

FX Interventions Rules for Central Banks International Experiences and a Novel Risk-Based Framework

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Goals and Intermediate Objectives of FX Interventions

Goals

- ▶ Price stability: disanchored inflation expectations due to exchange-rate pass-through
- ▶ Financial stability: preserving market functioning, curbing excessive volatility

Intermediate Objectives

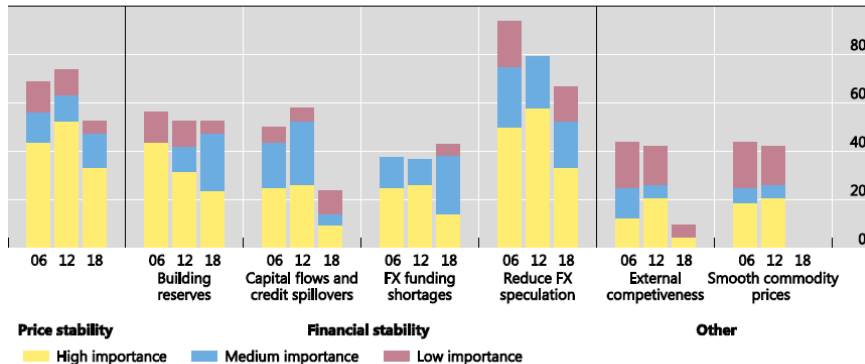
- ▶ Mitigating excessive volatility and limit pressure due to volatile capital flows
- ▶ Liquidity provision to thin markets

BIS Survey: Goals

Price stability and curbing FX speculation remain key goals for FX intervention

As a percentage of respondents

Graph 1



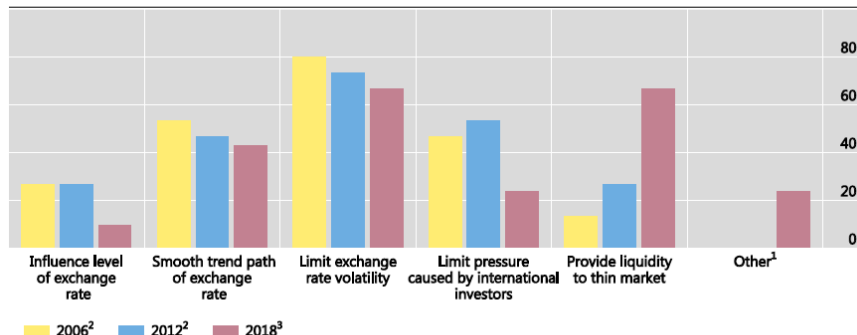
Source: BIS surveys from 2012, 2018 and 2019.

BIS Survey: Intermediate Objectives

Intermediate objectives of FX intervention: Increasing role of liquidity provision

As a percentage of respondents

Graph 2



¹ Mostly non-floating exchange rate arrangements. The "Other" option was not provided in 2006 and 2012. ² 15 central banks.

³ 19 central banks.

Source: BIS surveys in 2012 and 2018.

FX Interventions Rules

- ▶ An intervention is deemed rule-based **when it reacts to predetermined parameters to deliver predictable responses**

Intervention rules have many advantages:

- ▶ Consistent approach with the policy objectives
- ▶ Robust operational framework
- ▶ If public: anchors agents' expectations and influence their behavior to reach the policy objectives
- ▶ Supports market functioning and market development
- ▶ Strengthens the central bank credibility and independence

The large majority of FX interventions rules implemented by central banks are based on **fixed-volatility thresholds**: cf. Mexico, Columbia and Guatemala

Bank of Mexico FX Operations

The BM put in place two types of FX operations:

1. To accumulate or sell foreign reserves
 - Via pre-determined put options for purchases
 - And auctions for selling foreign reserves
2. To intervene on the market to limit extreme exchange rate volatility and provide liquidity to ensure proper market operating conditions
 - Using minimum-prices auctions (rule-based)
 - No-minimum prices auctions (discretionary prices)

We focus on the second type of operations, the FX interventions

Minimum Bid Price Mechanism

- ▶ The central bank auctions a **prespecified amount of US dollars** every day and sets a minimum accepted price
- ▶ The trigger to sell US dollars to the market is predetermined by market conditions without meddling with the free-floating exchange rate regime
 - ▶ The minimum price accepted was set equal to the **previous day closed value plus a 2 percent depreciation factor** (was changed to 1.5 and then 1 after 2014 and 2015)

No Minimum Bid Price Mechanism

- ▶ Sometimes, a constant demand for US dollars that could distort operating conditions and generate volatility is expected to persist
- ▶ The total amount offered corresponded to the **expected** accumulation of international reserves during the following quarter (most of the accumulation came from the national oil company sales to the CB)
 - ▶ Sometimes, the amount was directly decided by the central bank, on a discretionary basis

Columbia: Volatility Options

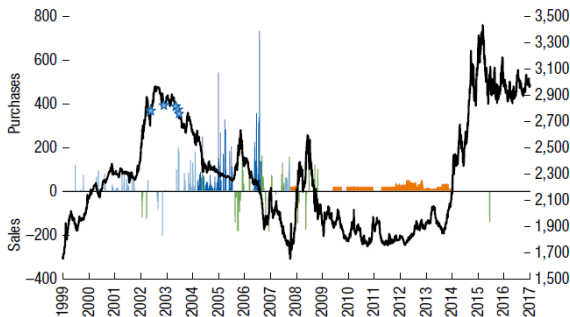
- ▶ The central bank publicly committed to offer, through auctions, call (put) options with one-month maturity
- ▶ Whenever the representative bilateral rate (TRM) was higher/lower than its 20-day moving average ± 5 percent (then changed to 2 percent in 2011 then 7 percent later)
- ▶ The strike price was the TRM, and the condition for being able to exercise the option was the same as for the activation of the auction.
- ▶ Objective to mitigate extreme fluctuations: amount auctioned large compared to market turnover
- ▶ However, the central bank struggled to find the right threshold (5-7-2 percent), and had a lot of try and miss

