Foreign Exchange Interventions and their Impact on Expectations: Evidence from the USD/ILS Options Market

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Few papers have analyzed the effect of interventions on FX options markets

- Since the Great Financial Crisis (GFC) **many central banks** have adopted an **foreign exchange intervention (FXI) regime** as part of their **monetary policy toolkit** (Domanski et al., 2016).
- **Many** papers have **analyzed** the effect of FXI on **spot FX markets** (see the survey in Menkhoff (2013), Neely (2005) and Sarno and Taylor (2001)).
- **Few** papers have **analyzed** the effect of FXI on **market expectations** as reflected in **FX options** (Galati et al. (2007) and Galati et al. (2005)).
- These papers have found a **weak/no significant relation** between **FXI** in the spot FX market and price movements in the **FX options market**.

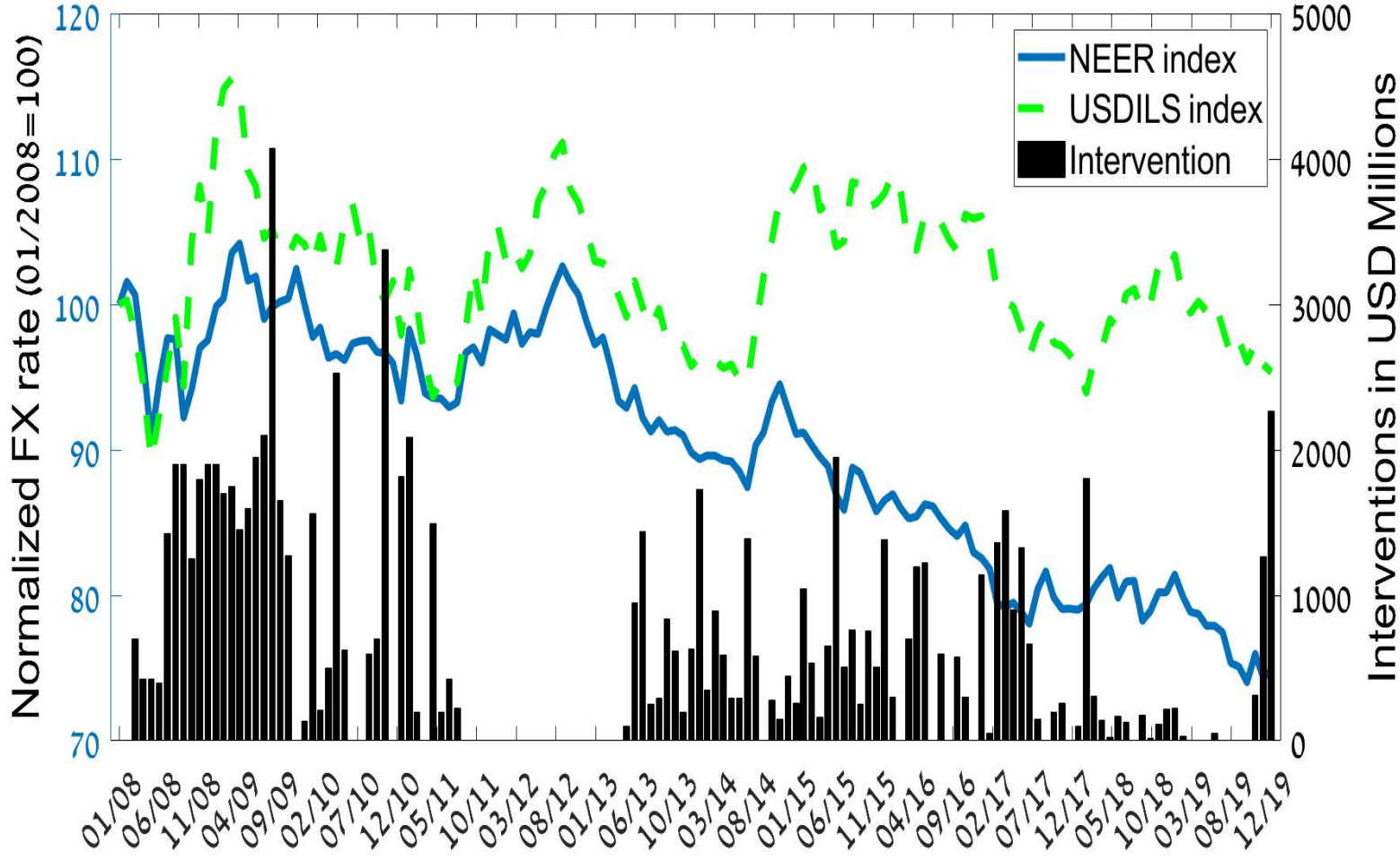
Why examine the effect of FXI on market expectations

