

# FX Interventions Rules for Central Banks

## A Risk-Based Framework

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Singapore Training Institute, 20 April 2023



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# 1 Conceptual Framework

## 2 Model

## 3 Forecasting

## 4 Benchmarking

## 5 Policy Uses

# 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 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**

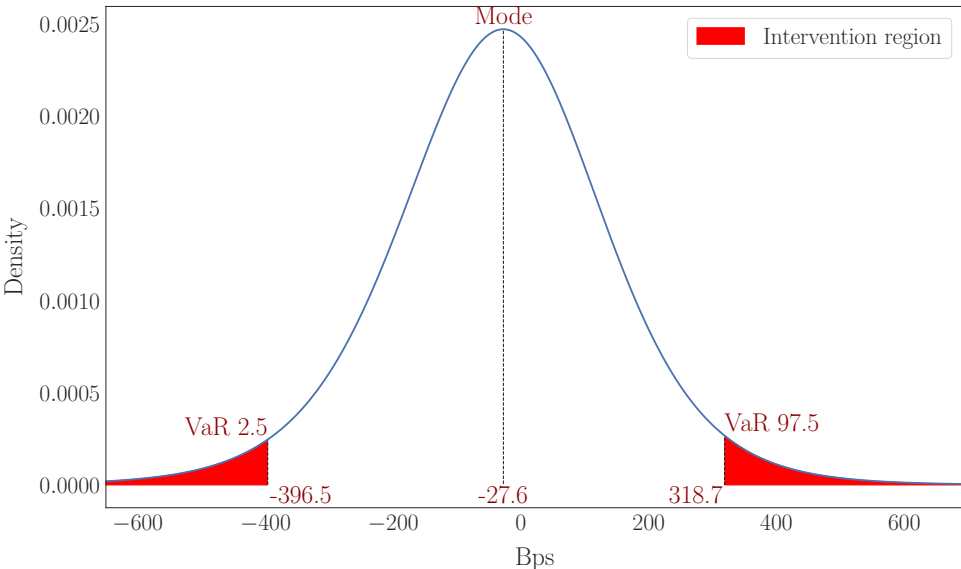
We propose an FX intervention rule based on **Conditional Value-at-Risk**

## 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% compared to previous day)
- 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 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**: buy/sell at the best expected 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 package, **free and open-source** (available on Github): estimation, forecasting, out-of-sample evaluation, optimization, benchmarking, etc. Results are **fully replicable**
- Can be used alongside other types of interventions: put auctions, NDF, etc.

# 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, **under certain conditions** 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 Ex-post 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

1 Conceptual Framework

2 Model

3 Forecasting

4 Benchmarking

5 Policy Uses

# 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	-2.34	-2.29	-1.74	-2.55	-1.63
Lag FX log returns	-0.07***	-0.08***	-0.08***	-0.08***	-0.08***
Bid ask abs	5.67	24.45	-33.58	-2.68	3.22
Min max abs	35.62	34.68	33.32	34.45*	26.2
Forward points first difference	23.29***	17.79***	26.33***	19.82***	19.44***
Interbank rate vs Libor		33.61***	39.43***	34.75***	33.86***
EURUSD log returns			-0.14***	-0.17***	-0.16***
VIX first diff				15.67***	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*	0.07	0.09*	0.07*	0.08***
R2	5.8 %	6.7 %	10.4 %	27.3 %	27.6 %
R2 adjusted	5.8 %	6.6 %	10.3 %	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