Columbia FX Operations

Figure 9.1. Colombian Central Bank Foreign Exchange Intervention, 1999–2017

(Millions of US dollars, left scale; US dollar/Colombian peso official exchange rate, right scale)

- Discretionary intervention
- Foreign exchange competitive auctions (spot purchases)
- Volatility options
- Options (purchases/sales)
- Exchange rate
- ★ Denotes put auctions not on a monthly basis



Source: Central Bank of Colombia.

Note: Data are from September of each year.

Guatemala: Auctions With Maximum Allotment

- ▶ Intervention if the reference exchange rate reaches or exceeds the fluctuation band of $\pm 0.80\%$ around the moving average of the reference exchange rates from the past five business days
- ▶ Auction to buy or sell up to US\$10 million in foreign currency
- ▶ No more than five auctions a day are allowed
- ▶ The results of public auctions are disclosed to the public by publication on the website of the BOG and through print mass media.

Fixed-Volatility Rules in Perspective

Fixed-volatility rules are simple, transparent and consistent with inflation targeting. However:

- ▶ The fixed thresholds are difficult to decide and have to be revised often (cf Columbia and Mexico)
- ▶ Rigid to market conditions: might prove inadequate in extreme stress periods
- ▶ Prone to market manipulation, and don't properly align the incentives of market participants with CB objectives
- ▶ Fixed triggers lead to asymmetric interventions, and can put the FX reserves at risk
- ▶ Often, tend to over-hedge FX risk for market participants, leading to moral hazard and constraining FX market development
- ▶ Interventions are not financially optimal from a cost perspective

We have developed a new framework to address these shortcomings

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Contributions

- ▶ Design a rule to **address tail-risks** related to direct and indirect FX exposures in the economy
- ▶ Provides guidance on **when** to intervene ("triggers")
- ▶ Appropriate for **floating exchange rate regimes** with FX macrofinancial risks (e.g. dollarization)
- ▶ Consistently target **FX risk** in the economy
- ▶ A **risk management framework** for central banks' financial stability mandate: aligned with **industry's best practices** in risk management

Desirable Properties of FXI Rules

Foreign Exchange intervention rules should be:

- ▶ **Adaptative**, depend on market conditions
- ▶ **Objective**, anchored to a risk tolerance level rather than an arbitrary FX level threshold
- ▶ Capture FX **non-linearities and asymmetries** between appreciation and depreciation
- ▶ Be easily **operationalizable**, and **financially viable**

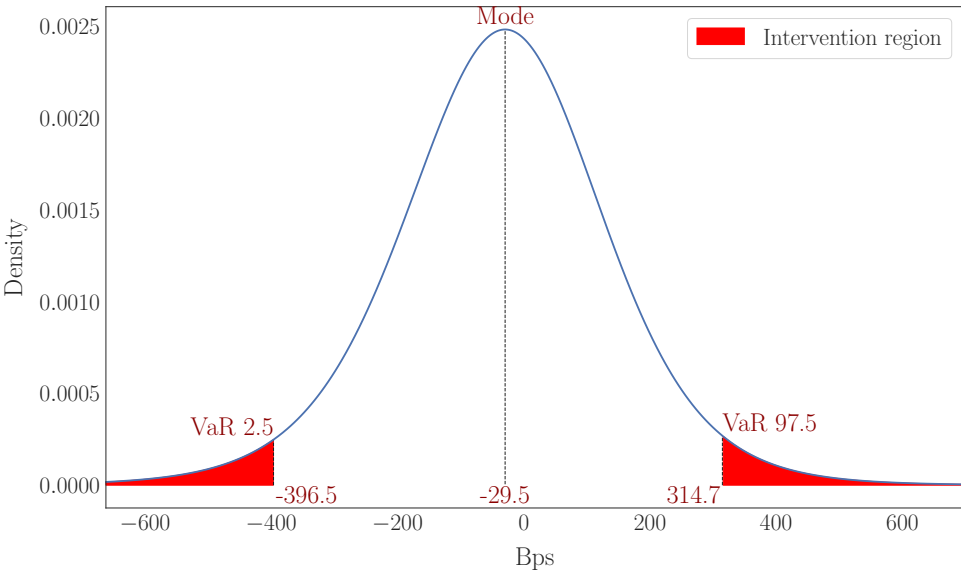
We propose an FX intervention rule based on **Conditional Value-at-Risk**

Concept: Value-at-Risk FXI Rule

- ▶ Rather than using a fixed volatility rule (e.g. intervene if daily exchange rate varies by more than 2%)
- ▶ Use a **risk-based rule**: intervene when the daily exchange rate log-returns fall within the tails of the conditional distribution
- ▶ Measure the tail-risk via the concept of **Value-at-Risk** (the conditional quantile of the log returns distribution)
- ▶ The conditional distribution is estimated daily with a standard financial GARCH model and **varies with market conditions**
- ▶ The central bank decides on the **risk tolerance**: e.g. intervene in the tail at 1%, 5%, 10%, etc.