- **Effect of FXI** on spot FX rate **short-lived, if expectations** do **not respond** to FXI in the intended direction (Miyajima, 2013).
- We may ask ourselves, to what extent **FXI affect crash risk** as reflected in FX options markets:
  - **QE announcements** significantly **reduce market crash risk** (Hattori et al., 2016) as reflected in equity options.
  - **QE policies** and **FXI both affect FX rates** in theory and empirically (Jarrow and Li (2015) and Dedola et al. (2021)).
- With **limits to arbitrage**, **derivatives** are **no longer redundant**.
  - Derivatives help **complete the market**.
  - **Risk-neutral density** (RND) reveals **expectations** about the higher-order moments of the **distribution of future spot rates** and **risk premia** (Figlewski, 2018).

The Case of Israel before COVID-19

- We analyze the Bank of Israel's FXI regime from **January 2013 to December 2019**.
- Background information:
  - **ILS** under **appreciation pressure** since GFC.
  - **USA** is the **major trading partner** of Israel $\Longrightarrow$ **USD purchases** from March 2008 onwards.
  - **Several intervention regimes**. We analyze the **regime before COVID-19** pandemic erupted.
  - **Sterilized interventions** = sold ILS-denominated government securities in (approx.) the same size (monetary base is unchanged).
  - Aggregated **FXI data published** on a monthly basis.
  - We use (confidential) **daily FXI data**.

A bird's-eye view of BOI's monthly interventions



Our findings (1/3)

- First, we estimate the **effect of FXI** on the USD/ILS **spot rate** and the nominal effective exchange rate (NEER).
- We find that:
  - 1 billion USD intervention $\Longrightarrow$ a **depreciation** of the ILS by **0.82% (NEER)– 0.85% (USD/ILS)**.
  - **No subsequent reversal** $\Longrightarrow$ BOI's **FXI policy successful** (according to standard "success criteria") in **affecting** both **spot rates** in the **intended direction**.
- **Findings** are **similar** to Ribon (2017) and Caspi et al. (2018).

Our findings (2/3)

- The **effect** on the **USD/ILS forward rate** that is **lower** (0.72%), but significant.
- Notice that money market **interest rate differentials** are small in the period of interest (and approx. constant between two trading days).
- **Cross-currency basis** (CCB) = $r_t^{US} - \left[r_t^{IL} - (f_t - s_t)\right] \approx f_t - s_t$ becomes **more negative** ...
- ... as **theoretically predicted** by the Amador et al. (2020) model in a low interest rate environment.
  - **Framework** to study the problem of a central bank that pursues an **exchange rate policy** at the **zero lower bound**.
  - Central bank can **achieve** optimal **FX rate policy with FXI** by allowing **CIP deviation to widen**.

