New Data, Methods and Models around FX Intervention

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Context

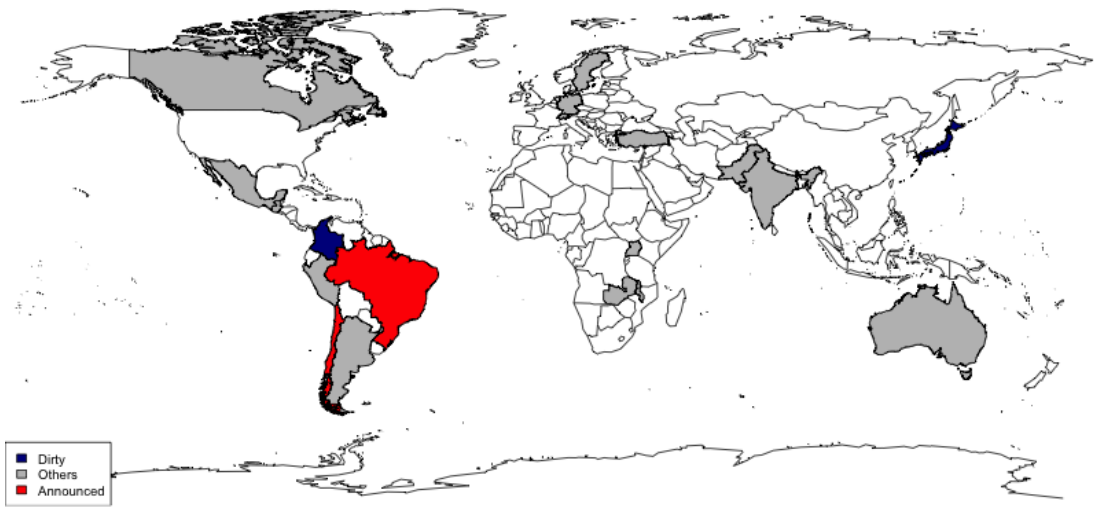
- The "*corner* or *bipolar hypothesis*" began to lose popularity after the East Asia crises (1997-98) and the failure of Argentina's currency board (2001) -Eichengreen (1994), Obstfeld and Rogoff (1995)

- Since then, many central banks have opted for monetary policy autonomy (but reluctant to relinquish control over currencies)
  - Developed economies have led concerted initiatives: Smithsonian Agreement (1971), Plaza Accord (1985), Louvre Accord (1987), Chiang Mai Initiative (2000) and Pittsburg Agreement (2009)
  - EMEs have frequently and widely intervened (less coordinated): Of the 19 central banks that respond to the BIS questionnaire, 1/3 intervene regularly ($>$ 50% of days) -Mihaljek (2005)

EMEs intervene so frequent to the extent of becoming an empirical regularity
-Calvo and Reinhart (2002), Neely (2005)

Context

Figure: Countries with Announced vs Secret Interventions



Taken from Arango et al. (2020) "The Effectiveness of FX Interventions: A Meta-Analysis" *Journal of Financial Stability*. The Figure shows 20 surveyed countries (the US is not colored because it represents the benchmark case)

Context

Table: Surveyed Countries and Decades

Country	1970	1980	1990	2000	2010	Total
ARGENTINA	0	0	0	1	0	1
AUSTRALIA	0	5	3	2	0	10
BRAZIL	0	0	1	5	4	10
CANADA	0	1	1	0	0	2
CHILE	0	0	1	3	2	6
COLOMBIA	0	0	3	10	8	21
GERMANY	1	4	3	0	0	8
GUATEMALA	0	0	0	1	1	2
INDIA	0	0	4	1	3	8
JAPAN	0	1	26	21	4	52
MALAWI	0	0	0	1	0	1
MEXICO	0	0	4	4	2	10
PAKISTAN	0	0	0	1	0	1
PERU	0	0	0	2	1	3
SWEDEN	0	0	1	0	0	1
SWITZERLAND	0	1	1	0	0	2
TURKEY	0	0	0	8	2	10
UGANDA	0	0	0	1	1	2
ZAMBIA	0	0	2	1	1	4
Total	1	12	50	62	29	154

Taken from Arango et al. (2020). Each value denotes the number of studies by country and by decade in which the empirical exercise took place.