VaR FXI Rule

Conditional Density and Intervention Rule Based on 2020-04-03 Information



A Risk-Management Approach to FX Interventions

- ▶ Tail-risks hedge not always available: **incomplete markets**
- ▶ **The central bank is transferring FX risk from the market to its balance sheet.** It buys a risky asset (FX) and issues a risk-free asset (local currency)
- ▶ Provide a **public good** to address market failure. Leave a fix share of risk for the market to hedge
- ▶ Risk tolerance should depend on the **macrofinancial risk**
- ▶ The financial stability mandate of the central bank is properly formalized and quantified via VaR metric

Main Features

1. Allows flexible exchange rate to act as a **shock absorber**: more flexibility in crisis time => **avoid overshooting**
2. **No excessive interventions** in crisis time, often ineffective and costly (exhaust FX reserves)
3. No free insurance to the market: avoid **moral hazard**, foster the **development of hedging market**
4. Prevent **market manipulation and windfall effects**
5. Guarantees **fixed-frequency** interventions:
 - **Certainty** about interventions: the central bank can intervene with **larger FX amounts**, making the interventions **more efficient**
 - **Budget neutrality** with symmetric risk preference
6. **Financially optimized**: always buy/sell at the best price

Operational Implementation

- ▶ **Standard data requirements**, easily accessible for a central bank, can be customized
- ▶ Parsimonious GARCH model featuring **embedded heteroskedasticity, asymmetries** (appreciation/depreciation), **non-linearities** (exponential volatility) and parametric **density forecasting**
- ▶ We created a Python wrapper, **free and open-source** (soon on Github): estimation, forecasting, out-of-sample evaluation, benchmarking, etc. Results are **fully replicable**
- ▶ Can be readily used by central banks and deployed during Technical Assistance (TA) missions

Challenges

- ▶ Some central banks might be reluctant to use a VaR-rule: **more difficult to communicate** to the public
 - ▶ However, FXI occur on the wholesale FX market, where market participants are fully aware of the VaR concept
- ▶ Some policymakers might **prefer to keep discretion** over FXI
 - ▶ Trade-off: a transparent rule anchors better market expectations, maximize efficiency and strengthen central bank's independence

The Framework Extends Beyond FXI triggers

1. Determine FX Intervention triggers
2. Conduct market monitoring and provide policy guidance
3. Benchmark FX interventions, including discretionary interventions
 - ▶ We present below an application of the toolkit to the Mexican Peso, based on publicly available data
 - ▶ More than 4500 daily observations, from 2009 to 2018, with Bank of Mexico (public) FX interventions, mostly concentrated in 2009 and 2016

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Specification

- ▶ Non-linear, Exponential GARCH (EGARCH) model
- ▶ The dependent variable is the FX log-returns, $r_t = \log(\frac{e_t}{e_{t-1}})$, where e_t is the bilateral market exchange rate against the major currency (e.g. USD)
- ▶ **Drift AR-X(1):** $r_{t+1} = \alpha_d + \rho r_t + \beta X_{t+1} + \epsilon_{t-1}$
- ▶ **Exponential volatility:** $\log \sigma_{t+1}^2 = \omega + \beta g(r_t)$ where $g(r_t) = \alpha_v r_t + \gamma(|r_t| - \mathbb{E}|r_t|)$
- ▶ **Error term distribution** $\epsilon_t = \sigma_t \varepsilon_t$, $\varepsilon_t \sim \text{TSK}(0, 1, \nu)$
- ▶ The forecasted conditional probability distribution function is defined as:

$$\hat{f}(r_{t+1}|r_t, X_{t+1}) = \text{TSK}(\hat{r}_{t+1}, \hat{\sigma}_{t+1}^2, \hat{\nu})$$

Estimation

- ▶ The GARCH estimation is standard and done with maximum likelihood
- ▶ Selection of parameters is done via AIC/BIC criteria.
- ▶ Our Python package allows to flexibly select:
 - ▶ The set of exogeneous regressors
 - ▶ The number of lags
 - ▶ The volatility specification (exponential, RiskMetric, standard GARCH, etc.)
 - ▶ The distribution family of the error-terms (Gaussian, Student, Tskew, Generalized Gaussian, etc.)
- ▶ More complex models (e.g. copulas, non-parametric kernels, etc.) can be used within the same VaR framework. However, more difficult to understand and to implement

Exogeneous Regressors

1. **FX microstructure:** FX bid-ask spread (averaged over the day)
2. **CIP:** daily interest rate differential with the US Libor
3. **Hedging costs:** one-month forward exchange rate
4. **Past policy interventions:** lagged amount of central bank FX intervention
5. **Global risk sentiment:** The VIX, implied volatility on the S&P 500
6. **Global FX factor:** The EURUSD exchange rate

