FX Interventions Rules for Central Banks
A Risk-Based Framework

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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:

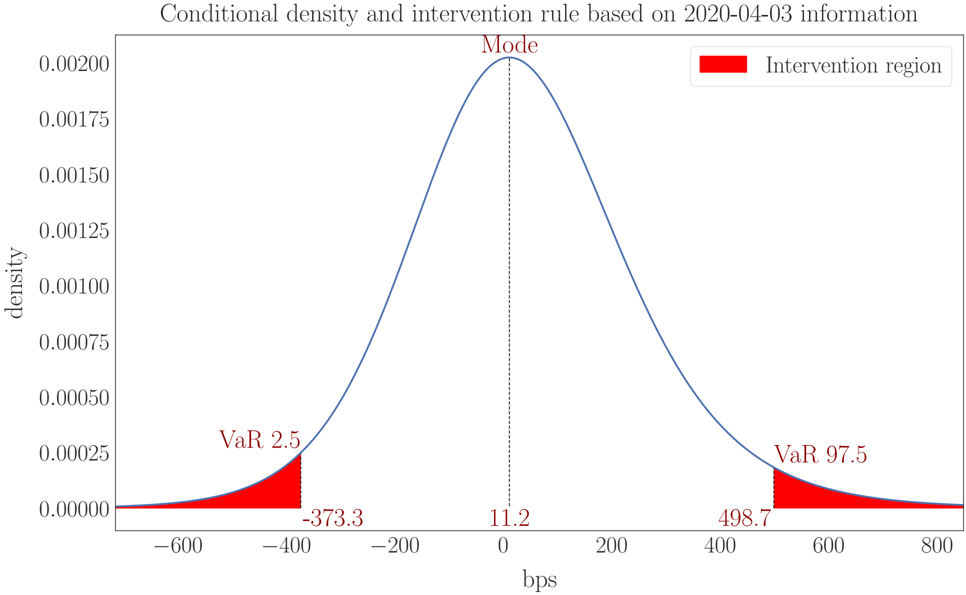
- **Adaptative**, depend on market conditions
- **Objective**, anchored to a risk tolerance level rather than an aribtrary FX level threshold
- Capture FX **non-linearities and asymmetries** between appreciation and depreciation
- Be easily **operationalizable**, and **financially viable**

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
Mode
Intervention region
0.00200
0.00175
0.00150
0.00125
0.00100
0.00075
0.00050
0.00025
0.00000
density
VaR 2.5
VaR 97.5
-373.3
11.2
498.7
−600
−400
−200
0
200
400
600
800
bps

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 speculation and windfall effects**

5. Guarantees **fixed-frequency** interventions:
   - **Certainty** about interventions: the central bank can intervene with **larger amounts**, 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:** $\log \sigma^2_{t+1} = \omega + \beta g(r_t)$ where $g(r_t) = \alpha_v r_t + \gamma(|r_t| - \mathbb{E}|r_t|)$
- **Error term distribution** $\epsilon_t = \sigma_t \varepsilon_t$, $\varepsilon_t \sim \mathrm{TSK}(0, 1, \nu)$
- The forecasted conditional probability distribution function is defined as:

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

Estimation

- The GARCH estimation is standard and done with maximimum 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

	Constant	Microstructure	CIP	FXI	Baseline	Robustness
Intercept	1.09	-2.16	2.15	1.67***	1.63	1.64***
Lag FX log returns	0.09***	0.08***	0.08***	0.08***	0.08***	0.08***
Bid-ask spread abs value		0.11**	0.15***	0.14***	0.15***	0.15***
Forward points first difference		0.32***	0.32***	0.32***	0.27***	0.27***
Interbank rate vs Libor			-1.11***	-0.98***	-1.02***	-1.03***
FX intervention in USD lag				0.04	0.04	
VIX first diff					9.78***	9.79***
EURUSD log returns					0.13***	0.13***
FX intervention dummy lag						4.13
Omega	0.15***	0.14***	0.13***	0.13***	0.14***	0.14***
Alpha	0.17***	0.19***	0.18***	0.18***	0.19***	0.19***
Gamma	0.06***	0.06***	0.06***	0.05***	0.05***	0.05***
Beta	0.98***	0.98***	0.98***	0.99***	0.98***	0.98***
Nu	8.81***	9.11***	9.18***	9.15***	7.77***	7.77***
Lambda	0.13***	0.11***	0.12***	0.12***	0.1***	0.1***
R2	0.4 %	4.9 %	5.1 %	5.1 %	14.3 %	14.3 %
R2 adjusted	0.4 %	4.8 %	5.0 %	5.0 %	14.2 %	14.1 %
Number of observations	4511	4511	4511	4510	4510	4510
Significance *10%, **5%, ***1%						

