	0.214***	0.223***	0.234***	0.251***
	(3.974)	(4.160)	(4.198)	(4.469)
$\Delta(i_t - i_t^*)$	-1.466		-2.498**	
	(-1.501)		(-2.356)	
$\pi_t - \pi_t^*$	-0.005***	-0.005***	-0.005***	-0.005***
	(-3.284)	(-3.227)	(-2.983)	(-2.888)
(LiqRat_{t-1})	0.009*	0.010**	0.009	0.012*
	(1.843)	(2.180)	(1.437)	(1.783)
constant	-0.011***	-0.012***	-0.011*	-0.012**
	(-2.965)	(-3.178)	(-1.959)	(-2.167)
N	204	204	157	157
adj. R^2	0.10	0.10	0.15	0.12

t statistics in parentheses.

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

Add VIX, but Liquidity Ratio's significance and size does not decline:

Table 2: Relationship of change of exchange rates and measures of banking liquidity, with VIX

	01M2-18M1	01M2-18M1	05M1-18M1	05M1-18M1
$\Delta(\text{LiqRat}_t)$	0.173***	0.179***	0.177***	0.189***
	(3.251)	(3.392)	(3.336)	(3.539)
$\Delta(i_t - i_t^*)$	-1.234		-2.079**	
	(-1.306)		(-2.100)	
$\pi_t - \pi_t^*$	-0.004**	-0.004**	-0.004**	-0.003*
	(-2.532)	(-2.472)	(-2.046)	(-1.941)
ΔVIX_t	0.002***	0.002***	0.002***	0.002***
	(3.956)	(4.038)	(4.960)	(5.101)
LiqRat_{t-1}	0.009**	0.010**	0.009	0.011*
	(1.979)	(2.284)	(1.554)	(1.866)
constant	-0.010***	-0.011***	-0.009*	-0.011*
	(-2.808)	(-2.991)	(-1.796)	(-1.975)
N	204	204	157	157
adj. R^2	0.17	0.16	0.26	0.25

t statistics in parentheses.

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

Add U.S. convenience yield (as in Du-Schreger, Engel-Wu, Jiang et al.)

Table 3: Relationship of change of exchange rates and measures of banking liquidity, with VIX and convenience yield

	01M2-18M1	01M2-18M1	05M1-18M1	05M1-18M1
$\Delta(\text{LiqRat}_t)$	0.173***	0.140**	0.187***	0.153***
	(3.345)	(2.590)	(3.599)	(2.739)
$\pi_t - \pi_t^*$	-0.003**	-0.003**	-0.003*	-0.004**
	(-2.147)	(-2.078)	(-1.672)	(-2.051)
ΔVIX_t	0.002***	0.002***	0.002***	0.002***
	(3.592)	(3.619)	(4.446)	(4.459)
$\Delta\eta_t$	4.909***	6.162***	4.882***	6.076***
	(3.235)	(3.777)	(3.182)	(3.568)
LiqRat_{t-1}	0.010**	0.011**	0.011*	0.016**
	(2.267)	(2.566)	(1.876)	(2.416)
η_{t-1}		2.297**		2.352
		(1.997)		(1.583)
constant	-0.010***	-0.016***	-0.010*	-0.020**
	(-2.876)	(-3.494)	(-1.916)	(-2.438)
N	204	204	157	157
adj. R^2	0.20	0.21	0.29	0.30

t statistics in parentheses.

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

Two points to note:

- The liquidity ratio is not an exogenous variable. It is endogenous in the economy and in the model.
    - We show how changes in uncertainty/volatility drive this correlation in the model

- These regressions account for exchange rate changes using a *quantity* variable rather than the usual regression of an exchange rate on financial return or price variables.
    - The exchange rate is not used in construction of the liquidity ratio.

The Model

- Based on Bianchi-Bigio (2019) closed-economy model
- 2-country (Europe is home, U.S. is foreign)
- General equilibrium, stochastic, infinite horizon, discrete time
- There is a single good, law of one price holds, prices flexible
- Households consume, supply labor, save in both currencies
- Firms produce using labor, have working capital requirement that requires loans
- Preferences, technology and environment are rigged up so that household and firm decisions are essentially static
- The action comes from bank behavior
    - Continuum of "global banks"
    - Assets: Loans to firms, euro "reserves" and dollar "reserves"
    - Liabilities: euro deposits, dollar deposits
- A vector of aggregate shocks, but will focus on shocks to volatility of withdrawals/deposits and to interest on reserves

Three preliminary comments:

- This draft is preliminary. Comments/suggestions welcome!
- This is not a banking model with Kiyotaki-Moore balance-sheet constraints. (Not like Gertler-Karadi or Gabaix-Maggiori.)
- Agents are risk-neutral. No risk premiums.