Regression Table

	Microstructure	CIP	Dollar move	Risk Appetite	Baseline
Intercept	-2.33***	-2.23	-1.84	-2.55	-1.63
Lag FX log returns	-0.07***	-0.08***	-0.08***	-0.08***	-0.08***
Bid ask abs	5.73***	24.55	-35.84	-2.48	3.43
Min max abs	35.55***	34.27	34.36***	34.44*	26.16*
Forward points first difference	23.29***	17.85***	26.44***	19.82***	19.44***
Interbank rate vs Libor		33.7***	39.31***	34.76***	33.87***
EURUSD log returns			-0.14***	-0.17***	-0.16***
VIX first diff				15.66***	15.37***
FX intervention dummy lag					2.23
Oil prices log returns					-0.02***
Omega	0.13***	0.13***	0.12***	0.11***	0.12***
Alpha	0.17***	0.17***	0.16***	0.16***	0.15***
Gamma	0.07***	0.06***	0.06***	0.05***	0.05***
Beta	0.98***	0.99***	0.99***	0.99***	0.99***
Nu	8.33***	8.67***	8.92***	8.71***	8.54***
Lambda	0.08***	0.08	0.09***	0.07*	0.08***
R2	5.8 %	6.7 %	10.4 %	27.3 %	27.6 %
R2 adjusted	5.8 %	6.6 %	10.4 %	27.2 %	27.5 %
Number of observations	5986	5986	5682	5682	5680
Significance *10%, **5%, ***1%					

Formalization of the Intervention Rule

- ▶ Consider the estimated conditional distribution of the exchange rate log returns r_t defined as

$$\mathbb{P}[r_t \leq x] = \int_{-\infty}^x \hat{f}(r_t | r_{t-1}, X_t) dr_t$$

- ▶ The Conditional Value-at-Risk at threshold τ is simply defined as the conditional τ -quantile

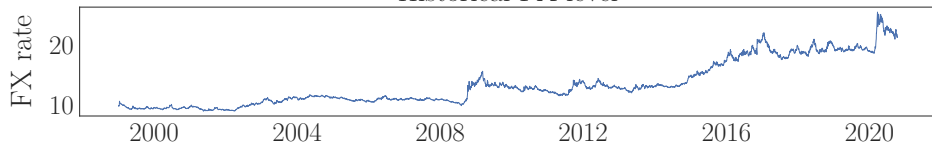
$$Q(r_t, \tau) \equiv \mathbb{P}[r_t \leq Q(r_t, \tau)] = \tau, \text{ for } \tau \in (0, 1)$$

- ▶ The FXI intervention rule is a simple boolean rule, based on two risk-thresholds ($\underline{\tau}, \bar{\tau}$), for depreciation and appreciation, potentially risk-symmetric ($\bar{\tau} = 1 - \underline{\tau}$)

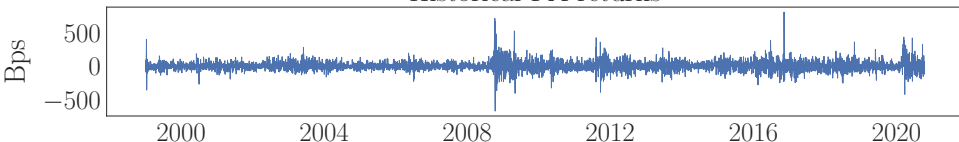
$$\mathbb{1} [\{r_t \leq Q(r_t, \underline{\tau})\} \cup \{r_t > Q(r_t, \bar{\tau})\}]$$

