Foreign Exchange Intervention Redux

Roberto Chang

Rutgers University and NBER

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Polar views about foreign exchange intervention:
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- Academic research: empirical evidence on sterilized FX intervention is mixed and inconsistent, which accords with the theory (e.g. Backus and Kehoe 1989).

Central bankers intervene frequently and often, and believe that FX intervention is beneficial and effective (Adler and Tovar 2011, Chutasripanish and Yetman 2015).
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Peru: FX Intervention (Daily, US$ Millions)

Source: Central Bank of Peru
Table 1. Stylized Facts of Foreign Exchange Purchases, 2004–10

<table>
<thead>
<tr>
<th>Frequency (Percent of working days)</th>
<th>Cumulative intervention as percent of GDP(^1,2)</th>
<th>Daily average (Millions of U.S. dollars(^1))</th>
<th>Daily maximum (Millions of U.S. dollars(^1))</th>
<th>Has there been active FX intervention in 2011?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chile</td>
<td>6</td>
<td>3.8</td>
<td>50</td>
<td>yes</td>
</tr>
<tr>
<td>Colombia</td>
<td>32</td>
<td>10.3</td>
<td>50</td>
<td>yes</td>
</tr>
<tr>
<td>Guatemala</td>
<td>19</td>
<td>1.6</td>
<td>9</td>
<td>yes</td>
</tr>
<tr>
<td>Mexico(^3)</td>
<td>1</td>
<td>0.6</td>
<td>600</td>
<td>yes</td>
</tr>
<tr>
<td>Peru</td>
<td>39</td>
<td>36.1</td>
<td>55</td>
<td>yes</td>
</tr>
<tr>
<td>Latin America(^4)</td>
<td>19</td>
<td>10.5</td>
<td>150</td>
<td>yes</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia(^5)</td>
<td>62</td>
<td>2.5</td>
<td>15</td>
<td>n.a.</td>
</tr>
<tr>
<td>Israel</td>
<td>24</td>
<td>22.3</td>
<td>84</td>
<td>no(^5)</td>
</tr>
<tr>
<td>Turkey</td>
<td>66</td>
<td>12.5</td>
<td>61</td>
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Source: Adler and Tovar (2011)
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To analyze FX intervention, then, it is crucial to allow for financial frictions, here external debt limits.

But to be consistent with the empirical evidence, the debt limits are taken to bind only occasionally.
A typical central bank balance sheet:

**Assets**
- FX reserves
- Net Credit

**Liabilities**
- Money Supply
- Net Worth
How FX Intervention "Really" Works

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- In the absence of financial frictions, banks borrow an offsetting amount from abroad, and credit to the private sector does not need to change.
- But if there a limit to external credit, it can be reached, and sterilization crowds out domestic loans.

Also Benes, Berg, Portillo and Vavra (2015), Vargas, González, and Rodríguez (2013), Cavallino (2017), Montoro and Ortiz (2017), Gabaix and Maggiori (2015). But in these other contributions financial frictions bite all the time, which may be unrealistic.

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In addition, the treatment here is much simpler and clarifies what is essential about sterilized FX intervention.
The mechanism just described:

- Does not rely on imperfect substitutibility of assets
- Is not about currency denomination or currency mismatches (although it can interact with them)
- Is not about policy signaling
- Does depend on financial frictions and institutions
- Has a close connection with the problem of reserves accumulation and...scal policy (quasi-...cal de...cits)
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- Does depend on financial frictions and institutions
- Has a close connection with the problem of reserves accumulation and fiscal policy (*quasi-fiscal deficits*)
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• Accumulation of FX reserves can be excessive and lead to a credit crunch
A policy of FX purchases in response to appreciation and sales when there is depreciation may help relaxing financial constraints when they bind, but also make them bind in response to appreciation.
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A superior FX intervention policy: to respond to *credit spreads*.
If there are nominal rigidities, FX intervention policy is irrelevant in a local approximation of the model.
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FX intervention can be an independent instrument, but one must take nonlinearities into account.
The Model
Commodities and Demand

Small open economy, $t = 0, 1, 2, \ldots$

Two traded goods, home and foreign

Price of foreign goods fixed at one in terms of an international currency (dollar)

