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The Persistent Widening of Cross-Currency Basis: When Increased FX Swap Demand Meets Limits of Arbitrage*

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Abstract

This paper examines customer demand-side factors that affect deviation from covered interest rate parity (CIP) with respect to the dollar (i.e., cross-currency basis), particularly when arbitrageurs are constrained. Using novel detailed daily transaction-level data on the universe of Israeli institutional investors (IIs), we employ a granular instrumental variable (GIV) estimation to investigate how IIs' FX swap demand affects CIP deviation. Our findings demonstrate that a one standard deviation shock to IIs' FX swap demand when capital is abundant has a null effect on IIs' basis. However, when capital is scarce, the demand shock produces significant and persistent reduction of 3.9-8.4 basis points in IIs' basis, remaining significant for over 500 trading days. Our results, which are unchanged when we consider the complementary and popularized Bartik instrument approach instead of the GIV one, showcase how limits of arbitrage, together with demand shocks from a large customer base, can drive CIP deviations.

JEL classification: E44,F3,G15,G23

Keywords: LOA-Dependent FX Swap Demand Channel; Cross-Currency Basis; Limits of Arbitrage; Granular Instrumental Variable; Bartik Instrument; Open FX Swap Position; Institutional Investors; Bayesian State-Dependent Local Projections.

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1 Introduction

The covered interest parity (CIP) condition is a cardinal no-arbitrage principle in international finance, asserting that the interest rate implied by the foreign exchange (FX) swap market equates to the interest rate in the cash market. CIP has held fairly well prior to the 2008-2009 global financial crisis (GFC), even for daily data, but has broken down since the onset of the GFC with the cash market dollar interest rate having been lower than the FX-swap-market-implied dollar interest rate for most currencies (Du et al. (2018), Avdjiev et al. (2019), Cerutti et al. (2021), and Du and Schreger (2022)). Said differently, the literature has concluded that pre-GFC, the supply of FX swaps was perfectly elastic with the price being determined by the CIP condition, whereas now, post-GFC, it is no longer the case (Du and Schreger (2022)).

Much of the existing literature on CIP deviations has focused on the supply side of the FX market. Specifically, how Basel III regulations, implemented after the GFC, increased the costs for financial intermediaries such as banks to arbitrage these deviations away. However, the influence of demand-side factors on these deviations, as well as their interaction with supply-side elements, remains less understood. Our paper aims to fill this gap. To do so, we study the influence of one of the largest demand-side customers, institutional investors (IIs), on deviations from CIP.

In recent years, IIs have increased their share of investments abroad dramatically. Because their assets are subjected to currency risk, they hedge part of it with FX derivatives (Ben Zeev and Nathan (2022) and Du and Huber (2023)). One of their favored derivatives to hedge their FX exposure, which is the focus of our paper, is FX swaps. An FX swap consists of two parts or 'legs'. In the first leg the II receives dollars from an intermediary in exchange for local currency. Simultaneously, the II buys it back from the same intermediary in the forward market at the price of the prevailing forward rate, also known as the second leg of the swap. It is helpful to think of an FX swap as a collateralized dollar loan and a way for the II to receive dollar funding. Importantly, the FX swap hedges the II's exposure to fluctuations in the dollar exchange rate because of the

forward part of the transaction.¹

To conceptualize the effect the demand side has on CIP deviations and to discipline our subsequent empirical analysis, we develop a simple and tractable partial equilibrium model with testable implications for both prices and quantities. A theoretically appealing explanation for CIP violations that may be related to the notable demand by local IIs is that periods of significant limits of arbitrage (LOA) accompanied by rightward shifts in the demand for FX swaps of local IIs who wish to increase their exposure to foreign assets (without taking on FX risk) can lead to the type of persistent breakdown of CIP observed in the data since the GFC. This LOA-dependent FX swap demand channel builds on the idea that greater LOA imply a steepening of the FX swap supply curve, leading to a more significant widening of cross-currency basis in the presence of a rightward shift in the FX swap demand curve and less FX swap supplied quantities compared to the state when there are no LOA.

To achieve our research objectives, we utilize a unique dataset from the Bank of Israel (BOI) that provides detailed information on the universe of FX swap daily transactions of a panel of IIs over a 14-year period. The panel data enables us to use a granular instrumental variable (GIV) estimation approach, creating an IIs' aggregate demand shock as the difference between the size-weighted- and inverse-variance-weighted-average of idiosyncratic IIs' shocks that are orthogonal to various supply- and demand-related FX swap market factors. Importantly, we show in Section 6.5 that our results are robust to using the popularized and widely used [Bartik \(1991\)](#) instruments (also known as shift-share estimators) identification approach, which can be viewed as complementary to the GIV identification approach.

Summary of Main Results. Our results show that a one standard deviation shock to IIs' aggregate FX swap demand in the LOA state, i.e., when arbitrage capital is scarce, leads to a significant and persistent reduction of 3.9-8.4 basis points in IIs' cross-currency basis. This effect remains significant for 526 trading days, at which point the FX swap demand shock accounts for

¹IIs can also separately buy dollars in the spot market and simultaneously buy their local currency in the forward market. However, this is generally costlier for them because of transaction costs. Note, however, that they can use the forward market to hedge *existing* FX exposure. See [Ben Zeev and Nathan \(2022\)](#) for a detailed discussion on these institutional details.

63.1% of the basis' variation. (The peak share of the basis' variation accounted for by the FX swap demand shock is obtained after 269 trading days, reaching 72.9%.) By contrast, in the linear (no LOA) case when arbitrage capital is abundant, the aggregate FX swap demand shock produces an economically and statistically insignificant change in IIs' aggregate basis.

While these results agree with our model's predictions, the model also has testable implications for the initial reaction of equilibrium *quantities*, which our detailed transaction-level data can speak to and where much less is known in the literature. The results show that in the linear (no LOA) case, when arbitrage capital is abundant, a demand shock by IIs moves IIs' aggregate open FX swap position in the initial horizons by significantly more than the corresponding effect in the LOA state. These findings further corroborate the predictions of our model. Overall, we view our results as emphasizing the salience of the LOA-dependent FX demand channel in driving CIP deviations.

The paper unfolds in two parts. The first part lays out a simple conceptual framework that serves to fix ideas, motivate the empirical analysis, and form a suitable conceptual base for this paper. The second part of this paper conducts the empirical analysis. Before turning to discuss these two parts, we first briefly clarify some terminological issues to streamline this paper's exposition as well as provide some descriptive evidence on the salience of the global FX swap market to further motivate our paper.

Terminology. We define cross-currency basis as the difference between the cash market dollar interest rate and the FX-swap-market-implied (CIP-implied) dollar interest rate. Hence, when the former is lower (higher) than the latter, we refer to the associated basis as being negative (positive). And a 'widening' of the basis refers to its *declining*.

As previously mentioned, FX swap contracts are two-leg FX trades where the first leg is a spot transaction and the second leg is a forward transaction of an equivalent opposite amount. The most common use of FX swaps is for IIs to fund their FX balances and for CIP arbitragers to try to profit from CIP violations (Bergljot and Lian (2010)). 'FX swap demand' throughout this paper refers to demand of local IIs for the purchase of spot dollars (i.e., the first leg) and selling of forward dollars (i.e., second leg) of the same amount. And 'FX swap supply' refers to the opposite

end of this trade coming from arbitrageurs. In accordance with our focus on the *dollar* basis, we measure FX swap flows for the USD/ILS currency and ignore non-dollar related swap trades. (85.9% of our local IIs' FX swap volume is done in dollars, with the remaining small 14.1% share almost entirely done in euros (11.4%) and pounds (1.8%).)

Salience of Global FX Swap Market. FX swaps have gained popularity among many market participants in the FX markets in recent years. They are the most commonly traded FX instrument in the global FX market with 3.2 trillion dollars in average daily turnover in April 2019 (the date of the most recent BIS Triennial Survey) that represents a 48.6% share of global FX turnover (Schrimpf and Sushko (2019)).² As already mentioned, FX swaps are a popular tool to hedge among IIs. The corresponding numbers for IIs, who use FX swaps to fund their FX investments in an FX-risk-free manner, are also significant at 776.9 billion dollars and 27.3%, respectively. This type of funding with FX swaps produces vast amounts of off-balance sheet debt, or 'missing dollar debt', with the off-balance sheet US dollar debt of non-banks outside the U.S. substantially exceeding their on-balance sheet debt and growing faster - being twice as much in June 2022 after being 1.6 times as much in 2016 (Borio et al. (2022)).

Underlying Framework. This part lays out a simple structural partial equilibrium model of the FX swap market. The backbone of the model is a risk-averse local II that demands FX swaps to increase its (hedged) exposure to foreign assets, maximizing its profit in a mean-variance optimization setting, and a profit-maximizing risk-neutral arbitrageur with a pre-determined level of arbitrage capital that supplies FX swaps. We use this arbitrage capital variable to represent the notion of LOA. The two concepts are intrinsically related in that LOA implies that arbitrageurs are constrained in their ability to arbitrage away price anomalies and arbitrageurs' arbitrage capital is vital to the materialization of this ability. In essence, a constrained level of arbitrage capital is conceptually tantamount to LOA.

Our setting results in the following equilibrium result. Conditional on a positive FX swap demand white noise shock - represented by an exogenous decrease in the level of local II's risk

²The dollar's dominance in the global FX swap market is overwhelming, being one of the traded currencies in over 90% of FX swap trades.

aversion with respect to FX-swap-funded foreign investment,³ the downward-sloping demand curve of FX swaps shifts rightward along the arbitrageur's upward-sloping supply curve with the steepness of the latter supply curve being shaped by the level of the arbitrageur's arbitrage capital. In particular, the lower this arbitrage capital is (i.e., the greater LOA), the steeper the arbitrageur's FX swap supply curve. Hence, the ability of the rightward shift in the FX swap demand curve to produce a negative cross-currency basis is increasing in LOA severity.

The second part of the paper tests the model's prediction, i.e., that an increase in local IIs' demand for FX swaps leads to greater widening of the basis when LOA is greater. This prediction is the essence of the LOA-dependent FX swap demand channel.

Econometric Model. The second part of the paper (whose results have already been summarized above) studies the LOA-dependent effect of increased IIs' FX swap demand on their USD/ILS cross-currency basis, where we construct the latter as the volume-weighted average of IIs' transaction-level bases. Our identification strategy relies on a GIV estimation procedure within a suitable Bayesian state-dependent local projection model which we present in Section 5.2.1. The technical details concerning this model's estimation and inference are given in Appendix A of the online appendix to this paper.

Our Bayesian estimation and inference procedure provides a convenient numerical way to produce confidence intervals that account for estimation uncertainty in each of the two stages underlying our GIV estimation procedure. The Bayesian approach we take is in the spirit of a long tradition in the literature on impulse response estimation (see, e.g., [Del Negro and Schorfheide \(2011\)](#)) that has recently also caught on in the local projections literature (see, e.g. [Miranda-Agrippino and Ricco \(2021\)](#) and [Ben Zeev \(2023\)](#)). We view our dynamic modeling choice as one of the strengths of our paper as it allows for studying the rich dynamics that occur after the GIV-based FX swap demand shock.

Our estimation procedure succeeds in generating a panel of idiosyncratic demand shocks for

³This demand shock can be viewed as an exogenous shift in the II's geographical preference for investment. E.g., an exogenous decision by a pension fund's investment committee to allocate more funds to foreign investment, with such decision reflecting the committee's perception of foreign investment being more appealing now.

our IIs, possessing an average absolute pairwise correlation among the 14 IIs of 2.9% and a corresponding standard deviation of 2.2%. We control for a variety of aggregate supply- and demand-side factors in the estimation of the idiosyncratic shocks so as to ensure the validity of our identification approach. The difference between the size-weighted- and inverse-variance-weighted-average of these shocks is used as the GIV (the aggregate demand shock) in our setting. Alternatively, in Section 6.5 we also examine the results from constructing the aggregate demand shock as the mean of these shocks, which defines the Bartik instrument in our setting, and obtain quantitatively and qualitatively similar results. The Bartik instrument, popularized by [Blanchard and Katz \(1992\)](#), has been extensively used in many fields in economics ([Goldsmith-Pinkham et al. \(2020\)](#)).

Outline. The remainder of the paper is organized as follows. The next section provides a literature review. In the subsequent section the theoretical motivation for this paper is laid out. Section 4 provides institutional background for Israeli IIs' FX swap activity. Section 5 provides a description of the data and methodology used in this paper. Section 6 presents the baseline results (GIV-based results) as well as the results from using the Bartik instrument approach, ending with a brief discussion of additional robustness checks (the results of which are shown in Appendix B of the online appendix to this paper). The final section concludes.

2 Related Literature

To the best of our knowledge, this paper constitutes the first empirical investigation of the LOA-dependent FX swap demand channel that uses daily transaction-level FX swap flow and price data along with a daily measure of LOA to quantify this channel. The granular dimension and daily frequency of our data allow us to quite cleanly identify this channel.

The persistent violations of CIP since the GFC have attracted significant research in recent years on the potential drivers of these violations,⁴ focusing on the separate as well as joint role of

⁴CIP deviations' implications, rather than drivers, are also an important avenue of research. E.g., [Du et al. \(2022\)](#) show that innovations to cross-currency bases - proxying for intermediaries' constraints - play a meaningful role in the determination of asset prices; and [Keller \(2022\)](#) uses Peruvian data to show that positive cross-currency basis leads to a decline in local banks' local currency lending as they allocate funds away from local currency lending to fund their CIP arbitrage (the converse takes place when the basis is negative).

FX swap supply and demand factors as potential drivers of these violations. Our work is motivated by this research and is a part of the burgeoning literature associated with it.

FX Swap Supply. [Du et al. \(2018\)](#) and [Avdjiev et al. \(2019\)](#) use aggregate data to provide evidence that regulatory balance sheet constraints are an important driver behind CIP violations through their adverse effects on global banks' capacity to supply FX forward and swap contracts. [Puriya and Bräuning \(2020\)](#) use novel contract-level data for German banks' forward contracts and exploit regulation-driven quarter-end window-dressing practices - intended to avoid regulatory capital charges on FX exposure from net on-balance-sheet dollar assets - to identify significant CIP violations driven by banks' dollar forward selling. Interpreted through the lens of the FX swap market, which the authors abstract from doing, this interesting forward market mechanism can be reasonably viewed as inducing a leftward shift to banks' FX swap supply in a setting where these banks have substitutability between conducting CIP arbitrage activity and conducting regulation-driven quarter-end window-dressing activity.

[Cenedese et al. \(2021\)](#) use micro (dealer-level) data to show that regulatory changes concerning U.K. banks' leverage ratios have increased CIP deviations for high-leverage U.K. dealers. [Anderson et al. \(2021\)](#) provide evidence from micro data on global banks that the large negative wholesale funding shock from the 2016 U.S. money market mutual fund reform had a significant widening effect on USD/JPY cross-currency basis. And [Obstfeld and Zhou \(2022\)](#) and [Cerutti and Zhou \(2023\)](#) find evidence which stresses the role of global risk appetite and funding stress in driving CIP deviations in emerging markets and developing economies.

FX Swap Demand. [Liao \(2020\)](#) use micro data to show that CIP deviations are mainly driven by differences between corporate credit spreads in different currencies, drawing attention to a mechanism where firms facing high dollar credit spreads can choose to issue non-dollar debt with lower corporate spreads and then swap the issuance's non-dollar proceeds into dollars through an FX swap - which in turn generates demand pressure for FX (dollar) swaps.

[Syrstad and Viswanath-Natraj \(2022\)](#) construct a daily measure of FX swap order flow - buyer initiated minus seller initiated trades - and show that the basis effect of a one standard deviation

change in this measure has increased from less than one basis point prior to 2008 to about five basis points after 2008. (They look at three currency pairs: USD/EUR, USD/CHF, and USD/JPY.) Much like [Syrstad and Viswanath-Natraj \(2022\)](#), we concentrate on the demand side. However, we differ from them in several important ways. First, our data provides valuable insights into the identity of the dealers' customers, namely IIs, which are increasingly influential in the global economy. This adds to the existing literature on the various ways in which IIs affect the financial system (see the last paragraph in the literature review). Second, unlike [Syrstad and Viswanath-Natraj \(2022\)](#), which rely on order flow data from the inter-dealer market and cannot identify customer trades directly, our dataset allows us to identify all IIs in our sample as we directly observe the customer-dealer market, thus allowing us to extract exogenous demand shocks using the GIV and Bartik instrument approaches. By contrast, [Syrstad and Viswanath-Natraj \(2022\)](#)'s data can not speak to the nature of the shocks they are capturing. For example, as noted by the authors, their estimated demand shocks might also reflect instances where dealers seek to increase their inventories, leading to a limited supply of swaps (due to reduced selling activity), which could be interpreted as a negative supply shock that in turn potentially explains a widening of the basis. Third, our theoretical model explores broader implications beyond the effect of demand shocks on prices. Specifically, our theoretical model has testable implications for equilibrium quantities, which can be corroborated using our detailed dataset while this is not the case for [Syrstad and Viswanath-Natraj \(2022\)](#) who do not observe quantities, further strengthening our confidence in the results.

Papers Looking at Both FX Swap Supply and Demand Channels. [Rime et al. \(2022\)](#) use micro data to contribute to the understanding of the role of both FX swap supply and demand movements as drivers of persistent CIP violations. For the FX swap supply channel, [Rime et al. \(2022\)](#) provide evidence that meaningful risk-free CIP arbitrage opportunities are limited to only a narrow group of top-rated global banks whose balance sheet constraints prevent them from eliminating the associated CIP violations. For the FX swap demand channel, [Rime et al. \(2022\)](#) show that low-rated non-U.S. banks find it difficult to obtain dollar funding in the cash market and hence produce demand pressure for dollar funding via FX swaps. [Cerutti et al. \(2021\)](#) use

aggregate data in a vast study of CIP violations' drivers and find evidence supporting meaningful roles for risk-taking capacity, FX market liquidity, unconventional monetary policy, and financial regulation, highlighting an intricate and time-varying role for both supply and demand shifts in the FX swap market as drivers of CIP violations.

The paper that is conceptually closest to ours is [Sushko et al. \(2016\)](#),⁵ which in turn builds and expands on ideas laid out in [Borio et al. \(2016\)](#). These ideas pertain to the combination of some form of LOA and hedging demand. Specifically, [Sushko et al. \(2016\)](#) estimate a state space model with a measurement equation linking an FX swap demand proxy to cross-currency basis and a state equation in the unobserved, time-varying elasticity of the basis with respect to hedging demand. They then show this elasticity to be closely correlated with the product of FX option-implied volatility and bank credit spreads, which can be interpreted as being consistent with the notion that the latter elasticity is higher when arbitrage limits are stricter.