Restrictions

Theoretical

- The impossible trinity (*trilemma*) indicates that a country cannot
  - Allow for free capital flows
  - Have autonomous monetary policy
  - Adopt a fixed or managed exchange rate

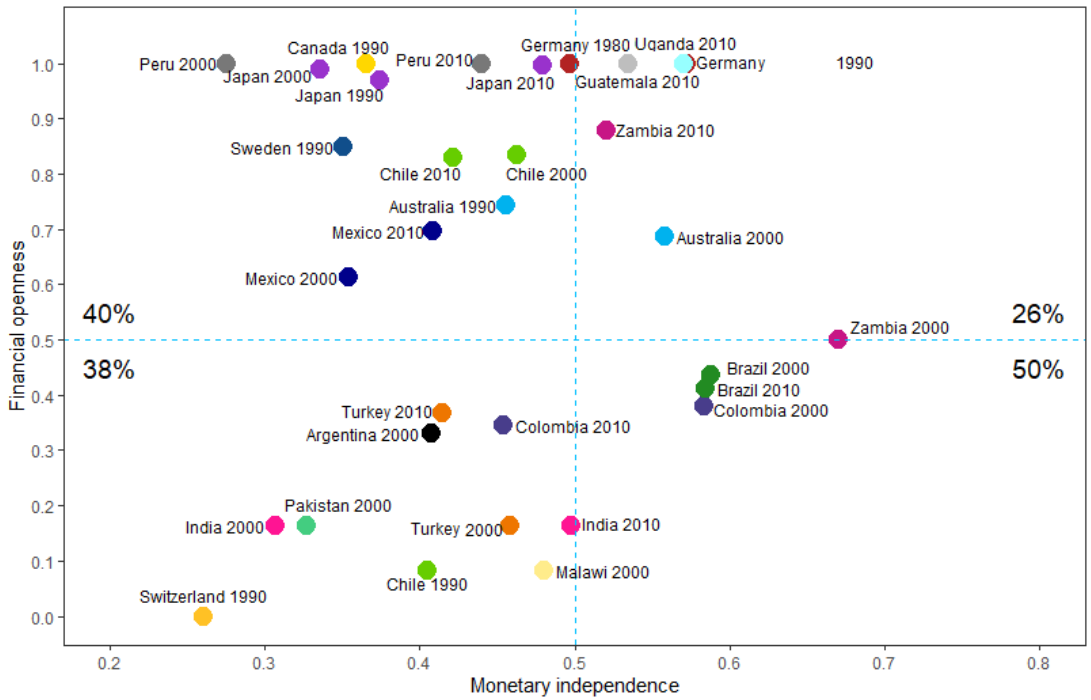
Policymakers can only regain control of the exchange rate if they abandon monetary policy or enact capital controls

Empirical

- Isolating effects of FXI is empirically challenging; many studies in the field are plagued with identification issues
  - Measurement error: data is scarce and many studies proxy FXI with Δ in FX reserves, even at the risk of capturing confounding factors (e.g. valuation effects)
  - Simultaneity bias: central banks $\leftrightarrow$ economic conditions
  - Omitted variable bias: difficult to pinpoint the relevant information that monetary authorities used when setting their policy decisions

Restrictions

Figure: Trilemma Indices



Taken from Arango et al. (2020). The Figure plots surveyed studies categorized by the trilemma indices proposed in Aizenman et al. (2008): degree of financial openness (y-axis) and monetary autonomy (x-axis). Values (in %) denote the fraction of studies with significant results in the expected direction.

