FX Interventions Rules for Central Banks
A Risk-Based Framework

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The views expressed in this presentation do not necessarily represent the views of the IMF, its Executive Board, or IMF management

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Contributions

- Design a rule for central banks to prevent **FX tail risks and disorderly market conditions**
- Provides guidance on **when** to intervene ("triggers")
- Appropriate for **floating exchange rate regimes** with FX macrofinancial risks (e.g. FX unhedged exposures, dollarization, etc.)
- Consistently target **FX risk** rather than arbitrary FX volatility/level threshold
- A **risk management framework** for central banks' financial stability mandate: aligned with **industry's best practices** in risk management

What the rule is NOT about

- Not designed to reach or to preserve a given FX level (e.g. alignment with the **equilibrium exchange rate level**)
- Doesn't prevent **appreciation/depreciation trends** to occur...
- ... but can be compatible with other approaches, e.g. discretionary FXI
- We **don't discuss the efficiency** of FX interventions from a welfare/macro point of view
- Not a guide to calibrate **FX interventions amount**
- Not a guide for the optimal **currency allocation** of FX reserves

Key Messages

Foreign Exchange intervention rules should be:

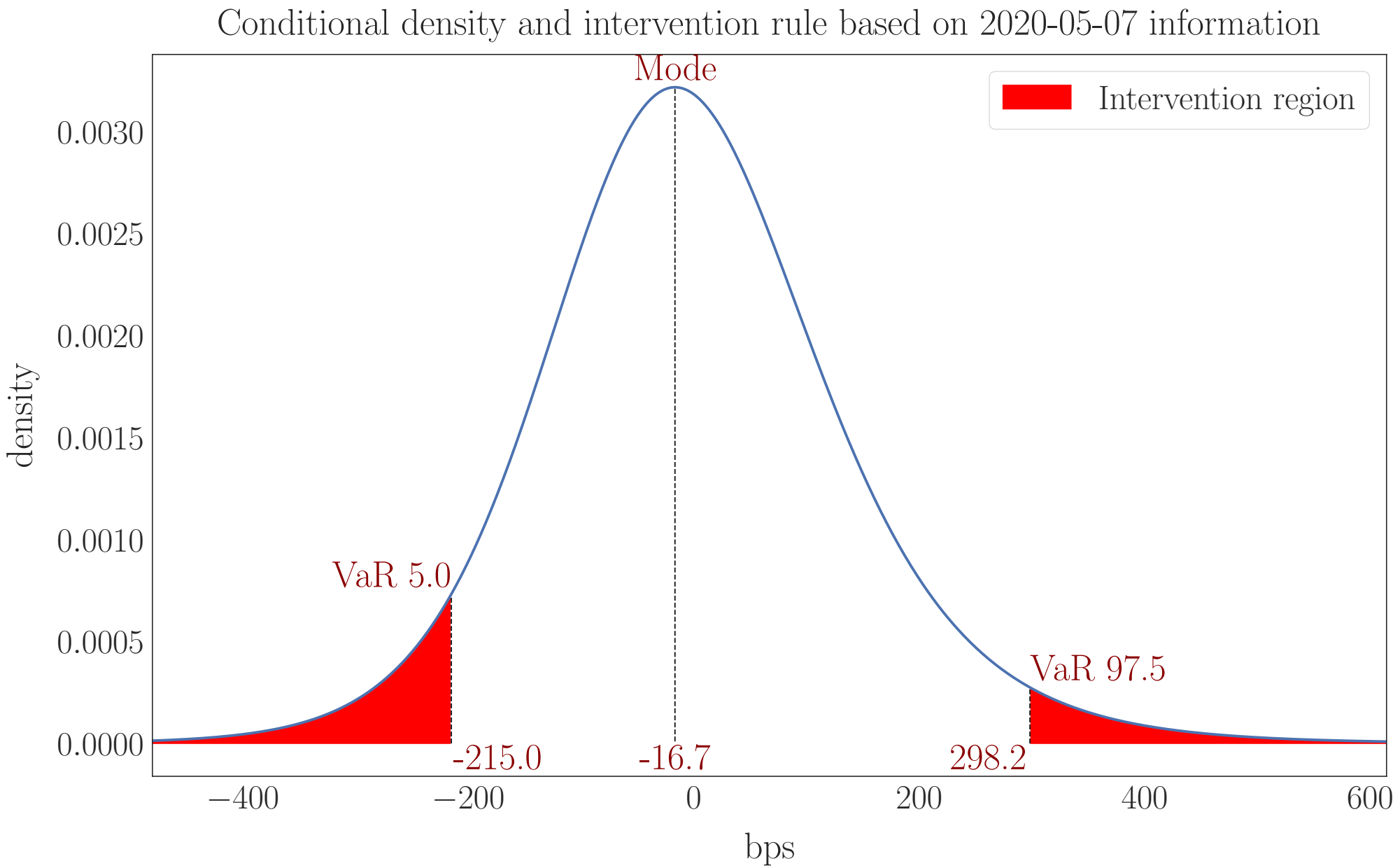
- **Adaptative**, depend on market conditions
- **Objective**, anchored to a risk tolerance level rather than an aribtrary FX level threshold
- Capture FX **non-linearities and asymmetries** between appreciation and depreciation
- Be easily **operationalizable**, and **financially viable**

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 2020-05-07 information
Mode
Intervention region
VaR 5.0
VaR 97.5
-215.0
-16.7
298.2
density
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
−400
−200
0
200
400
600
bps

A Risk-Management Approach to FX Interventions

- Tail-risks hedge not always available: **incomplete markets**
- Provide a **public good** to address market failure. Leave the market to hedge non-tail risks
- **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)
- Risk tolerance should depend on the **macrofinancial risk** (FX unhedged exposures from residents, dollarization, etc.) and **market resilience**
- The financial stability mandate of the central bank is properly formalized and quantified via VaR metric.

Main Features

1. This rule allows flexible exchange rate to act as a **shock absorber**: provides more flexibility in crisis time.

2. Doesn't provide a free insurance to the market: avoid **moral hazard** and support the **development of hedging market**

3. Adaptative rule prevent **market manipulation and windfall effects**

4. This rule guarantees that the interventions will occur with a **fixed frequency** over the medium term => **budget neutrality** with symmetric risk preference

5. **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** and **density forecasting**
- We programmed a Python package, open-source: estimation, forecasting, out-of-sample evaluation, benchmarking, etc.
- Can be readily used by central banks and deployed during TA missions

Usages

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):** $r_{t+1} = \text{Intercept} + \rho r_t + \beta X_{t+1} + \epsilon_{t-1}$
- **Exponential volatility:** $\log \sigma_{t+1}^2 = \omega + \beta g(r_t)$ where $g(r_t) = \alpha r_t + \gamma(|r_t| - \mathbb{E}|r_t|)$
- **Error term distribution** $\epsilon_t = \sigma_t \varepsilon_t, \ , \varepsilon_t \sim \text{TSK}(k, v)$
- The forecasted conditional probability distribution function is defined as:

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

Estimation

- The GARCH estimation is standard and done with MLE; selection of parameters is done via AIC/BIC criteria.

