Trade Invoicing, Bank Funding, and Central Bank Reserve Holdings

By Gita Gopinath and Jeremy C. Stein*

* Gopinath: Harvard Economics Department, Littauer Center 206, Cambridge MA, 02138 (email: gopinath@fas.harvard.edu). Stein: Harvard Economics Department, Littauer Center 219, Cambridge MA, 02138 (email: jeremy_stein@harvard.edu). We are grateful to Chris Anderson and Taehoon Kim for outstanding research assistance.

In recent work (Gopinath and Stein (2017)) we explore how a currency like the dollar can become entrenched as a dominant global currency, focusing on the two-way feedback between trade invoicing and banking structure. The basic idea is that when a larger share of a country's imports are invoiced in dollars, its citizens have a greater demand for dollar-denominated safe claims. This in turn leads the local banking sector to become more dollarized, in the sense of funding itself more with dollar-denominated liabilities. Here we extend the framework of that paper to consider the implications for central-bank reserve holdings. We show that when a country's banks are more heavily dollar funded, this induces the central bank—in its role as lender of last resort—to hold a larger stockpile of dollar reserves.[1] We also provide some suggestive evidence which is consistent with this hypothesis.

I. The Model

We model the behavior of three sets of agents in a representative emerging-market country: households, banks, and the central bank. There are two dates, 0 and 1. The time-0 exchange rate ε_0 (in units of local currency per dollar) is normalized to 1. The time-1 exchange rate ε_1 is (1+*z*) with probability *p* = 0.5, and is (1–z) with probability (1–*p*) = 0.5. The parameter *z* is thus a proxy for the volatility of the exchange rate. In the event that $\varepsilon_1 = (1+z)$, i.e. that the local currency depreciates against the dollar, there is a probability *q* of a banking crisis which requires the central bank to bail out a fraction of the banking sector. Thus banking crises are correlated with a weaker domestic currency; this is a key assumption of the model.

[1] Other papers that analyze central-bank reserve holdings from the perspective of a lender of last resort include Obstfeld, Shambaugh and Taylor (2010) and Bocola and Lorenzoni (2017).

A. Households

Households have linear utility over consumption at time 0 and time 1. In addition, they also derive additional utility from holding safe claims, both in dollars and in local currency. Importantly, their relative taste for dollar safe claims is increasing in the fraction of dollar-invoiced goods that they import from abroad; this formulation follows Gopinath and Stein (2017). In particular, we assume that household utility is given by:

$$(1) \quad C_0 + \beta E_0(C_1) + \theta\alpha_\$ \log(D_\$) + \delta(1-\alpha_\$)D_h,$$

where $D_\$$ is the quantity of dollar-denominated safe claims held by the household sector, D_h is the quantity of local-currency-denominated safe claims, and $\alpha_\$$ is a proxy for the fraction of consumption goods that are dollar-invoiced. Note that we assume that utility is linear in D_h but concave in $D_\$$; this is done solely to simplify the algebra but is of no real consequence.

Maximizing household utility subject to the usual budget constraints yields these first-order conditions:

$$(2) \qquad Q_h = \beta + \delta(1-\alpha_\$),$$

$$(3) \qquad Q_\$ = \beta + \frac{\theta\alpha_\$}{D_\$},$$

where Q_h is the time-0 price of a safe-local currency claims that pays off 1 at time 1, i.e., $Q_h = 1/(1+r_h)$, and $Q_\$$ is the time-0 price of a safe dollar claim that pays off 1 at time 1, i.e., $Q_\$ = 1/(1+r_\$)$. We assume that $Q_\$$ is exogenously determined in world markets, and unaffected by any decisions made in the small emerging-market country under consideration. This means that equation (3), along with the parameter $\alpha_\$$, serves to pin down the quantity $D_\$$. As we explain in more detail below, local residents' holdings of $D_\$$ can come from one of two sources: they can either be provided by local banks when these banks borrow in dollars, or they can be acquired from abroad, as there is effectively an elastic supply of safe dollar claims (think Treasury securities) available at the exogenous price of $Q_\$$.

By contrast, Q_h is dependent on local factors, and in particular is decreasing in $\alpha_\$$. For notational convenience, we define the "spread" S as

$$(4) \qquad S \equiv \frac{Q_\$}{Q_h} - 1 = \frac{Q_\$}{\beta + \delta(1-\alpha_\$)} - 1.$$

This spread tells us that safe dollar claims are more highly valued—or alternatively, have a lower relative interest rate as compared to local currency claims—when the country imports a larger share of dollar-invoiced goods.