Mix Findings

"the effectiveness of sterilized intervention is less obvious on both theoretical and empirical grounds" -Blanchard et al. (2015)

- In the empirical literature, there is a general lack of consensus regarding the effectiveness of Central Bank intervention
  - Menkhoff (2013): 15/25 studies find significant effects
  - Villamizar and Perez (2015): 16/32 studies find significant effects
  - Brychka et al. (2019): 7/13 studies find significant effects
  - Chamon et al. (2019): 19/29 studies find significant effects
  - Arango et al. (2020): 45/74 studies find significant effects

Sources

Low Frequency Data

- Macro-economically oriented studies relying on monthly or quarterly Δ in FX reserves as proxy for FXI (Blanchard et al. 2015, Adler et al. 2019)

FX reserves have surged from 5% of GDP in 1990 to almost 30% in 2018 (BIS)

High Frequency Data

- Published work (e.g. Fratzscher et al. (2019): daily FXI, 33 countries (mostly advanced economies), during 1995-2011)
- Official Sites
  - Federal Reserve Economic Data (FRED)
  - Bank for International Settlements (BIS)
  - International Monetary Fund (IMF)
  - Central Bank Websites

Types of Data

- Market Conditions
  - Exchange Rate Regimes (IMF, Ilzetzki et al. 2019)
  - Trilemma Measures (Aizenman et al. 2008)
  - Capital Controls (Fernandez et al. 2016)
  - Currency Crises (Laeven and Valencia, 2020)

- Way in which interventions are conducted
  - Secret (*dirty*) vs Announced
  - Discretionary vs Rule-based
  - Mechanism: auctions, trades in spot market, derivatives*

As a result of the 2020 pandemic, many countries have intervened with the use of derivatives e.g. FX swaps (Brazil, Colombia, India, Korea, Turkey), USD Repo lines (Brazil, Korea), NDFs (Colombia, Indonesia)

Methods

Exogenous variation needed to identify causal effects $\rightarrow$ FXI Shocks

- In the majority of cases, a central bank policy function needs to be estimated
  - Reaction functions using Probit/Logit/Tobit:
    - Dominguez (1998), Guimaraes (2004), Ishii et al. (2006), Kamil (2008), Fatum et al. (2011), Tuna (2011), Moura et al. (2013), Trivedi et al. (2016), Villamizar (2016), Herrera (2016), Echavarria et al. (2017), Onder et al. (2018)

"the absence of sales suggests the existence of some external factor or constraint that prevents monetary authorities to symmetrically react to economic conditions"
-Echavarria et al. (2013)

Main Drawbacks: Heavily dependent parametric approach, assumptions needed about the structure of the economy

Methods

- Few papers base their identification on a quasi-experimental framework
  - Propensity Score Matching techniques (Fatum & Hutchison 2010, Moura et al. 2013)
  - Regression Discontinuity Designs (Kuersteiner et al. 2018, Perez & Villamizar 2019, Vargas & Villamizar 2020)

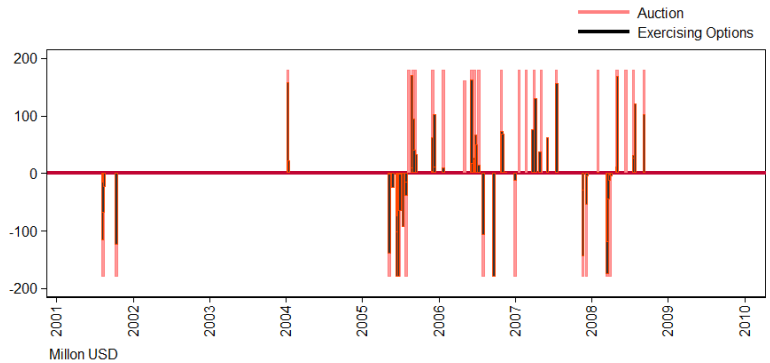
Studies using RDDs:

"Rule-based interventions have the advantage that the rule by which interventions are triggered is known to the public. Uncertainty in the market thus only relates to the question of whether the rule was triggered, not what the rule is" -Kuersteiner et al. (2018)

Kuersteiner et al. (2018)