We differ from [Sushko et al. \(2016\)](#) along two main dimensions, which are also relevant for understanding the contribution of our paper to the broader literature. The first is our daily transaction-level data on IIs' FX swap flows and prices as well as our use of a daily measure of LOA based on the global financial institutions' market leverage measure from [He et al. \(2017\)](#), all of which allow us to identify the LOA-dependent FX swap demand channel quite cleanly.⁶ [Sushko et al. \(2016\)](#) use a rough proxy for FX swap demand at a monthly frequency given by the implied cross-currency position of banks, IIs, and corporations, while also lacking a direct measure of these agents' basis. Second, our GIV-based local projection estimation approach allows us

⁵[Bush \(2019\)](#) employs a similar approach to [Sushko et al. \(2016\)](#) by running monthly frequency panel regressions (for July 2013-November 2017) of 10 emerging markets' bases on proxies for hedging demand as well as the interaction of these proxies with measures of arbitrageurs' balance sheet constraints. [Bush \(2019\)](#) finds significant evidence for a direct basis effect of hedging demand but only mixed evidence for a meaningful interaction effect.

⁶The underlying motivation for our LOA measure choice comes from the intrinsic link between intermediaries' funding capacity and LOA ([Shleifer and Vishny \(1997\)](#)), as limits on the former prevent from arbitrageurs to obtain the capital they need to arbitrage away price anomalies. This notion is very well captured by [He et al. \(2017\)](#)'s global intermediaries' leverage measure as this measure reflects the soundness of the financial intermediary sector - representing in large part agency/contracting frictions' severity, regulation strictness, and intermediaries' portfolios' performance; hence, sharp increases in this measure capture well meaningful increases in LOA. (Another important paper emphasizing the intrinsic link between intermediaries' funding capacity and LOA is [Anderson et al. \(2021\)](#), whose data allows them to measure the CIP-relevant arbitrage capital from the amount of global banks' unsecured short-term borrowing that is funded at a lower rate than the CIP-implied one.)

to study the LOA-dependent persistence of CIP violations conditional on an arguably exogenous FX swap demand shock that is in turn orthogonal to a rich array of other supply- and demand-related FX swap market factors. As such, it can be interpreted as a pure aggregate demand shock arising from large IIs' idiosyncratic desire to increase their (hedged) exposure to foreign assets.

Papers Looking at the Effect of IIs on Financial Markets. Last, we also contribute to the extant literature investigating the many ways in which IIs affect financial markets ([Greenwood and Vayanos \(2010\)](#), [Ellul et al. \(2011\)](#), [O' Hara et al. \(2018\)](#), [Klingler and Sundaresan \(2019\)](#), [Hendershott et al. \(2020\)](#), [Kojien and Yogo \(2022\)](#), and [Pinter \(2023\)](#) among others). We add to this literature by showing how hedging demand by IIs affects CIP deviations.

3 Theoretical Motivation

In what follows we lay out a simple structural framework which is meant to fix ideas and form a suitable conceptual base for this paper's empirical analysis. Understanding the drivers of CIP deviations is tantamount to understanding the workings of the FX swap market (see [Du and Schreger \(2022\)](#) and references therein). Accordingly, the framework we use is a partial equilibrium of the FX swap market consisting of two time periods (t and $t + 1$) and two agents. The first agent is a risk-neutral arbitrageur who supplies FX swaps. The second is a risk-averse local institutional investor (II) who demands FX swaps to obtain FX-risk-free foreign currency funding. The use of this foreign currency funding is for the local II to increase its (hedged) exposure to foreign assets.

We start our depiction of the model with a presentation of the supply side of the FX swap market by presenting the arbitrageur's supply of FX swaps. We then show demand for FX swaps by the local II. We end the section by defining equilibrium and presenting the model's main prediction.

3.1 Supply of FX Swaps

General Setting. There is a risk-neutral arbitrageur that represents the supply side of the FX swap market. The arbitrageur's aim is to profit from the local II by creating a synthetic forward rate that is cheaper than the market's observed forward rate. The arbitrageur's trade can be broken

down into two parts. First, it buys spot $Q_{t,ARB}S_t$ local currency units and sells spot $Q_{t,ARB}$ foreign currency units in period t , conducting this trade entirely with the local II. Second, it sells forward $Q_{t,ARB}S_t(1 + i_{t+1,L})$ local currency units at forward rate $F_{t,t+1}$, where $Q_{t,ARB}S_t$ is the local currency amount sold forward to the local II in the second leg of the associated arbitrageur-local II FX swap trade and $Q_{t,ARB}S_t i_{t+1,L}$ represents the interest related amount sold forward in an outright forward trade the arbitrageur conducts with some (unmodeled) broker-dealer institution.

The rationale for the second part of the trade can be explained as follows. Using its pre-determined arbitrage capital, the arbitrageur conducts CIP arbitrage as well as other arbitrage trades (whose depiction is deferred for now). Given its role as arbitrageur, and since FX swaps trades do not perfectly align with CIP arbitrage as they exclude the interest proceeds element,⁷ the arbitrageur additionally sells forward $Q_{t,ARB}S_t i_{t+1,L}$ local currency units, where $Q_{t,ARB}$ is the arbitrageur's FX swap supply (in foreign currency units) and $i_{t+1,L}$ is the local risk-free interest rates, respectively. (While left unmodeled, the counterparty to this interest proceeds forward trade can be thought of as a broker-dealer institution.)

The arbitrageur's level of predetermined arbitrage capital will be used below as the model's LOA measure in the sense that a lower such capital level implies greater LOA. While this LOA representation constitutes a reduced-form encapsulation of LOA, we view it as the most natural way to represent LOA in our structural setting.

We assume that the arbitrageur can borrow foreign currency frictionlessly in the cash market at interest rate $i_{t+1,W}$ and hence has no constraints on its funding of foreign currency. (I.e., $i_{t+1,W}$ represents the opportunity cost of arbitrageur's FX swap trade. In our setting it is viewed as the effective cost of the FX swap trade as we assume the arbitrageur funds this trade by borrowing the required funds in the cash market.) However, we assume that it faces frictions in the FX swap market, as we now turn to explain.

Haircut. Following [Ivashina et al. \(2015\)](#), we assume that a haircut (initial margin) is applied to the arbitrageur's FX swap trade in the amount of $\kappa Q_{t,ARB}$. That is, the arbitrageur's FX swap

⁷While this element is necessary for conducting CIP arbitrage, it is noteworthy that it is also very small (relative to the principal) given that FX swap trades' maturities are usually short ([Schrimpf and Sushko \(2019\)](#)).

trade requires it to incur a linear haircut-induced cost through the depositing of share κ of its swap position to the local II.⁸

Arbitrageur's Alternative Arbitrage Activity. By allocating $\kappa Q_{t,ARB}$ for CIP arbitrage, the arbitrageur has to take these funds away from its pre-determined arbitrage capital A_t . In other words, $A_t - \kappa Q_{t,ARB}$ represents the arbitrageur's available capital for another (non-CIP) arbitrage activity (e.g., fixed income arbitrage). Following [Ivashina et al. \(2015\)](#), this other arbitrage activity has a net *concave* return given by $G(A_t - \kappa Q_{t,ARB})$, where $G(\cdot) > 0$, $G'(\cdot) > 0$, $G''(\cdot) < 0$, and $G'''(\cdot) > 0$.⁹

These assumptions on $G(\cdot)$ are met by standard production/revenue functions, including the logarithmic specification used in [Ivashina et al. \(2015\)](#). More generally, considering the commonly used positively homogenous production/revenue functions, it is straightforward to show that concavity ($G''(\cdot) < 0$) in fact implies a positive third derivative ($G'''(\cdot) > 0$) as the latter condition requires a returns to scale that is lower than 2 while the former implies a returns to scale that is lower than 1 (i.e., decreasing returns to scale). This is an important observation because evidence from the literature on bank investment returns (see [Zhu \(2008\)](#) and references therein) and the literature on mutual fund investment returns ([McLemore \(2019\)](#)) supports the notion of decreasing return to scale for financial institutions' investments.

Arbitrageur's Profit Maximization. We are now in position to write the arbitrageur's profit from its arbitrage activity as

$$Q_{t,ARB} \frac{S_t}{F_{t,t+1}} (1 + i_{t+1,L}) - Q_{t,ARB} (1 + i_{t+1,W}) + G(A_t - \kappa Q_{t,ARB}). \quad (1)$$

The FOC that results from maximizing the profit from Equation (1) with respect to $Q_{t,ARB}$ is

$$b_t \equiv 1 + i_{t+1,W} - \frac{S_t}{F_{t,t+1}} (1 + i_{t+1,L}) = -\kappa G'(A_t - \kappa Q_{t,ARB}), \quad (2)$$

⁸For simplicity, we abstract from the opposing haircut facing the local II.

⁹The concavity of G is consistent with the limits-to-arbitrage notion from [Shleifer and Vishny \(1997\)](#). For internal consistency between such arbitrage limits existing across all of the arbitrageur's arbitrage activities, we could also have assumed a *convex* haircut-induced cost as in [Liao and Zhang \(2020\)](#) which seems more consistent with such limits than our linear haircut assumption. Such modeling choice does not change our model's main prediction and hence, for simplicity, we stick to the linear haircut modeling approach from [Ivashina et al. \(2015\)](#).

where b_t is the cross-currency basis (defined in accordance with the literature) and $\frac{S_t}{F_{t,t+1}}(1 + i_{t+1,L})$ represents the synthetic, CIP-implied foreign (gross) risk-free interest rate which is clearly higher than the cash market one owing to the haircut-induced cost. In other words, Equation (2) implies a negative cross-currency basis b_t that is caused by the swap trade's haircut-induced friction.

Relation between $Q_{t,ARB}$ and $-b_t$. Minus of the cross-currency basis (i.e., $-b_t$) from FOC (2) is the arbitrageur's marginal profit from increasing its FX swap position. As such, the minus of the cross-currency basis can also be economically viewed as the price of the FX swap. Accordingly, it is therefore reasonable to expect that the arbitrageur's supply of FX swaps increases in $-b_t$. To show this formally, we differentiate $-b_t$ from FOC (2) with respect to $Q_{t,ARB}$:

$$\frac{\partial(-b_t)}{\partial Q_{t,ARB}} = -\kappa^2 G''(A_t - \kappa Q_{t,ARB}) > 0, \quad (3)$$

where the positive sign of Equation (3) comes from the assumed concavity of net return function $G(A_t - \kappa Q_{t,ARB})$. Given the interpretation of $-b_t$ as FX swap price, Equation (3) delivers the standard result of an upward-sloping supply curve: higher price (marginal profit) of FX swaps induces the arbitrageur to supply more such swaps. Moreover, we can show that the slope of the arbitrageur's FX swap supply curve flattens (steepens) when initial arbitrage capital is higher (lower) by differentiating Equation (3) with respect to A_t :

$$\frac{\partial^2(-b_t)}{\partial Q_{t,ARB} \partial A_t} = -\kappa^2 G'''(A_t - \kappa Q_{t,ARB}) < 0. \quad (4)$$

This result clearly follows from the arguably weak assumption of $G(\cdot)$'s positive third derivative (see related discussion on this assumption on Page 13). I.e., more (less) initial arbitrage capital induces less (more) rigidity in the willingness of the arbitrageur to supply FX swaps. Result (4) lies at the heart of our paper.

3.2 Demand for FX Swaps

General Setting. We assume a risk-averse local II that borrows in the swap market $Q_{t,II}$ foreign currency units for the purchase of foreign assets whose expected rate of return is denoted by $\mathbb{E}_t i_{t+1,FA}$, where \mathbb{E}_t is the expectation operator conditional on period t information. (The $i_{t+1,FA}$

return variable can be thought of as some weighted average of returns of foreign stocks, bonds, and loans.) Specifically, the local II enters an FX swap with the arbitrageur of size $Q_{t,II}$. In the first leg of the trade the local II sells $Q_{t,II}S_t$ local currency spot units and buys $Q_{t,II}$ foreign currency units. And in the second leg, which takes place in period $t + 1$, the local II buys $Q_{t,II}S_t$ local currency units at forward rate $F_{t,t+1}$ and sells $\frac{Q_{t,II}S_t}{F_{t,t+1}}$ foreign currency units. We abstract from the haircut that the local II realistically faces in this swap trade as well as from its non-swap-related investments. Adding these elements would complicate the exposition without affecting the main prediction of our model.

Expectation and Variance of Local II's Profit. We can write the local II's next period's expected profit (in foreign currency terms) from its swap-related foreign investment, which we assume to be positive and denote by $\mathbb{E}_t\Pi_{t+1,II}$, as

$$\mathbb{E}_t\Pi_{t+1,II} = Q_{t,II}(1 + \mathbb{E}_t i_{t+1,FA}) - Q_{t,II} \frac{S_t}{F_{t,t+1}}. \quad (5)$$

We can use the definition of cross-currency basis from Equation (2) to write Equation (5) equivalently as

$$\mathbb{E}_t\Pi_{t+1,II} = Q_{t,II}(1 + \mathbb{E}_t i_{t+1,FA}) - Q_{t,II} \left(\frac{1 + i_{t+1,W} - b_t}{1 + i_{t+1,L}} \right). \quad (6)$$

And the variance of local II's profit ($\mathbb{V}_t\Pi_{t+1,II}$) can be written as $\mathbb{V}_t\Pi_{t+1,II} = Q_{t,II}^2 \mathbb{V}_t(1 + i_{t+1,FA})$, where \mathbb{V}_t is the variance operator conditional on period t information.

Mean-Variance Optimization Problem. We assume the local II chooses its demand for FX swaps $Q_{t,II}$ so as to maximize

$$\begin{aligned} \mathbb{E}_t\Pi_{t+1,II} - \frac{e^{\epsilon_t}}{2} \mathbb{V}_t\Pi_{t+1,II} &= Q_{t,II}(1 + \mathbb{E}_t i_{t+1,FA}) - Q_{t,II} \left(\frac{1 + i_{t+1,W} - b_t}{1 + i_{t+1,L}} \right) - \\ &\frac{e^{\epsilon_t}}{2} Q_{t,II}^2 \mathbb{V}_t(1 + i_{t+1,FA}), \end{aligned} \quad (7)$$

where ϵ_t represents an FX swap demand white noise shock which in turn determines the level of local II's risk aversion with respect to swap-related foreign investment. Importantly, as formally shown below, a positive (negative) ϵ_t induces a leftward (rightward shift) in the demand for FX

swaps. More generally, when one considers the alternative local investment opportunities facing the local II, such shocks essentially represent exogenous shifts in the local II's geographical investment preferences.

The FOC that results from maximizing the objective function from Equation (7) with respect to $Q_{t,II}$ is

$$Q_{t,II} = \frac{1 + \mathbb{E}_t i_{t+1,FA}}{e^{\epsilon_t} \mathbb{V}_t(1 + i_{t+1,FA})} - \frac{1 + i_{t+1,W} - b_t}{(1 + i_{t+1,L}) e^{\epsilon_t} \mathbb{V}_t(1 + i_{t+1,FA})}. \quad (8)$$

Equation (8) essentially represents local II's demand for FX swaps.

Relation between $Q_{t,II}$ and $-b_t$. In the previous section we interpreted $-b_t$ as the price of FX swaps. As such, we should expect to have a negative relation between this price and demand for FX swaps. To show this negative relation (i.e., a downward sloping FX swap demand curve), let us differentiate Equation (8) with respect to $-b_t$:

$$\frac{\partial Q_{t,II}}{\partial(-b_t)} = -\frac{1}{(1 + i_{t+1,L}) e^{\epsilon_t} \mathbb{V}_t(1 + i_{t+1,FA})} < 0. \quad (9)$$

Relation between $Q_{t,II}$ and ϵ_t . We argued above that a positive (negative) realization for ϵ_t represents a leftward (rightward) shift in local II's FX swap demand. To show this formally, let us differentiate Equation (8) with respect to e^{ϵ_t} :

$$\frac{\partial Q_{t,II}}{\partial e^{\epsilon_t}} = -\frac{1 + \mathbb{E}_t i_{t+1,FA}}{e^{2\epsilon_t} [\mathbb{V}_t(1 + i_{t+1,FA})]^2} + \frac{1 + i_{t+1,W} - b_t}{e^{2\epsilon_t} [\mathbb{V}_t(1 + i_{t+1,FA})]^2 (1 + i_{t+1,L})} < 0, \quad (10)$$

where the negative sign of Equation (10) comes from the fact that local II's expected profit, $1 + \mathbb{E}_t i_{t+1,FA} - \left(\frac{1 + i_{t+1,W} - b_t}{1 + i_{t+1,L}}\right)$, is assumed to be positive.

3.3 Model Equilibrium

We define equilibrium in the FX swap market as the equality $Q_{t,II} = Q_{t,ARB} = Q_t$, where Q_t denotes the equilibrium level of FX swap flows. The latter equilibrium equation, when substituted into FOCs (2) and (8) produce two equations in two unknowns b_t and Q_t . (A proof that relies on a fixed-point argument for the existence and uniqueness of a solution to this demand-supply

equation system is available upon request from the authors.) We can use our previous results on the nature of the FX swap supply and demand curves to deduce the main prediction of our model.

The A_t -Dependent Relation Between ϵ_t and b_t . Consider our model's FX demand-supply framework in the space of $-b_t$ and Q_t . Equation (2) defines an upward-sloping FX swap supply curve whose slope becomes steeper with a lower A_t . Equation (8) defines a downward-sloping FX swap demand curve which shifts rightward in response to a negative realization of swap demand shock ϵ_t . In equilibrium, such favorable swap demand shock is predicted to produce an increase in $-b_t$ (i.e., a widening of the basis) which depends on the level of the arbitrageur's initial arbitrage capital A_t : the lower (higher) this capital is, the stronger (weaker) the widening effect of the demand shock.