Our findings (3/3)

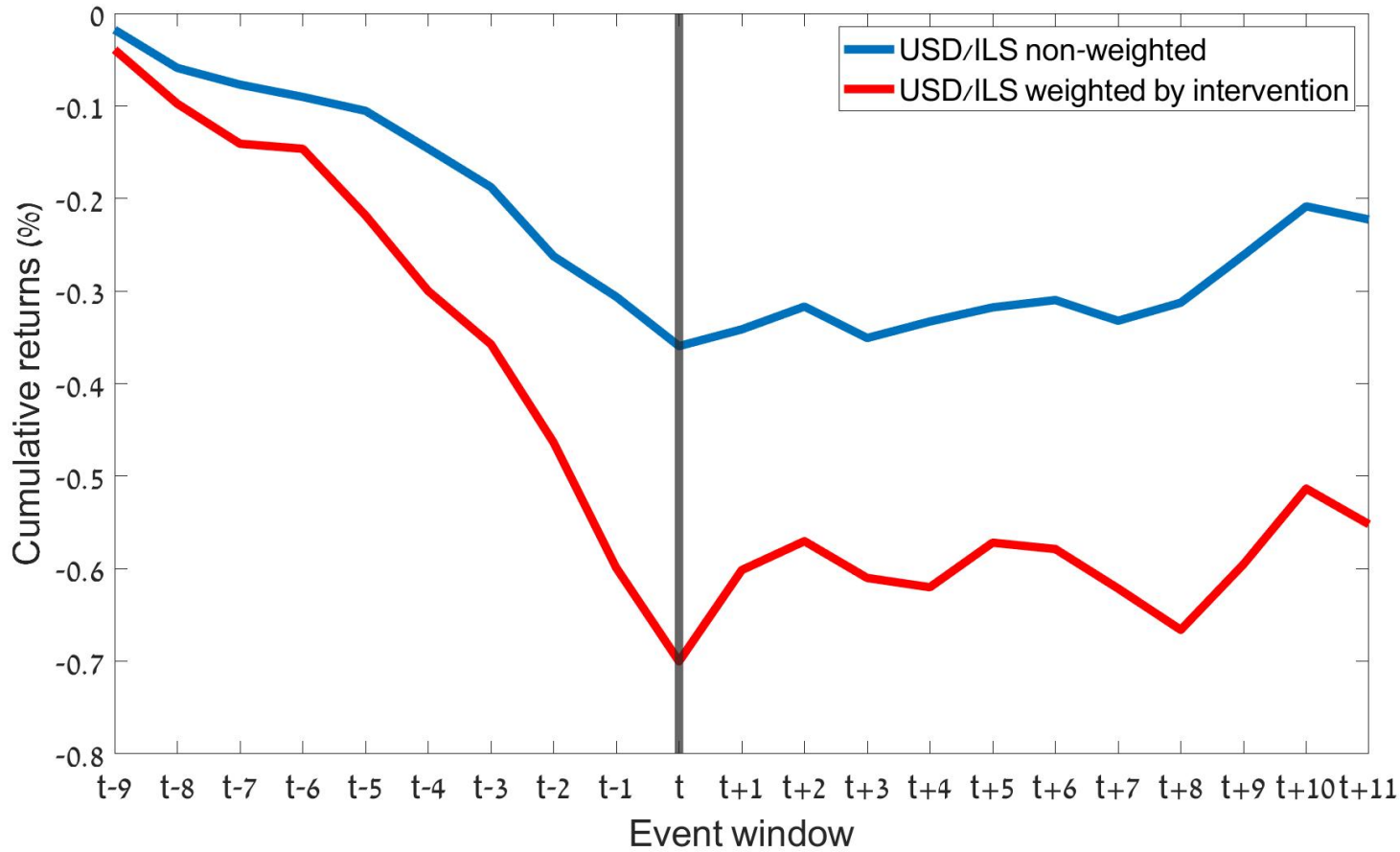
- We analyze the **relation** between **FXI** and the **USD/ILS options market** and find that:
  - **Options market** seems to **price in future FXI** (controlling for the effect on the USD/ILS spot rate).
  - **Higher moments** of the **RND** – proxied by the price quotes of scaled USD/ILS options – do **not change** when the BOI intervenes.
  - **Large effect** on the USD/ILS **forward** rate: **FXI** locationally **shift the RND** towards higher USD/ILS values **without affecting higher-order risks** – e.g. crash risk is unaffected.
- BOI **successful in shaping market expectations** in the intended direction (ILS depreciation).