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

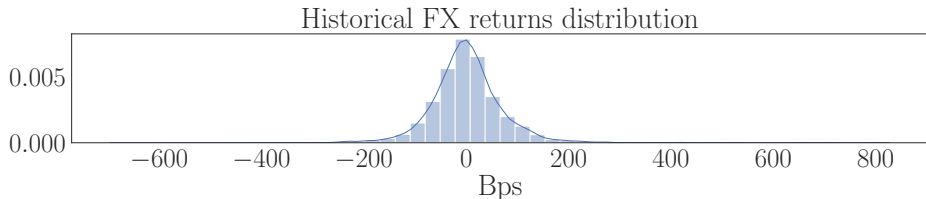
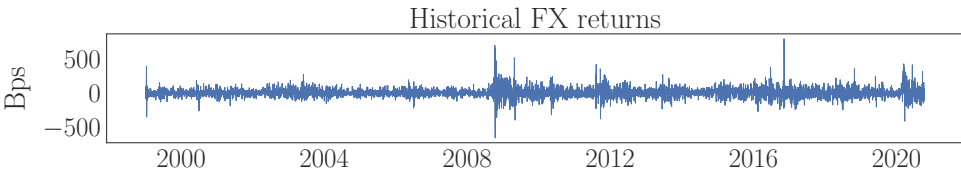
- The Conditional Value-at-Risk at threshold  $\tau$  is simply defined as the conditional  $\tau$ -quantile

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

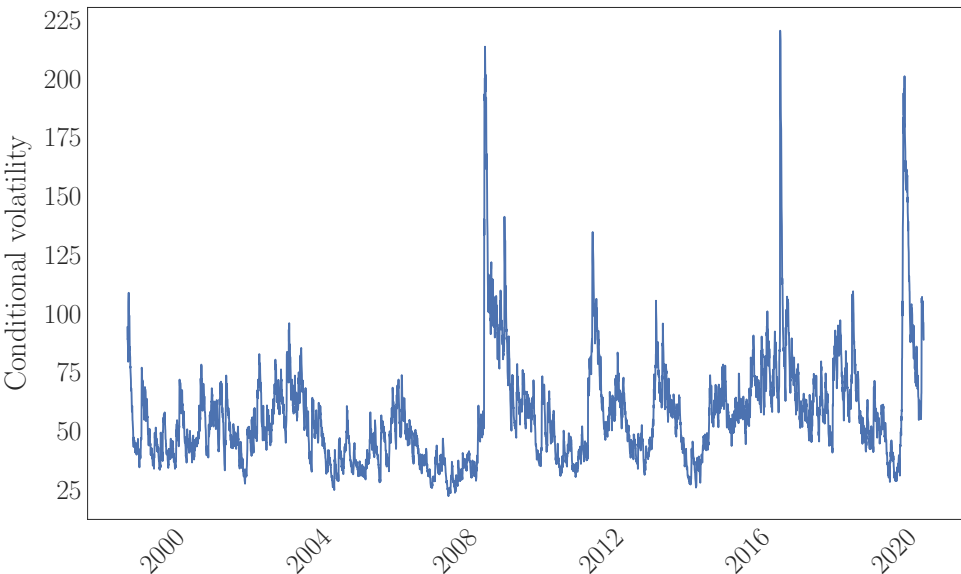
- The FXI intervention rule is a simple boolean rule, based on two risk-thresholds ( $\underline{\tau}, \bar{\tau}$ ), for depreciation and appreciation, potentially risk-symmetric ( $\bar{\tau} = 1 - \underline{\tau}$ )