Formalization of the Intervention Rule

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

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

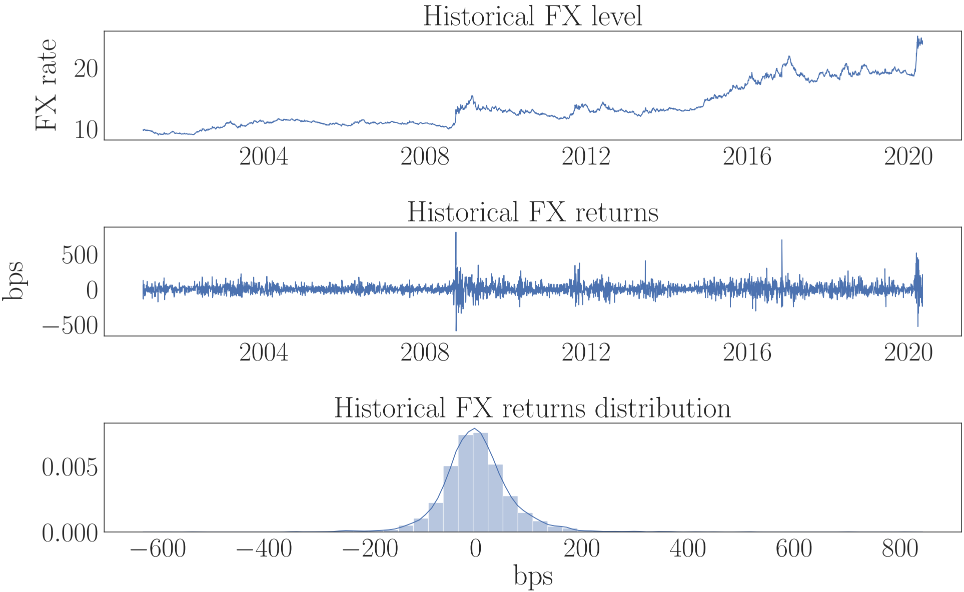
- The Conditional Value-at-Risk at threshold τ is simply defined as the conditional τ-quantile

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

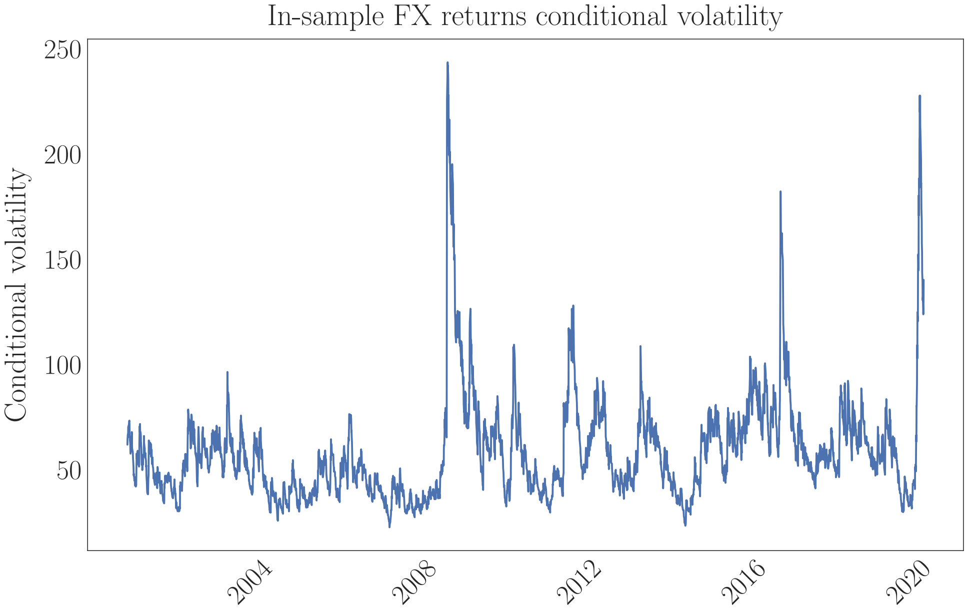
- The FXI intervention rule is a simple boolean rule, based on two risk-thresholds $(\underline{\tau}, \overline{\tau})$, for depreciation and appreciation, potentially risk-symmetric $(\overline{\tau} = 1 - \underline{\tau})$