Estimating the effect of daily FXI on the spot rate

- Regressing the USD/ILS spot rate on FXI $\implies$ **bad idea** because of **simultaneity:** decision to intervene depends on observed FX rate movements.
- A solution (which we use): **instrumental variables**.
  - **First stage regression:** variables correlated with FXI at time t, but uncorrelated with FX rate shocks at t.
  - **Instruments** that are **common** in the FXI literature.
- We use the **CU-GMM** estimator due to its **good finite-sample properties** (Hansen et al., 1996).

An informal "estimation": USD/ILS spot rate

Figure: Cumulative Returns of the USD/ILS Spot Rate.



Weighted = each intervention episode weighted by its size relative to the total FX intervention volume in the period under review.

First-stage regression: no weak instruments

	Dependent variable: $\mathbf{FXI}_t$ (in USD billion)
Controls	
Intercept	0.012***
	(5.90)
ΔEUR/USD$_{t-1,t}$	0.010***
	(2.39)
ΔVIX$_{t-5,t}$	0.0001
	(0.18)
ΔLIBOR$_{t-5,t}$	0.146*
	(1.65)
Instruments	
FXI$_{t-1}$	0.1781***
	(3.94)
$1_{\{\text{FXI}_{t-6,t-1}>0\}}$	0.0095**
	(2.26)
ΔUSD/ILS$_{t-61,t-1}$	−0.0018***
	(−3.04)
ΔNEER$_{t-3,t-1}$	−0.0148***
	(−3.63)
ΔNEER$_{t-13,t-3}$	−0.0031*
	(−1.69)
ΔCDS$_{t-21,t-1}$	−0.0004
	(−1.55)
ΔVIX$_{t-12,t-1}$	0.0004
	(0.74)
Adjusted R^2	7.24
Kleinbergen and Paap rk Wald F	7.91(>3.5)

Contemporaneous effect on the spot and forward rate

Dependent variable: $\Delta \ln(\text{USDILS}_t)$ (in %)			
	[1]: OLS	**[2]: CU-GMM**	**[3]: 2SLS**
Intercept	−0.0203***	−0.0273***	−0.0259***
	(−2.57)	(−2.16)	(−2.11)
FXI_t	0.55***	0.85***	0.84***
	(4.75)	(2.10)	(2.04)
$\Delta\text{EUR/USD}_{t-1,t}$	−0.41***	−0.41***	−0.41***
	(−23.51)	(−21.69)	(−21.43)
$\Delta\text{VIX}_{t-5,t}$	0.01***	0.01***	0.01***
	(4.31)	(3.45)	(3.50)
$\Delta\text{LIBOR}_{t-5,t}$	0.01	−0.01	−0.02
	(0.02)	(−0.03)	(−0.07)
Hansen J-statistic		1.79	
Hansen J-statistic p-value		0.94	
Dependent variable: $\Delta \ln(\text{3M Forward}_t)$ (in %)			
	[1]: OLS	**[2]: CU-GMM**	**[3]: 2SLS**
Intercept	−0.0180**	−0.027**	−0.02*
	(−2.27)	(−2.11)	(−1.82)
FXI_t	0.46***	0.720*	0.66
	(3.95)	(1.68)	(1.52)
$\Delta\text{EUR/USD}_{t-1,t}$	−0.33***	−0.333***	−0.33***
	(−18.00)	(−16.43)	(−16.07)
$\Delta\text{VIX}_{t-5,t}$	0.01***	0.011***	0.01***
	(4.22)	(3.48)	(3.49)
$\Delta\text{LIBOR}_{t-5,t}$	0.03	0.344	0.33
	(0.08)	(0.66)	(0.64)
Hansen J-statistic		4.546	
Hansen J-statistic p-value		0.603	

Summary spot and forward rate

- FXI:
  - Trading day with FXI (amounting to USD 1 billion) leads to a **depreciation of the ILS by 0.85%** vis-à-vis the USD.
  - Estimated coefficients are **large by historical and international standards**.
  - The effect on the USD/ILS **forward rate is smaller** (0.72%, but significant).
  - The BOI's interventions make the **CCB** (CIP deviation) **more negative**.
- **Higher VIX** (= proxy for global uncertainty) is associated with a **depreciation** of the ILS, but economically irrelevant.
- **Intercept** reflects the **sustained appreciation pressure** of the ILS.