To see this relation formally, we take three steps. First, we substitute Equation (8) into Equation (2) (after substituting into both equations the equilibrium condition $Q_{t,II} = Q_{t,ARB} = Q_t$) to obtain the following equilibrium equation for b_t :

$$b_t = -\kappa G' \left(A_t - \kappa \left(\frac{1 + \mathbb{E}_t i_{t+1,FA}}{e^{\epsilon_t} \mathbb{V}_t(1 + i_{t+1,FA})} - \frac{1 + i_{t+1,W} - b_t}{(1 + i_{t+1,L}) e^{\epsilon_t} \mathbb{V}_t(1 + i_{t+1,FA})} \right) \right). \quad (11)$$

Second, we implicitly differentiate Equation (11) with respect to e^{ϵ_t} to obtain the effect of the latter on b_t .¹⁰

$$\frac{\partial b_t}{\partial e^{\epsilon_t}} = \frac{\kappa^2 G''(\cdot) \frac{\partial Q_{t,II}}{\partial e^{\epsilon_t}}}{1 - \kappa G''(\cdot) \frac{\partial Q_{t,II}}{\partial b_t}} > 0. \quad (12)$$

The positive sign of Equation (12) relies on the assumed concavity of G and the derived negative signs of $\frac{\partial Q_{t,II}}{\partial(-b_t)}$ and $\frac{\partial Q_{t,II}}{\partial e^{\epsilon_t}}$ from Equations (9) and (10), respectively. Third, we differentiate Equation (12) with respect to A_t :

$$\begin{aligned} \frac{\partial^2 b_t}{\partial e^{\epsilon_t} \partial A_t} &= \frac{\kappa^2 G'''(\cdot) \frac{\partial Q_{t,II}}{\partial e^{\epsilon_t}} (1 - \kappa G''(\cdot) \frac{\partial Q_{t,II}}{\partial b_t}) + \kappa^2 G''(\cdot) \frac{\partial Q_{t,II}}{\partial e^{\epsilon_t}} G'''(\cdot) \frac{\partial Q_{t,II}}{\partial b_t}}{\left(1 - \kappa G''(\cdot) \frac{\partial Q_{t,II}}{\partial b_t}\right)^2} = \\ &\frac{\kappa^2 G'''(\cdot) \frac{\partial^2 b_t}{\partial e^{\epsilon_t}} \left(1 - G''(\cdot) \frac{\partial Q_{t,II}}{\partial b_t} (\kappa^2 - \kappa)\right)}{\left(1 - \kappa G''(\cdot) \frac{\partial Q_{t,II}}{\partial b_t}\right)^2} < 0. \end{aligned} \quad (13)$$

¹⁰To streamline the remaining two derivations' exposition, which is otherwise quite cumbersome, we avoid writing out the argument in G as well as the explicit expressions from $\frac{\partial Q_{t,II}}{\partial(-b_t)}$ and $\frac{\partial Q_{t,II}}{\partial e^{\epsilon_t}}$ from Equations (9) and (10). The signs of these expressions are sufficient for our purposes in these two derivations.

The negative sign of Equation (13) relies on the assumed concavity of G , its assumed positive third derivative, the fact that $\kappa < 1$, and the derived negative signs of $\frac{\partial Q_{t,II}}{\partial(-b_t)}$ and $\frac{\partial Q_{t,II}}{\partial \epsilon^t}$ from Equations (9) and (10), respectively. Equations (12) and (13) formally demonstrate that a negative realization for ϵ_t (i.e., a rightward shift in FX swap demand) is predicted to generate a stronger widening of the basis (i.e., a larger decline in b_t) if the initial value of A_t is lower (i.e., if LOA are greater).

This prediction has strong economic intuition given that lower A_t , by limiting the availability of funds for arbitrageurs' arbitrage activity and thus inducing greater LOA, should make their FX swap supply more rigid and hence make the basis (b_t) more responsive to a rightward shift in FX swap demand. The A_t -dependent FX swap demand channel embodied by Equation (13) can also be equivalently referred to as the LOA-dependent FX swap demand channel (as done in the previous sections as well as hereafter), which is the central object of study of this paper.

Figure 1 qualitatively depicts the LOA-dependent FX swap demand channel. There are two noteworthy facts from this figure. First, to most vividly convey the crux of the LOA-dependent FX swap demand channel, we focus on the two extreme cases of perfectly *elastic* FX swap supply (leftward panel of the figure, i.e., LOA state) and perfectly *inelastic* FX swap supply (rightward panel of the figure, i.e., No LOA state). While the precise manifestation of these cases in our model depends on what is assumed about the asymptotic behavior of $G''(\cdot)$, one can view these cases as reasonable proxies for states of abundant versus scarce levels of initial arbitrage capital.

Second, Figure 1 reflects the fact that an LOA state corresponds to both a steeper and a more leftward FX swap supply curve in our model. That is, having an initially lower arbitrage capital implies not only a steeper FX swap supply curve but also a lesser quantity of FX swaps and wider basis. Hence, while the core of our demand channel lies in the effect of A_t on the slope of the FX swap supply curve, for completeness we also reflect A_t 's shifting effect on this curve in Figure 1.

4 Institutional Background

This section lays out information about the IIs in Israel and the environment in which they operate in the context of their FX swap activity.

Definition of IIs. IIs are broadly defined as financial intermediaries who pool funds from numerous investors and invest these funds in various financial assets on behalf of these investors. The BOI's definition of IIs in Israel that guides its collection of the transaction-level II FX flow data treats IIs as the universe of entities that manage the public's long-term savings in Israel. Such entities include pension funds, provident funds, severance pay funds, advanced training funds,¹¹ and life insurance policies.¹² IIs are important players in the Israeli financial market, managing 770.81 billion dollars on behalf of the public as of December 2021, which is 47% of the public's entire financial asset portfolio and 160% of GDP.

Regulatory Background. Until 2003, 70% of pension funds' investments, which comprise roughly 50% of total IIs' investment, were allocated to earmarked government bonds. In a watershed regulatory change, that occurred in 2003, the Israeli government lowered this 70% threshold to 30%, thereby triggering a gradual increase in IIs' investment in foreign assets as a share of total assets. Moreover, in 2008 the Israeli government enacted compulsory pension arrangements for all workers, further increasing the portfolio managed by IIs while pushing them to seek alternatives to their investments in Israel.¹³ Against this regulatory backdrop, IIs' have already allocated roughly 10% of their assets to foreign ones in the beginning of our sample (which starts in 2008) and have steadily raised this share to over 29% at the end of our sample.

IIs' FX Swap and Spot Trading. To fund their foreign investments, IIs can either do spot trades where they sell ILS and buy USD or FX swap trades where they do opposing spot and for-

¹¹The name 'advanced training fund' is somewhat misleading. In its inception, this fund was designed to be a tax-deductible saving vehicle to further one's education. Nowadays, it serves as a means to invest long-term.

¹²Mutual funds and exchange traded funds, whose investment is mostly for short- and medium-term purposes, are not included in the BOI's definition of IIs. In terms of the type of financial firms (rather than types of funds) which comprise our sample, the universe of investment banks and insurance companies are the entities managing the public's long-term savings in Israel for our sample (i.e., they are the owners of the funds that manage the public's long-term savings). Commercial banks, who have been banned in 2004 from managing the public's long-term savings in Israel, are thus excluded from the list of entities that comprises our sample.

¹³These regulatory changes have taken place against the backdrop of a 2001 regulatory shift from defined benefit to defined contribution pension plans, which is yet another historical regulation-driven growth source for Israeli IIs' portfolios.

ward trades. To gain an understanding about which one of these two options is favored by them, Figure 2 shows the evolution of accumulated daily FX swap (solid line) and spot (dashed line) flows for 1/7/2008-3/31/2022. (This sample is chosen to accord with our empirical analysis's baseline sample.) Negative accumulated swap and spot flows' values represent the accumulated spot selling of foreign currency; positive values represent the accumulated buying of foreign currency. In accordance with the literature, this paper's focus is on the *dollar* basis; hence, the FX flows shown in Figure 2 represent only trades in the currency pair USD/ILS.¹⁴

The FX swap flow series takes into account the offsetting forward flows from the associated second leg of each trade. As such, in accordance with our structural model and the literature's interpretation of the FX swap market as a vehicle for obtaining FX-risk-free collateralized dollar funding, the accumulated flow series represents IIs' FX-swap-market-implied dollar loan balance. Equivalently, this accumulated series can also be interpreted as IIs' FX-swap-induced open position on the dollar, where positive values represent a short such position.¹⁵

There are two noteworthy facts that are borne out by Figure 2. First, for most of the sample, Israeli IIs have obtained dollar funding through spot trades moderately more than through swap trades. But the two alternatives are quite comparable. And towards the end of the sample the FX-risk-free funding alternative of FX swaps surpasses the spot based alternative, with the accumulation of swaps reaching a peak of 80.1 Billion dollars on 1/25/2022 compared to a corresponding accumulated spot value of 49.9 Billion dollars.¹⁶

¹⁴85.9% of IIs' FX swap flow volume is in dollars. The remaining share is almost entirely in euros (11.4%) and pounds (1.8%). 87.8% of IIs' FX spot volume is done in dollars, with the remaining share also almost entirely done in euros (9.7%) and pounds (1.6%).

¹⁵While we do not have the starting level of IIs' open position prior to our sample's inception, and hence the accumulated swap flows are only a proxy for the associated open position, FX swap flow activity was quite modest prior to 2008 thereby implying that the latter proxy should be quite accurate. In any case, since we are interested in the *changes* in IIs' open FX swap position (rather than their level) for this paper's purposes, this issue is of null importance to our analysis.

¹⁶Outright forwards constitute an additional FX trade category that IIs use and is not shown here due to its irrelevance to this paper's analysis. This irrelevance is rooted in cross-currency basis being the price of FX swaps, thus rendering the understanding of the drivers of CIP deviations tantamount to the understanding of the workings of the FX swap market (see [Du and Schreger \(2022\)](#) and references therein). IIs use outright forwards to hedge against the FX risk from increases in their foreign stocks portfolio, an hedging mechanism that underlies the equity hedging channel of exchange rate determination ([Ben Zeev and Nathan \(2022\)](#)).

Sectoral Comparison of FX Swap Flows. Figure 3 shows the evolution of accumulated daily aggregate FX swap flows for 1/7/2008-3/31/2022 for three additional sectors on top of the IIs sector (which, for completeness, is also included in the figure): real sector, which represents the net FX flows from swap transactions involving Israeli exporters and importers; local arbitrageurs sector, which includes Israeli commercial banks, mutual funds, exchange traded funds, hedge funds, and proprietary trading firms; and foreign arbitrageurs sector, which includes all foreign firms engaged in financial activity (i.e., foreign commercial and investment banks, pension and insurance funds, mutual funds, exchange traded funds, hedge funds, and proprietary trading firms).¹⁷

Our sectoral decomposition follows our structural model from the previous section which underscores arbitrageurs as IIs' central counterparty in their FX swap trades. Although our model does not differentiate between local and foreign arbitrageurs, we present local and foreign arbitrageurs separately in Figure 3 to be consistent with our separate consideration of them in our empirical analysis. This consideration is motivated by the fact that foreign arbitrageurs' global nature and size advantage arguably renders them to be the potentially more relevant counterparties conditional on an aggregate demand shock to IIs' FX swap demand in the LOA state.

Figure 3 demonstrates that the sole effective buyers of dollar swaps among market participants are IIs, against which the two sellers of dollar swaps are the foreign and local arbitrageurs sectors. The real sector is a net buyer of dollar swaps but its activity is negligible. That the foreign and local arbitrageurs sectors act as sellers of dollar swaps is consistent with the modeling approach taken in the previous section which assumes that arbitrageurs are IIs' counterparties, supplying IIs' their demanded FX swaps.

IIs' Aggregate Cross-Currency Basis. We end this section with an exposition of the aggregate cost of IIs' FX swaps, as measured by the cross-currency basis and defined in the usual way as the difference between the dollar Libor rate and CIP-implied rate, facing IIs over our sample. The availability of both spot and forward rates in our transaction-level dataset allows us to construct this IIs-specific basis as the daily volume-weighted average of the associated transaction-level

¹⁷The foreign *real* sector's FX swap volume is negligible and is therefore excluded from Figure 3.

bases. Figure 4 shows the evolution of the latter measure of IIs' aggregate basis. For comparison purposes we also depict in this figure the market-wide 1-, 3-, and 6-month USD/ILS cross-currency market-wide bases constructed from spot and forward rate data from Thomson Reuters.

It is clear that Israeli IIs, as did many of their international counterparts, faced a meaningful cost of obtaining dollar funding from the FX swap market for our considered sample period. The mean of IIs' aggregate basis is -43.3 basis points. Encouragingly, our transaction-level based IIs' basis is very similar to the market-wide Thomson Reuters based ones, with correlations between our basis and the 1-, 3-, and 6-month bases standing at 85.1%, 93.9%, and 90.5%, respectively. (The means of the Thomson Reuters based bases are -44.1, -44.2, and -37.2 basis points.)

IIs' meaningful average basis also embodies significant volatility, with the basis actually being positive early on in the sample but then starting to become negative in early 2009. While the basis remains in this negative territory throughout the vast majority of the sample, it is clear that the most significant widening of the basis takes place following the GFC period with this material widening being very persistent lasting for roughly 4 years. We then observe some relatively short-lived and modest bouts of basis widening until the COVID-ridden period where more significant and more persistent basis widening again takes place (albeit to a much lesser extent than the post-GFC dynamics).

5 Methodology

This section elucidates the methodology used in the empirical analysis undertaken in this paper. We first describe the data used in the estimation after which we turn to present the general lines of the estimation. Further technical details of our estimation approach are shown in Appendix A of the online appendix to this paper.

5.1 Data

Our data are daily and cover the period 1/7/2008-3/31/2022. The specific starting and ending points of this approximate 14-year period are dictated by the availability of the Bank of Israel (BOI) proprietary FX swap data.

5.1.1 FX Swap Flows and Prices Data

We have proprietary daily transaction-level data covering both quantities and prices (spot and forward rates) for Israeli IIs as well as local (Israeli commercial banks, mutual funds, exchange traded funds, hedge funds, and proprietary trading firms) and foreign arbitrageurs (represented by all types of foreign financial firms and institutions). We also have such data for the local and foreign real sectors but in our empirical analysis we abstract from these additional sectors because they are insignificant players in the FX swap market.

FX Swap Flows. We construct from our micro data aggregate FX swap flow series for IIs and local and foreign arbitrageurs sectors. The aggregate FX swap flow variable for a specific sector measures (in dollars) the daily net change in the corresponding sector's open swap position. This position is calculated from the net transaction flows from the sector's buying and selling of U.S. dollars on the FX swap market, while accounting for such flows from both legs of the swap trades. A positive (negative) value for this variable for a given observation takes place when the sector was a net buyer (seller) of swap-linked dollars on the corresponding day. While we do not have the starting level of the sectors' open position prior to our sample's inception, and hence the accumulated swap flows are only a proxy for the associated sectoral open position, FX swap flow activity was quite modest prior to 2008 for USD/ILS thereby implying that the latter proxy should be quite accurate. In any case, since we are interested in the *changes* in a sector's open FX swap position (rather than their level) for this paper's purposes, this issue is of null importance to our analysis.

Table 1 presents the maturity distribution in the FX swap market by sector. (For completeness - in addition to the central II and local and foreign arbitrageurs sectors - we also include the local real sector in this table.) The median maturity of IIs' FX swap trades is 54 days whereas that for local and foreign arbitrageurs are 7 and 3 days, respectively, highlighting an interesting maturity gap between the major short and long dollar swap position holders. Local banks, who in addition to their local arbitraging role are also the main market makers in the USD/ILS FX swap market against which IIs conduct the majority of their swap trades (roughly 83% - with the remaining share being conducted against foreign financial firms), face the task of managing the risk from this

maturity mismatch.

We restrict attention to USD/ILS trades given our literature-consistent focus on the *dollar* basis. (85.9% of our local IIs' FX swap volume is done in dollars, with the remaining small 14.1% share almost entirely done in euros (11.4%) and pounds (1.8%).)

II-Level FX Swap Flows. Our GIV-based identification comes from our ability to observe transaction-level FX swap flows for individual IIs' fund families. There is a total of 14 such IIs' fund families on which we base our GIV-based identification procedure. These IIs are the universe of asset managers in Israel managing its public's long-term savings and comprise of investment banks and insurance companies. The long-term savings industry in Israel is quite concentrated, as reflected by an average Herfindahl-Hirschman Index of 0.26 for IIs' (absolute) open FX swap positions.¹⁸

It reasonable to expect only modest correlation among our 14 IIs' FX swap flows given the high-frequency (daily) nature of our data. This expectation is borne out by the data with an average absolute pairwise correlation among the 14 IIs of 12.6% and a corresponding standard deviation of 8.9%. Importantly, by removing the effects on these flows of various common drivers, our estimation procedure is capable of materially reducing these numbers to 2.9% and 2.2%, respectively. I.e., the high-frequency nature of our data along with the suitability of our estimation procedure facilitate the extraction of daily idiosyncratic II-level FX swap demand shocks where the difference between the size-weighted- and inverse-variance-weighted-average of these shocks (i.e., GIV shock) in turn provides a valid aggregate demand shock for the testing and quantification of our LOA-dependent FX swap demand channel.

IIs' FX Swap Prices. We construct a direct measure of IIs' aggregate basis by computing a volume-weighted average of their associated transaction-level bases. This is made possible for us by the availability of the spot and forward rates underlying each transaction in our dataset. Transactions' bases are computed the standard way as the difference between the cash market risk-free dollar interest rate at the corresponding maturity and the CIP-implied dollar interest

¹⁸Only one II in our sample consistently holds long, rather than short, open FX swap positions. All other IIs consistently hold short such positions.

rate (i.e., forward premium multiplied by gross local risk-free rate). Note that these transaction-level bases represent the *actual* price incurred by IIs from tapping into the FX swap market for FX funding; hence, the aggregate basis variable at our disposal measures the actual cost of FX swaps facing the IIs sector.

The dollar risk-free interest rate is measured by Libor. To construct the CIP-implied dollar rate, we use the Tel Aviv Inter-Bank Offered Rate (Telbor) as our measure of the Israeli cash market risk-free interest rates. (Telbor is based on interest rate quotes by a number of commercial banks in the Israeli inter-bank market.) As IIs' swap transactions' maturity distribution is fairly continuous, we use linearly interpolated interest rates from the 1-, 3-, 6- and 12-month maturities' Thomson Reuters interest rate values to compute the transaction-specific interest rates.

5.1.2 Market-Wide USD/ILS Cross-Currency Bases

To provide external validity for our sample of contracts, we also construct the USD/ILS cross-currency bases for the 1-, 3-, and 6-month maturities in the standard way, i.e., as the difference between the cash market risk-free dollar interest rate at the corresponding maturity and the CIP-implied dollar interest rate (i.e., forward premium multiplied by gross local risk-free rate). To construct these bases, we use the Thomson Reuters 4:00 PM London time spot and forward rate data as well as Thomson Reuters end-of-day quotes for USD and ILS interest rates (Libor and Telbor).

5.1.3 Additional Macro-Financial Data

We use several daily frequency macro-financial variables in our analysis, all of which cover the baseline empirical sample of 1/7/2008-3/31/2022. Except for the LOA measure, these variables are taken from Bloomberg and their values are end-of-day quotes.