B. Banks

There are a continuum of identical banks of measure one. The representative bank is endowed with a set of positive-NPV projects that it needs to finance. The cost of these projects at time 0 is given by F. In non-crisis states, the projects always pay off more than F. In a crisis state, each bank faces an independent probability of m that it fails and its projects pay off 0, leaving the bank with no resources to pay off its debts, but in this case the bank is fully bailed out by the central bank. Given this bail-out feature, each bank can always finance itself entirely with deposits that are seen as riskless from the perspective of depositors. It can choose to issue either dollar deposits $B_\$$ or local-currency deposits B_h, subject to the financing constraint:

$$Q_h B_h + Q_\$ B_\$ = F. \tag{5}$$

On the one hand, the bank seeks to minimize its funding cost, which can lead it to borrow in dollars if dollar deposits have a lower interest rate. On the other hand, doing so can expose it—or, equivalently, the local firms it lends to—to exchange-rate mismatch, which can be costly. We assume that these mismatch costs are incurred only in those states of the world where the local currency depreciates (which happens with probability p) and conditional on being in those states are given by $\phi B_\$^2 / 2$.[2]

Thus overall, the bank seeks to minimize:

$$\begin{aligned} &(1-p)[B_h + (1-z)B_\$] + \\ &(p(1-q) + pq(1-m))[B_h + (1+z)B_\$] + \\ &p\phi B_\$^2 / 2, \end{aligned} \tag{6}$$

subject to the financing constraint in (5). The first term in (6) is the repayment the bank makes in the state when the local currency appreciates, and the second term is the repayment it makes in the states when the local currency depreciates but the bank itself does not fail; recall that the bank does not pay anything when it does fail, as it is bailed out by the central bank in this case. Finally, the last term is the expected cost to the bank (and its borrowers) of currency mismatch.

[2] To micro-found this quadratic functional form, one can assume that when a bank funds itself in dollars, it hedges its own currency risk by turning around and lending the same amount in dollars to a continuum of local firms who face heterogeneous costs of distress (say due to liquidity constraints) when the local currency depreciates relative to the dollar. If these distress costs are uniformly distributed on some interval, the quadratic formulation we posit will follow.

This objective function leads to a first-order condition for the bank in an interior optimum:

$$B_{\$} = \frac{1}{\phi p}[(1 - pqm)S + pqmz]. \tag{7}$$

Note that since the spread S is pinned down by exogenous parameters, so is the solution for $B_{\$}$ in (7). As can be seen, there are two intuitive determinants of $B_{\$}$. First, banks borrow more in dollars when they are a cheaper source of funding relative to local currency, i.e. when S is higher. This in turns occurs when households purchase more dollar-invoiced imported goods. Second, there is a moral hazard effect in bank funding choice: banks borrow more in dollars when exchange rate volatility, as proxied for by z, is greater. This is because bailouts tend to occur when the dollar has appreciated, which means that from the bank's perspective, dollar borrowing effectively embeds a call option on the dollar.

Once $B_{\$}$ has been determined as in (7), B_h comes from the financing constraint in (5). Markets then clear as follows: banks' local-currency borrowings are the only source of local-currency deposits for households, so $B_h = D_h$. And households can obtain dollar safe claims either from local banks, or by purchasing them on the global market, so that $D_{\$} = B_{\$} + X_{\$}$, where $X_{\$}$ denotes the value of these non-locally-acquired dollar assets.

C. The Central Bank

What we call a "central bank" in our model is more accurately thought of as a consolidated government entity that encompasses both a monetary and a fiscal authority. We assume that the only objective of the central bank is to bail out depositors in the event of a banking crisis, and to do so while imposing the lowest deadweight cost of taxation. It has two tools available to do so: it can either hold dollar reserves ex ante, at time 0, or it can impose distortionary taxes on the household sector ex post, at time 1, to finance the bailout.

The basic tradeoff we are seeking to capture is this: on the one hand, if the central bank holds more dollar reserves, it will have to raise less in taxes in the crisis state, since the dollar is appreciating against the local currency in this state. Moreover, this benefit of holding dollar reserves is particularly valuable when the central bank has to bail out dollar-denominated deposits issued by the banking sector, which are also appreciating in value at the same time. On the other hand, holding dollar reserves is costly to the extent that they bear a lower interest rate than local-currency assets—i.e., a stockpile of dollar reserves earns a negative carry.

The central bank's balance sheet constraint at time 0 is given by:

$$Q_\$ R_\$ = Q_h B_h^c, \tag{8}$$

where $R_\$$ is the central bank's holding of dollar reserves on the asset side of its balance sheet, and B_h^c is its issuance of (interest-bearing) local-currency bills on the liability side.

At time 1, the central bank liquidates its dollar reserve holdings, and uses the proceeds, plus any taxes it raises, to pay off the maturing local-currency bills. Across the different states, the expected shortfall, or negative carry C that the central bank needs to finance with tax receipts, is given by:

$$C = SR_\$. \tag{9}$$

Simply put, holding reserves imposes an on-average cost to the central bank—and hence requires taxation at time 1—in proportion to the spread between dollar and local-currency interest rates. We assume that the taxes required to finance this expected negative carry impose deadweight costs that are linear in the amount of taxation.