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

# Dynamics of the Mexican Peso against USD



# Conditional In-Sample Volatility of the Mexican Peso



1 Conceptual Framework

2 Model

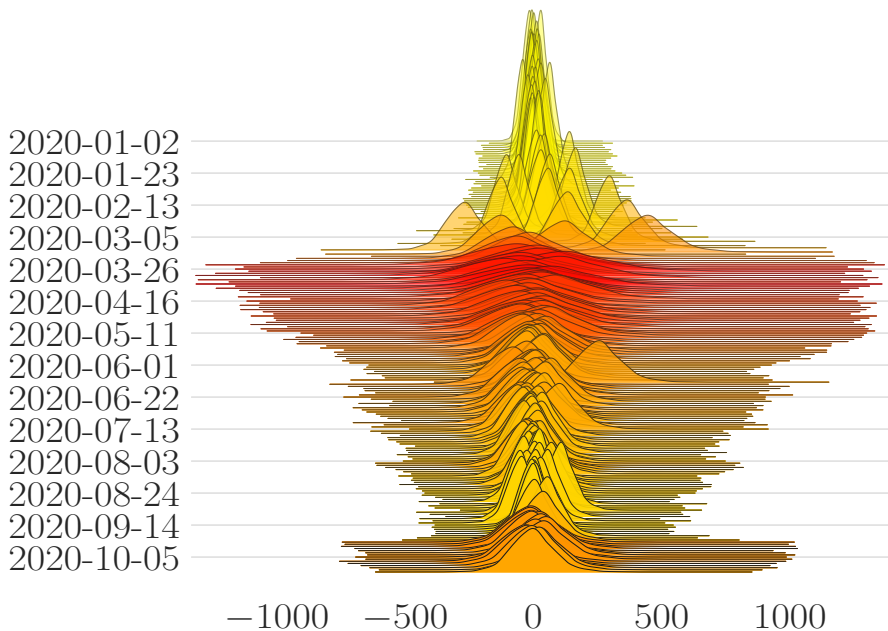
3 Forecasting

4 Benchmarking

5 Policy Uses

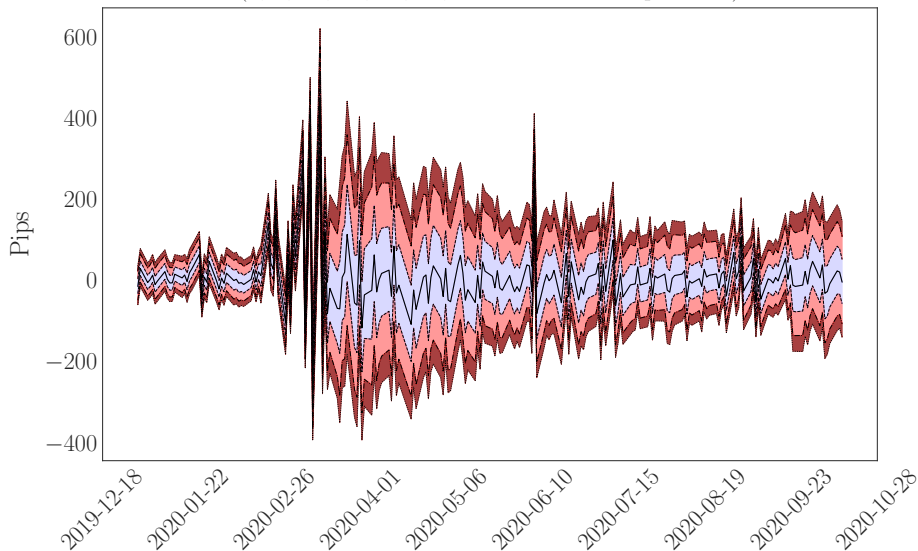
# Forecasting

- 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
- Optimize the choice of the mean (drift) and density models, specifically:
  - The model on the mean/drift
  - The model for the conditional variance
  - The distribution of the perturbations, that determines the whole distribution