Dynamics of the Mexican Peso against USD

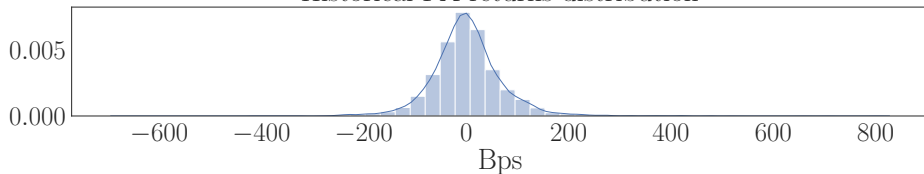
Historical FX level



Historical FX returns



Historical FX returns distribution



Conditional In-Sample Volatility of the Mexican Peso

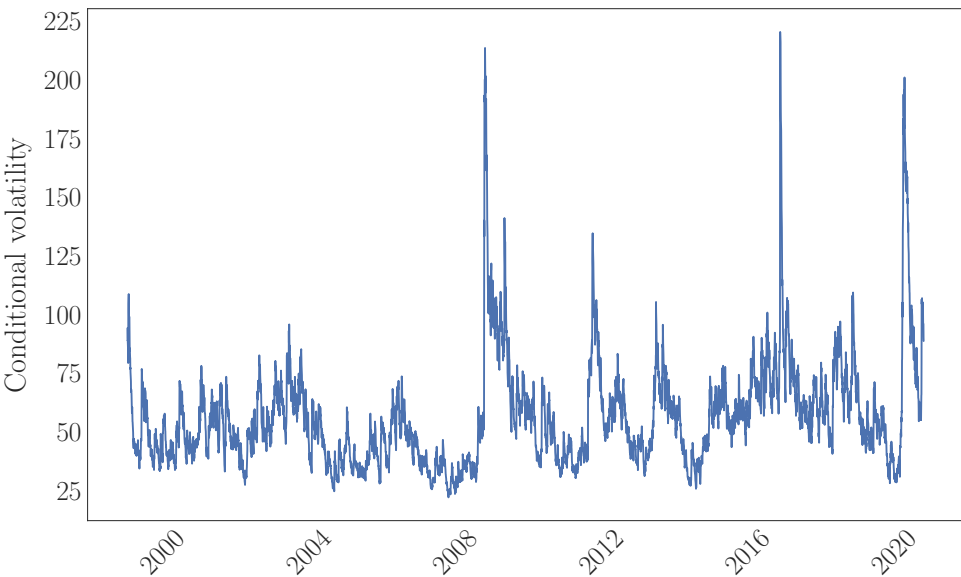


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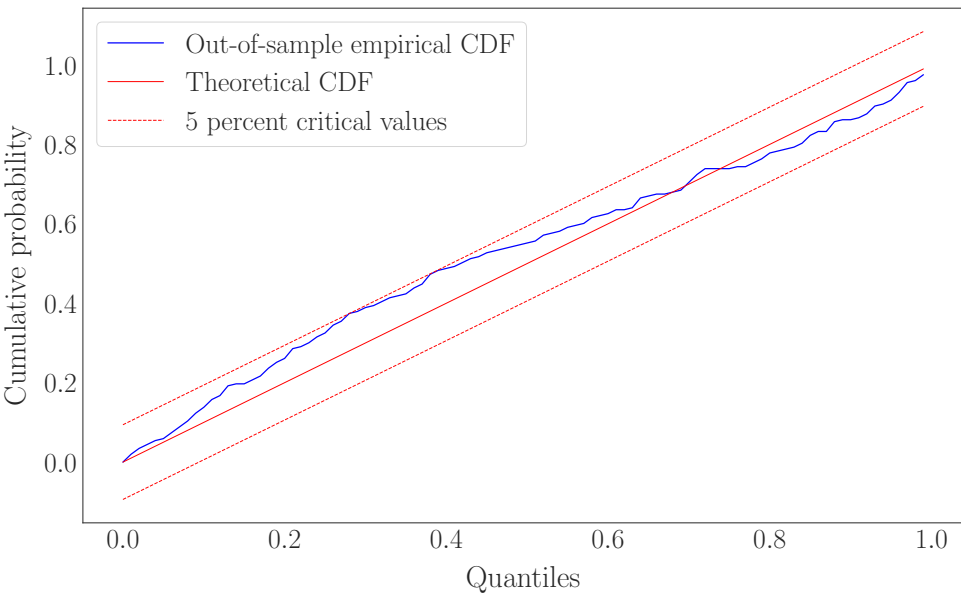
Benchmarking

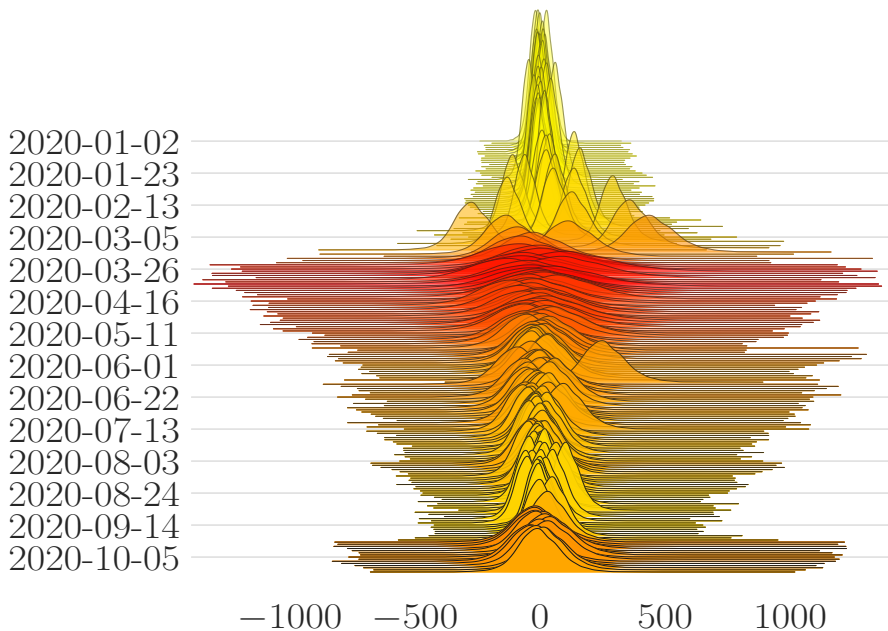
Policy Implications and Future Work

Forecasting

- ▶ Real-time forecasting based on market conditions
- ▶ Estimate the GARCH and derive the forecasted drift and volatility
- ▶ Infer the **full-fledged conditional distribution** of FX log returns for any point in time
- ▶ Assess model accuracy via (i) in-sample metrics and (ii) out of sample performance (probability integral transform test)
- ▶ The probability integral transform test assess on whether the random variable defined as $PIT(R) \equiv F_R R$ is uniformly distributed $F_R R \sim U(0, 1)$, where R is the stochastic process of the FX log returns $r_t, \forall t \in [0, T]$