So what is going on?

- Banks hold liquid assets in case of unexpected deposit withdrawals
- If they run out of liquid assets they must undertake costly borrowing on interbank market, or even more costly borrowing from central bank discount window
- Increased volatility of dollar withdrawal/deposits leads to:
    - Higher liquid asset/deposit ratio for dollars
    - Higher "liquidity yield" on liquid dollar assets
    - Appreciation of the dollar

Banks

Each period there is an investment stage and a balancing stage. In the investment stage, banks choose:

loans to firms ($\tilde{b}_t$),
home (foreign) reserves $\tilde{m}_t$ ($\tilde{m}_t^*$)
home (foreign) deposits $\tilde{d}_t$ ($\tilde{d}_t^*$)
dividends, Div_t, all expressed in real terms.
Net worth, n_t, is a state variable.

Subject to constraint:

$$Div_t + \tilde{m}_t + \tilde{b}_t + \tilde{m}_t^* = n_t + \tilde{d}_t + \tilde{d}_t^*$$

In the balancing stage, deposits are either added to or withdrawn. If there is a withdrawal, bank *j* pays out of reserves. Must use euros to pay euro depositors, dollars to pay dollar depositors:

$$s_t^j = m_t + \omega_t^j d_t \qquad\qquad s_t^{j,*} = m_t^* + \omega_t^{j,*} d_t^*$$

where ω_t^j ($\omega_t^{j,*}$) is a random variable, mean-zero, adds to zero over all banks.

Focusing on home (foreign is analogous), if $s_t^j < 0$ must go to interbank market and search for funds from banks for whom $s_t^k > 0$.

There is a search and matching problem. Probability of a borrowing bank finding a match depends on market tightness:

$$\theta_t = S_t^- / S_t^+$$

S_t^- (S_t^+) is aggregate shortfall (surplus) of borrowing (lending) banks.

With probability $\psi^-(\theta)$ a bank with a shortfall makes a match and borrows at the interbank rate. Otherwise it must borrow from the central bank.

With probability $\psi^+(\theta)$ a bank with a surplus finds a match and lends at the interbank rate. Otherwise it earns interest on its unlent reserves.

The expected real cost of a shortfall (relative to real returns on reserves) is given by:

$$\chi^{-}(\theta)=\psi^{-}(\theta)\left(R^{f}-R^{m}\right)+\left(1-\psi^{-}(\theta)\right)\left(R^{w}-R^{m}\right)$$

Expected real gain for a bank with a surplus is:

$$\chi^{+}(\theta)=\psi^{+}(\theta)\left(R^{f}-R^{m}\right)$$

where i^{f} is interbank rate (determined by Nash bargaining),
i^{m} is interest on reserves (set by central bank)
i^{w} is discount window rate (set by central bank)
$i^{m}<i^{f}<i^{w}$, and $R^{z}=E\left[\left(1+i^{z}\right)/\left(1+\pi\right)\right]$

Banks choose assets and deposits to maximize expected value of the bank in investment stage.

Real Economy

Demand for deposits from households (arising from CIA constraint):

$$R_{t+1}^{d} = \Theta^{d}\left(D_t^{s}\right)^{-\varsigma} \qquad R_{t+1}^{*,d} = \Theta^{*,d}\left(D_t^{s}\right)^{-\varsigma^{*}}$$

And demand for working capital loans from firms:

$$R_{t+1}^{B} = \Theta^{b}\left(B_t\right)^{\varepsilon}$$

Government/ Central Bank

Each central chooses the two interest rates previously mentioned, as well as the nominal reserve supply, *M*. Let *W* denote discount-window loans. Government budget constraint:

$$M_t + T_t + W_{t+1} = M_{t-1}\left(1 + i_t^{m}\right) + W_t\left(1 + i_t^{w}\right)$$

Equlibrium

- F.O.C's for banks hold.
- Real economies' supply of deposits and demand for loans are satisfied.
- Supply of deposits equals demand for deposits.
- Demand for reserves equals supply of reserves.
- Law of one price holds.

Market tightness θ_t is consistent with the portfolios and the distribution of withdrawals while the matching probabilities, $\psi^{-}(\theta)$, $\psi^{+}(\theta)$ and the interbank rate, i^f, are consistent with market tightness θ_t.

Returns in Equilibrium

Let $\Phi\left(\frac{m}{d}\right)$ be the probability a bank ends up in deficit in reserves in the home currency, which is an endogenous object.