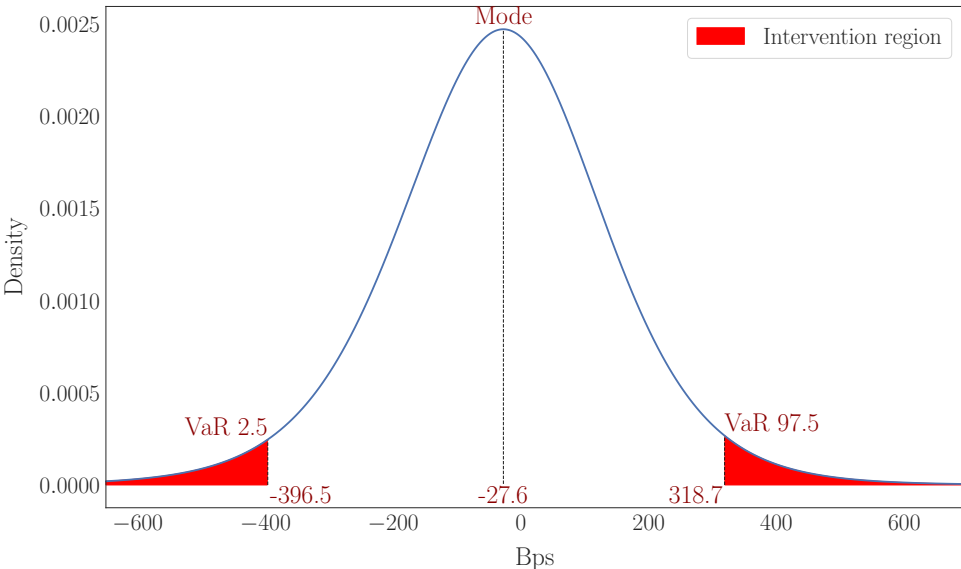
# Fan Chart

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



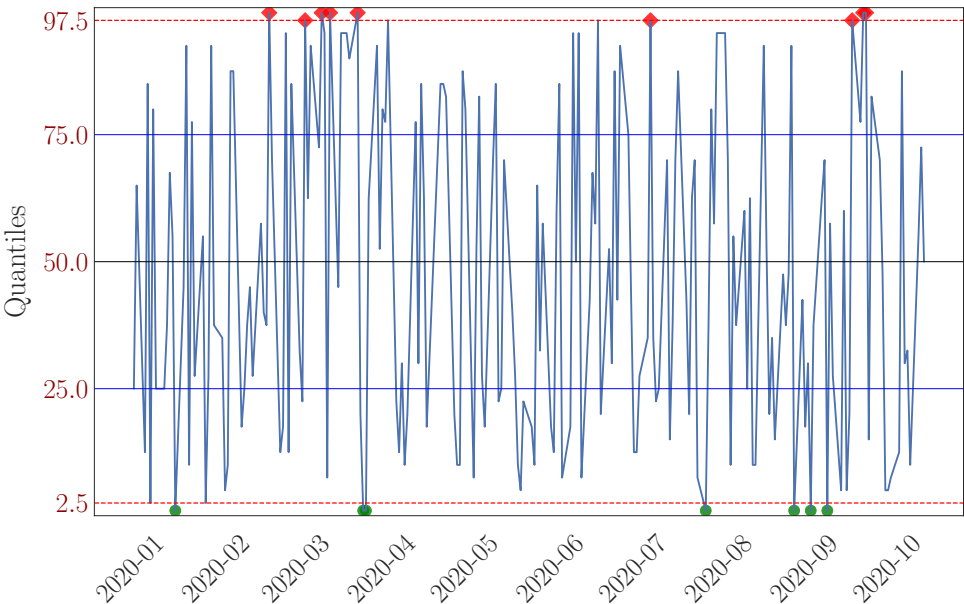
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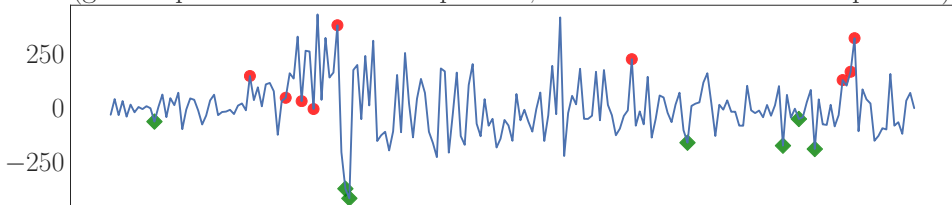