Figure: Colombian Rule-based FXI

(a) Exchange rate vs moving average



(b) Options issued and exercised

The assignment of treatment, (D_t), is completely determined by a cutoff-rule based on an observable and continuous running variable (X_t):

$$D_t = \mathbf{1}\{X_t \geq x_0\}$$

Kuersteiner et al. (2018)

- Consider the following linear setting

$$y_t = \alpha + \beta D_t + \epsilon_t$$

- In a RDD framework, any bias, defined as $E(\epsilon_t|D_t = 1) - E(\epsilon_t|D_t = 0)$, locally washes out at the limit:

$$\begin{aligned}
&\lim_{\gamma \downarrow 0} E\left(Y_t | X_t = x_0 + \gamma\right) - \lim_{\gamma \uparrow 0} E\left(Y_t | X_t = x_0 + \gamma\right) \\
&= \left(\alpha + \beta + \lim_{\gamma \downarrow 0} E[\epsilon_t | X_t = x_0 + \gamma]\right) - \left(\alpha + \lim_{\gamma \uparrow 0} E[\epsilon_t | X_t = x_0 + \gamma]\right) \\
&= \beta.
\end{aligned}$$

This holds as long as the conditional distribution of potential outcomes $\Pr\left(Y_{it} \leq y \mid X_t = x\right)$ is continuous at $X_t = x_0$, for $i \in \{0, 1\}$

Kuersteiner et al. (2018)

Table: Regression of Intervention Dummy on Fundamentals

	(1) All	(2) All	(3) BW = 0.8	(4) BW = 0.4	(5) BW = 0.2
A. Puts					
Put Lag Log Change in Spot Rate	2.88***	-0.98	-1.01	5.55	-15.6
	(0.82)	(0.66)	(2.99)	(6.18)	(11.9)
Lag Exercised Forward Rate	-5.77	-6.99*	-21.7	-1.18	173.1
	(4.48)	(4.01)	(29.1)	(79.7)	(614.7)
Lag Interbank Rate	0.013***	0.013***	0.026***	0.022	0.0021
	(0.0020)	(0.0017)	(0.0076)	(0.014)	(0.019)
Lag Credit Default Swap Spread	-0.012***	-0.011***	0.027***	0.036	0.021
	(0.0021)	(0.0017)	(0.0060)	(0.023)	(0.043)
Running Variable		-0.15***	-0.70***	-1.80***	-3.90***
		(0.017)	(0.039)	(0.12)	(0.31)
Fundamentals = 0, F	11.2	12.5	10.7	1.2	0.9
Fundamentals = 0, p-value	0.000	0.000	0.000	0.332	0.480
Run. Var. = 0, F		82.3	316.1	211.2	159.1
Run. Var. = 0, p-value		0.000	0.000	0.000	0.000
R-Squared	0.04	0.26	0.61	0.64	0.69
N	2429	2350	458	120	63

Taken from Kuersteiner et al. (2018).

Models

- Portfolio Balance Channel
  - Agents care about the mix of different currency denominated assets (assets are imperfect substitutes)
    - Henderson & Rogoff (1981), Kouri (1981), Branson & Henderson (1985), Gabaix & Maggiori (2015), Hofmann et al. (2016), Perez & Villamizar (2019), Vargas & Villamizar (2020)
  - Microstructure approach: Kyle (1985), Evans & Lyons (2001)
- Signaling Channel
  - Conveys information regarding the future stance of monetary policy
    - Dornbusch (1976), Mussa (1981), Vitale (1999), Kim (2003)

Vargas & Villamizar 2020

Model's Ingredients

- Short time period: macro aggregates (y, y^*, p, p^*) are taken as given
- UIP fails: guarantees that sterilized FXI will have an effect on the exchange rate
- CIP holds: forward market allows risk-averse investors to place currency bets

- 2 type of agents
  - Risk-averse speculators who bet on the currency using the forward market
  - Private banks who arbitrage interest rate differentials (also using the forward market), but with no open net FX positions
    - A shift in banks' forward position is matched by an opposite shift in their spot position