$$\mathbb{1}\left[\{r_t \leqslant Q(r_t, \underline{\tau})\} \cup \{r_t > Q(r_t, \overline{\tau})\}\right]$$

Dynamics of the Mexican Peso against USD



Conditional In-Sample Volatility of the Mexican Peso



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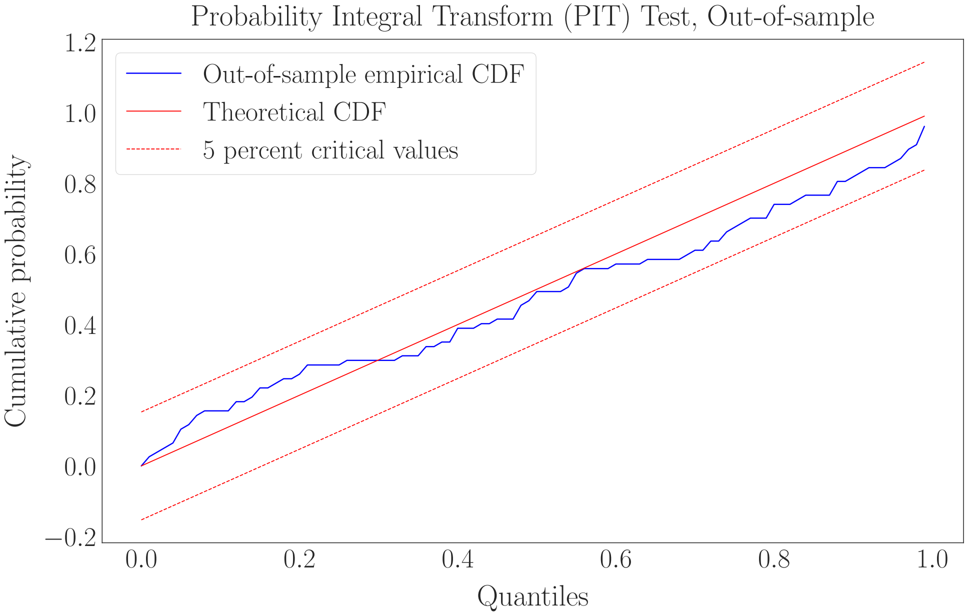
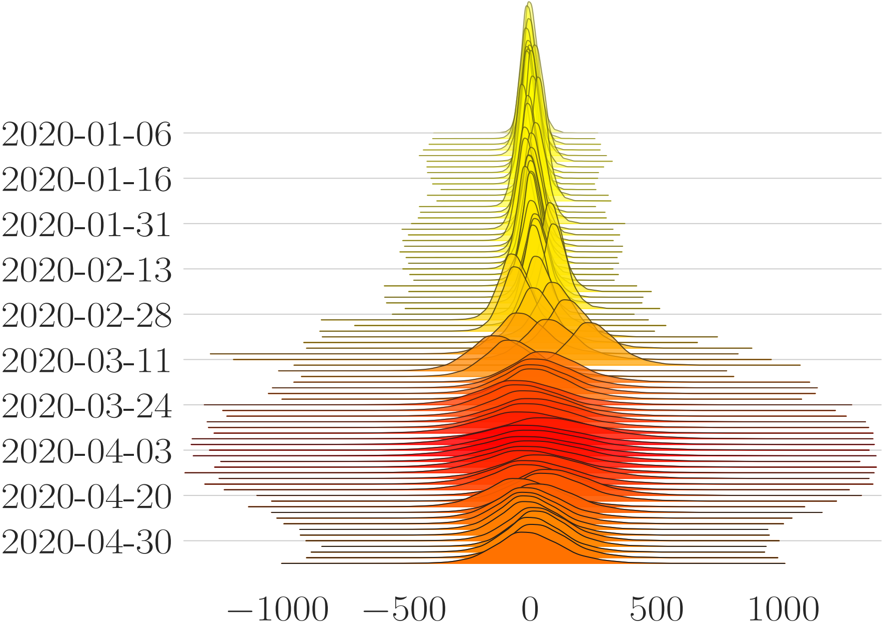
Forecasting