- The Python package we designed allows to select:
  - The exogeneous regressors
  - The lag
  - The volatility specification (exponential, RiskMetric, standard GARCH, etc.)
  - The distribution family of the error-terms (Gaussian, Student, Tskew, Generalized Gaussian)

Exogeneous Regressors

FX microstructure: FX bid-ask spread (averaged over the day)

CIP: daily interest rate differential with the US Libor

Hedging costs: one-month forward exchange rate =>

Past policy interventions: lagged amount of central bank FX intervention

Global risk sentiment: The VIX, implied volatility on the S&P 500

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

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

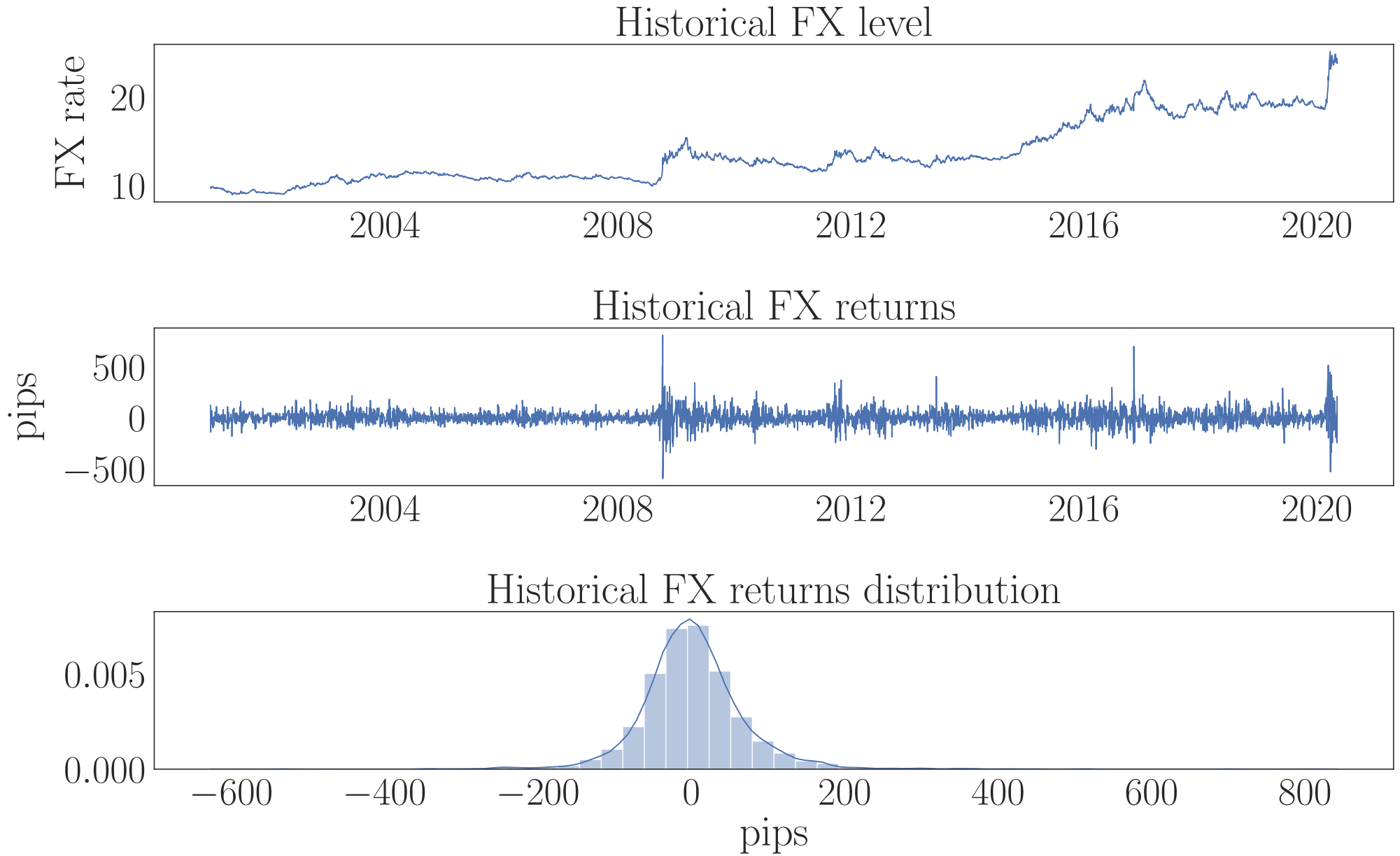
- The Conditional Value-at-Risk at threshold τ is simply defined as the conditional τ-quantile