LOA Measure. Building on the intrinsic link between intermediaries' funding capacity and LOA (Shleifer and Vishny (1997)) (also see discussion from Footnote 6), we measure LOA with

the daily market leverage series from He et al. (2017).¹⁹ This variable is an aggregate leverage ratio for the intermediary sector, which is defined as the set of primary dealers - a select group of financial intermediaries that serve as trading counterparties to the Federal Reserve Bank of New York in its implementation of monetary policy, and is computed as the ratio between the sum of the intermediary sector's market equity and book debt values and the sum of this sector's market equity value (i.e., a value-weighted average of intermediaries' leverage ratios). He et al. (2017) use the intermediary leverage ratio to capture intermediary sector soundness. As such, it constitutes an appealing high-frequency measure of LOA which we utilize in our empirical framework to estimate the LOA-dependent FX swap demand channel.

Figure 5 shows the time series of the leverage ratio that we use. The period of the GFC stands out. However, there were some other noteworthy periods when the measure was high, such as 2011-2012 and the recent COVID-19 turmoil.

VIX. The VIX is a volatility index that measures the near-term expected volatility of the S&P 500 Index and is calculated from real-time S&P 500 Index European options with an average expiration of 30 days. We use its log-first-differences (in lagged and current form) in the micro-level regressions that identify the idiosyncratic FX swap demand shocks to control for global uncertainty shocks.

Broad Dollar Index. The broad dollar index is a trade-weighted U.S. dollar index measuring the value of the dollar relative to other world currencies while updating the weights yearly. We use its log-first-differences (in lagged and current form) in the micro-level regressions that identify the idiosyncratic FX swap demand shocks to control for global risk appetite shocks (Avdjiev et al. (2019)).

S&P 500 and TA-35 Indices. The commonly used S&P 500 is our measure of global stock prices while the TA-35 index is our measure of local stock prices, with the two indices listing

¹⁹This data are available at <https://voices.uchicago.edu/zhiguohe/data-and-empirical-patterns/intermediary-capital-ratio-and-risk-factor/>.

the largest 500 and 35 companies in U.S. and Tel-Aviv Stock Exchanges, respectively. We include current and lagged values of the log-first-differences of these two indices in the micro-level regressions that identify the idiosyncratic FX swap demand shocks so as to ensure that these shocks do not capture endogenous demand variation due to variation in stock market performance in the U.S. and Israeli stock markets. Notably, the inclusion of the local stock market return variable also serves to ensure that shocks specific to the Israeli economy are not contaminating our identification.

USD/EUR Cross-Currency Bases. To ensure that our FX swap demand shock is unrelated to variation in frictions in the global FX swap market, we control for current and lagged values of the first-differences of the 1- and 12-month USD/EUR cross-currency bases in the micro-level regressions that identify the idiosyncratic FX swap demand shocks. We compute these bases correspondingly to how we compute the USD/ILS ones, taking the 1- and 12-month Euribor rates as the risk-free rates for the Euro. As explained in Footnote 21, these two maturities are sufficient for our purposes given the high correlations between the first differences of the 1- and 3-month bases and the 6- and 12-month bases.

Select Variable Correlations. In Table 2, the first row displays the daily correlation between our LOA measure and the II basis measure as well as the other macro-financial variables described in this section, where all variables are in log-first-differences except for the bases. It is reassuring to observe that the LOA measure exhibits minimal correlation with our II basis measure. This finding, when coupled with our subsequent empirical results, aligns with the notion that the LOA measure adequately captures the steepness of the supply curve while shocks to this measure do not produce fluctuations in our II basis. It is worth noting that even if the LOA measure did capture some variations in the basis, this would not bias our estimation as we have included both the one-day lagged level of our LOA measure as well as the current and lagged values of its first-difference as controls in our regression analysis.

Moving to the second row of the table, we observe that the II basis demonstrates limited daily correlation with the USD/EUR bases as well as our other considered and commonly followed

financial variables. Taken together with the low correlation between the II basis measure and LOA, these limited correlations further strengthen our confidence that the day-to-day fluctuations in our II basis measure are not primarily driven by global financial/FX swap market forces, which in turn provides motivation for the exploration of the role played by unique local demand shocks.

5.2 Estimation

We estimate a daily frequency Bayesian state-dependent local projection model whose core lies in the granular instrumental variable (GIV) approach from [Gabaix and Koijen \(2020\)](#). The estimation proceeds in two steps. In the first, we identify idiosyncratic FX swap demand shocks from 14 micro-level regressions of our IIs' swap flows on their own raw lags, the interactions of their current and lagged values with the one-day lagged value of the LOA variable, and a rich array of controls which capture FX swap supply- and demand-side factors. This rich specification ensures that the micro-level innovations to the IIs' FX swap series from the micro-level regressions represent well idiosyncratic FX swap demand shocks. We think about these idiosyncratic shocks in terms of our structural model from Section 3, i.e., as representing idiosyncratic changes in IIs' geographical portfolio preferences. (Also see related discussion in Footnote 3.)

Following [Gabaix and Koijen \(2020\)](#), and as still part of our estimation's first step, we construct the GIV (i.e., aggregate shock to IIs' FX swap demand) as the difference between the size- and inverse-variance-weighted-average of the 14 idiosyncratic micro-level FX swap demand shocks, where II-level sizes are calculated from the shares of swap flows' average volume of each II in total IIs' average volume. As shown in [Gabaix and Koijen \(2020\)](#), this GIV construction is optimal in the sense that the resulting estimation possesses the highest precision.

In the second step of our estimation, we run local projection regressions of IIs' cross-currency basis on our GIV shock from the first estimation step as well as on the interaction between this GIV shock and the one-day lagged LOA measure. This allows us to estimate the LOA-dependent dynamic effect of the FX swap demand shock on the basis.

5.2.1 Econometric Model

Specification. We estimate the following two-stage model:

$$\Delta SP_{i,t} = \alpha_{i,0,L} + \alpha_{i,1,L}\mathbb{T}_t + \Gamma_i\mathbb{D}_t + \beta_{i,1,L}\Delta SP_{i,t-1} + \dots + \beta_{i,p_i,L}\Delta SP_{i,t-p_i} \quad (14)$$

$$\begin{aligned} &+ LOA_{t-1} \left(\alpha_{i,0,I} + \alpha_{i,1,I}\mathbb{T}_t + \beta_{i,0,I}\Delta SP_{i,t} + \dots + \beta_{i,p_i,I}\Delta SP_{i,t-p_i} \right) \\ &+ A_{i,1}\Delta b_{t-1} + \dots + A_{i,p_i}\Delta b_{t-p} + C_{i,0}Z_t + \dots + C_{i,p_i}Z_{t-p_i} + \epsilon_{i,t}, \\ b_{t+h} - b_{t-1} &= \alpha_{2,L,h} + \Xi_{L,h}\hat{\epsilon}_t + LOA_{t-1} \left(\alpha_{2,I,h} + \Xi_{I,h}\hat{\epsilon}_t \right) + u_{t+h}, \end{aligned} \quad (15)$$

where i and t index IIs and time at daily frequency; $\alpha_{i,0,L}$ is the fixed effect, \mathbb{T}_t is a time trend, and \mathbb{D}_t is a day-dummy matrix containing binary variables for Monday through Thursday with corresponding matrix coefficient Γ_i ; $\Delta SP_{i,t}$ is II i 's FX swap flows (i.e., the first-difference of this II's open FX swap position); LOA_{t-1} is the deviation of the logged He et al. (2017)'s intermediary leverage ratio variable at $t - 1$ from its mean divided by this variable's standard deviation; p_i denotes the number of lags for II i 's equation;²⁰ $A_{i,j}$ ($j = 1, \dots, p_i$) are coefficient scalars and Δb_{t-j} is lagged first-difference of aggregate (volume-weighted average) IIs' cross-currency basis; $C_{i,s}$ ($s = 0, \dots, p_i$) are 1×8 coefficient vectors and Z_{t-s} are 8×1 variable vectors whose components are detailed below; $\epsilon_{i,t} \sim i.i.d. N(\mathbf{0}, \sigma_{i,\epsilon}^2)$ is Equation (14)'s residual (i.e., true idiosyncratic FX swap demand shock for II i) where $\sigma_{i,\epsilon}$ is its standard deviation; b_t is IIs' aggregate (volume-weighted average) cross-currency basis; h is Regression (15)'s rolling horizon ($h = 0, \dots, H$); $\hat{\epsilon}_t = \sum_{i=1}^{14} \hat{\epsilon}_{i,t} w_i - \sum_{i=1}^{14} \hat{\epsilon}_{i,t} v_i$ is the difference between the size-weighted- and inverse-variance-weighted-average of estimated residuals from Equation (14) (this GIV is normalized to have unit standard deviation), i.e., the estimated aggregate IIs' FX swap demand shock, where w_i is II i 's share of swap flows' average volume in the sum of IIs' average volumes and v_i is the share of $\hat{\epsilon}_{i,t}$'s inverse variance in the sum of estimated residuals' inverse variances; and $u_{t+h} \sim i.i.d. N(\mathbf{0}, \sigma_{u,h}^2)$ is Equation (15)'s residual where $\sigma_{u,h}$ is its standard deviation.

²⁰We compute the AIC, corrected AIC, BIC, and HQIC lag length criteria tests for each II i 's regression. For the baseline case, we take the average lag specification across the latter four considered tests for each II-level regression. The average lag across the different II-level specifications is 11.9 with a standard deviation of 5.1. We show the robustness of our results to an alternative lag specification in online appendix's Section B.3.

Identification. To be internally consistent, we identify the idiosyncratic FX swap demand shocks from Equation (14) by regressing IIs' swap flows on both their raw lags, whose associated coefficients are with index L as they represent the *linear* part of that equation, as well as on the interactions between the one-day lagged LOA variable and current and lagged IIs' swap flows, whose associated coefficients are with index I as they represent the nonlinear (interaction-terms) part of Equation (14). The inclusion of the interaction between the one-day LOA variable and the current value of IIs' swap flows ensures that the identified idiosyncratic shocks do not erroneously capture the interaction of the true shock with the one-day lagged LOA variable. And we separately control for the one-day lagged LOA variable to ensure that our identified idiosyncratic shocks do not erroneously pick up the effects of greater/lesser LOA.

Disciplined by our structural model, we also project onto a rich array of additional variables in Equation (14) to ensure the validity of our identification. The inclusion of lagged first-differences of IIs' aggregate cross-currency basis purges from our identified idiosyncratic shocks any variation related to the past dynamics of aggregate FX swap prices. And variable vector Z_{t-s} includes the following variables: log-first-differences of S&P 500 and TA-35 indices and first-difference of the spread between the 3-month Libor and Telbor rates, the inclusion of which ensures that foreign and local equity price and interest rate spread changes are not driving our results; log-first-difference of VIX and broad dollar index, the controlling of which ensures our identified idiosyncratic shocks are unrelated to global uncertainty and risk appetite shocks, respectively; first-differences of USD/EUR 1- and 12-month cross-currency bases,²¹ the controlling of which removes the possibility that our identified idiosyncratic shocks capture shocks to frictions in the global FX swap market; and first-differences of the LOA variable (logged financial intermediaries' leverage ratio), whose inclusion assures our identified idiosyncratic shocks are not picking up shocks to LOA.²²

A crucial element of our econometric model is that we allow for all of the coefficients in Equa-

²¹While results are robust to including the first-differences of the 3- and 6-month USD/EUR bases, the former has a 70% correlation with the 1-month basis and the latter has an 85% correlation with the 12-month basis. Hence, the 1- and 12-month bases appear to be sufficient for capturing the frictions present in the global FX swap market. (The correlation between these two variables is 41%.)

²²The merit of Specification (14) is borne out by its high average R^2 of 81.2% across the 14 II-level regressions.

tion (14) to vary with i . Technically, this implies that we separately estimate this equation for each of our 14 IIs. Substantively, this heterogenous coefficient setting allows us to remove common variation in IIs' FX swap demand arising not only from the common variables in Equation (14) but also from the *way* by which IIs' swap flows respond to these variables. This is important because in addition to time-invariant differences across IIs' swap demand (captured by fixed effect $\alpha_{i,0,L}$) there are also time-varying such differences stemming from heterogenous sensitivities of IIs' swap flows to lagged II-specific FX swap flows, the interaction between one-day lagged LOA and current and lagged II-specific FX swap flows, and common FX swap market drivers. The latter heterogeneity is what our heterogenous coefficient setting precisely accounts for, resulting in a panel of 14 idiosyncratic demand shocks that exhibit a mere average absolute pairwise correlation of 2.9% with a standard deviation of 2.2%. And our GIV construction from these idiosyncratic shocks removes any additional remaining common variation, particularly that potentially coming from contemporaneous price effects, thus aiding in identifying a valid aggregate demand shock.

The coefficients of interest are $\Xi_{L,h}$ and $\Xi_{I,h}$ from Equation (15), whose central explanatory variable is the aggregate FX swap demand GIV shock constructed as difference between the size-weighted- and inverse-variance-weighted-average of estimated 14 idiosyncratic demand shocks from Equation (14). Building on the conceptual base provided by our structural model, we construct the effects of a one standard deviation aggregate FX swap demand shock in the LOA state on cross-currency basis at horizon h as $\Xi_{L,h} + 2\Xi_{I,h}$, i.e., the LOA state is defined by the LOA variable being 2 standard deviations higher than its mean. The 2 value corresponds to the 96th percentile of the LOA variable's distribution. Interpreted through the lens of our model's conceptual framework, $\Xi_{L,h} + 2\Xi_{I,h}$ captures the effects of an FX swap demand shock conditional on the supply curve of FX swaps being significantly rigid. For comparison purposes, we will also show the linear responses (i.e., $\Xi_{L,h}$) which give the effects of the aggregate FX swap demand shock when the LOA variable is at its mean value; hence, these responses will inform us about the effects of the aggregate FX swap demand shock when there are no meaningful LOA.

It is noteworthy that our object of interest is *not* the slope of the FX swap supply curve. That is, our paper does not set out to estimate how much the basis changes for a dollar change in FX swaps coming from a rightward shift in FX swap demand. While this structural slope object can

be estimated in our setting by simply dividing the basis' impact response by the impact response of IIs' aggregate open FX swap position, we avoid doing so for two reasons. First, this paper's objective is to quantify the meaningfulness of the LOA-dependent FX swap demand channel. As such, it suffices to consider the dynamic effects of our demand shock on the basis while also making sure that FX swap quantities behave across the LOA state and the no LOA case in a manner that accords with our shock's interpretation as a demand shock. Second, we can not meaningfully estimate this slope for the LOA state given that quantities' impact response in this state is effectively null.

Let the stacked $K_i \times 1$ $B_i = [\alpha_{i,0,L}, \dots, C_{i,p_i}]'$ (K_i is the number of parameters for the RHS of Equation (14)) and 5×1 $Q_h = [\alpha_{2,L,h}, \dots, \gamma_h]'$ matrices represent the coefficient matrices from Equations (14) and (15), respectively. I.e., the parameters to be estimated from these two equations can be summarized by coefficient matrices B_i s and residual variance $\sigma_{i,\epsilon}^2$ for Equation (14) and coefficient matrix Q_h and residual variance $\sigma_{u,h}^2$ for Equation (15). (These nomenclatures will be used in Appendix A of the online appendix to this paper to facilitate this appendix's detailed depiction of the inference and estimation procedure for Equations (14) and (15).)

Impulse Response Estimation Method. We estimate Equations (14) and (15) jointly by applying the Bayesian estimation algorithm for strong block-recursive structure put forward by [Zha \(1999\)](#) for block-recursive VARs, where the likelihood function is broken into the different recursive blocks. In our case, we only have two blocks, where the first consists of Equation (14) and the second contains Equation (15). As shown in [Zha \(1999\)](#), this kind of block separation along with the standard assumption of a normal-inverse Wishart conjugate prior structure leads to a normal-inverse Wishart posterior distribution for the block-recursive equation parameters.

To account for temporal correlations of the error term in Equation (15), we apply a Newey-West correction to the standard errors within our Bayesian estimation procedure. In doing so we accord with the reasoning from [Miranda-Agrippino and Ricco \(2021\)](#), who estimate a hybrid VAR-local-projections model and follow the suggestion from [Müller \(2013\)](#) to increase estimation precision in the presence of a misspecified likelihood function (as in our and their setting) by replacing the original posterior's covariance matrix with an appropriately modified one. Moreover, given

the high-frequency nature of our data and the general tendency of impulse responses from local projections to exhibit jaggedness, we apply the smoothing procedure from [Plagborg-Møller \(2016\)](#) to our estimated raw impulse responses. (Details on this smoothing procedure are provided in Appendix A of the online appendix to this paper.)

FEV Estimation Method. For the forecast error variance (FEV) decomposition estimation, we utilize the estimated (smoothed) LOA-dependent impulse responses to compute the LOA-dependent FEV contributions of our swap demand shock as follows:

$$C_{LOA,h} = \frac{\mathbb{V}(\hat{\epsilon}_t | LOA) (\hat{\Xi}_{L,0} + 2\hat{\Xi}_{I,0})^2 + \dots + (\hat{\Xi}_{L,h} + 2\hat{\Xi}_{I,h})^2}{\mathbb{V}(b_{t+h} - b_{t-1} | LOA)}, \quad (16)$$

$$C_{NLOA,h} = \frac{\hat{\Xi}_{L,0}^2 + \dots + \hat{\Xi}_{L,h}^2}{\mathbb{V}(b_{t+h} - b_{t-1})}, \quad (17)$$

where $\hat{\Xi}_{L,h}$ and $\hat{\Xi}_{I,h}$ are the estimated linear and nonlinear (interaction-term) impulse response coefficients from Equation (15); *LOA* and *NLOA* correspond to the LOA state and non-LOA (linear) state, respectively; $\mathbb{V}(b_{t+h} - b_{t-1} | LOA)$ represents the variance of IIs' cross-currency basis' accumulated differences conditional on the LOA state and $\mathbb{V}(b_{t+h} - b_{t-1})$ is the unconditional variance of this variable; and, similarly, $\mathbb{V}(\hat{\epsilon}_t | LOA)$ is the estimated aggregate FX swap demand shock's variance conditional on the LOA state, respectively.

Operationally, we define the LOA state for the FEV estimation as the group of observations where the LOA series values are above or equal to the LOA series's 92th percentile. The rationale for this definition is based on the fact that the LOA state for the impulse response estimation is defined by the LOA variable being equal to its 96th percentile value. (The LOA variable's 2 standard deviation value corresponds to its 96th percentile.) Hence, we define the variance conditional on this state as the variance that results from considering observations that closely and symmetrically surround the impulse response estimation's LOA state value but at the same time delivers a sufficient number of observations for FEV estimation. The non-LOA state, because it corresponds to the linear effect of the aggregate FX swap demand shock, is defined in an unconditional sense on the basis of all observations - i.e., the variance of both the aggregate FX swap demand and IIs' cross-currency basis' accumulated differences conditional on this state are simply the *uncondi-*

tional variances.²³ (Recall that the unconditional variance of the aggregate FX swap demand shock is unit and hence does not appear in Equation (17).)