Domestic consumption a Cobb Douglas function of home and foreign goods, with price in pesos (the CPI):

$$P_t = P_{ht}^{\alpha} E_t^{1-\alpha}$$

where $P_{ht}$ is the price of domestic output and $E_t$ the nominal exchange rate
Define the real exchange rate by 
\[ e_t = \frac{E_t}{P_{ht}}. \]

Total demand for domestic output:
\[ y_t = \alpha e_{t-1} \alpha t_c t + \{e_{t+\chi_t R. Chang (Rutgers University and NBER) FX Intervention Redux March 2018 12 / 53} \]
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\[ \Rightarrow \text{ Total demand for domestic output:} \]

\[ y_t = \alpha e_t^{1-\alpha} c_t + \kappa e_t^{\lambda} \]
Production

The home good is the usual Dixit Stiglitz aggregate.

Firm $i$ has technology $y_{it} = A_t n_{it}$

Assuming *flexible prices* for now, usual markup rule leads to

$$P_{ht} = \left(1 - \frac{1}{\epsilon}\right) MC_t = \left(1 - \frac{1}{\epsilon}\right) \frac{W_t}{A_t}$$
Rest of World

Interest rate $R^*$
Foreign debt $d(t)$

Banks

$\text{Interest rate } R^*$

$\text{Foreign debt } d(t)$

$\text{Domestic private loans } l(t)$

$\text{Loan Rate } 1 + \varrho(t)$

$\text{Equity } k(t)$

$\text{Financial Flows}$

Central Bank bonds $b(t)$
Rate $1 + \varrho(t)$

Central Bank

$F(t) = b(t)$

Households

Equity $k(t)$

Domestic private loans $l(t)$

Loan Rate $1 + \varrho(t)$
At the beginning of each period, a typical bank raises equity from households. It then borrows dollars from world investors, at an interest rate $R_t$. Financial frictions: $\theta_k$. The bank can issue domestic loans $l_t$ or purchase central bank bonds $b_t$. Loans and bonds are perfect substitutes and carry the same interest rate $\varphi_t$ (everything in dollars, for now). 

Banks' flow constraint: $b_t + l_t = k_t + d_t R$. 

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The bank’s profits are

\[ \pi_{t+1} = (1 + \varrho_t)(l_t + b_t) - R_t^* d_t \]
\[ = R_t^* k_t + (1 + \varrho_t - R_t^*)(l_t + b_t) \]
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Optimal policy:

- If $1 + \varrho_t > R_t^*$, $d_t = \theta k_t$, and so credit supply is $b_t + l_t = (1 + \theta)k_t$
- If $1 + \varrho_t = R_t^*$, indeterminate as long as $b_t + l_t = k_t + d_t$ and $d_t \leq \theta k_t$
Sterilized FX intervention: The central bank simply buys dollars by issuing bonds.

$$b_t$$ denotes the quantity of sterilization bonds as well as official FX reserves.
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$\implies$ Hence $b_t$ denotes the quantity of *sterilization* bonds as well as *official FX reserves*.

$\implies$ We assume that $b_t \geq 0$ (official reserves cannot be negative).
**Sterilized FX intervention:** The central bank simply buys dollars by issuing bonds.

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Crucial: sterilization bonds are financed by domestic banks, which can be subject to the external credit limit.
Between periods, the central bank invests official reserves at the external interest rate $R_t^*$.

$\implies$ In period $t$, the central bank has a quasifiscal deficit:

$$T_t = (1 + q_{t-1} - R_{t-1}^*) b_{t-1}$$
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We assume that $T_t$ is financed with a lump sum tax on households (but the role of the quasifiscal deficit is an open and interesting issue)
Households

Standard utility function which depends on consumption and labor effort.