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

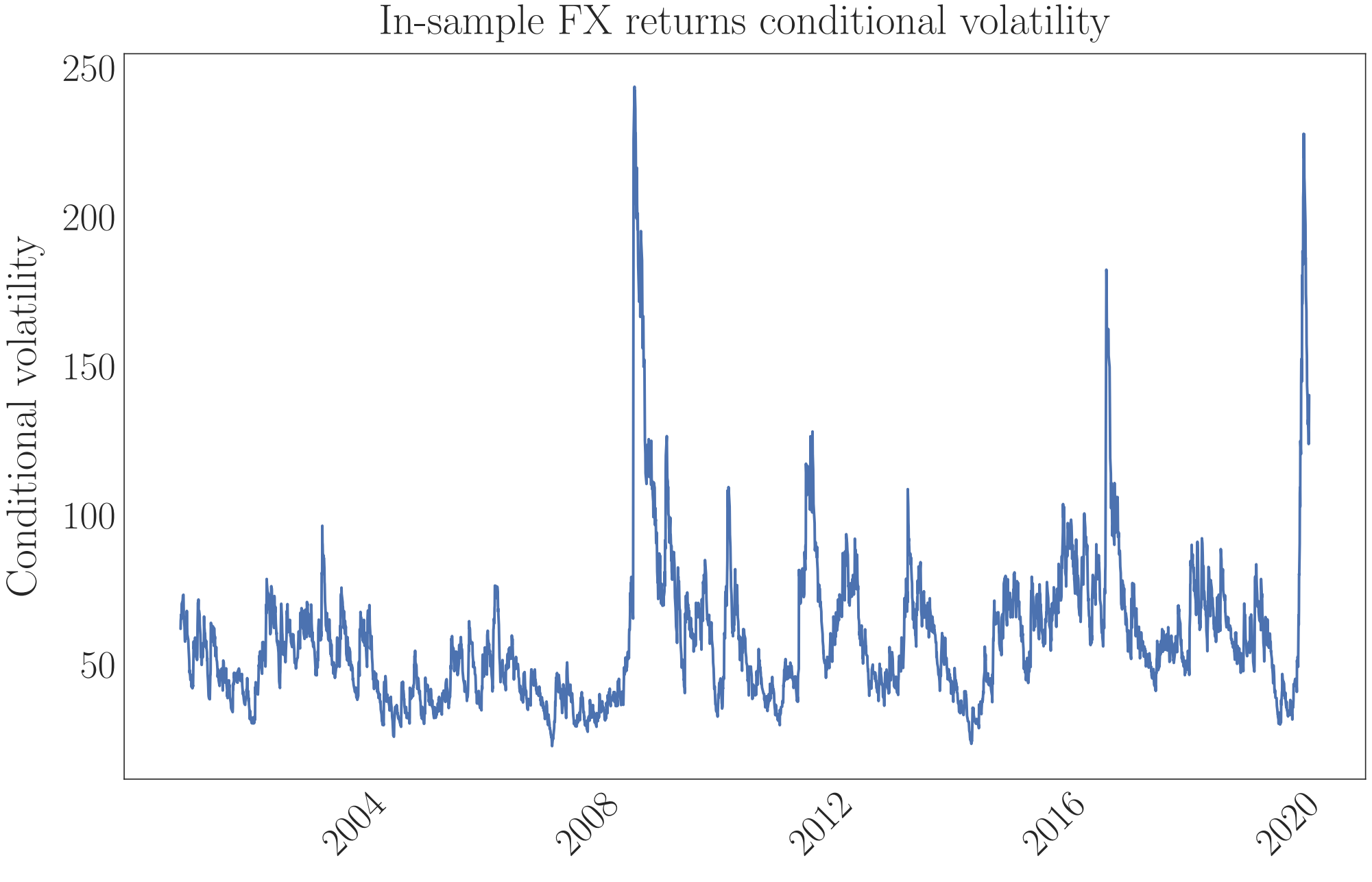
- The FXI intervention rule is a simple boolean rule, based on two risk-thresholds $(\underline{\tau}, \overline{\tau})$, for depreciation and appreciation, potentially risk-symmetric $(\overline{\tau} = 1 - \underline{\tau})$