6 Empirical Evidence

This section presents the main results of the paper. In all considered figures, solid lines represent the median LOA-dependent responses of the corresponding variable to a one standard deviation shock to aggregate IIs' FX swap demand while dashed lines depict 95% posterior confidence bands; 600 daily horizons are considered. Note that these 600 horizons represent IIs' FX swap active trading days. After accounting for non-swap-activity days on the part of IIs, these 600 horizons roughly reflect 3.3 calendar years. To further our understanding of the quantitative importance of the LOA-dependent FX swap demand channel, we also present forecast error variance (FEV) decomposition results for our IIs' cross-currency basis variable. After showing the results for IIs' basis, we turn to the results for the IIs' open FX swap position variable. We then end the section with two robustness checks: results for market-wide bases as outcome variables and results from replacing the GIV-based identification approach with the Bartik instrument one.

6.1 IIs' Cross-Currency Basis' Impulse Responses

Figure 6 shows the LOA-dependent effects of a one standard deviation aggregate FX swap demand shock on the aggregate (volume-weighted average) IIs' basis. The first two columns of the figure present the effects of the shock in the LOA state and the linear (no LOA) case, respectively. The third column of the figure shows the difference between the impulse responses in the LOA state and linear case.

The results demonstrate a significant and persistent widening of the basis in response to the

²³In the spirit of [Gorodnichenko and Lee \(2020\)](#)'s FEV method for local projections (termed LP-B in their paper) which ensures that the computed FEV share does not exceed one, we compute the denominator in Equations (16) and (17) as the sum of the corresponding numerator and the variance (conditional one for Equation (16) and unconditional one for Equation (17)) of the residual from Equation (15)'s implied moving average decomposition. (As in the empirical results whose presentation follows next, this moving average decomposition is based on estimated impulse responses up to the 600th horizon, which covers roughly 3.3 years of calendar years after accounting for non-swap-activity days on the part of IIs.) While asymptotically this alternative way of computing the variance in the denominator is equivalent to computing it from the actual data, the latter computation in finite samples can lead to estimated FEV shares that exceed one.

aggregate FX swap demand shock in the LOA state. There is a significant widening of the basis on impact of 3.9 basis points with the dynamics of this effect exhibiting a hump-shaped pattern, peaking at 8.4 basis points after 333 trading days. Notably, the effect maintains its significance for 526 trading days.

In contrast to the LOA-state-dependent responses, the linear (no LOA) response is both economically and statistically insignificant for all considered horizons. Therefore, the magnitude and the persistence of the differences between the responses in the LOA state and linear case are similar to those observed for the LOA-state-dependent responses. Response differences across the LOA state and linear case remain significant for 473 trading days.

In sum, the results from Figure 6 support the story from our structural model. When LOA are meaningful, FX swap supply is sufficiently rigid such that a favorable aggregate FX swap demand shock causes a significant widening of the basis. And our dynamic framework allows us to uncover a significant persistence to this LOA-dependent mechanism. By contrast, when LOA are not meaningful (the linear case), FX swap supply is sufficiently elastic so as to prevent from the favorable aggregate FX swap demand shock to widen the basis. We now turn to the FEV results.

6.2 IIs' Cross-Currency Basis' FEV

Figure 7 shows the LOA-dependent contributions of the aggregate FX swap demand shock to the FEV of IIs' basis. The FX swap demand shock's peak contribution is 72.9%, taking place at the 269th horizon. That the swap demand shock accounts for such a meaningful FEV share indicates that the LOA-dependent FX swap demand channel we uncover in this paper is quantitatively important for explaining IIs' cross-currency basis' variation. Specifically, the dynamic nature of our analysis, by capturing the persistence of the basis' response, is the crucial element in allowing the estimation of this quantitative importance.

In contrast to the LOA state, the second column of Figure 7 shows that FEV contributions in the linear (no LOA) case are negligible, peaking at 1.6% (600th horizon). These unimportant FEV shares are consistent with the view that our linear case captures an elastic FX swap supply curve. The third column of Figure 7 confirms that the economically large differences between the FEV shares across the LOA state and the linear case are also statistically significant, showing

significant differences for all 600 considered horizons.

6.3 IIs' Aggregate Open FX Swap Position

To further bolster confidence in the interpretation of our results as evidence for a meaningful LOA-dependent FX swap demand channel, it is important to confirm that IIs' aggregate open FX swap position's differential response across the LOA state and the linear case accords with the latter channel. Specifically, if this channel is truly driving our results for IIs' basis, then we should expect to see IIs' aggregate open FX swap position *initially* respond more strongly to the aggregate FX swap demand shock in the linear case than in the LOA state.

Figure 8 shows the LOA-dependent impulse responses of IIs' aggregate open FX swap position along with the corresponding responses for the local and foreign arbitrageurs sectors. These responses are obtained from replacing IIs' cross-currency basis' accumulated difference outcome variable in Equation (15) with the accumulated difference in each sector's aggregate open FX swap position (i.e., $SP_{t+h,j} - SP_{t-1,j}$ where $j = [IIs, LAs, FAs]$).²⁴ The results from Figure 8 accord well with those from Figure 6: IIs' aggregate open FX swap position increases significantly more initially in the linear case than in the LOA state, reaching a significantly greater impact response of 331.3 million dollars in the former compared to an insignificant 58.3 million dollar response in the latter. This materially greater impact response in the linear (no LOA) case supports the interpretation of our results as being driven by an LOA-dependent FX swap demand channel where the linear case (LOA state) identifies an elastic (inelastic) FX swap supply curve.

Notwithstanding the initial response differences (in the direction of linear case response), which are significant for a total of 99 trading days, in later horizons we observe a strong persistence in the swap position's response in the LOA state which renders a significant rise in the swap position in this state for the 47th-375th horizons. In other words, while initially IIs face difficulty obtaining funding in the FX swap market, their efforts to do so ultimately bear fruit at later horizons. This persistent effort in turn clearly places a heavy burden on the FX market, inducing significant upward pressure on FX swap prices. Hence, our results uncover an interesting dy-

²⁴We also add to the RHS of Equation (15) a time trend, both separately as well as interacted with LOA_{t-1} , so as to control for possible trending behavior of IIs' and local foreign arbitrageurs' accumulated FX swap flows.

dynamic propagation mechanism for the aggregate FX swap demand shock in the LOA state which rests on the persistent nature of this shock and the associated perseverant IIs' effort to ultimately obtain the funding they had set out to procure to begin with.

Who provides FX swaps to IIs following their demand shock? Figure 8 shows that in the linear case both local and foreign arbitrageurs serve as suppliers of FX swap dollars to IIs. However, in the LOA state, foreign arbitrageurs are the sole such suppliers. This finding likely stems from these institutions' greater capacity to obtain arbitrage capital in times of distress relative to local arbitrageurs.

6.4 Market-Wide Cross-Currency Basis

To externally validate our results, it is useful to also consider the response of market-wide cross-currency basis in addition to our baseline aggregate (volume-weighted average) IIs' basis. Toward this end, we again estimate Equations (14) and (15) but now instead of using the aggregate IIs' basis as outcome variable in Equation (15) we use the 1-, 3-, and 6-month market-wide bases constructed from Thomson Reuters spot and forward rate data. (See Section 5.1.2 for further details on this data.)

The impulse responses and FEV results from this exercise are presented in Figures 9a and 9b, respectively. Encouragingly, results for market-wide bases are both quantitatively and qualitatively similar to the baseline ones, with the 1-, 3-, and 6-month bases exhibiting significant and persistent responses in the LOA state which reach peak widening of 6.2, 7.5, and 8.8 basis points after 294, 325, and 317 trading days, respectively. The corresponding peak FEV shares are 79%, 75.2%, and 72.5% (all at the 262th horizon), respectively.

6.5 Results from Bartik Instrument

Bartik (1991) instruments, also known as shift-share estimators, constitute an established and widely used identification approach in economics (see, e.g., Blanchard and Katz (1992), Autor et al. (2013), Adão et al. (2019), Goldsmith-Pinkham et al. (2020), and Borusyak et al. (2021)). Gabaix and Koijen (2020) define and compare the Bartik instrument in relation to their GIV instrument and emphasize that the two instruments should be viewed as complementary identification ap-

proaches. Specifically, while the GIV approach seems to be the natural and preferable method for identification when there are large idiosyncratic shocks driving the aggregate, the Bartik instrument may be more suitable when there are no such large shocks. It is therefore of value to confirm that this paper's results are robust to using the Bartik instrument identification approach.

Definition of Bartik Instrument. As in [Gabaix and Koijen \(2020\)](#), we define the Bartik instrument as the cross-sectional mean (equally-weighted-average) of our 14 IIs' idiosyncratic shocks. Recall that our GIV is defined as the difference between the size-weighted-average of these shocks and their inverse-variance-weighted-average. I.e., as opposed to the GIV shock, the Bartik instrument does not exploit large idiosyncratic shocks.

Results. To produce the Bartik-instrument-based results, we re-estimate our baseline econometric model (Equations (14) and (15)) with the required modification of constructing our aggregate shock from the first stage of the estimation as the mean of our 14 IIs' idiosyncratic shocks (i.e., Bartik instrument) rather than as the GIV shock. The results from this exercise are presented in Figures 10 (IIs' basis' impulse responses), 11 (IIs' basis' FEV), 12 (IIs' open FX swap position), and 13a and 13b (Market-Wide Basis' impulse responses and FEV), where exposition of all figures follows the baseline one.

The results are both quantitatively and qualitatively similar to the baseline ones. In fact, the opening of the basis in the LOA state is even moderately stronger for the Bartik instrument case with a peak basis widening of 10.1 basis points after 376 horizons and a peak FEV contribution of 82.3% after 544 horizons. The basis widening is significant for all considered horizons as is its difference with respect to the basis response in the linear (no LOA) case which is insignificant for all horizons. Lastly, IIs' aggregate open FX swap position increases significantly more on impact in the linear (no LOA) case relative to the LOA state where its response is effectively null, supporting the notion that the Bartik shock captures an aggregate FX swap demand shock. In sum, this section provides valuable evidence that this paper's baseline GIV-based results are insensitive to using the popularized Bartik-instrument-based identification approach.

6.6 Additional Robustness Checks

On top of the previous two sections' market-wide bases and Bartik instrument robustness analyses, Appendix B of the online appendix to this paper examines the robustness of the baseline results from the preceding three sections along three additional dimensions. The first uses an alternative intermediary leverage ratio as our LOA measure instead of the baseline He et al. (2017)'s intermediary leverage ratio variable. Toward this end, we construct a value-weighted leverage ratio variable for 12 intermediaries whose activity (transactions' volume) in the USD/ILS FX swap market accounts for 95% of the entire activity of foreign financial institutions.²⁵ These 12 intermediaries are a subset of He et al. (2017)'s group of intermediaries.²⁶

The second excludes the COVID-ridden period by truncating the sample at February 28, 2020. And the last robustness check examines results' sensitivity to a different lag choice in Equation (14). The results from these three robustness checks are similar to the baseline ones, bolstering confidence in this paper's message about a meaningful LOA-dependent FX swap demand channel.

7 Conclusion

The evidence provided in this paper supports a meaningful LOA-dependent FX swap demand channel. In particular, we show that the effect of an FX swap demand shock that shifts IIs' aggregate demand for swaps rightward meaningfully depends on the initial LOA state: when LOA are meaningful, the FX supply curve is rigid thereby resulting in a significant and persistent widening of IIs' cross-currency basis; by contrast, when LOA are immaterial, the FX supply curve is elastic thereby preventing a widening of the basis.

We have obtained these results by using a bottom-up, GIV-based econometric approach that constructs the aggregate FX swap demand shock as the difference between the size-weighted- and inverse-variance-weighted-average of estimated idiosyncratic demand shocks of individual

²⁵Cerutti and Zhou (2023) use a similar approach to construct a leverage ratio for the largest FX dealers in a large set of emerging markets which serves as a measure of these dealers' risk-bearing capacities in their analysis.

²⁶Specifically, they include BNP; UBS; Deutsche Bank; HSBC; Barclays; Credit Suisse; Societe Generale; Goldman Sachs; JPM; Citigroup; BoFA; and Wells Fargo.

IIs. And our IIs' basis measure is also based on micro data, constructed as the volume-weighted average of the *actual* basis incurred by individual IIs. That both our daily shock and outcome variables are founded on our unique transaction-level FX swap data strengthens our confidence in the validity of this paper's results. Moreover, this confidence is further bolstered by the robustness of our results to using the popularized and widely used [Bartik \(1991\)](#) instruments (also known as shift-share estimators) identification approach, which can be viewed as complementary to the GIV identification approach.

We hope this paper's results can advance our understanding of how cross-currency basis can persistently widen in the presence of favorable FX swap demand shocks. While our results are based on Israeli data, our view is that they can be externally valid for a much broader sample of economies which possess a developed FX swap market in which local IIs are central demanders for swap-linked dollars.

Finally, this paper's results have potentially meaningful policy implications. A quantitatively important LOA-dependent channel may render it optimal for policymakers looking to combat a swap-demand-driven basis widening to consider policy tools (e.g., taxation on dollar-denominated asset returns or quantity restrictions on dollar-denominated asset investments) that constrain local IIs' dollar swap demand. Studying the normative aspect of the employment of such policy tools in the presence of a meaningful LOA-dependent FX swap demand channel is a potentially fruitful avenue for future research.

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Table 1: FX Swap Market Transactions' Maturity Distribution by Sector.

Sector	Percentile				
	5th	25th	Median	75th	95th
IIs	3	21	54	84	198
Real	2	4	10	24	124
LAs	1	3	7	41	147
FAs	1	2	3	22	70
All	1	2	6	32	128

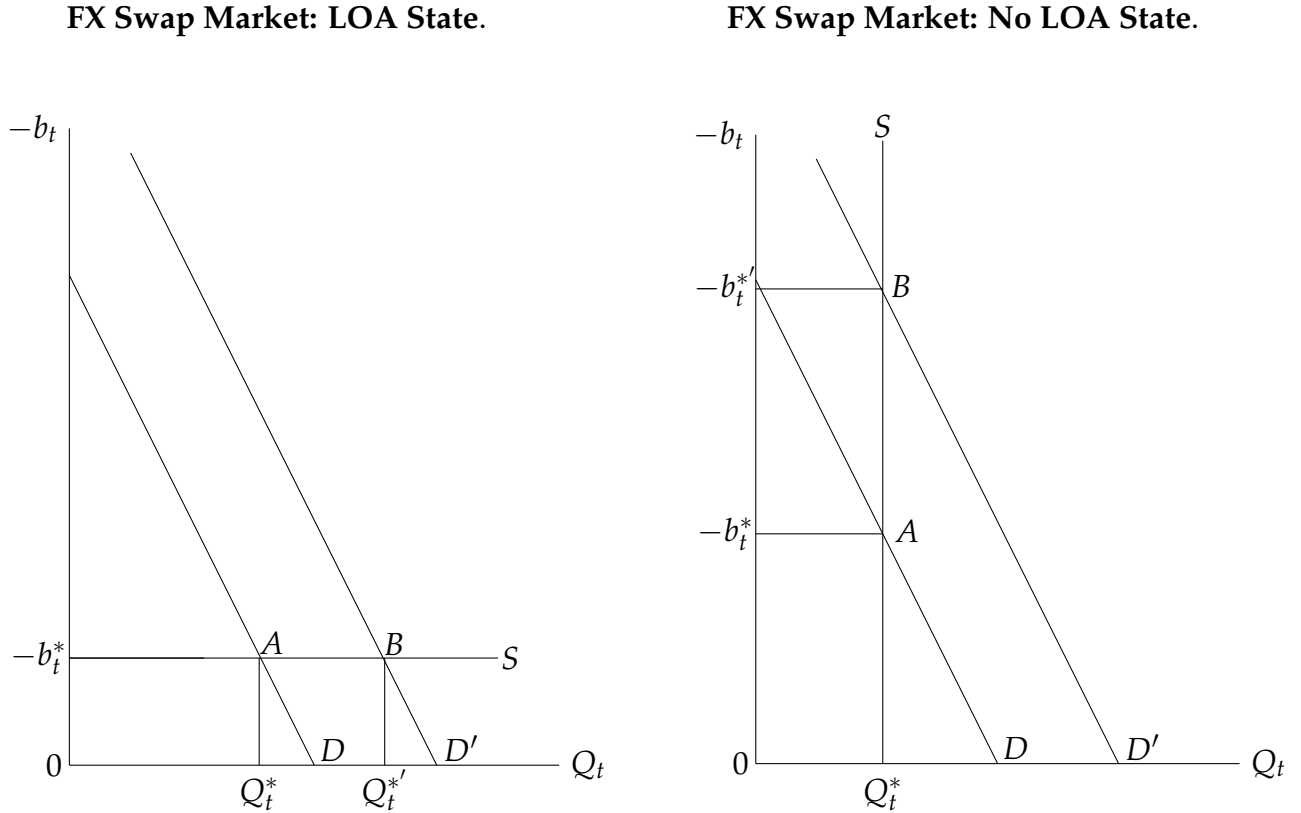
Notes: This table presents the maturity distribution (5th, 25th, 50th, 75th, and 95th percentiles) for FX swap transactions in our transaction-level dataset broken down by sector. On top of the IIs sector, this table includes three additional sectors: real sector, which represents the FX swap transactions involving Israeli exporters and importers; local arbitrageurs (LAs) sector, which includes Israeli commercial banks, mutual funds, exchange traded funds, hedge funds, and proprietary trading firms; and foreign arbitrageurs (FAs) sector, which includes all foreign firms engaged in financial activity (i.e., foreign commercial and investment banks, pension and insurance funds, mutual funds, exchange traded funds, hedge funds, and proprietary trading firms). Data are from the BOI and cover 1/7/2008-3/31/2022. Maturity distributions' percentiles are in terms of days.

Table 2: Correlation Matrix of Select Variables.