Does the effect of FXI persist?

Period (h)	**Dependent variable:** $\Delta \ln(\textbf{USDILS}_{t+h})$ **(%)**	$\Delta \ln(\textbf{NEER}_{t+h})$ **(%)**	$\Delta \ln(\textbf{3M Forward}_{t+h})$ **(%)**
1	0.680***	0.665***	0.685***
	(3.09)	(2.99)	(3.35)
2	0.543*	0.704**	0.546*
	(1.69)	(2.15)	(1.71)
5	0.666	0.745*	0.620
	(1.28)	(1.68)	(1.17)
10	0.833	1.069	0.892
	(0.81)	(1.27)	(0.82)

- **Long-horizon regressions** to assess the **"persistence" of FXI** is fairly **standard** (Galati et al., 2005).
- We **correct** for the potential **bias** in the **estimated coefficients** when running long-horizon regressions (Boudoukh et al., 2021).
- As we use **overlapping data**, we use the **correction** for the **t-statistic** proposed by Hjalmarsson (2011).

Interventions and market expectations

- Recap: We have seen that FXI are effective in creating a **strong and lasting depreciation.**
- Now: We want to see **how** these interventions **affect the FX options market**.

Risk reversals and butterfly spreads in FX markets

- **Risk reversal** = USD call/ILS put - USD put/ILS call
  - Proxy for **implied skewness** of the RND (when divided by the at-the-money implied vol. (ATMV)).
  - **Positive = tilt** of **expected return distribution** for the USD/ILS exchange rate **towards** an **USD appreciation**.
  - **FXI** should be associated with a **higher risk reversal**.
- **Butterfly spread** = Call with a strike K_1 - two calls with a strike K_2 + Call with a strike K_3, such that $K_1 < K_2 < K_3$.
  - Proxy for the **implied kurtosis** of the RND (when divided by the ATMV).
  - **Positive =** expectation of **higher volatility** over the lifetime of this option strategy than **expected** at the date of inception.
  - **Agnostic** about the effect **FXI** should have.
- **Key takeaway:** Implied vol$^2 \approx 2^{nd}$ moment, RR $\approx$ skewness, BF $\approx$ kurtosis.
- FX options **quoted in vola levels**.

First-stage regressions using lagged risk reversals, butterfly spreads and at-the-money implied volatilities

- **Maturities:** 1w, 1m, 3m, 6m, 9m, 12m.
- Due to lower liquidity, we **omit** the **one-week** USD/ILS **option contracts**.
- Control for **"systematic" positive correlation** between changes in FX spot rates and RRs and BF spreads.

	Dependent variable: $\mathbf{FXI_t}$				
	1 M	**3 M**	**6 M**	**9 M**	**12 M**
Intercept	0.012***	0.012***	0.012***	0.012***	0.012***
	(5.76)	(5.84)	(5.82)	(5.76)	(5.69)
$\Delta\overline{RR}_{t-11,t-1}$	0.104	0.159**	0.172*	0.186*	0.209*
	(1.56)	(2.09)	(1.71)	(1.79)	(1.82)
$\Delta\overline{BF}_{t-11,t-1}$	0.327	−0.026	−0.105	−0.246	−0.399
	(0.96)	(−0.09)	(−0.37)	(−0.91)	(−1.28)
$\Delta ATMV_{t-11,t-1}$	0.002	0.004	0.005	0.002	−0.001
	(0.38)	(0.67)	(0.90)	(0.41)	(−0.11)
Controls	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	6.70	6.70	6.71	6.69	6.75