Households borrow from banks and also can hold equity in banks, subject to the equity constraint:

\[ k_t \leq \tilde{k} \]

They receive an endowment of dollars \( z_t \) (e.g. copper income).
The budget constraint, in dollars:

\[ e_t^{-\alpha} c_t + k_t - l_t = (1 + \omega_{t-1}) R_{t-1}^* k_{t-1} - (1 + \rho_{t-1}) l_{t-1} + e_t^{-\alpha} w_t n_t + v_t + z_t - T_t \]
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\[ \implies \] The equity constraint binds in equilibrium if and only if the external constraint binds, so wlog we set \( k_t = \tilde{k} \)
Euler equation:

\[ c_t^{-\sigma} = \beta E_t c_{t+1}^{-\sigma} R_{t+1} \]

where:

\[ R_{t+1} = (1 + \rho_t) \left( \frac{e_{t+1}}{e_t} \right)^{\alpha} \]
Debt elastic interest rate (Schmitt Grohé-Uribe 2003):

\[ R_t^* = \bar{R}^* + \Psi(e_t^{\bar{l} - \bar{I}} - 1) \]
\[ = \bar{R}^* + \Psi(e_t^{d_t - b_t -(\bar{d}-\bar{b})} - 1) \]

where the world interest rate is \( \bar{R}^* \)
Equilibrium With Flexible Prices

Aggregate Supply:

\[ e_t^{-(1-\alpha)} c_t^{-\sigma} = (1 - \frac{1}{\epsilon}) \eta y_t^\phi / A_t^{1+\phi} \]

External balance:

\[ (1 - \alpha) e_t^{-\alpha} c_t - [z_t + \chi e_t^{\chi-1}] = d_t - b_t - R_t^* (d_{t-1} - b_{t-1}) \]

Collateral constraints:

\[ d_t = \theta \tilde{k} \quad \text{if} \quad 1 + \zeta_t > R_t^* \]

\[ d_t \leq \theta \tilde{k} \quad \text{if} \quad 1 + \zeta_t = R_t^* \]
Equilibrium is defined once we specify an FX intervention policy, i.e. a rule for choosing $b_t$. 
FX Intervention and Reserves Accumulation
Proposition: FX intervention can affect equilibria if and only if it affects binding financial constraints or makes the constraints bind in states of nature in which they would have not
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\[\Rightarrow\] Similar to Backus and Kehoe (1989)

\[\Rightarrow\] But, in contrast to BK, we explore what happens if FX intervention *does* matter.
For a precise statement: rewrite all equilibrium conditions, except the collateral constraints, in terms of a vector of variables that excludes $d_t$ and $b_t$.

The collateral constraints then can be rewritten as:

$$l_t = (1 + \theta)\bar{k} - b_t \text{ if } 1 + \rho_t > R_t^*$$

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- If constraint does not bind at $t$, a change in $b_t$ does not affect equilibria (unless it leads to a violation of the inequality)
- To affect equilibria, a change in $b_t$ must take place when constraint binds, or must make a nonbinding constraint bind.
\[ l_t = (1 + \theta)\tilde{k} - b_t \quad \text{if} \quad 1 + \psi_t > R_t^* \]

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When collateral constraints bind, a sale of FX reserves (a fall in $b_t$) results in an expansion of private loans. This reflects sterilization: selling reserves reduces the quantity of central bank bonds, making room for private credit. If $b_t$ cannot be negative, this can be seen as a benefit of reserves accumulation. Large average values of $b_t$, however, make it more likely that the collateral constraint binds, which can be seen as a cost of reserves accumulation.
Recall that in equilibrium:

\[ c_t^{-\sigma} = \beta E_t c_{t+1}^{-\sigma} R_{t+1} \]

where:

\[ R_{t+1} = (1 + \varrho_t) \left( \frac{e_{t+1}}{e_t} \right)^\alpha \]
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- Then real consumption based interest rate must adjust
- This requires changes in the loan interest rate as well as real exchange rates
Numerical Illustrations
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Numerical solution: \texttt{occbin} (Guerrieri and Iacovello)
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One cost: will not be able to talk about macroprudential issues.
A Transitory Fall in $z$
Consider a simple intervention policy of the form:

\[ b_t = \text{Max}\{\bar{b} + \rho_b (b_{t-1} - \bar{b}) + \epsilon_{bt}, 0\} \]

with \( \bar{b} \geq 0 \) the ss value of official reserves, and \( 0 \leq \rho_b < 1 \)
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with $\bar{b} \geq 0$ the ss value of official reserves, and $0 \leq \rho_b < 1$

$\Rightarrow$ Small $\varepsilon_{bt}$ do not affect real allocations (they are matched one for one by changes in $d_t$)