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

Dynamics of the Mexican Peso against USD



Conditional In-Sample Volatility of the Mexican Peso



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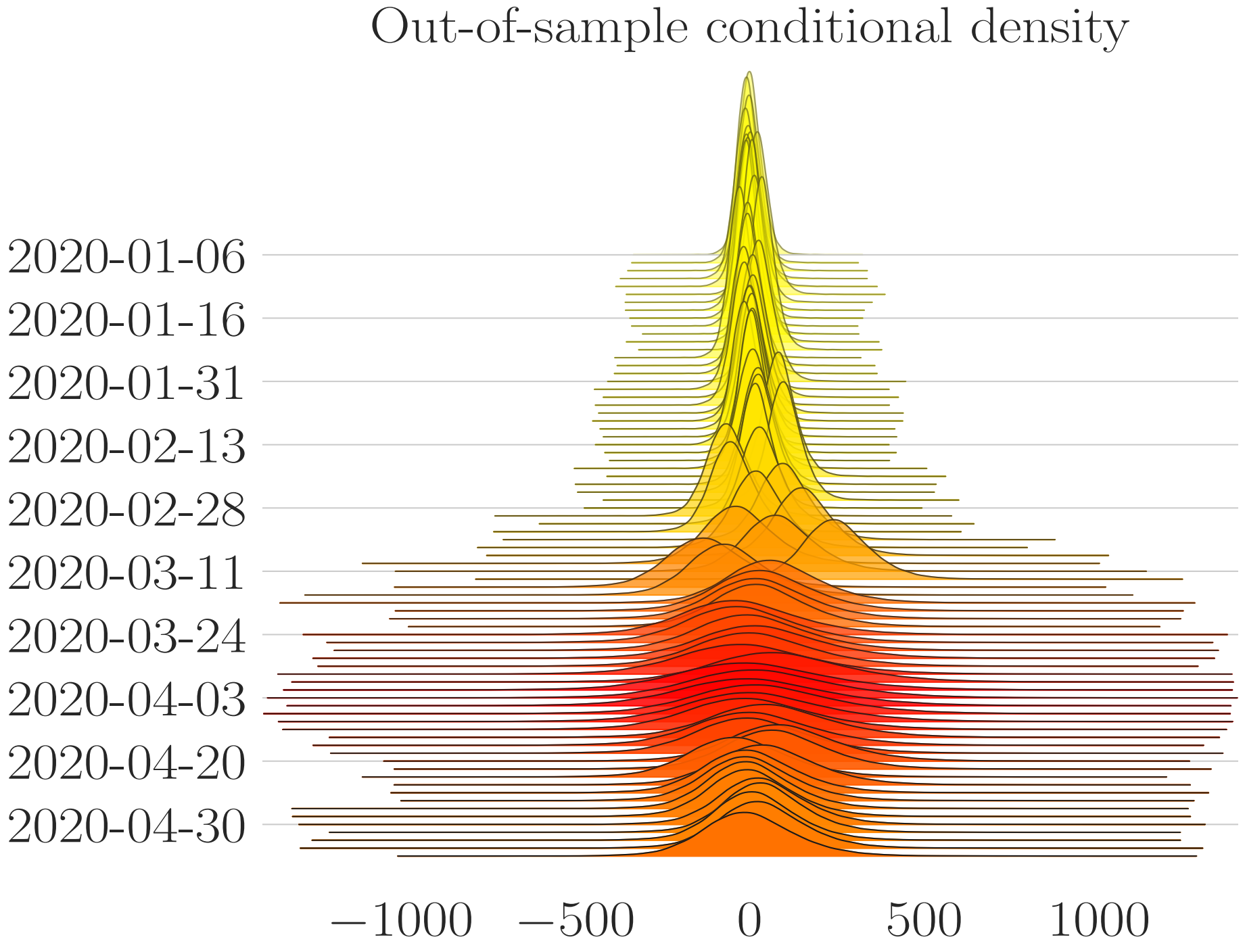
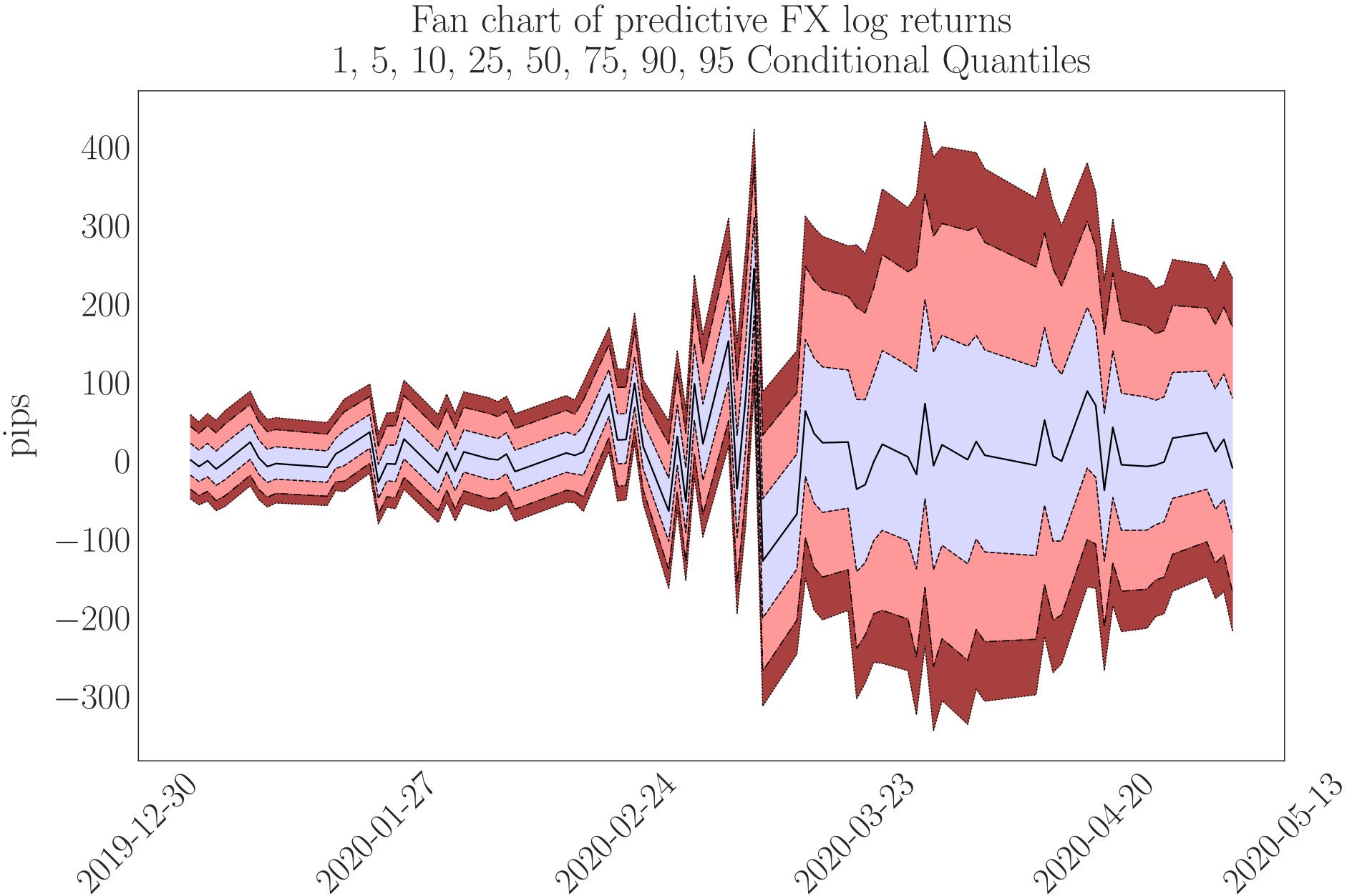
Forecasting

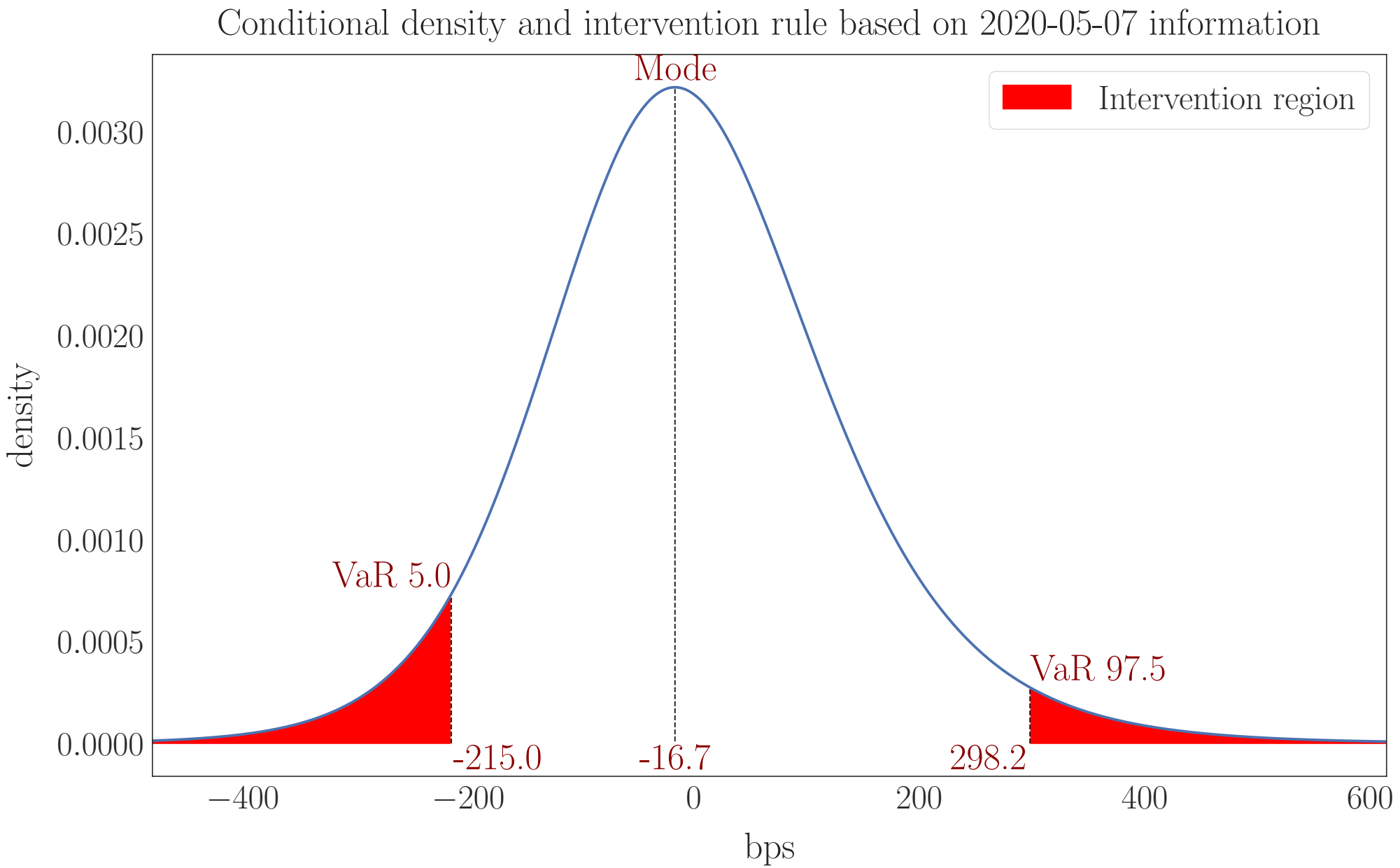
- Real-time forecasting based on market conditions
- Estimate the GARCH and derive the forecasted drift and volatility
- Infer the **full-fledged conditional distribution** of FX log returns for any point in time
- Assess model accuracy via (i) in-sample metrics and (ii) out of sample performance (probability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