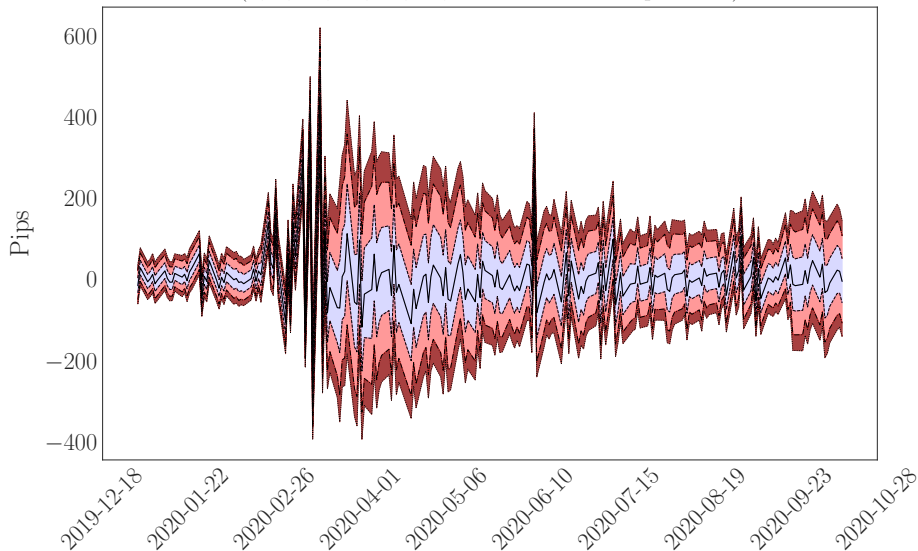
Density Evaluation





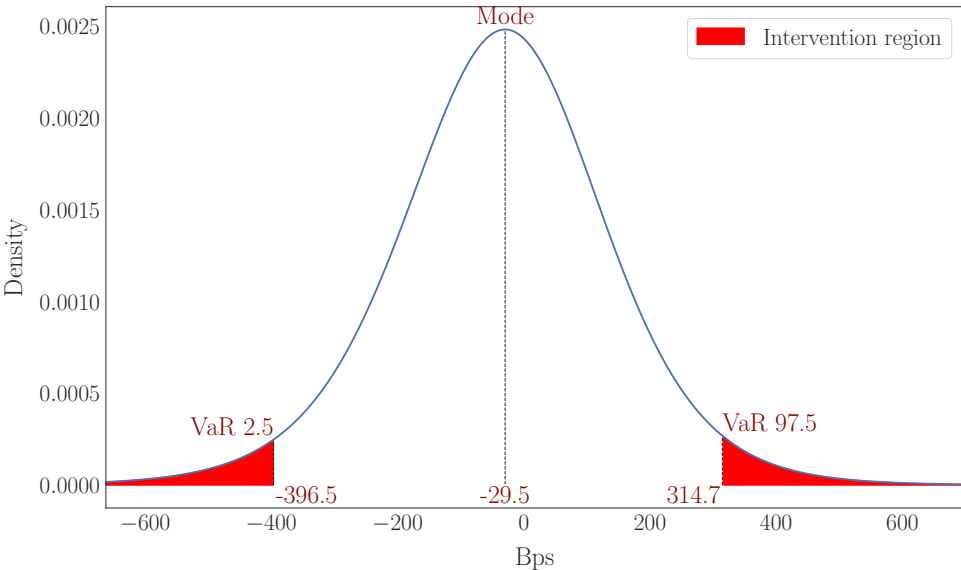
Fan Chart

Fan chart of predictive FX log returns
(1, 5, 10, 25, 75, 90, 95th conditional quantiles)

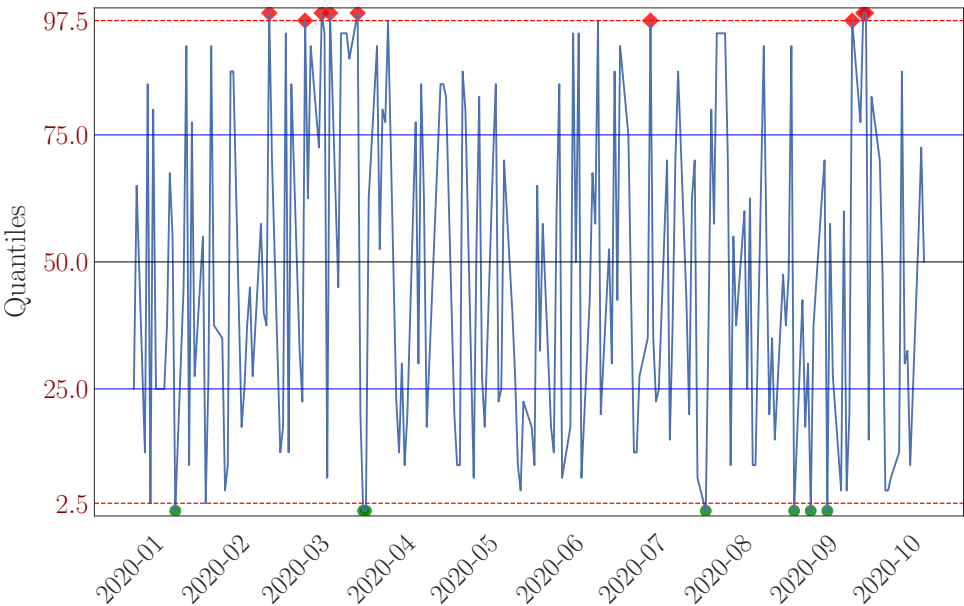


VaR FXI Rule

Conditional Density and Intervention Rule Based on 2020-04-03 Information

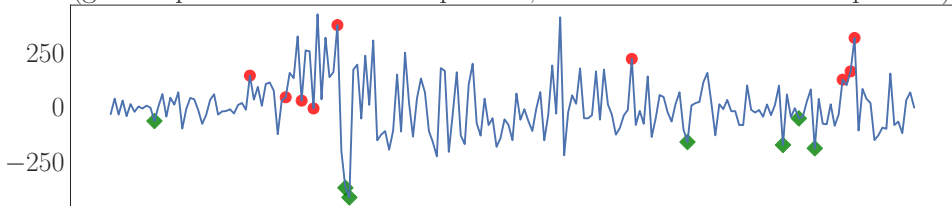


Conditional Cumulative Distribution Function



Conditional Exceedance

Log Returns and Conditional VaR Exceedance at 5 Percent
(green square: below VaR 2.5 percent, red dot: above VaR 97.5 percent)