Variable	Δ S&P 500	Δ TA35	Δ Broad Dollar	Δ VIX	Δ II Basis	Δ 1 Month USD/EUR Basis	Δ 1 Year USD/EUR Basis
Δ LOA	-77.86%	-50.68%	46.43%	50.29%	-2.72%	-17.58%	-24.24%
Δ II Basis	0.83%	3.69%	-3.14%	-2.62%		7.87%	0.13%

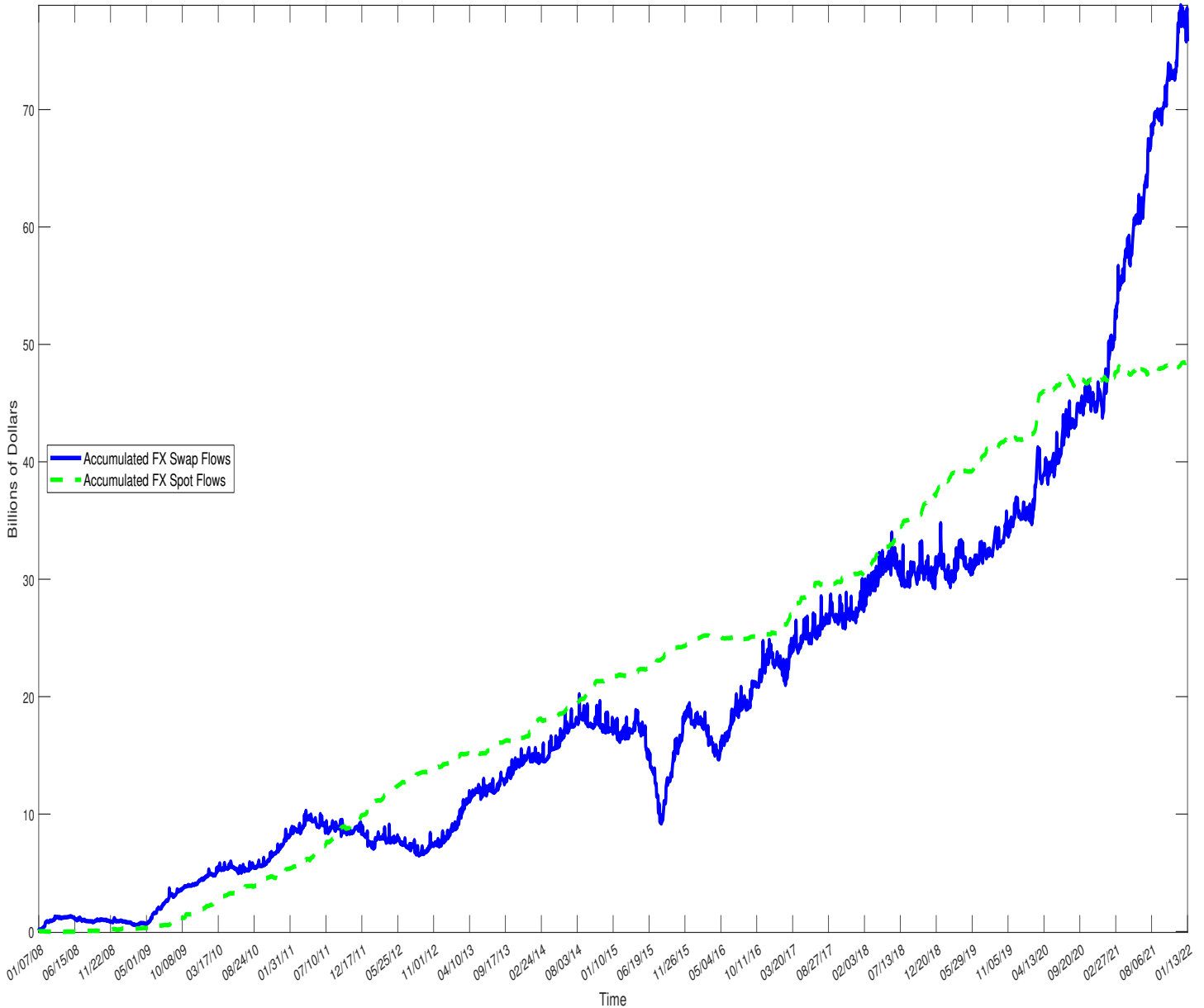
Notes: This table presents daily correlations of variables in our sample, where all variables are in log-first-differences except for the basis variables which are in first-differences. The first row shows the daily correlation between our LOA measure and IIs' aggregate (volume-weighted average) basis as well as the additional macro-financial variables which we control for in the regression analysis. The second row shows the daily correlation between IIs' aggregate (volume-weighted average) basis and the other variables. See Section 5.1 for the definitions and sources of the data. The data cover 1/7/2008-3/31/2022.

Figure 1: Diagrammatic Depiction of LOA-Dependent FX Swap Demand Channel.



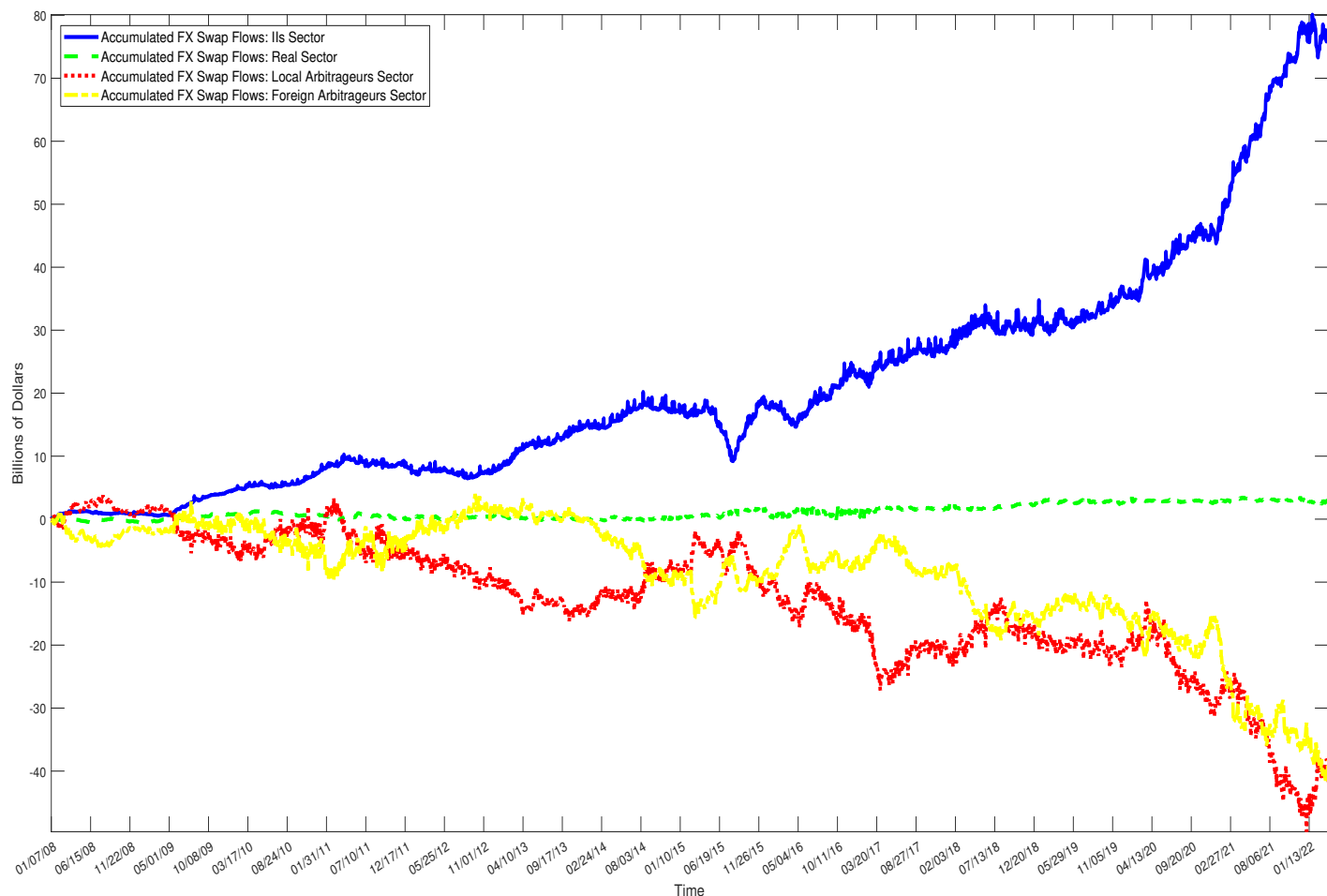
Notes: This figure provides a qualitative depiction of the LOA-dependent FX swap demand channel underlying the structural model from Section 3. The LOA (No LOA) state represents the state in which the level of A_t , i.e., the arbitrageur's arbitrage capital, is scarce (abundant). b_t is cross-currency basis defined in the usual way as the difference between the cash dollar interest rate and the CIP-implied dollar interest rate. These states are assumed to correspond to the extreme cases of perfectly *elastic* FX swap supply (leftward panel of the figure, i.e., LOA state) and perfectly *inelastic* FX swap supply (rightward panel of the figure, i.e., no LOA state). The core of this demand channel lies in how the responsiveness of the basis varies across the two states in the presence of a rightward shift in FX swap demand. $-b_t$ (which is on the y-axis) represents the marginal profit that arbitrageurs make from CIP arbitrage, which can in turn be interpreted as the price of FX swaps. The quantity of FX swaps, in dollar terms, is on the x-axis.

Figure 2: Time Series of IIs' Accumulated FX Swap and Spot Flows.



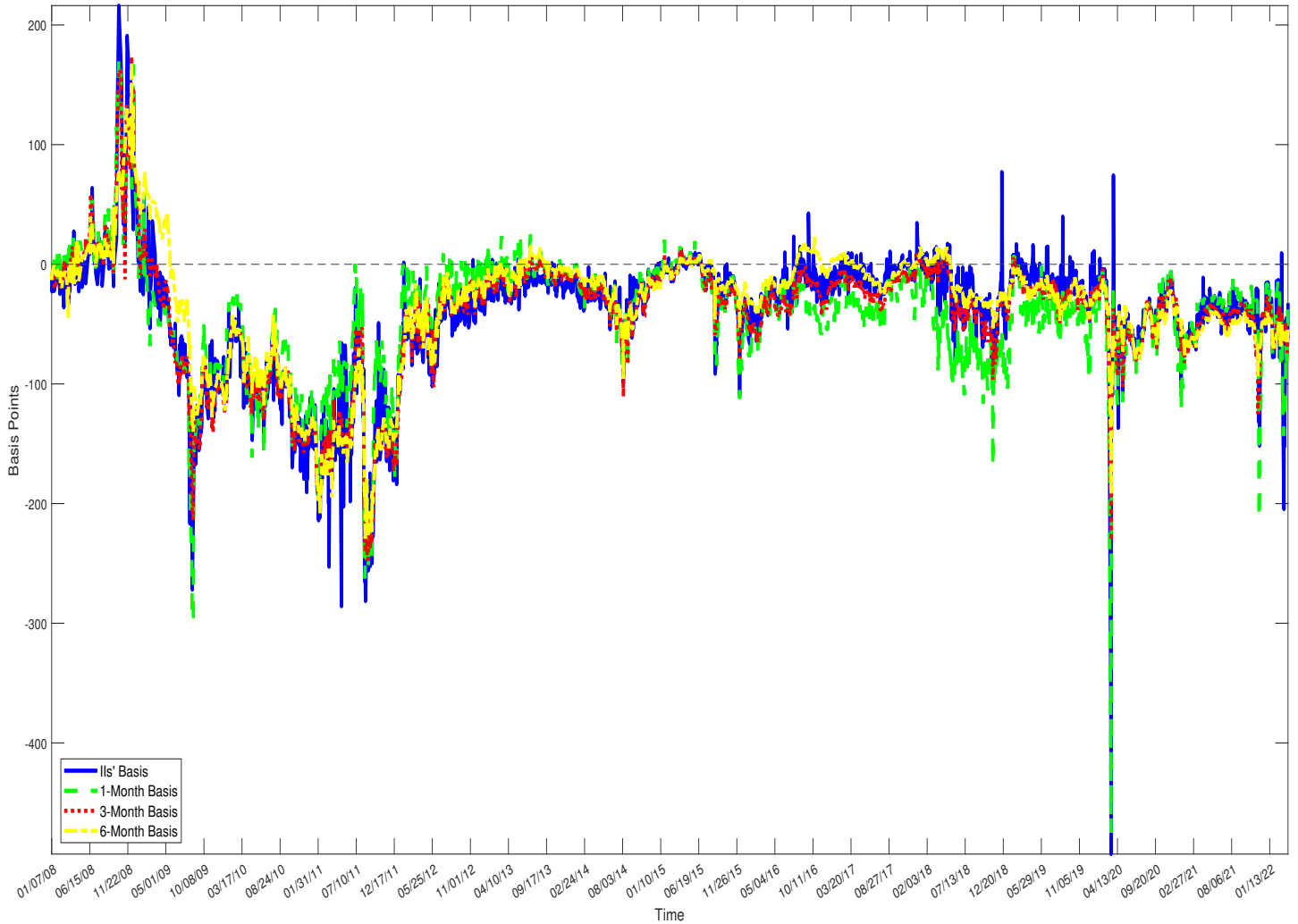
Notes: This figure presents the time series of the accumulated daily flows of IIs' FX swap (solid line) and spot (dashed line) trades in the USD/ILS currency pair. Since FX swap flows are changes in IIs' open FX swap position, their shown accumulated series can be viewed as IIs' open FX swap position. Hence, a positive (negative) value for the latter series represents an open short (long) FX swap position. Positive values for the accumulated spot flow series represent the accumulated buying of spot dollars. Data are from the BOI and cover 01/07/2008-3/31/2022. Time (in daily frequency) is on the x-axis. Values are in billions of dollars.

Figure 3: Time Series of Accumulated FX Swap Flows by Sector.



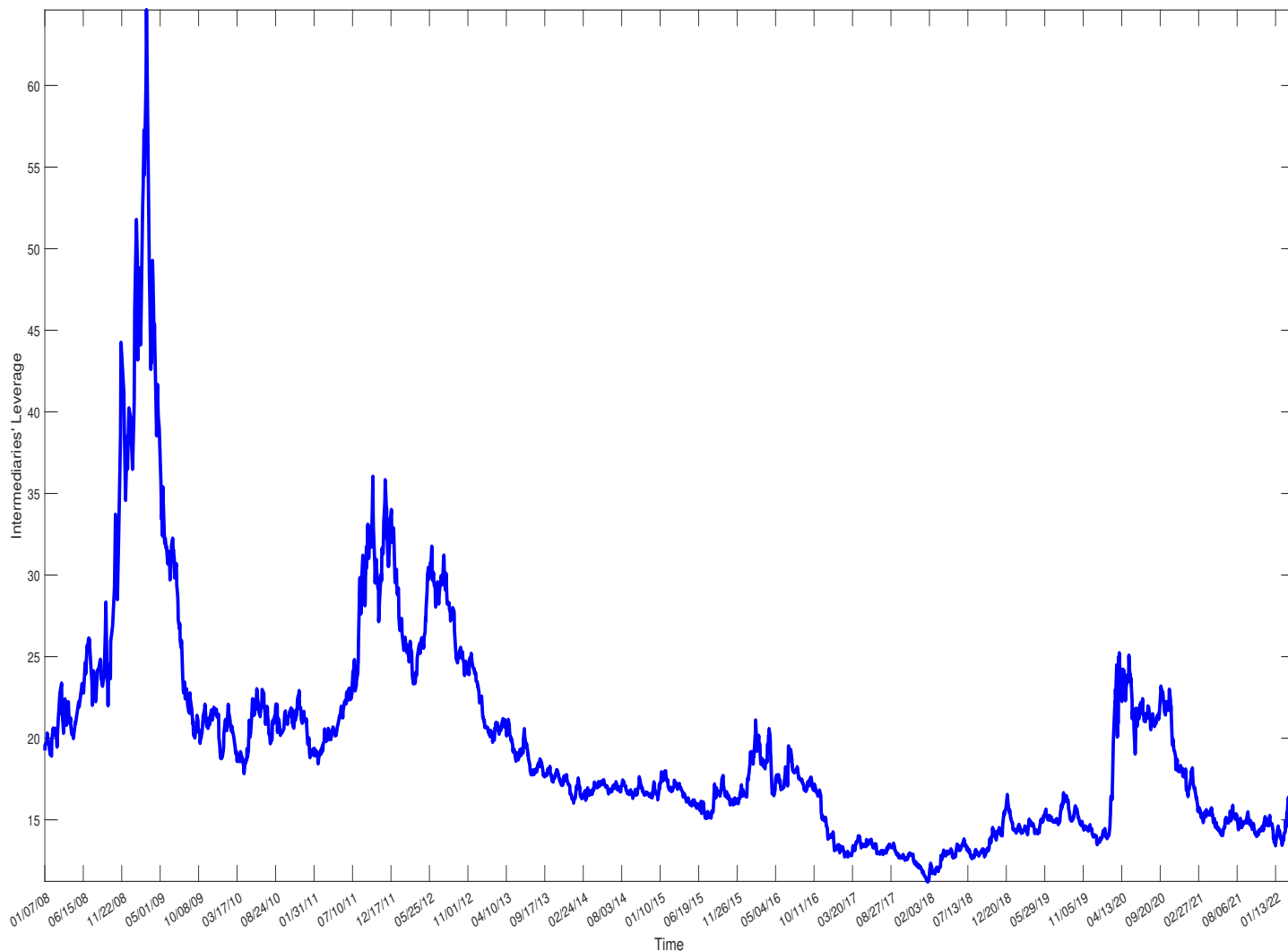
Notes: This figure presents the time series of accumulated daily FX swap flows by sector. Since FX swap flows are changes in the corresponding sector's open FX swap position, their shown accumulated series can be viewed as the corresponding sector's open FX swap position with positive (negative) values representing an open FX swap short (long) position. On top of the IIs sector (which, for completeness, is also included in the figure and is represented by the solid line), this figure includes three additional sectors: real sector (dashed line), which represents the net FX flows from swap transactions involving Israeli exporters and importers; local arbitrageurs sector (dotted line), which includes Israeli commercial banks, mutual funds, exchange traded funds, hedge funds, and proprietary trading firms; and foreign sector (dash-dotted line), which includes all foreign firms engaged in financial activity (i.e., foreign commercial and investment banks, pension and insurance funds, mutual funds, exchange traded funds, hedge funds, and proprietary trading firms). Data are from the BOI and cover 1/7/2008-3/31/2022. Time (daily dates) is on the x-axis. Values are in billions of dollars.

Figure 4: Time Series of USD/ILS Cross-Currency Basis.