Out-of-sample conditional density
2020-01-06
2020-01-16
2020-01-31
2020-02-13
2020-02-28
2020-03-11
2020-03-24
2020-04-03
2020-04-20
2020-04-30
−1000
−500
0
500
1000

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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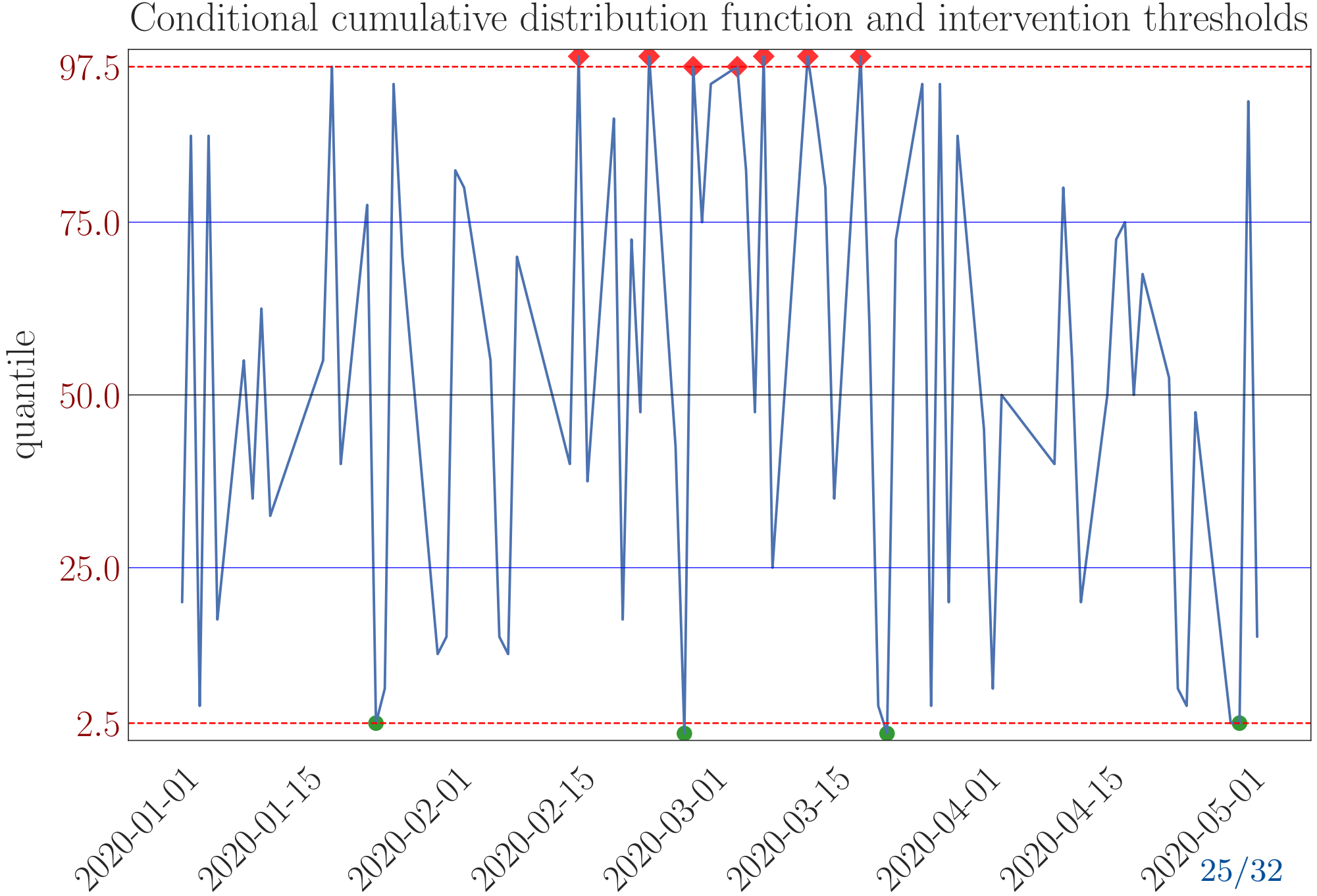
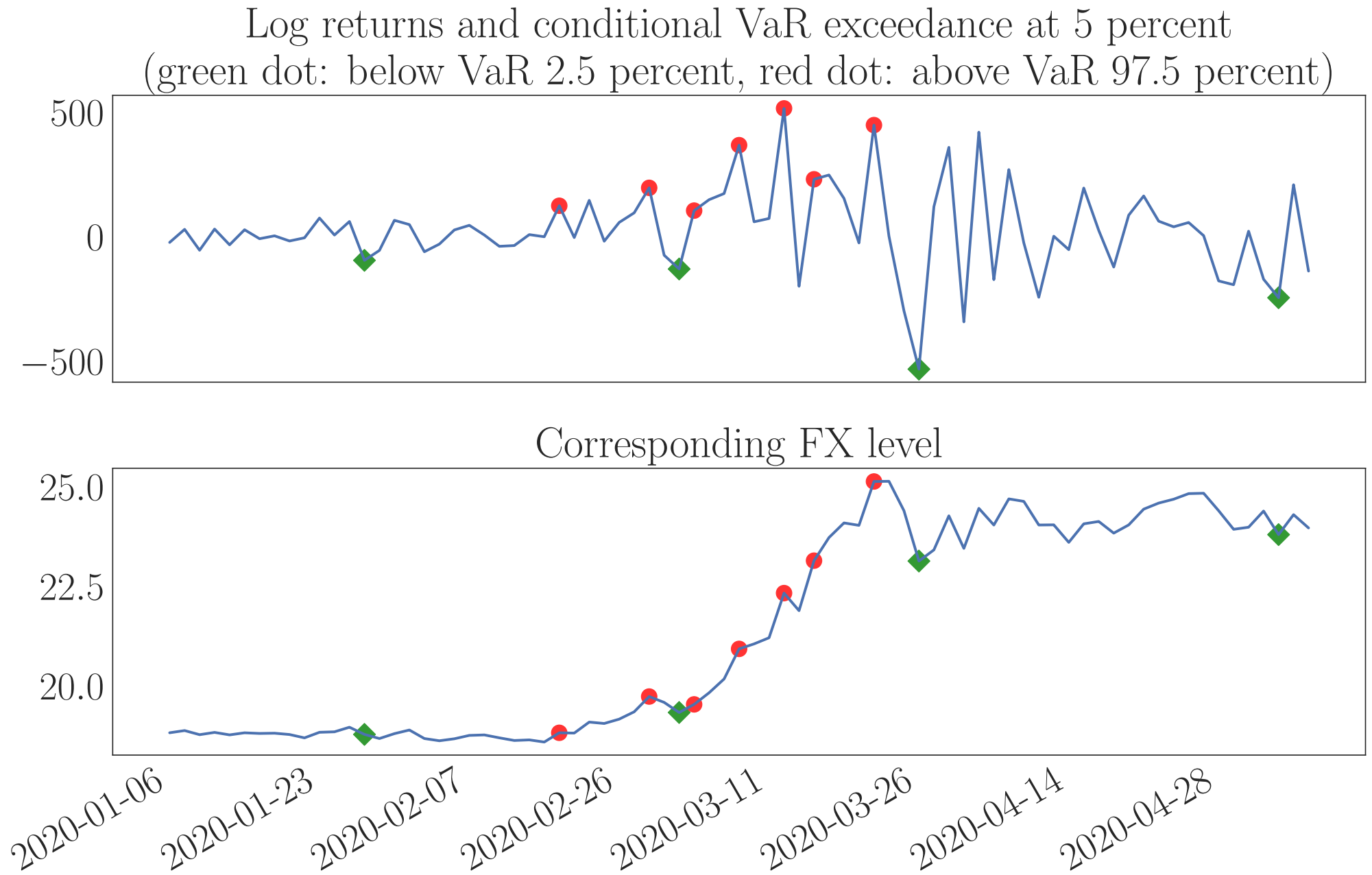
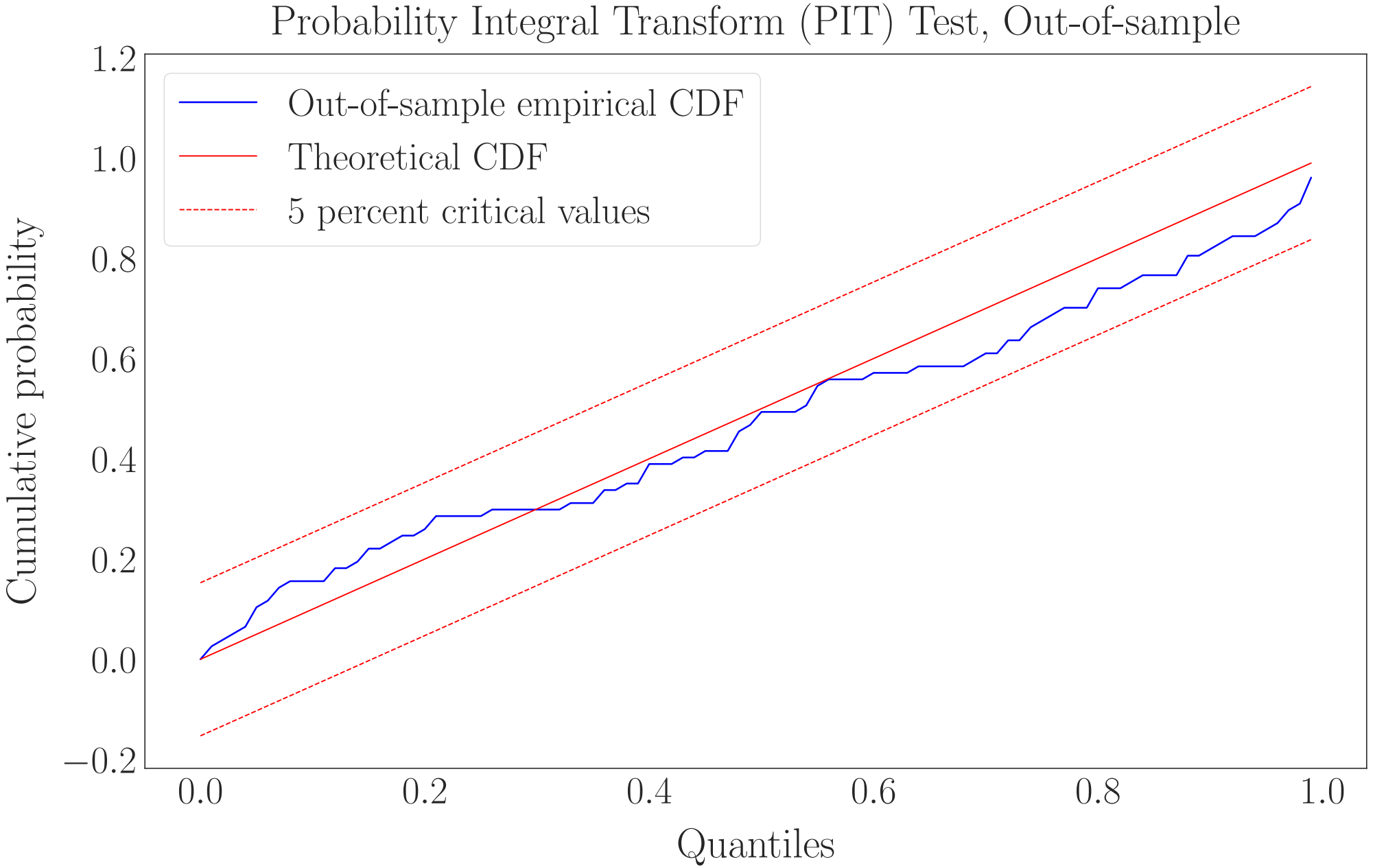
Conditional Cumulative Distribution Function