The expected excess return on one more unit of reserves is:

$$E\chi_m(s;\theta)=\left[\left(1-\Phi\left(\frac{m}{d}\right)\right)\chi^{+}(\theta)+\Phi\left(\frac{m}{d}\right)\chi^{-}(\theta)\right]$$

Similarly, we can define the expected excess return on one more unit of reserves in the foreign currency:

$$E\chi_{m^*}(s^*;\theta^*)=\left[\left(1-\Phi^*\left(\frac{m^*}{d^*}\right)\right)\chi^{+,*}(\theta^*)+\Phi^*\left(\frac{m^*}{d^*}\right)\chi^{-,*}(\theta^*)\right]$$

Then, in equilibrium we have:

$$R^b = R^m + E\chi_m(s;\theta) \quad \text{and} \quad R^b = R^{m,*} + E\chi_{m^*}(s^*;\theta^*)$$

We can use these two to write the deviation from UIP (in real terms):

$$R^m - R^{m,*} = \underbrace{E\chi_{m^*}(s^*;\theta^*) - E\chi_m(s;\theta)}_{\text{Dollar Liquidity Premium (DLP)}}$$

The euro (home) reserves pay a higher expected return when the dollar liquidity premium is higher.

A Couple of Results

A temporary increase in supply of dollar deposits increases the DLP.

- An unexpected increase in dollar deposits means banks are more likely to have a shortfall of reserves
- This increases the marginal value of reserves

An increase in the interest on dollar reserves lowers the DLP

- Higher interest on dollar reserves makes them more attractive, and so banks hold more (in real terms), thus lowering their marginal value
- Note how this goes in the direction of the Fama puzzle – higher U.S. interest rates implies lower ex ante excess returns on foreign bonds

The central bank has an *extra* instrument here, in that they can influence the DLP

Greater Volatility Appreciates the Dollar

Suppose ω (the fraction of deposits withdrawn/increased) takes on values δ or $-\delta$ with equal probability.

An increase in δ (i.e., an increase in volatility)

- increases the ratio of reserves/deposits
- increases the DLP
- appreciates the dollar

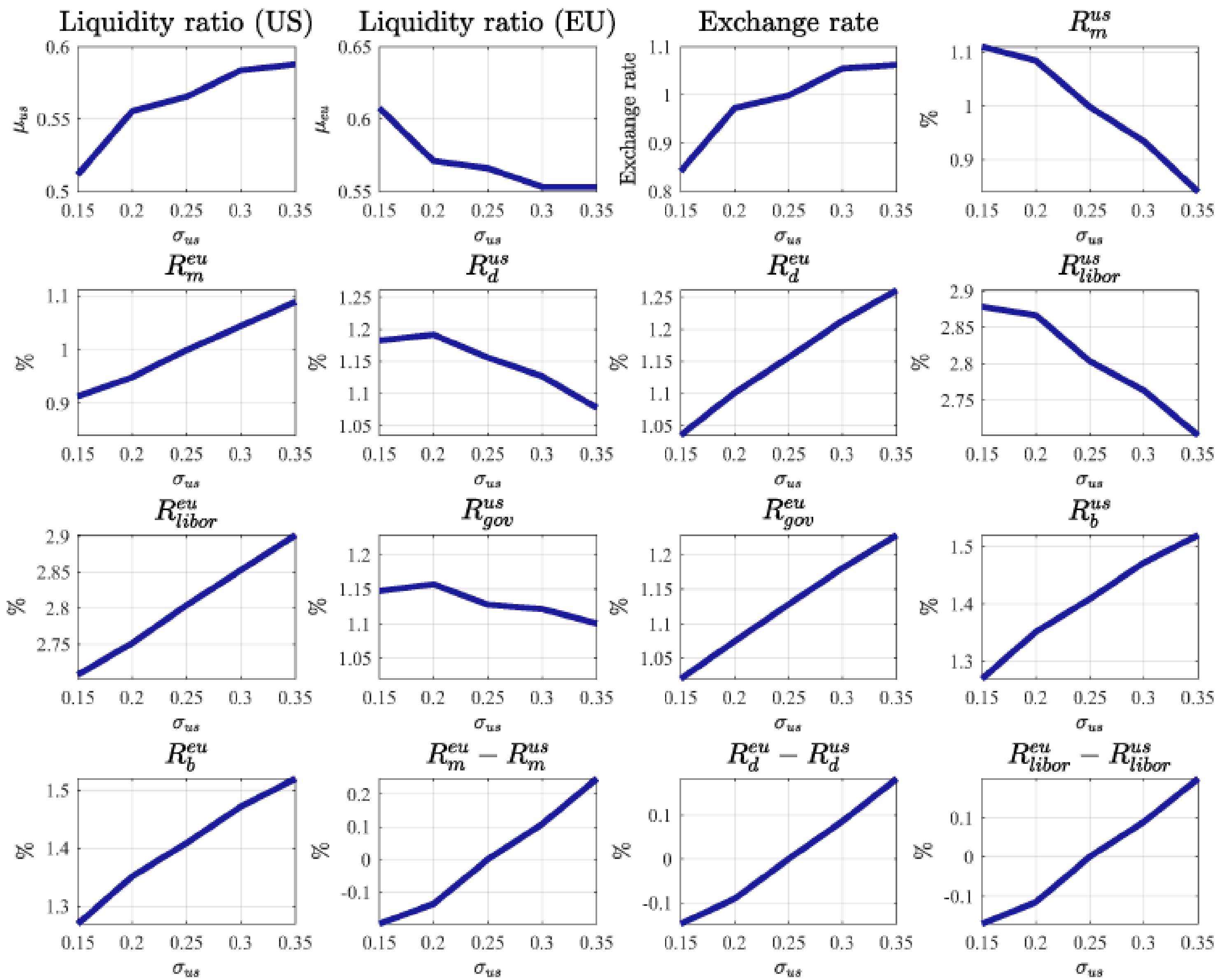
As volatility of deposits rise, the value of liquidity rises, and banks acquire more reserves.