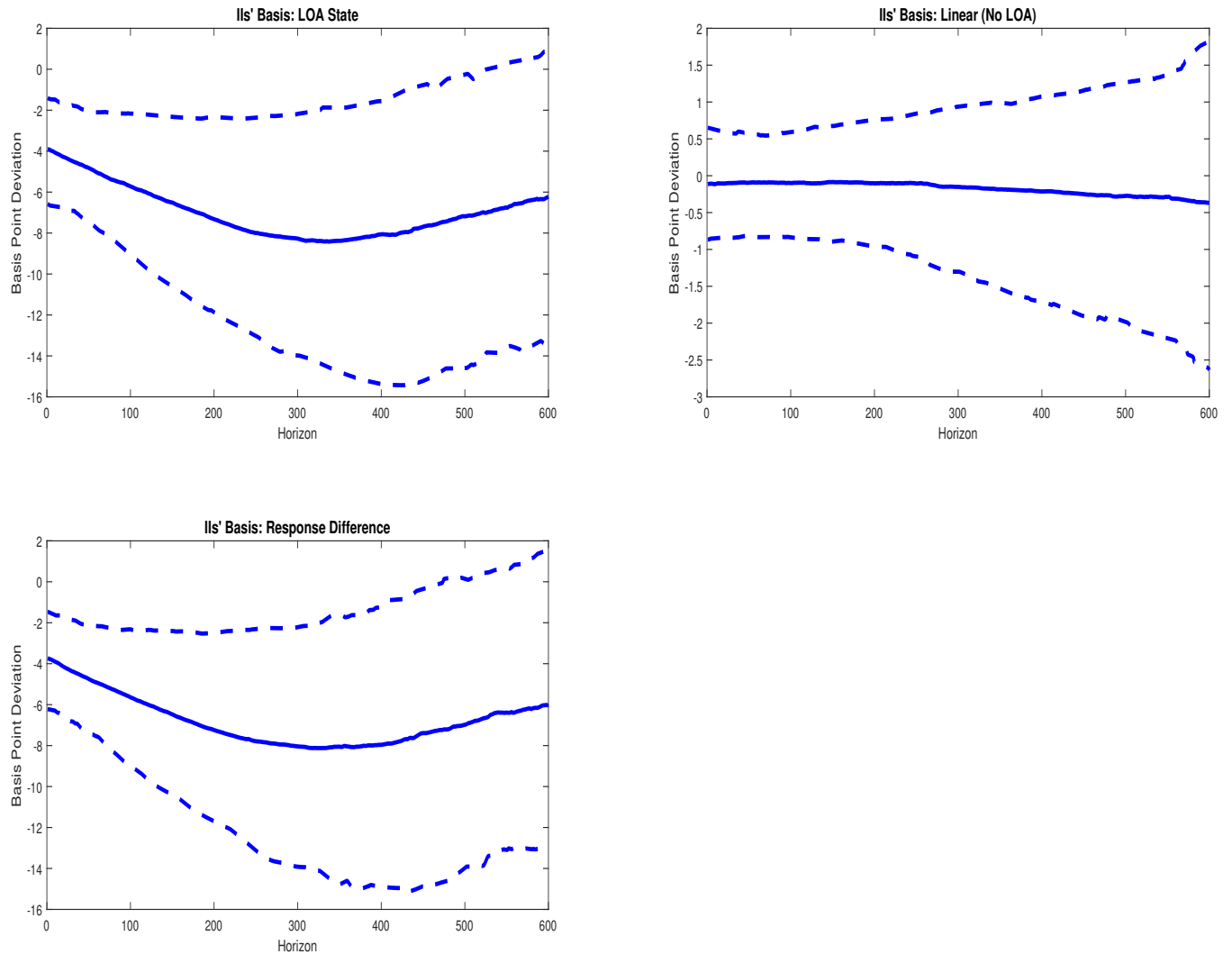
Notes: This figure presents the time series of daily USD/ILS cross-currency basis for IIs (constructed from our transaction-level FX swap dataset as the volume-weighted average of the transaction-level bases) (solid line) and the 1- (dashed line), 3- (dotted line), and 6-month (dash-dotted line) market-wide bases constructed from Thomson Reuters spot and forward rate data. The bases are computed as the difference between Libor dollar rates and CIP-implied dollar rates. The data cover 1/7/2008-31/3/2022. Time (daily dates) is on the x-axis. Values are in basis point terms.

Figure 5: Time Series of Intermediaries' Aggregate Leverage Ratio.



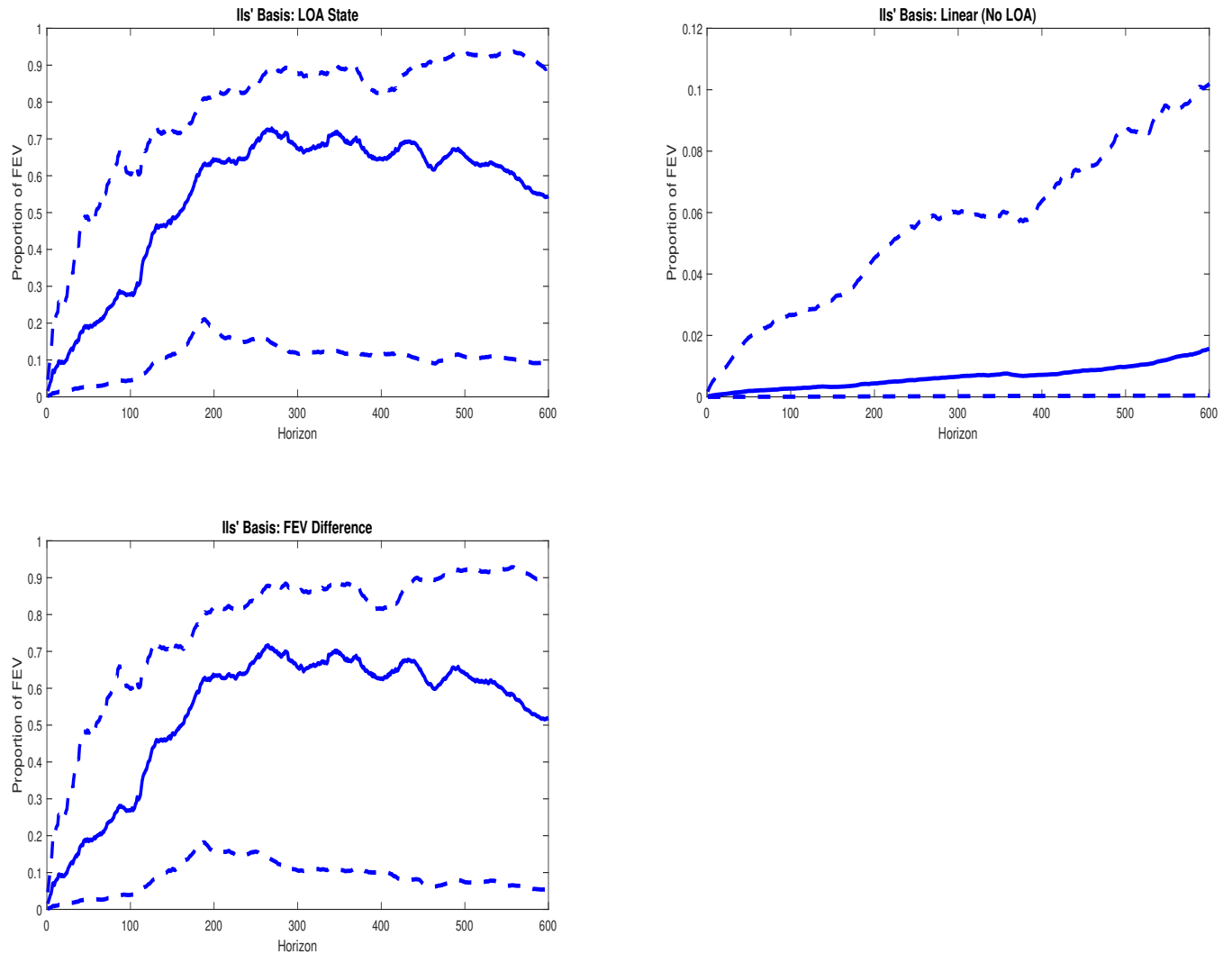
Notes: This figure presents the time series of intermediaries aggregate leverage ratio. Data are available from <https://voices.uchicago.edu/zhiguohe/data-and-empirical-patterns/intermediary-capital-ratio-and-risk-factor/>. The data cover 1/7/2008-31/3/2022. Time (daily dates) is on the x-axis. Values are in leverage (asset value over market equity) terms.

Figure 6: LOA-Dependent Impulse Responses of IIs' Aggregate Cross-Currency Basis to a One Standard Deviation Aggregate FX Swap Demand Shock.



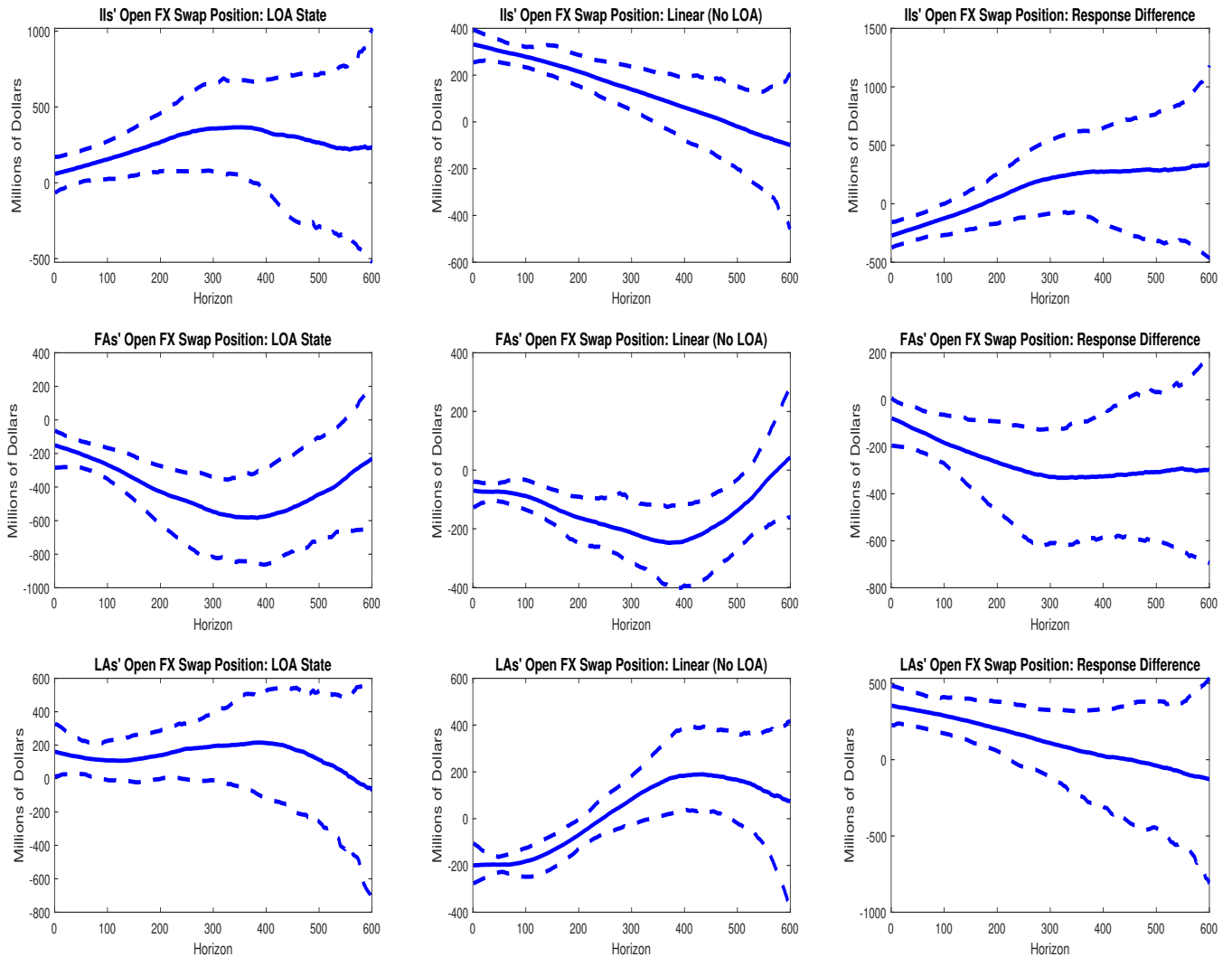
Notes: This figure presents the LOA-dependent impulse responses of IIs' aggregate cross-currency basis to a one standard deviation aggregate FX swap demand shock from the model described by Equations (14) and (15). The first and second columns show the responses in the LOA state and linear (no LOA) case, respectively; and the third column shows the response differences across these two cases. Responses are in terms of deviations from pre-shock values (basis point deviations). Horizon (on x-axis) is in days.

Figure 7: LOA-Dependent FEV Shares of IIs' Aggregate Cross-Currency Basis Attributable to the Aggregate FX Swap Demand Shock.



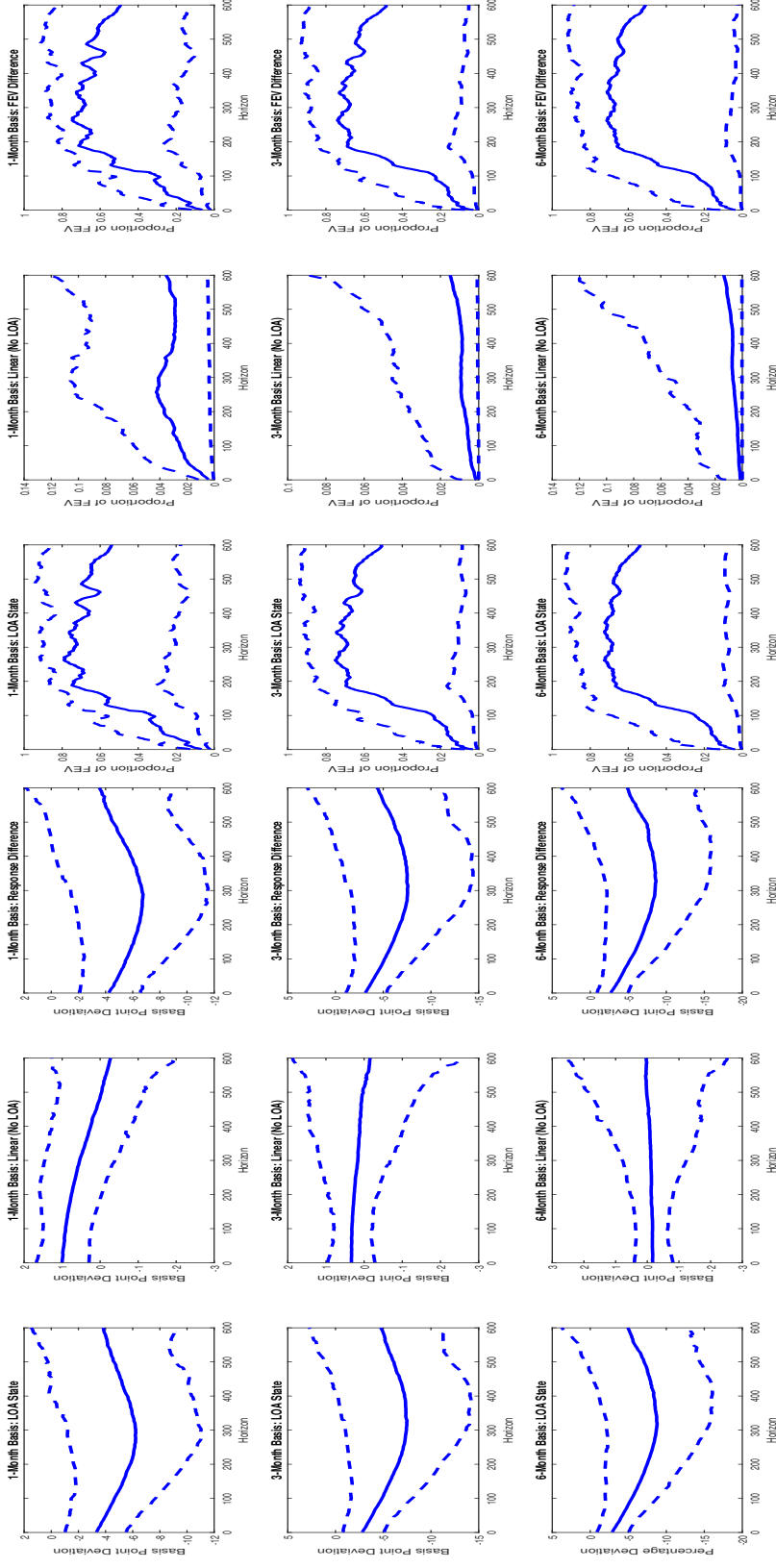
Notes: This figure presents the FEV share of IIs' aggregate cross-currency basis that is attributable to the aggregate FX swap demand shock from the model described by Equations (14) and (15). The first and second columns show the FEV contributions in the LOA state and linear (no LOA) case, respectively; and the third column shows the FEV contribution differences across these two cases. Horizon (on the x-axis) is in days and the FEV share is on the y-axis.

Figure 8: LOA-Dependent Impulse Responses of IIs' Aggregate Open FX Swap Position to a One Standard Deviation Aggregate FX Swap Demand Shock.



Notes: This figure presents the LOA-dependent impulse responses of IIs', local arbitrageurs' (LAs'), and foreign arbitrageurs' (FAs') aggregate open swap positions to a one standard deviation aggregate FX swap demand shock from the model described by Equations (14) and (15) where the outcome variable in the latter equation (accumulated difference in IIs' basis) is now replaced by the accumulated difference in the corresponding sector's open FX swap position (i.e., $SP_{t+h,j} - SP_{t-1,j}$, where $j = [IIs, LAs, FAs]$). The first and second columns show the responses in the LOA state and linear (no LOA) case, respectively; and the third column shows the response differences across these two cases. Responses are in terms of deviations from pre-shock values (in millions of dollars terms). Horizon (on x-axis) is in days.