If there is a banking crisis (which occurs probability pq), the central bank needs to raise an additional amount of tax τ_c given by:

$$\tau_c = m(B_h + (1+z)B_\$) - zR_\$. \tag{10}$$

The first term in (10) is the cost of bailing out the fraction m of the banking sector that has failed, and the second term is an offset that reflects the fact that the central bank has realized a capital gain of $zR_\$$ on its holdings of dollar reserves in this state of the world.

Unlike with the on-average negative carry, we assume that the deadweight costs of raising taxes to finance this additional crisis-related hole of τ_c are a convex function of τ_c. This is meant to crudely capture the idea that the marginal cost of raising taxes in the crisis state is more sharply increasing, due to strains on the sovereign's fiscal capacity. Thus, the central bank picks its optimal level of reserve holdings $R_\$$ to minimize:

$$C + pq\frac{\gamma}{2}\tau_c^2, \tag{11}$$

subject to the balance-sheet constraint in (8).

This yields the optimality condition for τ_c in an interior solution:

$$\tau_c = \frac{S}{pq\gamma z}. \tag{12}$$

Intuitively, the central bank relies more on ex post taxation—and thus less on dollar reserve holdings—to cover its bailout costs in the crisis state when the marginal deadweight cost of taxation γ is low, and when the spread S is high, since this implies a high carrying cost for dollar reserves. By contrast, taxation is less attractive relative to reserve holdings when z is large, i.e., when the dollar appreciates strongly in a crisis.

Using (12), along with (10) and (5), we can write the central bank's choice of $R_\$$ at an interior optimum as:

$$R_\$ = \frac{m(B_h + (1+z)B_\$) - \tau_c}{z} = \frac{m((z-S)B_\$ + F/Q_h)}{z} - \frac{S}{pq\gamma z^2} \tag{13}$$

Of particular interest is how $R_\$$ varies with the dollar-invoicing share $\alpha_\$$, or equivalently, with dollar-denominated bank funding $B_\$$, since these two variables are positively correlated. While we cannot unambiguously sign $dR_\$ / d\alpha_\$$ for all parameter values, it is easy to show that $dR_\$ / d\alpha_\$ > 0$ if either our proxy for exchange-rate volatility *z*, or the marginal cost of taxation in the crisis state γ, is sufficiently large. The former can be seen heuristically by looking at (13) and taking the limit as *z* goes to infinity; in this case we get the simpler expression $R_\$ = mB_\$$, implying that central bank reserves just match that fraction of the banking sector's dollar borrowing that will have to be bailed out in a crisis.

The intuition for this result is as follows. On the one hand, central bank reserves are a particularly attractive hedge against dollar-denominated borrowing by the banking sector, because both appreciate in value during a crisis, thereby limiting the central bank's need to raise taxes in this adverse state. However, an offsetting effect is that when $\alpha_\$$ is higher, the spread *S* is higher as well, which means that it is more costly for the central bank to stockpile reserves—the carry associated with doing so is more negative. However, as either z or γ becomes large enough, the first effect dominates the second, so that central bank dollar reserve holdings are primarily driven by the desire to hedge the currency risk associated with having to bail out dollar-denominated bank deposits.

II. Evidence

The model's empirical content can be summarized by saying that if we compare two countries *i* and *j*, and $\alpha_{\$i} > \alpha_{\$j}$, so that *i* has a greater share of dollar-invoiced imports than *j*, then we have two key predictions. First, *i* will have a more heavily dollarized banking system, i.e., $B_{\$i} > B_{\$j}$. Second, if either exchange-rate volatility z or the marginal cost of taxation in the crisis state γ, is sufficiently high, i's central bank will also hold more dollar reserves, i.e., $R_{\$i} > R_{\$j}$.

In Gopinath and Stein (2017), we present some evidence that is consistent with the first prediction.[3] Here we focus on the second. To do so, we obtain data on the dollar's share in a country's import invoicing from Gopinath (2015).[4] And we obtain data on the dollar's share in central bank foreign currency reserves from various sources.[5] We then plot the latter against the former for the 15 countries for which we have observations on both. The results can be seen in Figure 1, which shows a strong correlation between the two variables, with an R-squared of 0.50.

[Insert Figure 1 Here]

Of course, Figure 1 is nothing more than a simple correlation, and other interpretations are certainly possible. Nevertheless, it does appear to be strikingly consistent with the link between trade invoicing and central-bank reserve holdings that our theory emphasizes.