Table 4: PARAMETRIZATION

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
$\Theta^b = 100$	Global loan demand scale	normalization
$\epsilon = -35$	Loan Elasticity	Bianchi and Bigio (2020)
$\Theta^{d,*} = 40$	US Deposit Demand Scale	Liquidity ratio of 20%
$\varsigma^* = 35$	US Deposit Demand Elasticity	Bianchi and Bigio (2020)
$\Theta^d = 40$	EU Deposit Demand Scale	symmetry
$\varsigma = 35$	US Deposit Demand Elasticity	symmetry
$\sigma = 4\%$	EU withdrawal risk	$R^b - R^d = 2\%$
$\lambda^* = 3.1$	US interbank market matching efficiency	$\mathcal{EBP} = R^b - R^{*,m} = 1\%$
$\lambda = 3.1$	EU interbank market matching efficiency	symmetric value of λ^*
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 autocorrelation 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	autocorrelation annual US policy rate	data

Table 5: Model and Data Moments

Statistic	Description	Data/Target	Model
Targets			
$std(\log e)$	Std. Dev. of log exchange rate	0.1538	0.154
$\rho\,(\log e)$	Autocorrelation of log exchange rate	0.9819	0.9922
$\mathbb{E}\,(\mathcal{LP})$	Average bond premium	20bps	19.8bps
$\mathbb{E}\,(\mathcal{EBP})$	Average bond premium	100bps	100.1bps
Non-Targeted			
$std(\log \mu^{*})$	Std. Dev. of dollar liquidity ratio	0.422	0.0656
$\rho\,(\log \mu)$	Autocorrelation of dollar liquidity ratio	0.9961	0.9924
$std(\pi_{eu} - \pi_{us})$	Std. Dev. of inflation differential	1.29	1.84
$\rho\,(\pi_{eu} - \pi_{us})$	Autocorrelation of inflation differential	0.925	0.98



Liquidity ratio (US)
Liquidity ratio (EU)
Exchange rate
R_m^{us}
R_m^{eu}
R_d^{us}
R_d^{eu}
R_{libor}^{us}
R_{libor}^{eu}
R_{gov}^{us}
R_{gov}^{eu}
R_b^{us}
R_b^{eu}
$R_m^{eu} - R_m^{us}$
$R_d^{eu} - R_d^{us}$
$R_{libor}^{eu} - R_{libor}^{us}$
μ_{us}
μ_{eu}
Exchange rate
%
σ_{us}

Regression from Model

Table 6: Regression Coefficients with Simmulated Data

	σ^*−shocks only	$i^{*,m}$−shocks only	both shocks
$\Delta(\text{LiqRat}_t)$	2.2484***	1.0763***	1.9735***
	(0.0015)	(0.0440)	(0.0450)
(LiqRat_{t-1})	-0.0007	-0.0014	-0.0037
	(0.0004)	(0.0007)	(0.0015)
$\Delta(i_t^m - i_t^{*,m})$		-42.4640***	-14.5032***
		(1.5185)	(1.6027)
constant	-0.0	-0.015	-0.039
	0.01	0.008	0.0017
adj. R^2	0.999	0.9987	0.9953

t statistics in parentheses.

*** $p < 0.01$

Conclusions

- Many recent papers have looked at convenience yields or liquidity yields, but not with strong microfoundations
  - We locate the source of the convenience yield in the value of liquidity for financial institutions
  - Our model then draws a link between observed liquidity ratios and the value of the dollar
- Empirically we find that connection – a link between exchange rates and a balance sheet quantity
- We have many things left to do with the model – both in refining the model and drawing out further implications
  - And more work to be done with the data, as well.
  - Comments welcome!