Multi-period change in the price quotes of RR regressed on interventions

	Dependent variable: $\Delta(\overline{\mathbf{RR}}_{t+h})$				
Period (h)	**1 M**	**3 M**	**6 M**	**9 M**	**12 M**
0	−0.0024	−0.0005	0.0002	−0.0002	0.0009
	(−0.95)	(−0.19)	(0.08)	(−0.05)	(0.32)
1	−0.0027	−0.0003	0.0003	0.0002	0.0002
	(−0.59)	(−0.06)	(0.08)	(0.04)	(0.04)
5	−0.0023	0.0020	0.0018	0.0015	0.0025
	(−0.20)	(0.21)	(0.21)	(0.14)	(0.32)
10	0.0146	0.0171	0.0154	0.0099	0.0154
	(0.73)	(0.85)	(0.82)	(0.57)	(0.86)

Summary FX options

- Contemporaneous and long-horizon regressions show **FXI do not affect USD/ILS option prices**.
- In view of the **large effect** on the USD/ILS **forward rate:** FXI locationally **shift the RND** towards higher USD/ILS values **without affecting higher-order risks** – crash risk, for instance, is unaffected.
- More **pronounced tilt towards a strong USD appreciation** (i.e. a higher RR) is associated with **higher future FXI**.
- This finding is **robust across all maturities** $\Longrightarrow$ market perceives the upcoming **intervention activity** as having an **effect lasting at least one year**.
- Alternatively: BOI seems to **"lean with the wind"** in the USD/ILS options market, intervening more heavily when the option-implied skewness increases $\Longrightarrow$ **hard to implement** in practice.

Thank you!

Appendix

Amador et al. (2020)-framework (1/3)

- Economy of a **small open economy** hit by a negative **macro shock**.
- Central bank (CB) wants to **implement an exchange rate path** (e_t, e_{t+1}) to maximize the domestic households' welfare.
- **Violation of CIP**, when the **zero lower bound** constraint on nominal interest rates **binds** (hint: i_t "artificially" too high):

$$(1 + i_t) > \frac{(1 + i_t^*) * f_t}{e_t}.$$

- **Foreign intermediaries** have an incentive to **purchase domestic** currency **assets** .
- This generates large **capital inflows**.

Amador et al. (2020)-framework (2/3)

- Remember: **capital inflow = capital outflow + trade deficit**.
- In the model, **capital inflow** $>$ **trade deficit**. Hence, capital must flow out (e.g. buying foreign assets).
- **Domestic households no** incentive to **absorb** this inflow (hint: foreign assets dominated by domestic assets).
- CB forced to **issue** high-yielding **domestic liabilities** and **accumulate** low-yielding **foreign assets**.
- Generates **resource costs** to the economy that are **proportional to CIP deviations**.
- CB **minimizes costs** by setting **interest rates to zero**.

Amador et al. (2020)-framework (3/3)

- The **loss per** unit of **capital inflow** amounts to:

$$\Delta(i) = (1 + i_t)e_t / \left[(1 + i_t^*)f_t\right] - 1.$$

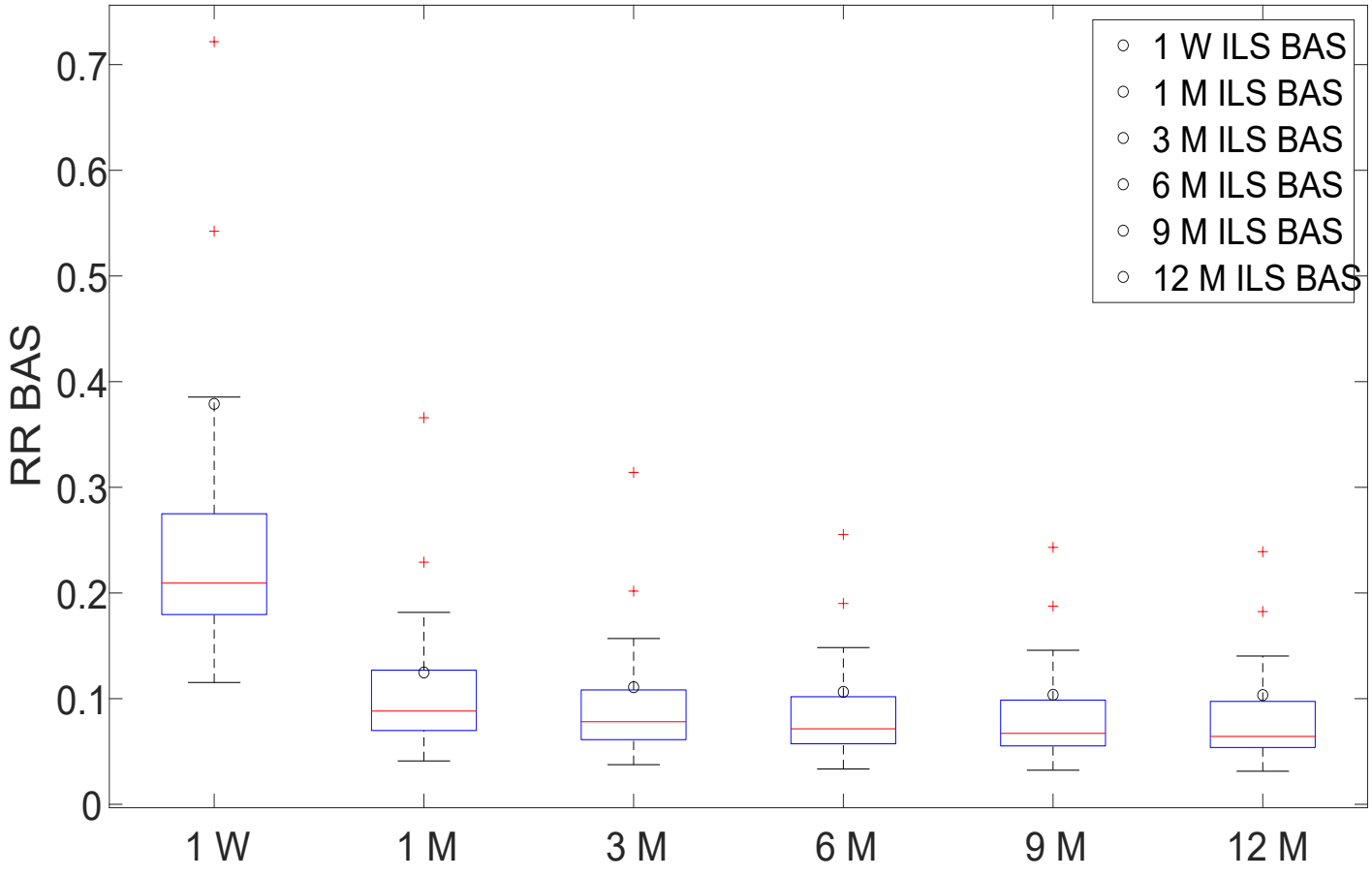
- The **losses** in period t equal:

$$\text{Losses}_t = \frac{\Delta(i)}{1 + \Delta(i)} F_t,$$

  where F_t represents the market value of the stock of reserves held in period t.