Conditional Exceedance



Density Evaluation



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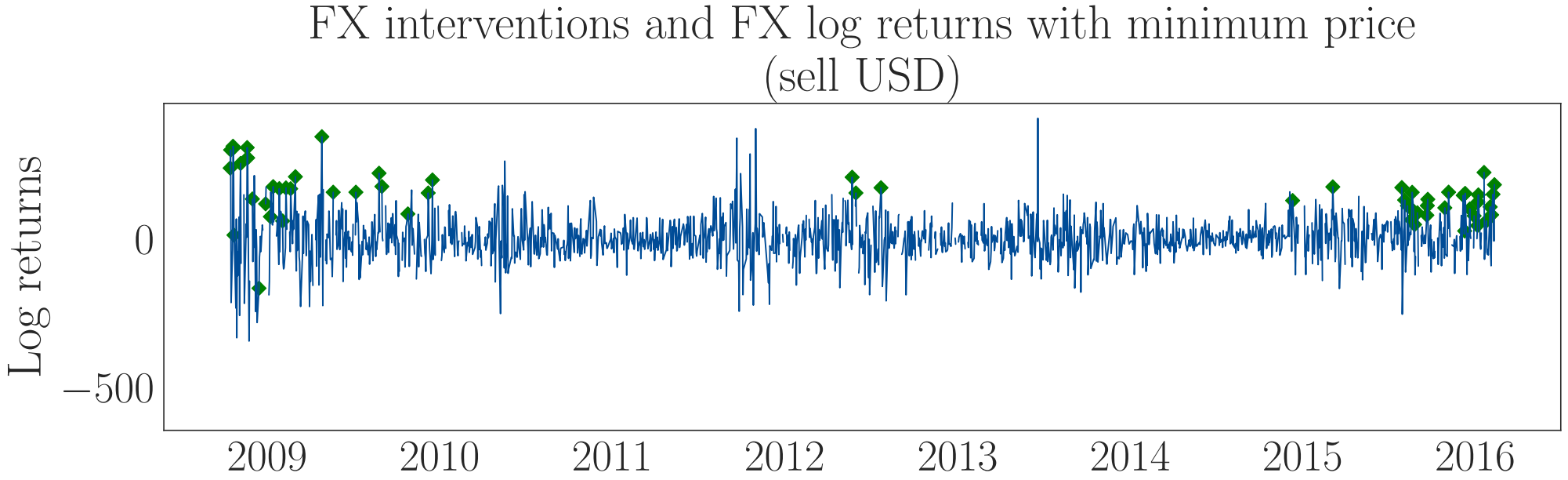
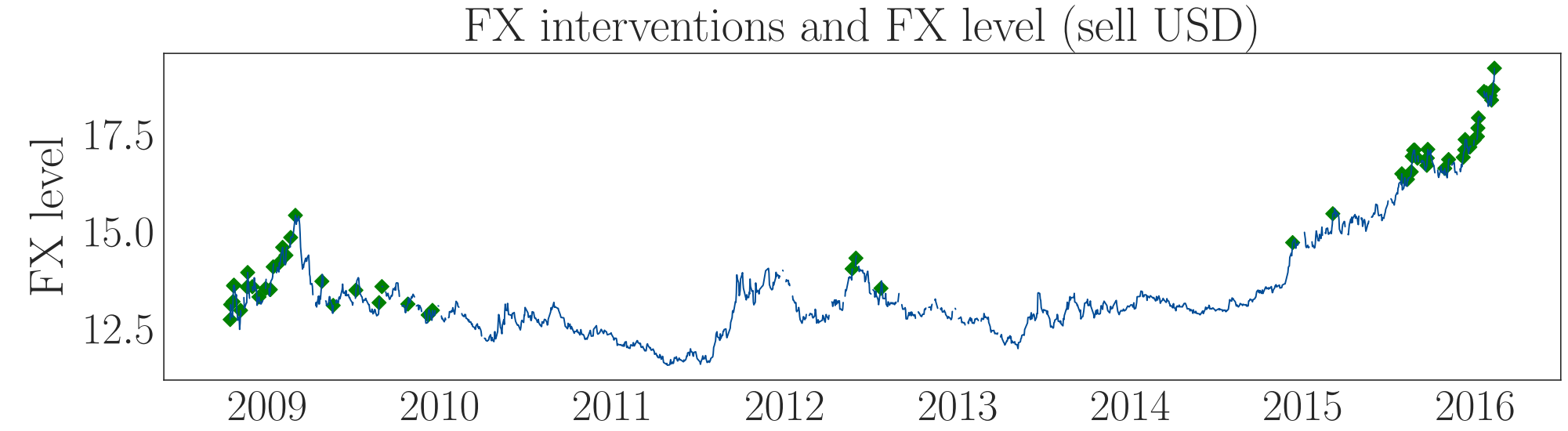
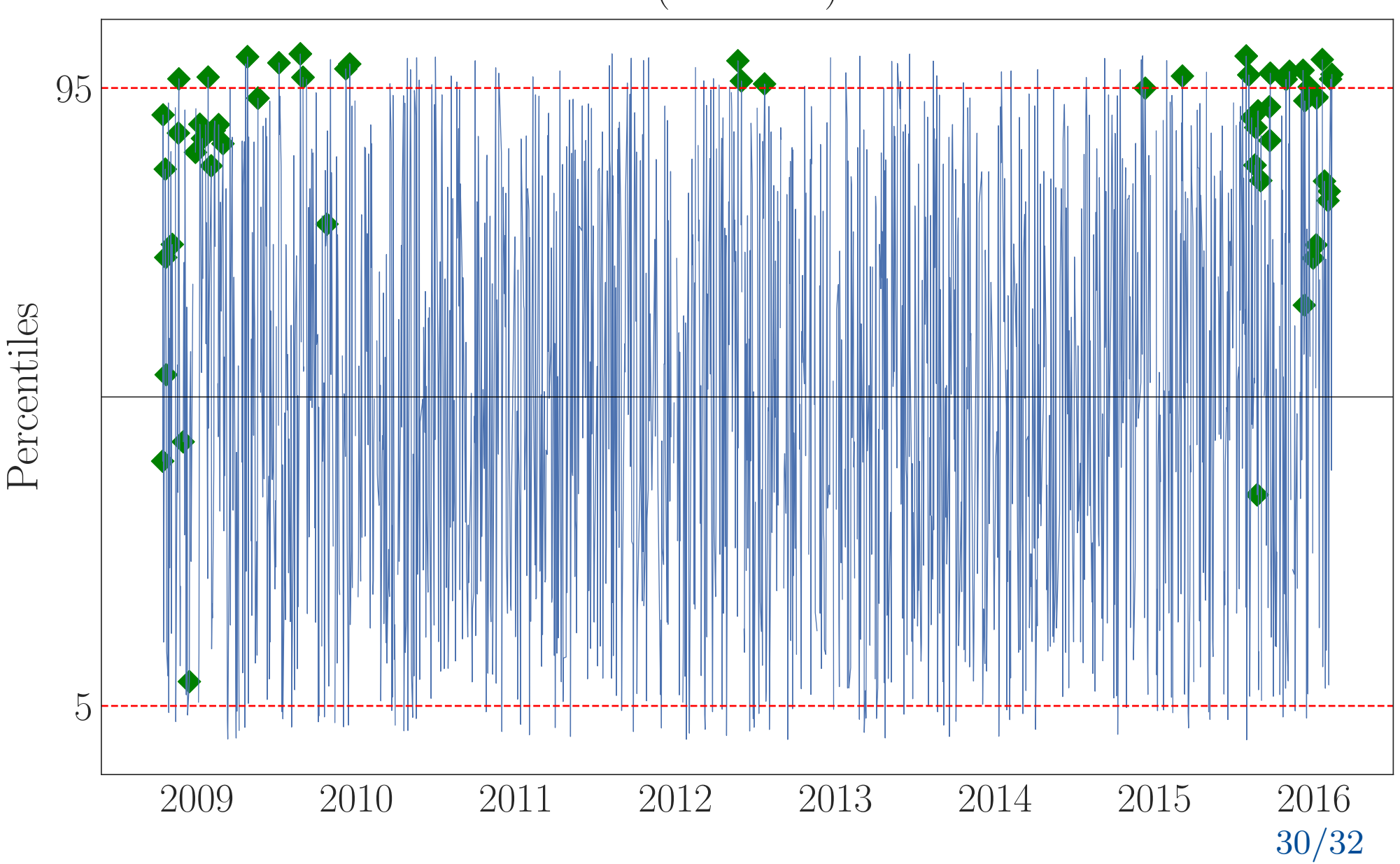
Rule-Based Benchmarking