$\Rightarrow$ A sufficiently negative value of $\varepsilon_{bt}$ leads to the exhaustion of FX reserves

$\Rightarrow$ A large, positive $\varepsilon_{bt}$ brings the economy to the constrained region
A Large Purchase of FX Reserves
The average value of reserves, $\bar{b}$, affects the probability that financial constraints bind.
Low vs High Reserves
Response of $d(t)$ to the same shock to FX rule
Solid line: High $\bar{b}$. Dashed line: Low $\bar{b}$
Consider now a rule of the form:

\[ b_t - \bar{b} = \rho_b (b_{t-1} - \bar{b}) - \nu_e (e_t - \bar{e}) \]

Here, the central bank sells reserves in response to a real depreciation.
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2. In "normal" times i.e., if financial constraints do not bind, this policy does not affect equilibria as long as shocks and \( \nu_e \) are small enough.
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2. In "normal" times i.e., if financial constraints do not bind, this policy does not affect equilibria as long as shocks and \( \nu_e \) are small enough.

3. In fact, if \( \nu_e \) is too large, the policy may have perverse effects.
Intervention and Exchange Rate Stabilization
A policy that depends on the credit spread:

\[ b_t - \bar{b} = \rho_b (b_{t-1} - \bar{b}) - \nu (1 + \varrho_t - R_t^*) \]

is superior, in that it prescribes intervention only when financial constraints bind.
FX Intervention and Credit Spreads Stabilization
Nominal Rigidities
Introducing Price Rigidities

- Calvo protocol
Introducing Price Rigidities

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- Domestic inflation then has the form

$$\pi_{ht} = \beta E_t \pi_{h,t+1} + \lambda (\log mc_t - \mu)$$
Calvo protocol

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Marginal costs are

$$mc_t = \frac{MC_t}{P_{ht}} = \frac{(W_t / A_t)}{P_{ht}}$$

$$= \eta e_t^{1-\alpha} c_t^\sigma y_t^\phi / A_t^{1+\phi}$$
Monetary Policy

To close the model we need to specify a monetary policy rule.

For the time being, assume that the policy instrument is the expected consumption based interest rate:

\[ i_t \equiv E_t R_{t+1} = E_t (1 + \varrho_t) \left( \frac{e_{t+1}}{e_t} \right)^{\alpha} \]

And start with a Taylor rule such as:

\[ i_t = \log R^*_t + \phi_\pi \pi_t + u_{mt} \]
A (Large) Monetary Policy Contraction
Now we can use the model to understand interaction between monetary policy and FX Intervention
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Here FX is an independent policy tool.
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Here FX is an independent policy tool.

But nonlinearities are essential, and alter the analysis in significant ways.
Assume monetary policy is given by a Taylor rule. Then we see that:

1. If the economy is financially unconstrained, FX intervention is irrelevant for small enough shocks (unless it brings the economy to the financially constrained region).

2. In particular, FX intervention plays no useful role responding to shocks that imply an exchange rate appreciation.

3. Selling official reserves does play a beneficial role in response to an adverse shock that makes constraints bind.

4. An FX intervention rule that responds to credit spreads is better than one that responds to the exchange rate.
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Monetary Policy and FX Intervention

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Monetary Policy and Active FX Intervention
The Role of Currency Denomination and Mismatches
We have assumed that the economy is "financially dollarized"

But it is not too hard to introduce assets in domestic currency

The model looks almost the same if domestic loans and central bank debt are denominated in pesos
Allowing for Peso Securities
Our discussion on the effectiveness of FX intervention has not relied on the interaction between currency mismatches and balance sheet effects.

Clearly, one can add such effects in this model.

For instance, the equity constraint may be denominated in pesos, implying that $e_t^\alpha k_t \leq \tilde{k}$ rather than $k_t \leq \tilde{k}$.

In that case, a real depreciation tightens the debt limit.
Final Remarks
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- This perspective may explain e.g. why empirical evidence on the impact of foreign exchange intervention has been elusive.
- The effectiveness of FX intervention is tied to the degree of financial frictions and details of financial institutions.
- No "competitiveness" rationale for reserves accumulation.
- As mentioned, no discussion of macroprudential issues.
- Lots of room for further research, especially optimal policy, quasifiscal policy, and empirical issues.