- 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 uniformally distributed $F_R R \sim U(0,1)$, where R is the stochastic process of the FX log returns $r_t, \forall t \in [0,T]$

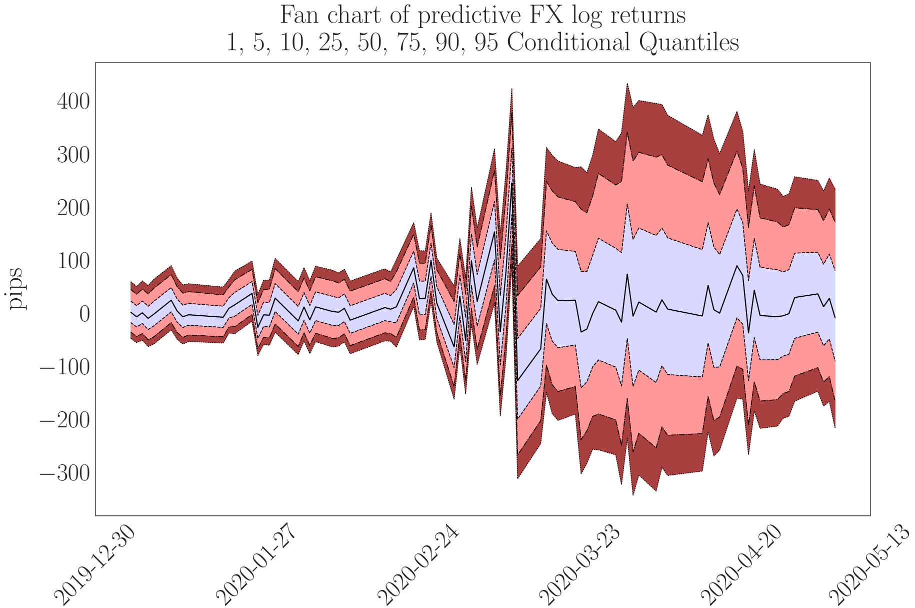
Density Evaluation



Out-of-sample conditional density

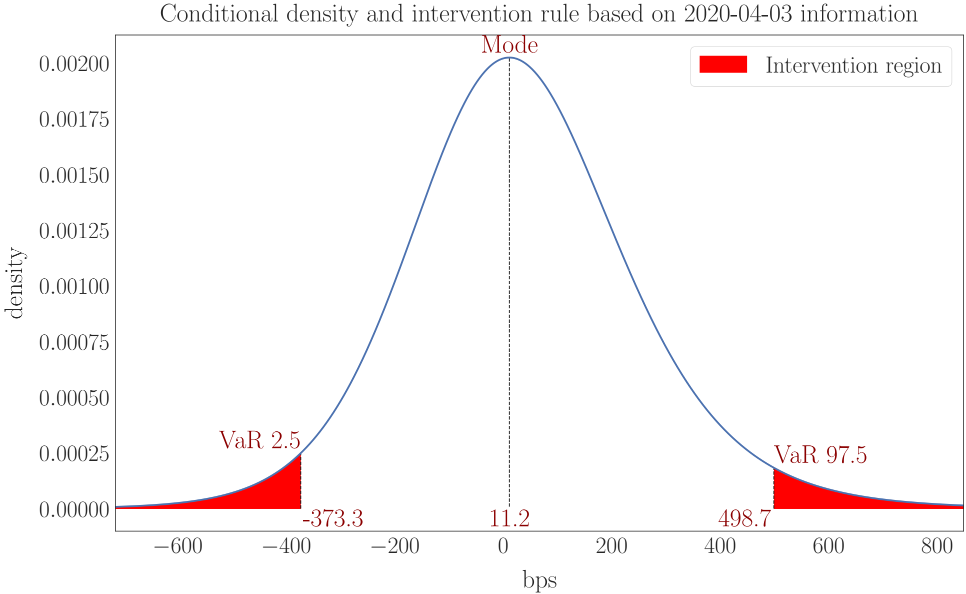


Fan Chart



Fan chart of predictive FX log returns
1, 5, 10, 25, 50, 75, 90, 95 Conditional Quantiles
pips
400
300
200
100
0
−100
−200
−300
2019-12-30
2020-01-27
2020-02-24
2020-03-23
2020-04-20
2020-05-13