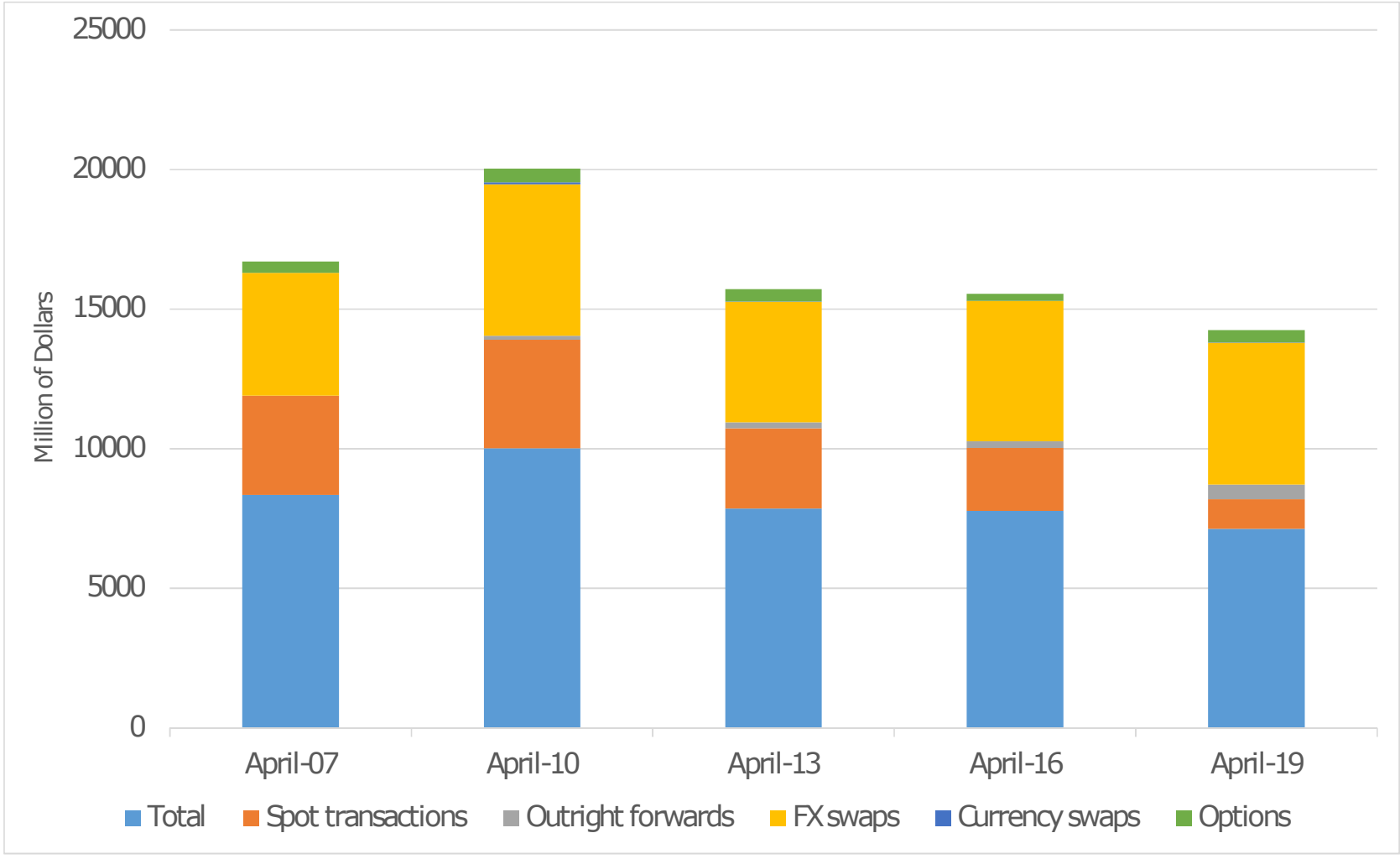
- **Deviations from CIP** are **positively related to foreign reserves** accumulated by the monetary authority.
- Their **model supports** the idea that **some of the CIP deviations** observed after the financial crises are due to a **conflict between exchange rate policies** and the **zero lower bound** on nominal interest rates.

Liquidity 1: Relative bid-ask spread of the USD/ILS option contracts similar to the metric for other FX rates



Liquidity 2: BIS survey indicates that the ILS option market is large by international standards

The triennial central bank survey covers 54 countries and includes data from close to 1'300 banks and other dealers.



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