# Conditional Cumulative Distribution Function

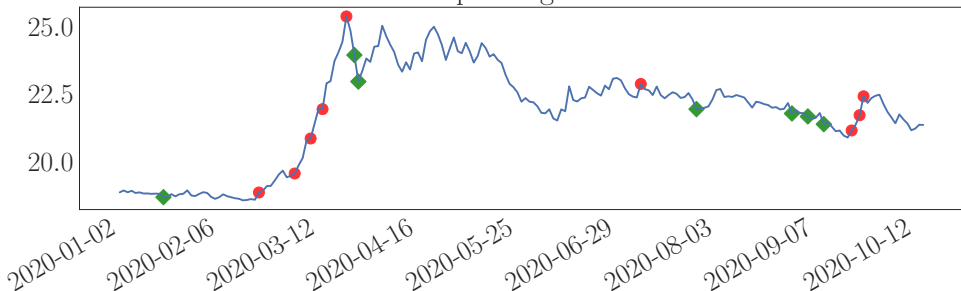


# Conditional Exceedance

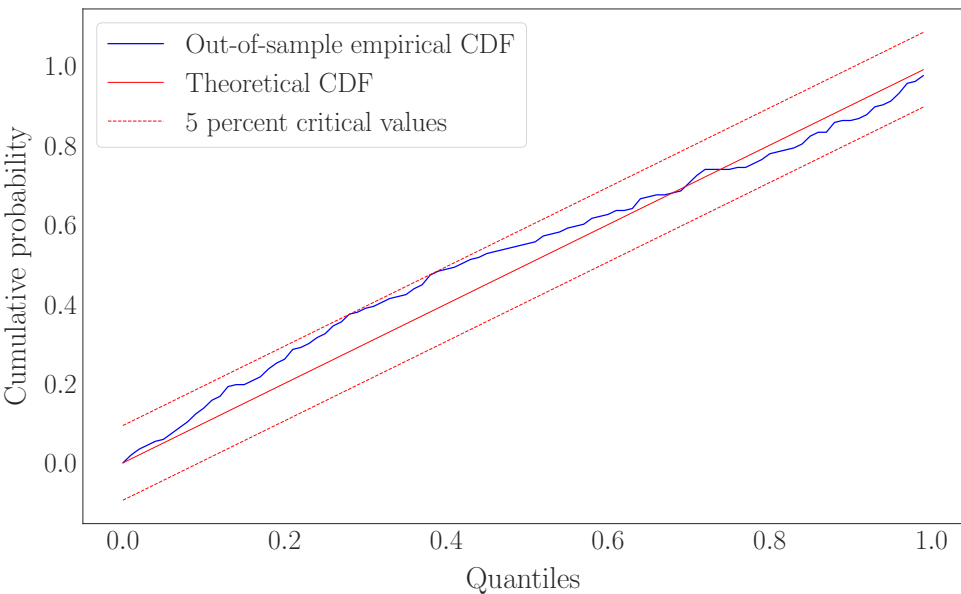
Log Returns and Conditional VaR Exceedance at 5 Percent  
(green square: below VaR 2.5 percent, red dot: above VaR 97.5 percent)



Corresponding FX level



# Density Evaluation



# In Practice

- The package we design handles the optimization seamlessly (see the Zigzag discussed previously)
- It outputs the optimal functional forms and parameters
- However, it might be time consuming, given that it involves optimizing over a large number of functional forms
- Hence, users might want to re-run the optimization from time to time, but not everytime
  - For instance, every month
  - Or after a structural break, a crisis, etc.