VaR FXI Rule



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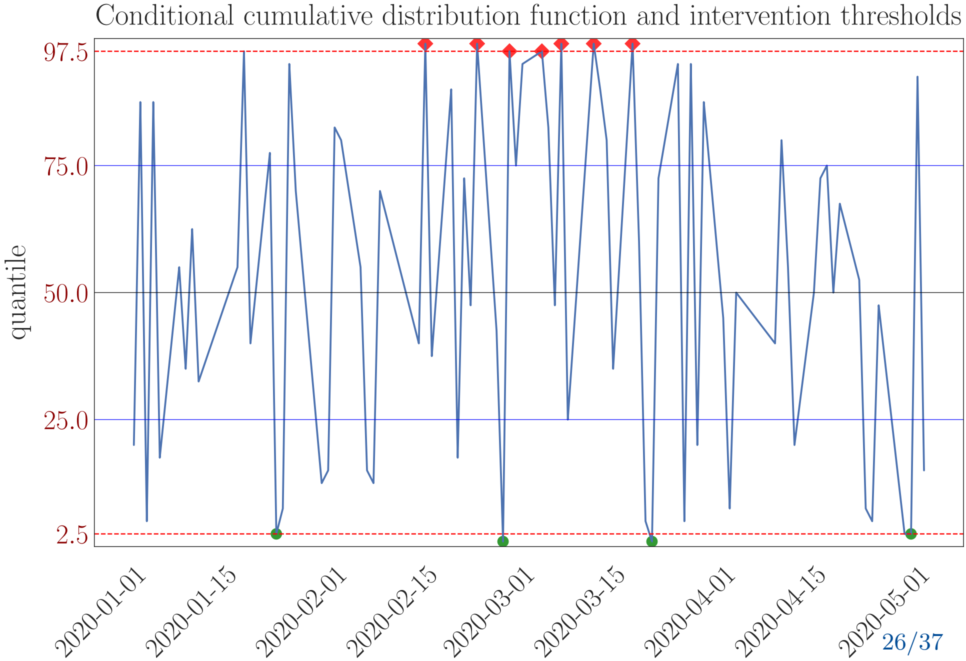
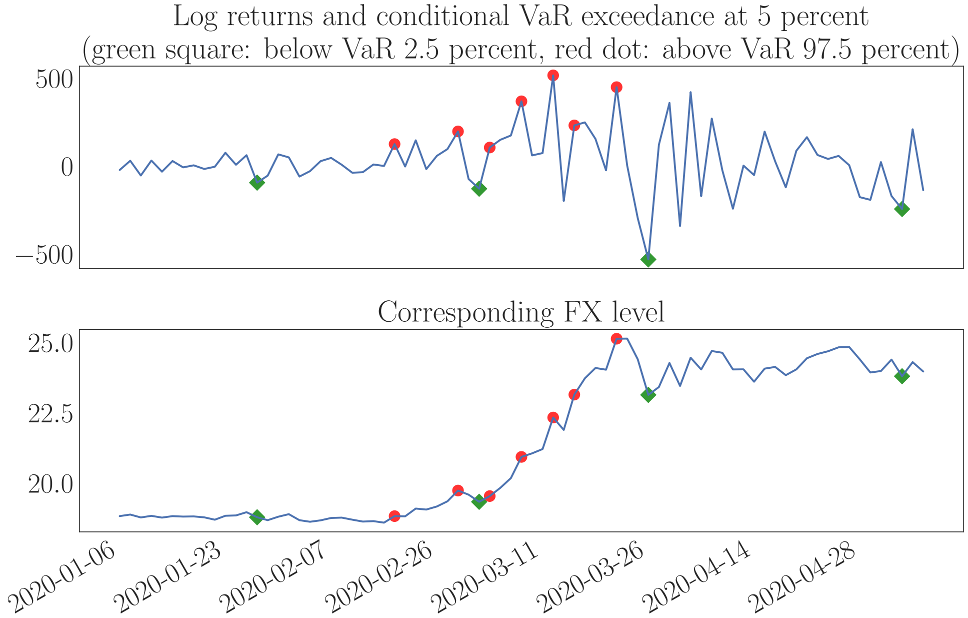
0.00175
0.00200
−600
−400
−200
0
200
400
600
800
bps