III. Discussion

We have focused on the model's positive content, but a couple of normative points may be worth further exploring. First, equation (7) highlights a moral hazard problem in bank funding choice, and suggests that if regulation does not lean explicitly against them doing so, banks will be inclined to tilt too much toward dollar-denominated borrowing relative to local currency-denominated borrowing. This is because bailouts tend to occur when the dollar is appreciating, and thus when the dollar claims that the banks get to walk away from are particularly valuable. Moreover the banks do not naturally internalize the carry cost that the central bank pays to stockpile dollar reserves against this contingency.

Second, in a richer model where $Q_{\$}$ was made endogenous, there might be something to say about the common-pool nature of dollar reserves. For example, when the central bank in country i chooses to hold more dollar reserves—rather than relying on ex-post

[3] Specifically, for 12 countries for which we have the data, we plot the dollar share in non-local-currency bank liabilities against the dollar share in import invoicing, and find a strong positive relationship.

[4] Gopinath (2015) computes for each country an average import-invoice share over the period 1999 to 2014, averaging across years for which the data are available.

[5] The 15 countries in our sample are: Slovakia (SK), Slovenia (SI), Ireland (IE), Switzerland (CH), Romania (RO), Norway (NO), Sweden (SE), United Kingdom (GB), Australia (AU), Ukraine (UA), Israel (IL), Brazil (BR), Korea (KR), Canada (CA), and Colombia (CO). In most cases we have reserve-composition data from 2016 or 2017, either from the IMF's International Reserves and Currency Liquidity Data, or from central bank annual reports. However, for Slovakia, Slovenia, Romania, United Kingdom and Colombia we are forced to use 2005 data reported in Wong (2007). Nevertheless, our results are almost identical if we exclude these five countries for which the data are relatively old.

taxation—as a means of protecting its own banking sector, it drives up $Q_{\$}$, or alternatively, drives down the safe dollar rate. This in turn tempts commercial banks in other countries to do more dollar funding, and induces their respective central banks to also hoard more dollar reserves. Although we have not worked out the details, we suspect that there may be some interesting cross-country externalities at play in such a setting.

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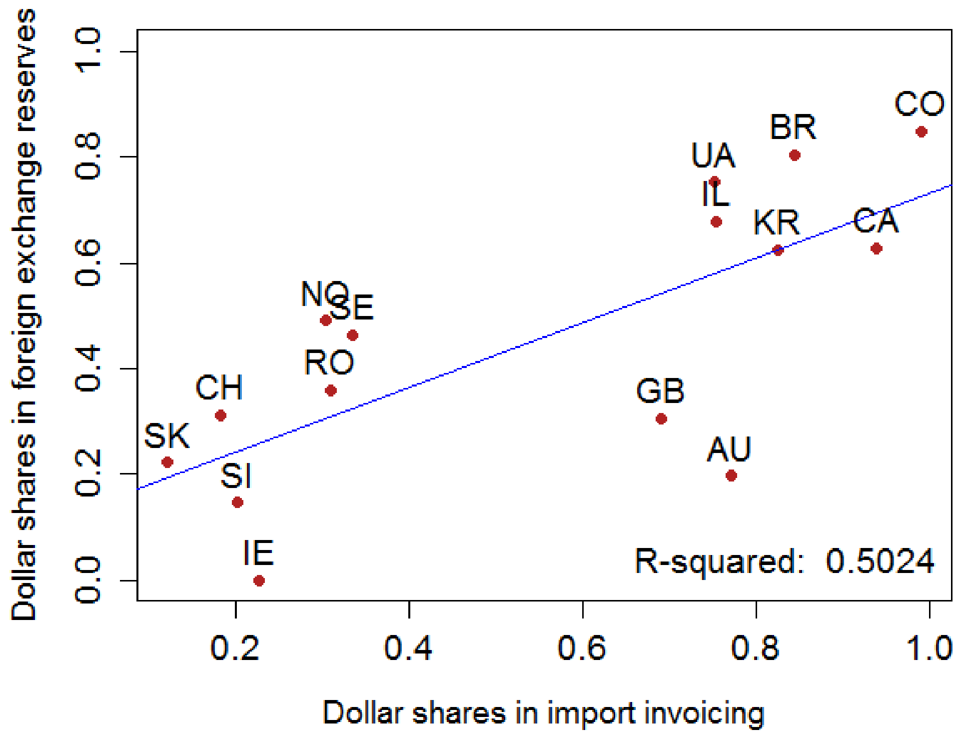

FIGURE 1. DOLLAR SHARE IN CENTRAL BANK FX RESERVES VS. DOLLAR SHARE IN IMPORT INVOICING

Note: The 15 countries in our sample are: Slovakia (SK), Slovenia (SI), Ireland (IE), Switzerland (CH), Romania (RO), Norway (NO), Sweden (SE), United Kingdom (GB), Australia (AU), Ukraine (UA), Israel (IL), Brazil (BR), Korea (KR), Canada (CA), and Colombia (CO).