1 Conceptual Framework

2 Model

3 Forecasting

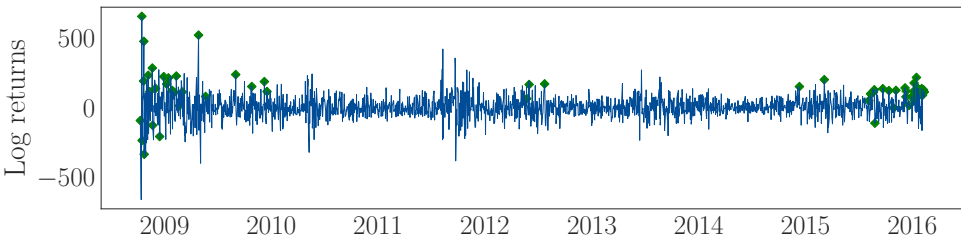
4 Benchmarking

5 Policy Uses

# 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?

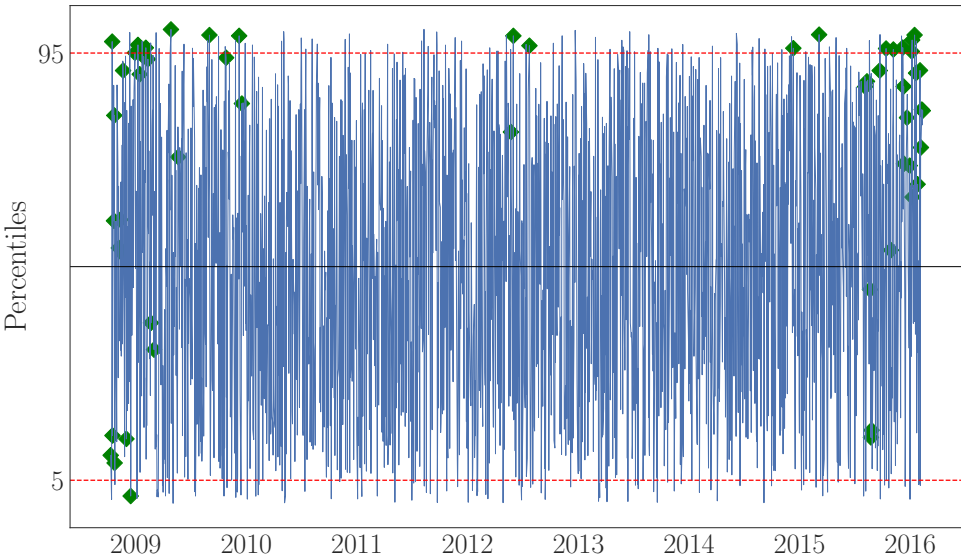
# Rule-Based Benchmarking



FX interventions and FX level (sell USD)

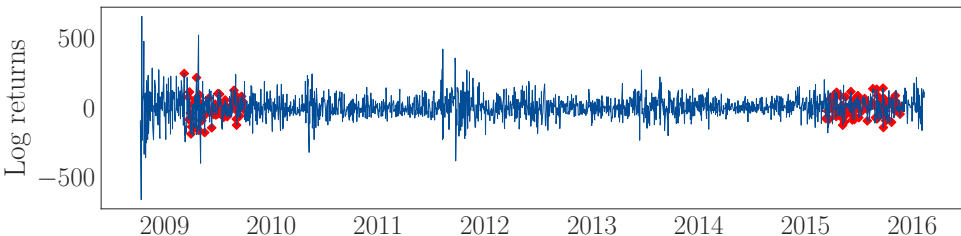


# Rule-Based Benchmarking: Risk-Level





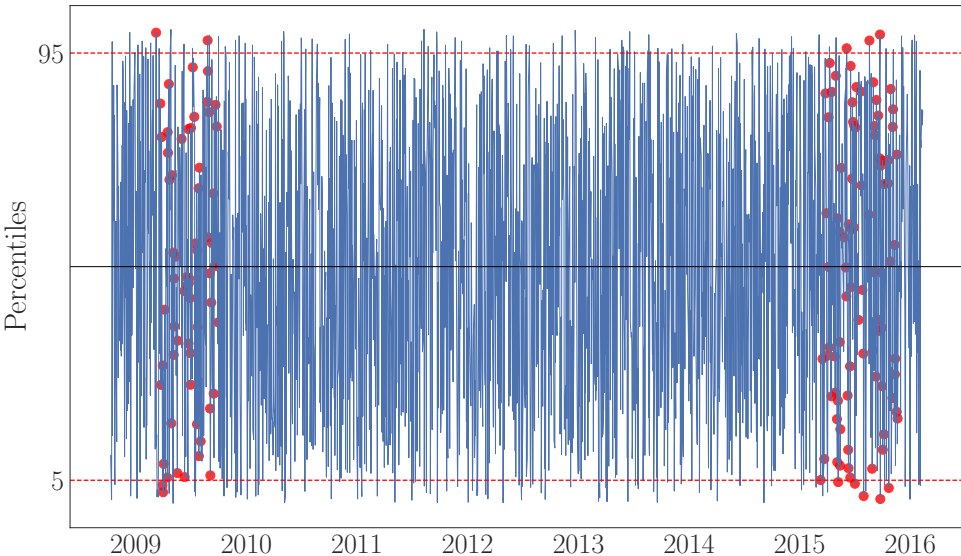
# Discretion-Based Benchmarking



FX interventions and FX level (sell USD)



# Discretion-Based Benchmarking: Risk-Level



# Benchmarking Results

- ❶ **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
- ❷ **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

1 Conceptual Framework

2 Model

3 Forecasting

4 Benchmarking

5 Policy Uses

# Policy Uses

- 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**

# 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