Conditional Cumulative Distribution Function



Conditional Exceedance



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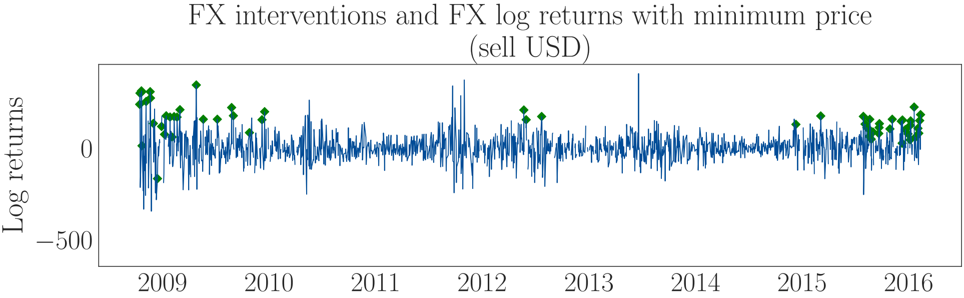
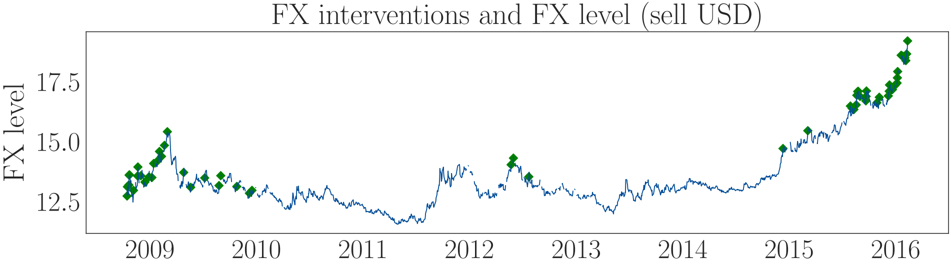
Bank of Mexico FX Interventions Setup

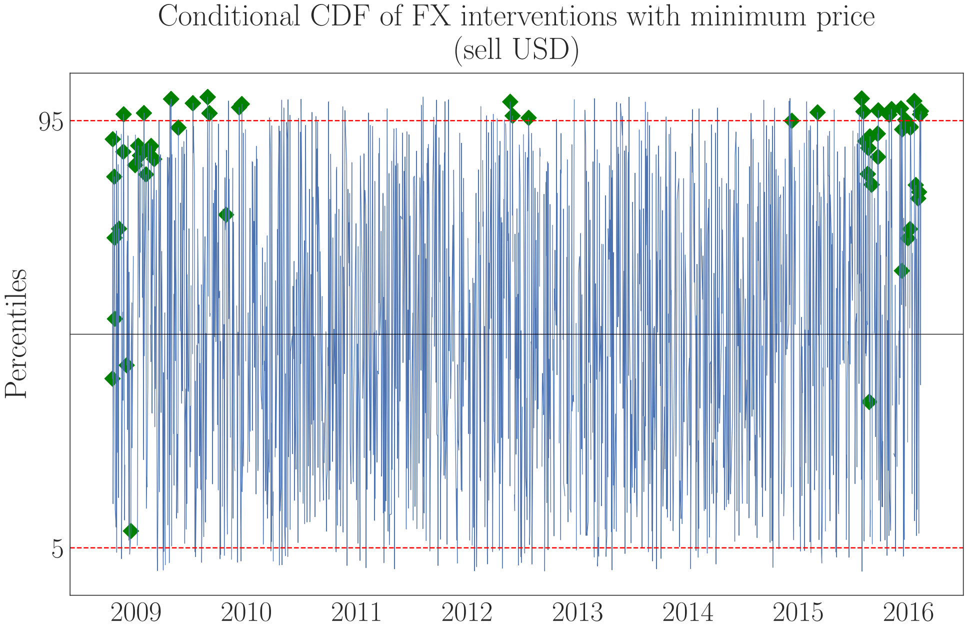
- The Banco Mexico (BM) implemented both ex-ante, transparent FX auctions and discretionary-rate auctions
- Different reservation rates:
  - **Rule-based setting**: BM operated an auction every day with a pre-announced **a minimum rate** for eligible bids
  - **Discretionary setting**: the auction was 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