Corresponding FX level

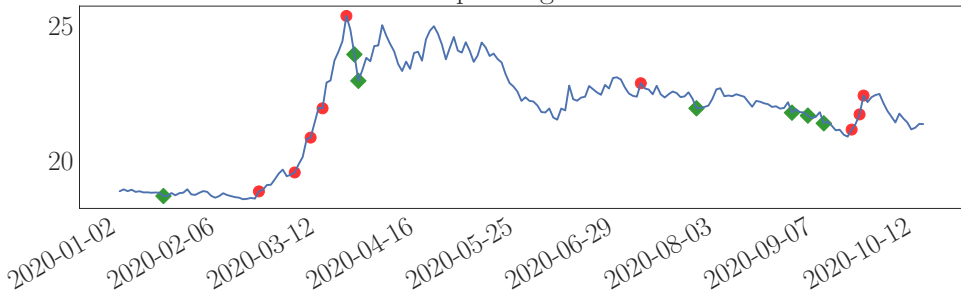


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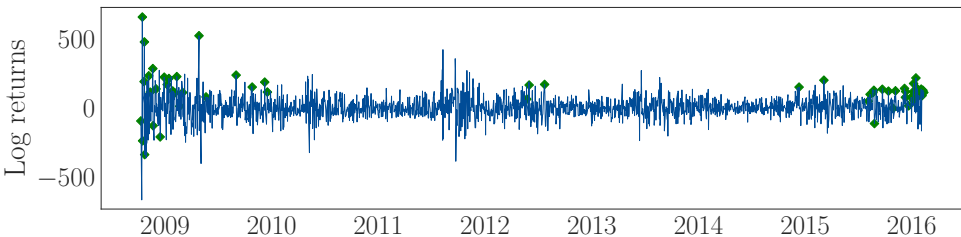
Benchmarking

Policy Implications and Future Work

Bank of Mexico FX Interventions Setup

- ▶ The Banco Mexico (BM) implemented both ex-ante, transparent FX auctions and discretionary-rate auctions
- ▶ Different reservation rates:
 - ▶ **Rule-based setting:** BM operated an auction every day with a pre-announced **a minimum rate** for eligible bids
 - ▶ **Discretionary setting:** the auction was organized at the BM's discretion without reservation rate
- ▶ Often, no demand for the ruled-based auction as the market rate was below the reservation rate
- ▶ No-minimum price auctions could be motivated by other considerations than the exchange rate level
- ▶ What was the risk level when the FXI occurred?

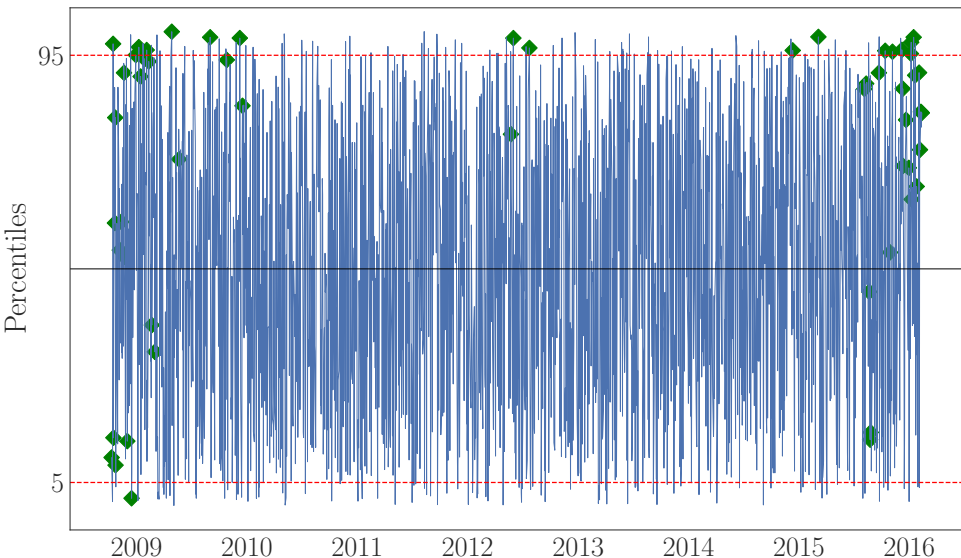
Rule-Based Benchmarking



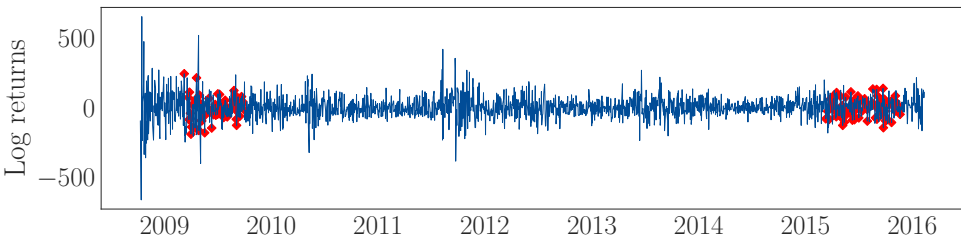
FX interventions and FX level (sell USD)