Results: When uncertainty is low (high), FXI is less (more) effective, for agents are willing to "bet more money" against the CB (will face a weaker countervailing force from speculators and arbitragers)

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FX market:

- *Net FX supply* $= NX(e) + K$, where $\frac{dNX(e)}{de} > 0$, and K is exogenous
- CIP: $f = \frac{e(1+i)}{(1+i^*)}$

Speculators:[1]

- $\max_F E[U(F(f - e_1))] \rightarrow \max_F \left[F(f - E(e_1)) - \frac{\lambda}{2} F^2 \sigma^2_{e_1}\right]$
- FOC: $F = \frac{f - E[e_1]}{\lambda \sigma^2_{e_1}}$
  - Net forward sales $|F|$ depends negatively on risk-aversion (λ) and speculator's variance ($\sigma^2_{e_1}$)

Equilibrium:

- $NX(e) + K = \frac{E[e_1]}{\lambda \sigma^2_{e_1}} - \frac{e(1+i)}{\lambda \sigma^2_{e_1}(1+i^*)}$

[1] Assuming CARA utility ($-exp^{\lambda w}$) and that $F(f - e_1) \sim N(F(f - E[e_1]), F^2 \sigma^2_{e_1})$.

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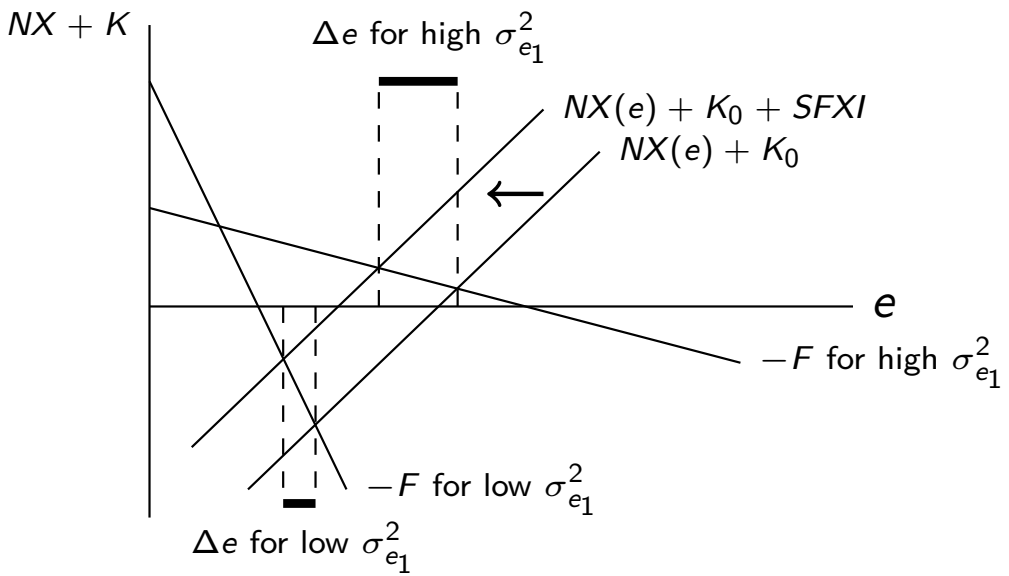
FXI effectiveness associated with σ_{e_1}

- $NX_e de + dK = -\frac{(1+i)}{(1+i^*)\lambda\sigma^2_{e_1}} de$
- $\frac{de}{dK} = -\left[NX_e + \frac{(1+i)}{(1+i^*)\lambda\sigma^2_{e_1}}\right]^{-1} < 0$
- $\frac{d^2e}{dKd\sigma^2_{e_1}} = -\left[NX_e + \frac{(1+i)}{(1+i^*)\lambda\sigma^2_{e_1}}\right]^{-2} \frac{(1+i)}{(1+i^*)\lambda(\sigma^2_{e_1})^2} < 0$