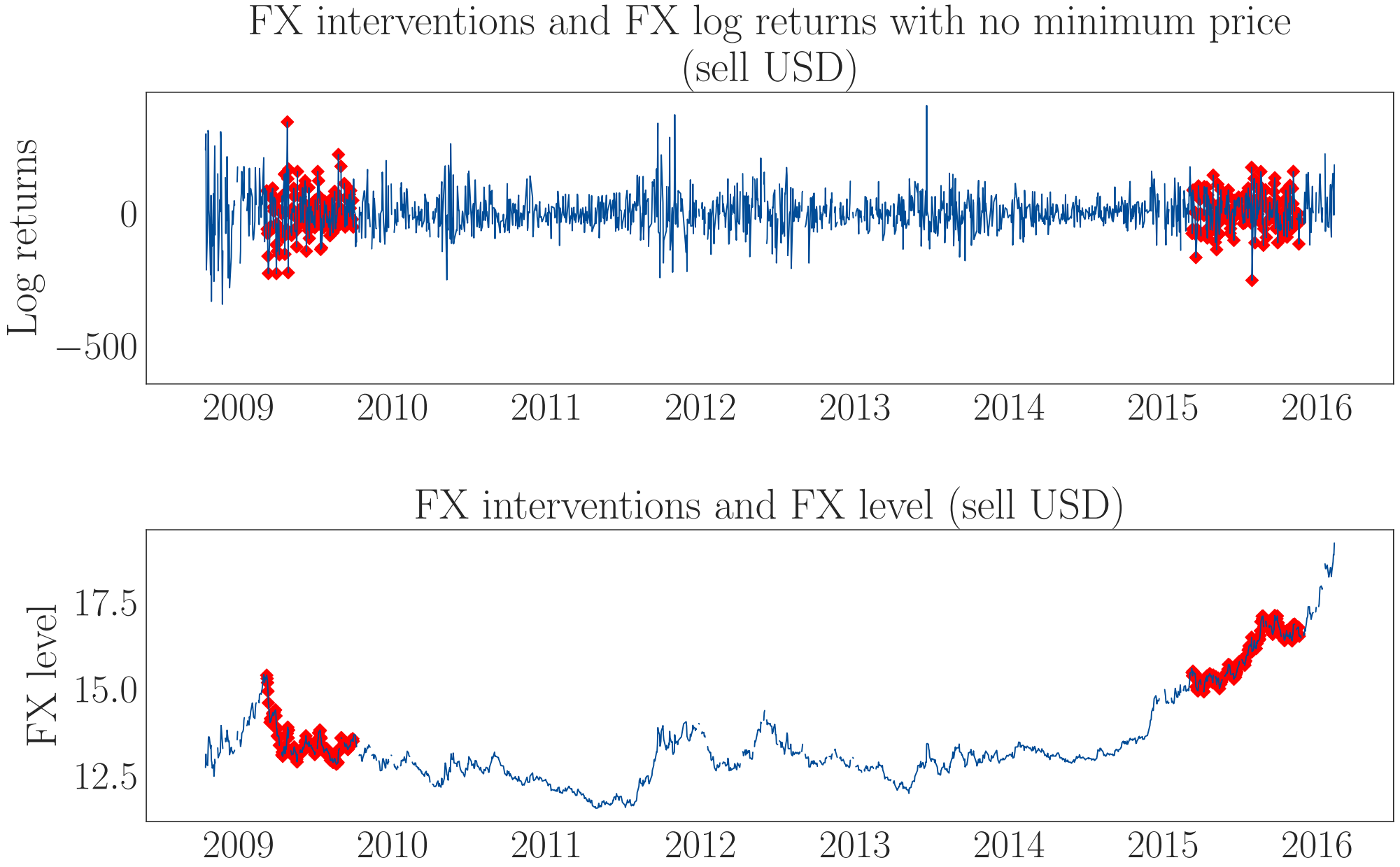




Rule-Based Benchmarking: Risk-Level



Discretion-Based Benchmarking



Discretion-Based Benchmarking: Risk-Level