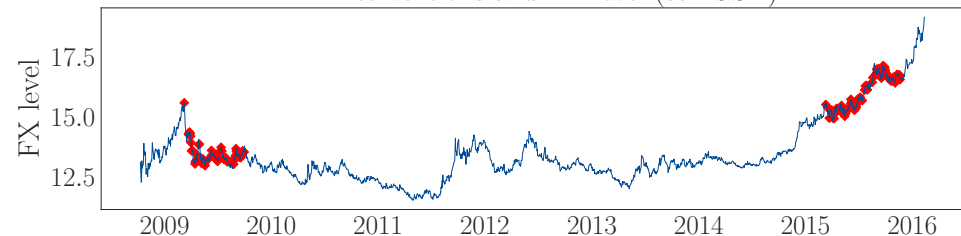
Rule-Based Benchmarking: Risk-Level



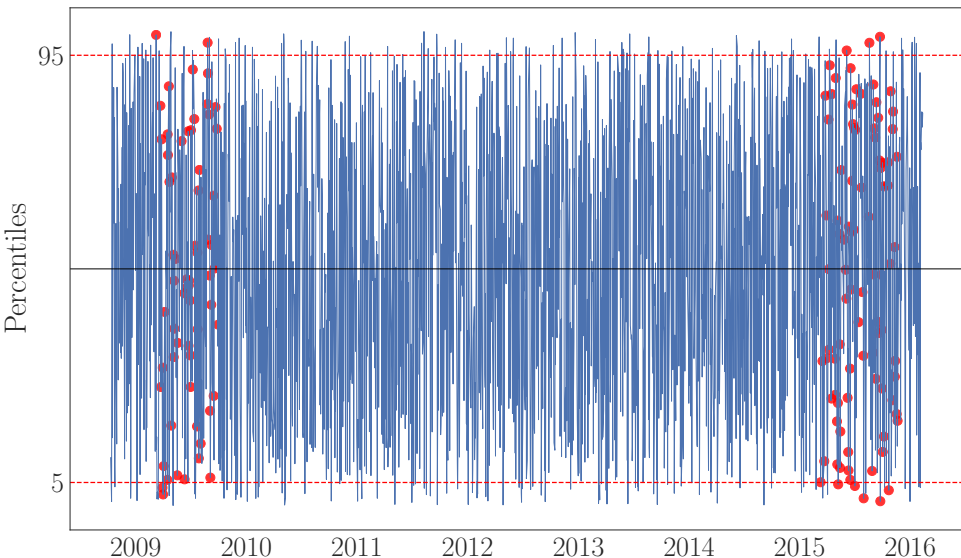
Discretion-Based Benchmarking



FX interventions and FX level (sell USD)



Discretion-Based Benchmarking: Risk-Level



Financial Performances

- ▶ We compared the financial performance of the three different interventions strategies: VaR, minimum price, without minimum price
- ▶ Using an entire year where the frequency of intervention was the same for auctions with and without minimum price
- ▶ We construct the counterfactual VaR interventions by calibrating the risk tolerance so that the frequency of intervention is the same as for auctions with and without minimum price
- ▶ Auctions with minimum price outperforms the no-minimum price auctions by 6.9% on average
- ▶ The VaR rule outperforms the no-minimum price auctions by 8.3% on average

Financial Performances: Results

	No minimum price	Minimum price	VaR rule
Daily variation bps	-6.1	108.8	164.8
Average exchange rate	16.6	17.8	18
FX Perf. vs. discretionary	0 %	6.9 %	8.3 %
Total volume bn USD	3.32	3.6	3.32
Number of interventions	18	18	18

Benchmarking Results

1. **FX auctions with ex-ante minimum price ("rule-based")**

- ▶ The minimum price auctions did not fully prevented BM to intervene outside of the tails of the conditional distribution
- ▶ In that respect, VaR-based intervention would have been better to mitigate tail-risks

2. **FX auctions with no ex-ante minimum price ("discretion-based")**

- ▶ No minimum prices interventions occurred at almost any risk level
- ▶ **Discretion triggers are not identifiable based on risk**

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Policy Implications

- ▶ Useful for floating rate regimes to **operationalize their financial stability mandate** with a risk-management framework
- ▶ The VaR-based rule could be considered **as one option** to improve the rules that central banks currently use
- ▶ Let the nominal exchange rate acts as a **shock absorber**
- ▶ Could be used to accompany the **transition to exchange rate flexibility**, with gradually less and less interventions
- ▶ More generally, could be used by central banks for **market and risk monitoring**

Future Work

1. Use expected shortfall (ES) instead of VaR, as ES has better risk properties
2. Look **beyond spot FX markets** and apply a similar and consistent approach to:
 - FX derivatives, e.g. forward spreads
 - Offshore/onshore interest rate markets
 - Fixed income market
3. Determine the risk tolerance by **identifying vulnerabilities** and their impact to the economy. Align with the "**at-risk**" work done in MCM

Alternative Models: Benchmarking

	PIT	Logscore diff against Baseline	Diff pvalue
Baseline	Pass		
Unconditional			
Quantile Reg			
Gaussian EGARCH	Fail	1.54	0.938
TSkew GARCH	Fail	1.768	0.961
Gaussian GARCH	Fail	1.755	0.96