We also show that the impact of FXI on FX volatility is greater in a context of higher σ_{e_1}

Hofmann et al. (2019)

Model builds on the banking model of Bruno and Shin (2015) and Merton's (1974)

- Continuum of: (1) risk-neutral entrepreneurs and (2) competitive banks.
- Credit risk is a standard normal $W_j = \sqrt{\rho}Y + \sqrt{1-\rho}X_j$, where Y and X_j are mutually independent. Y is the common risk factor, X_j is the idiosyncratic risk facing borrower "j".
- Borrowers default when the realization of the borrower's project (V_1) is less than its notional debt ($1 + r + \frac{1}{\theta}$), where θ is the USD/COP exchange rate.
- Equity (E) is used for bonds (E^B) and for loans (E^C).

Hofmann et al. (2019)

Proposition 1

$F_\theta(z) < F_{\theta'}(z)$ *if and only if* $\theta > \theta'$.

Intuition:

$$\downarrow F_\theta(z) = \Phi\left(\frac{\downarrow \Phi^{-1}(\varepsilon(\theta \uparrow)) + \sqrt{1-\rho}\Phi^{-1}(z)}{\sqrt{\rho}}\right)$$

where F is the c.d.f. of the realized value of one peso face value of loans, $\varepsilon(\theta)$ is the probability of default ($Pr[W_j \leq -d_j]$), and $\frac{\partial \varepsilon(\theta)}{\partial \theta} < 0$.

In other words, the tail risk of bank's loan portfolio from default declines as the peso appreciates (first-degree stochastic dominance).

Hofmann et al. (2019)

Proposition 2

Total lending C_i by bank i satisfies $C_i = \lambda E_i^C$.

Intuition (VaR binding implies that):

$$F((1+f)L_i) = \Phi\left(\frac{\Phi^{-1}(\varepsilon(\theta)) + \sqrt{1-\rho}\Phi^{-1}\left(\frac{(1+f)L_i}{(1+r)C_i}\right)}{\sqrt{\rho}}\right) = \alpha$$

where $\alpha > 0$ is the upper limit prob that loan losses exceed E^C, λ is the loan's leverage, such that $\frac{\partial \lambda}{\partial \theta} > 0$, and f, L are the funding rate and non-equity funding for loans. Re-arranging, if $\theta \uparrow$,

$$\frac{(1+f)L_i}{(1+r)C_i} =\uparrow \Phi\left(\frac{\sqrt{\rho}\Phi^{-1}(\alpha) - \downarrow \Phi^{-1}(\varepsilon(\theta \uparrow))}{\sqrt{1-\rho}}\right) =\uparrow \varphi(\alpha, \varepsilon, \rho)$$

Hofmann et al. (2019)

Proposition 2 Continuation

Using the balance sheet identity $E_i^C + L_i = C_i$ and replacing L_i,

$$\uparrow C_i = \uparrow \lambda E_i^C \Leftrightarrow \underbrace{\frac{E_i^C}{1 - \frac{(1+f)}{(1+r)} \cdot \varphi \uparrow}}_{C_i} = \underbrace{\frac{1}{1 - \frac{(1+f)}{(1+r)} \cdot \varphi \uparrow}}_{\lambda} E_i^C$$

The leverage of the loan unit increases when the peso appreciates (i.e $\theta \uparrow$), this translates into an increase in total lending C_i. This, because peso appreciation relaxes the VaR constraint and allows the bank to expand lending.

Hofmann et al. (2019)

Proposition 3

Bank lending to domestic borrowers in pesos expands when the peso appreciates against the dollar Intuition

$$\begin{aligned} C =& E^C \cdot \lambda(\theta) \\ =& (E - E^B) \cdot \lambda(\theta) \\ =& (E - \frac{\bar{B}}{\mu}) \cdot \lambda(\theta) \end{aligned}$$

- A peso appreciation increases the overall bank lending to local borrowers.
- Sterilized FXI that weakens the peso dampens domestic credit by lowering $\lambda(\theta)$

Thank you!