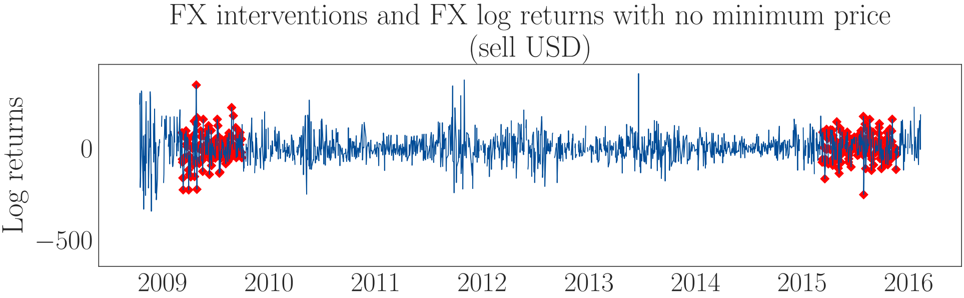


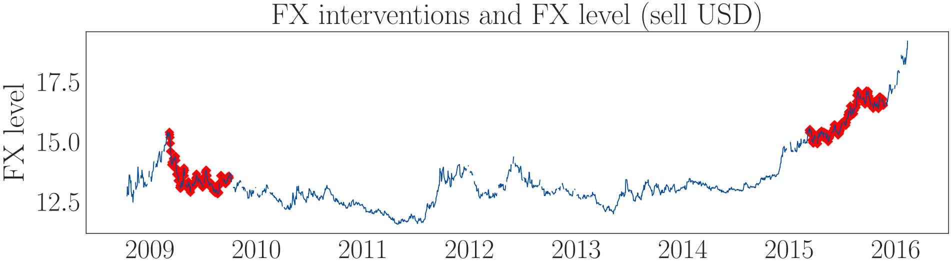


Rule-Based Benchmarking: Risk-Level

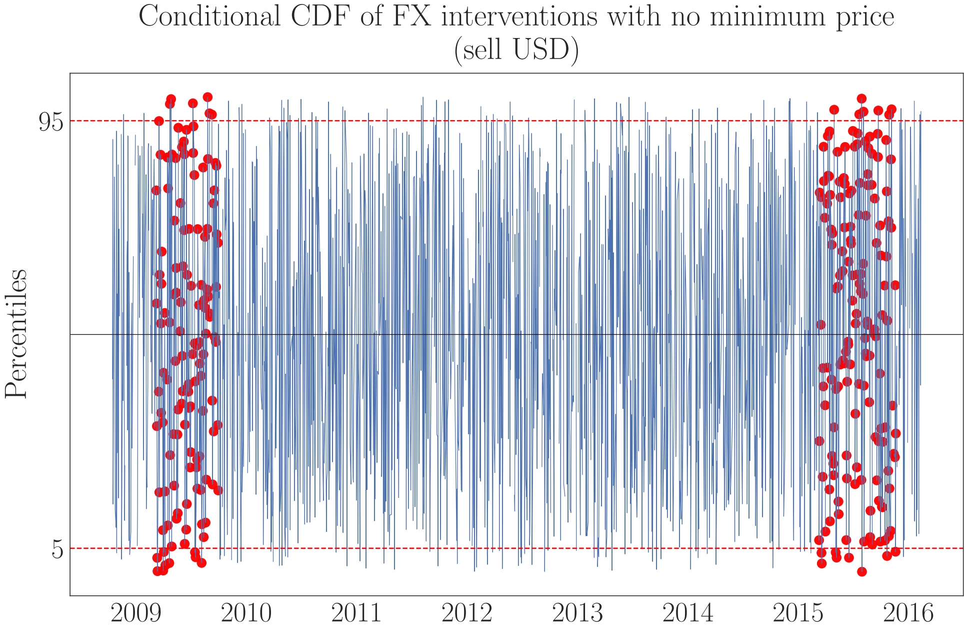


Discretion-Based Benchmarking





Discretion-Based Benchmarking: Risk-Level



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