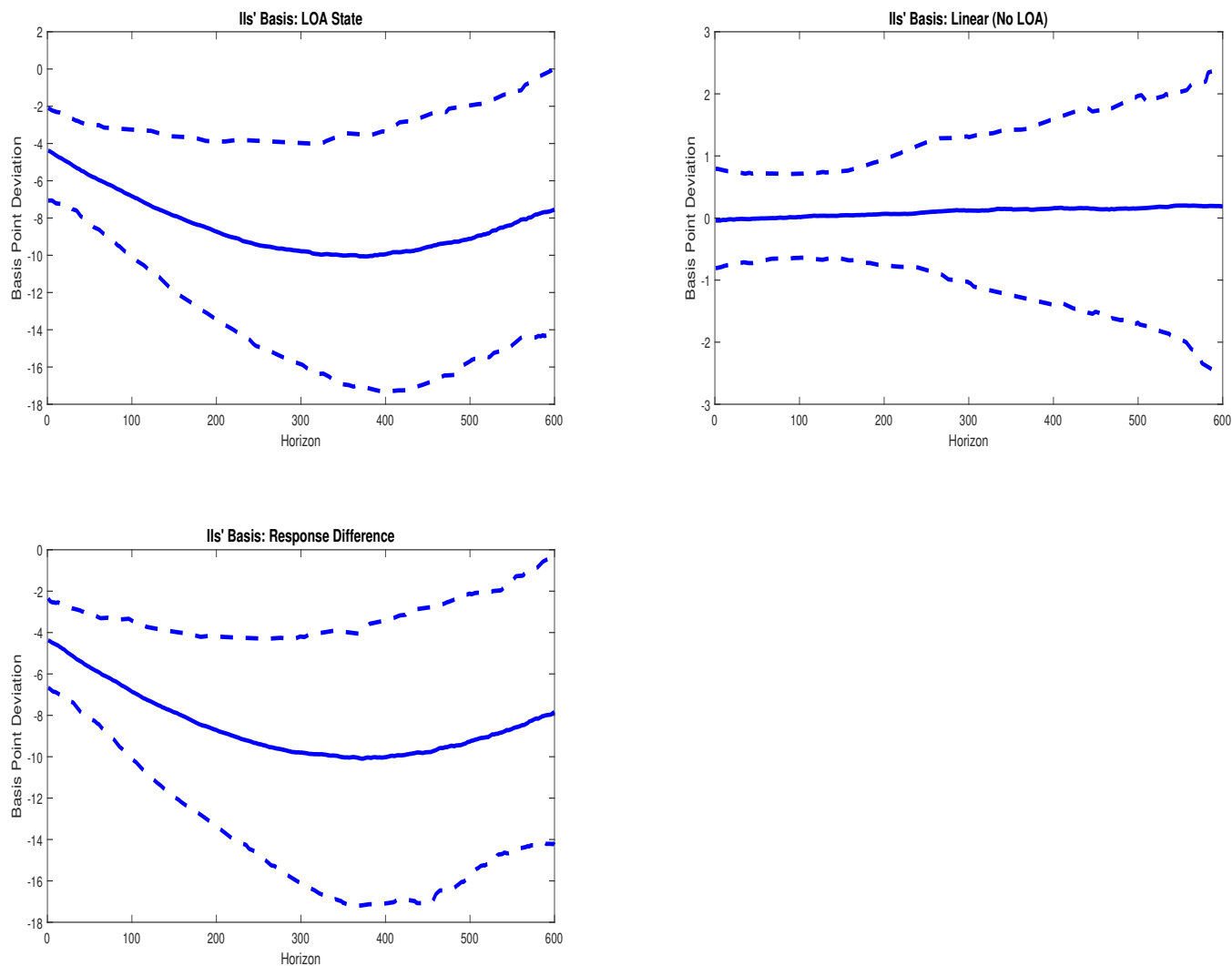
Figure 9: Market-Wide Cross-Currency Bases: (a) LOA-Dependent Impulse Responses; (b) LOA-Dependent FEVs.



(a) LOA-Dependent Impulse Responses of Cross-Currency Bases (b) LOA-Dependent FEV Shares of Cross-Currency Bases Attributable to FX Swap Demand Shock.

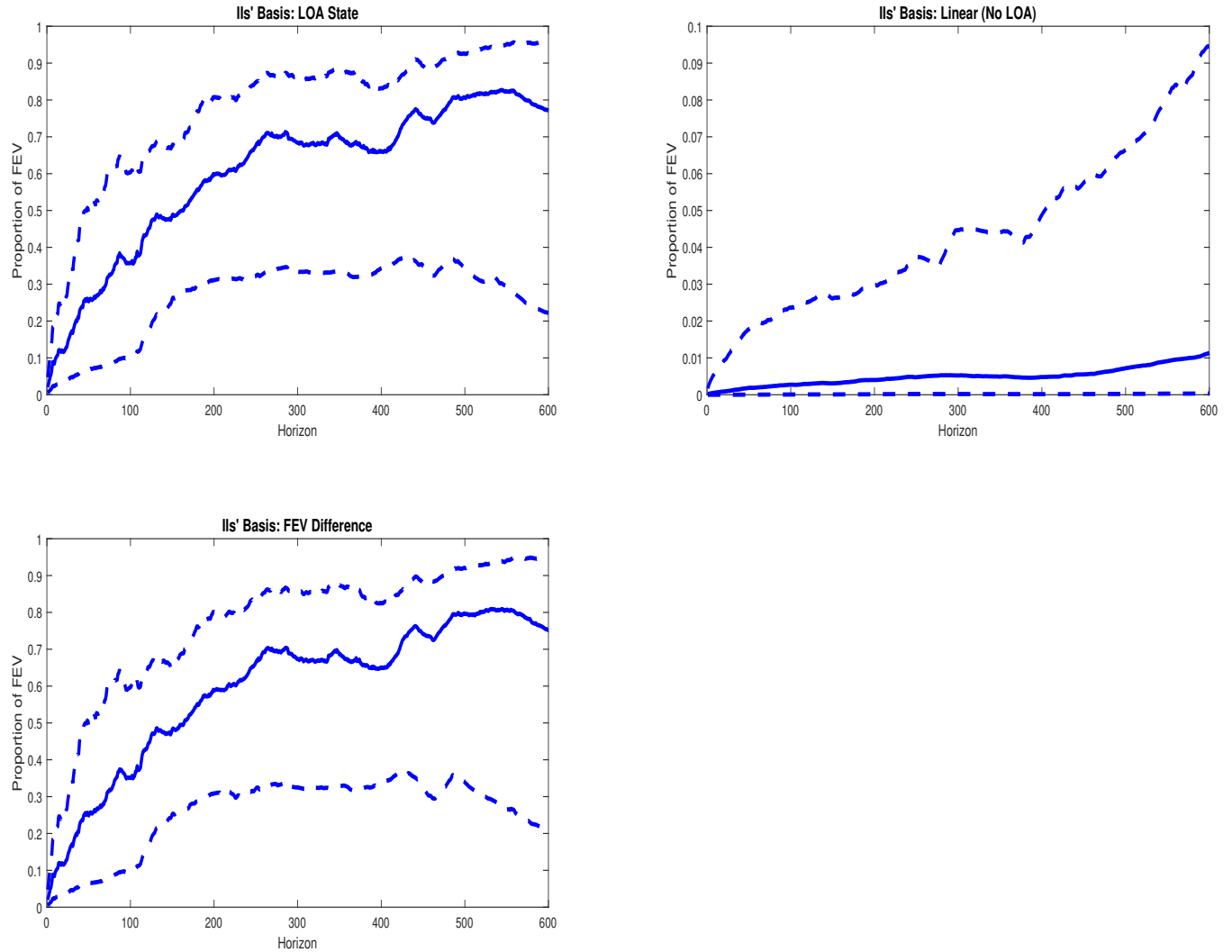
Notes: Panel (a): This figure presents the LOA-dependent impulse responses of the 1-, 3-, and 6-month market-wide cross-currency bases to a one standard deviation aggregate FX swap demand shock from the model described by Equations (14) and (15). These bases are constructed from Thomson Reuters spot and forward rate data. (See Section 5.1.2 for further details on this data.) The first and second columns show the responses in the LOA state and linear (no LOA) case, respectively; and the third column shows the response differences across these two cases. Responses are in terms of deviations from pre-shock values (basis point deviations). Horizon (on x-axis) is in days. Panel (b): This figure presents the FEV share of the cross-currency bases that is attributable to the FX swap demand shock from the model described by Equations (14) and (15). This figure shares the same expositional structure as Figure 9a. Horizon (on the x-axis) is in days and the FEV share is on the y-axis.

Figure 10: LOA-Dependent Impulse Responses of IIs' Aggregate Cross-Currency Basis to a One Standard Deviation Aggregate FX Swap Demand Shock: Bartik Instrument.



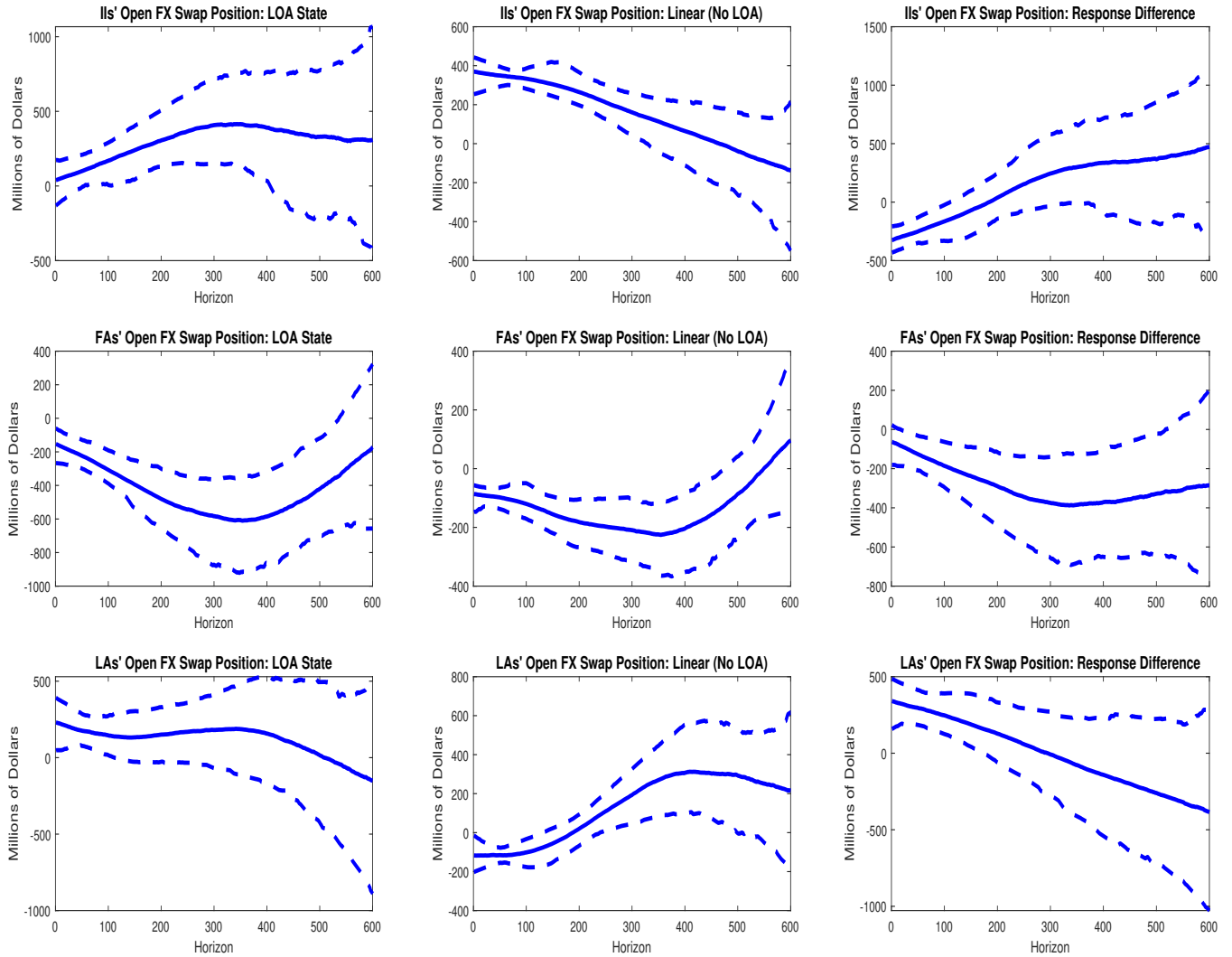
Notes: This figure presents the LOA-dependent impulse responses of IIs' aggregate cross-currency basis to a one standard deviation aggregate FX swap demand shock from the model described by Equations (14) and (15), where the aggregate shock is now constructed as the mean of the 14 IIs' idiosyncratic shocks (i.e., Bartik instrument). The first and second columns show the responses in the LOA state and linear (no LOA) case, respectively; and the third column shows the response differences across these two cases. Responses are in terms of deviations from pre-shock values (basis point deviations). Horizon (on x-axis) is in days.

Figure 11: LOA-Dependent FEV Shares of IIs' Aggregate Cross-Currency Basis Attributable to the Aggregate FX Swap Demand Shock: Bartik Instrument.



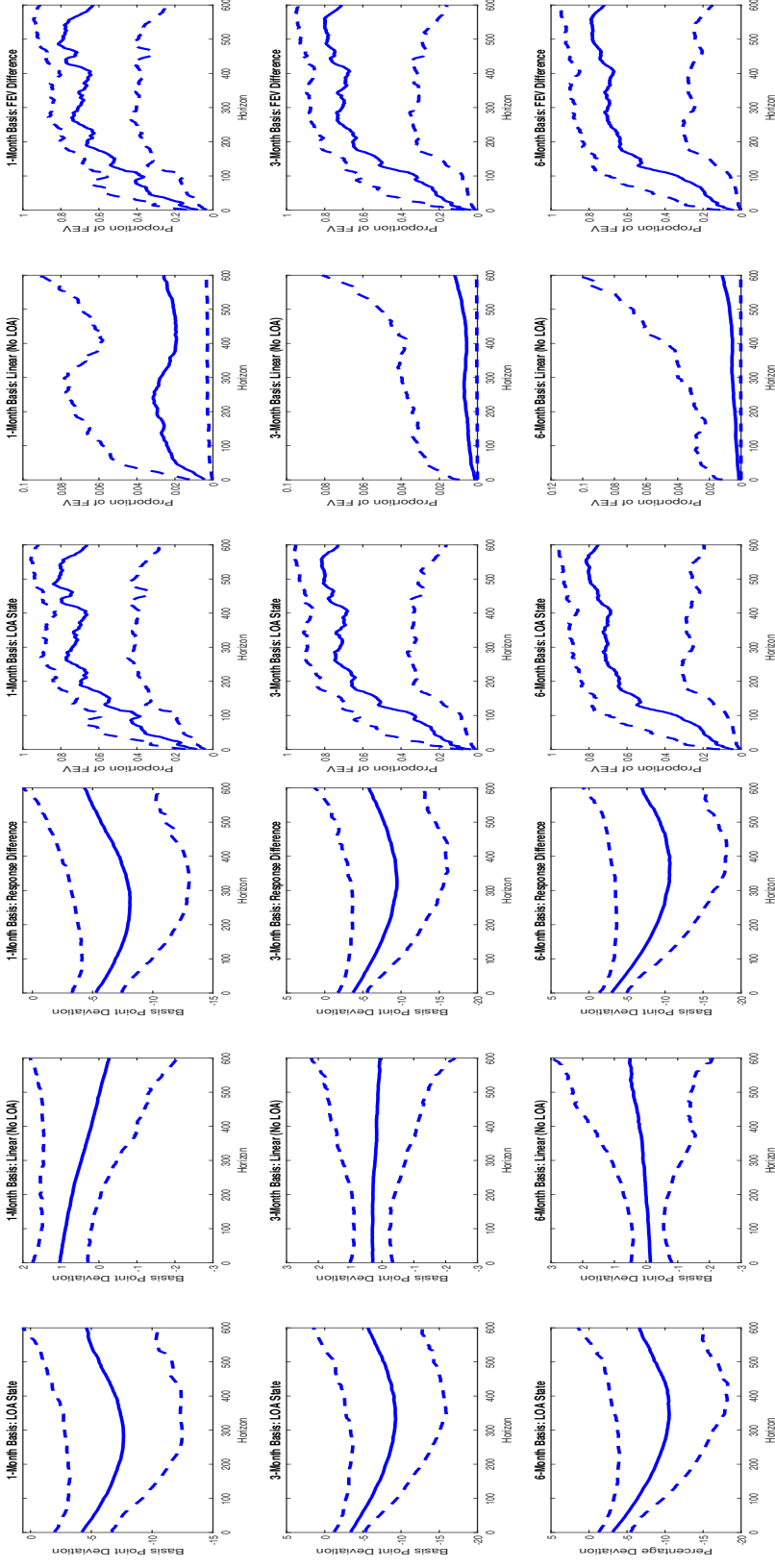
Notes: This figure presents the FEV share of IIs' aggregate cross-currency basis that is attributable to the aggregate FX swap demand shock from the model described by Equations (14) and (15), where the aggregate shock is now constructed as the mean of the 14 IIs' idiosyncratic shocks (i.e., Bartik instrument). The first and second columns show the FEV contributions in the LOA state and linear (no LOA) case, respectively; and the third column shows the FEV contribution differences across these two cases. Horizon (on the x-axis) is in days and the FEV share is on the y-axis.

Figure 12: LOA-Dependent Impulse Responses of IIs' Aggregate Open FX Swap Position to a One Standard Deviation Aggregate FX Swap Demand Shock: Bartik Instrument.



Notes: This figure presents the LOA-dependent impulse responses of IIs', local arbitrageurs' (LAs'), and foreign arbitrageurs' (FAs') aggregate open swap positions to a one standard deviation aggregate FX swap demand shock from the model described by Equations (14) and (15) where the outcome variable in the latter equation (accumulated difference in IIs' basis) is now replaced by the accumulated difference in the corresponding sector's open FX swap position (i.e., $SP_{t+h,j} - SP_{t-1,j}$, where $j = [IIs, LAs, FAs]$); and the aggregate shock is now constructed as the mean of the 14 IIs' idiosyncratic shocks (i.e., Bartik instrument). The first and second columns show the responses in the LOA state and linear (no LOA) case, respectively; and the third column shows the response differences across these two cases. Responses are in terms of deviations from pre-shock values (in millions of dollars terms). Horizon (on x-axis) is in days.

Figure 13: Market-Wide Cross-Currency Bases for Bartik Instrument: (a) LOA-Dependent Impulse Responses; (b) LOA-Dependent FEVs.



(a) LOA-Dependent Impulse Responses of Cross-Currency Bases (b) LOA-Dependent FEV Shares of Cross-Currency Bases Attributable to FX Swap Demand Shock.

Notes: Panel (a): This figure presents the LOA-dependent impulse responses of the 1-, 3-, and 6-month market-wide cross-currency bases to a one standard deviation aggregate FX swap demand shock from the model described by Equations (14) and (15), where the aggregate shock is now constructed as the mean of the 14 IIs' idiosyncratic shocks (i.e., Bartik instrument). These bases are constructed from Thomson Reuters spot and forward rate data. (See Section 5.1.2 for further details on this data.) The first and second columns show the responses in the LOA state linear (no LOA) case, respectively; and the third column shows the response differences across these two case. Responses are in terms of deviations from pre-shock values (basis point deviations). Horizon (on x-axis) is in days. Panel (b): This figure presents the FEV share of the cross-currency bases that is attributable to the FX swap demand shock from the model described by Equations (14) and (15), where the aggregate shock is now constructed as the mean of the 14 IIs' idiosyncratic shocks (i.e., Bartik instrument). This figure shares the same expositional structure as 13a. Horizon (on the x-axis) is in days and the FEV share is on the y-axis.