The Persistent Widening of Cross-Currency Basis: When Increased FX Swap Demand Meets a Shortage of Global Arbitrage Capital*

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Abstract

Recent research has documented and studied a persistent widening of cross-currency basis (i.e., deviation from covered interest rate parity) for a wide range of currencies with respect to the dollar since the global financial crisis. Theory of the foreign exchange (FX) swap market predicts that shortage of global arbitrage capital (GAC), by making the FX swap supply curve less elastic, would amplify the effect of increases in institutional investors' (IIs') demand for FX swaps on cross-currency basis. We use novel daily data on Israeli IIs' and global banks' FX swap flows to test this prediction within a suitable Bayesian local projection model, finding strong evidence supporting a meaningful and persistent such amplification mechanism.

JEL classification: E44,F3,G15,G23

Keywords: GAC-Dependent FX Swap Demand Channel; Cross-Currency Basis; Open FX Swap Position; Global Arbitrage Capital; 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)).

FX swap trades constitute 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)).[1] The corresponding numbers for institutional investors (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. Hence, the said persistent CIP violation implies a potentially meaningful increase in local institutional IIs' FX-risk-free dollar funding costs, which in turn can negatively impact the local economy's long-term savings. It is therefore of value to better our understanding of the forces which can lead to CIP's persistent violation.

One theoretically appealing explanation for this CIP violation is that periods of low arbitrage capital of global banks accompanied by rightward shifts in the demand for FX swaps of local institutional investors (IIs), who in turn wish to increase their exposure to foreign assets (without taking on FX risk), can lead to the persistent breakdown of CIP we observe in the data since the GFC. This global-arbitrage-capital-dependent (GAC-dependent) FX swap demand channel builds on the notion that lower GAC implies a steepening of the FX swap supply curve which in turn induces a greater widening of cross-currency basis in the presence of a rightward shift in the FX swap demand curve.

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

Objective and Contribution of this Paper. The main objective of this paper is to study the existence and quantitative relevance of the GAC-dependent FX swap demand channel. Toward this end, utilizing novel daily data on FX swap flows of Israeli IIs for a recent 14-year sample period along with a daily measure of GAC based on global financial institutions' ease of funding, we center our analysis around a straightforward litmus test for the importance of this channel. This litmus test concerns the estimation of the dynamic GAC-dependent effect of shocks to IIs' FX swap demand on USD/NIS cross-currency bases at various maturities. Motivated by our conceptual framework, we ensure that the latter shocks represent exogenous changes in IIs' preferences for exposure to foreign assets by restricting these shocks to be orthogonal to current and past values of a rich array of other supply- and demand-related FX swap market factors.

To accomplish our aforementioned objective, this paper unfolds in two parts. The first part lays out a simple conceptual framework that serves to fix ideas, motivate the aforementioned litmus test, and form a suitable conceptual base for this paper. The second part of this paper conducts the aforementioned litmus test. Before turning to discuss these two parts, we first briefly clarify some terminological issues so as to streamline this paper's exposition.

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*.

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 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 global banks. In accordance with our focus on the *dollar* basis, we measure FX swap flows for the USD/NIS 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%).)

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 global bank with a pre-determined level of arbitrage capital that supplies FX swaps.

This 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 aversion with respect to swap-related foreign investment,[2] the downward-sloping demand curve of FX swaps shifts rightward along the global bank's upward-sloping supply curve with the steepness of the latter supply curve being shaped by the level of the global bank's arbitrage capital. In particular, the lower this arbitrage capital is, the steeper the global bank'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 decreasing in the initial level of the global banks's arbitrage capital.

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 the initial level of GAC is lower. This prediction is the essence of the GAC-dependent FX swap demand channel.

Econometric Model. The second part of the paper studies the GAC-dependent effect of increased IIs' FX swap demand on USD/NIS cross-currency bases at various maturities. We use a 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 results can be summarized as follows.

A one standard deviation shock to IIs' FX swap demand in the low GAC state significantly and persistently lowers the cross-currency basis at all considered maturities (1-, 3-, 6-, and 12-month horizons). The impact effects for these horizons are significantly negative at, indicating

[2]This 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 a foreign investment being more appealing now.

an impact widening of 3.5, 2.3, 2, and 2.1 basis points, respectively. The effects for these bases maintain their significance for 126, 85, 134, and 140 trading days, respectively. And they reflect peak contributions of the FX swap demand shocks to the bases' variation of 31%, 13.4%, 17.6%, and 23.2%, respectively, taking place at the 114th, 33th, 33th, and 20th horizons.

By contrast, in the high GAC state, the FX swap demand shock produces an economically and statistically insignificant change in the cross-currency bases, while moving IIs' open FX swap position by significantly more than the corresponding effect in the low GAC state. On impact, IIs' open FX swap position increases by 249.6 million dollars in the high GAC state compared to only 44 million dollars in the low GAC state, with response differences across the two states being significant for a total of 113 horizons. Overall, these results support the presence of a meaningful GAC-dependent FX swap demand channel.

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 and briefly discusses 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 GAC-dependent FX swap demand channel that uses daily FX swap flow data along with a daily measure of GAC to quantify this channel. The daily frequency of this data allows 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,[3] focusing on the separate as well as joint role of

[3]CIP deviations' implications, rather than drivers, are also an important avenue of research. E.g., Keller (2021) 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. And 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.

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. And 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.)

Papers Looking at Both FX Swap Supply and Demand Channels. Rime et al. (2021) 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. (2021) 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. (2021) 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), which in turn builds and expands on ideas laid out in Borio et al. (2016). 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 data on IIs' FX swap flows as well as our use of a daily measure of GAC based on global financial institutions' ease of funding, both of which allow us to identify the GAC-dependent FX swap demand channel quite cleanly.[4] Sushko et al. (2016) use a proxy for FX swap demand at a monthly frequency given by the implied cross-currency position of banks, institutional investors, and cor-

[4]The underlying motivation for our GAC measure choice comes from Anderson et al. (2021), who highlight the crucial role of global banks' funding ease as a measure of GAC. Their data allows them to measure the CIP-relevant GAC from the amount of global banks' unsecured short-term borrowing that is funded at a lower rate than the CIP-implied one. Since we lack access to their data, we resort to the reasonable alternative of a daily measure of global financial institutions' ease of funding given the crucial role of this funding as a necessary condition for obtaining a sufficient level of GAC.

porations and do not focus on arbitrage capital per se but rather more broadly on measures of arbitrage limits. Second, our local projection estimation approach allows us to study the GAC-dependent persistence of CIP violations conditional on an FX swap demand shock is orthogonal to a rich array of other supply- and demand-related FX swap market factors and can therefore be interpreted as a pure demand shock arising from IIs' desire to increase their (hedged) exposure to foreign assets.

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 global arbitrageur (GA) 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 GA'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 global arbitrageur (GA) that represents the supply side of the FX swap market. The GA's trade can be broken down into two parts. First, it buys spot $Q_{t,GA}S_t$ local currency units and sells spot $Q_{t,GA}$ foreign currency units in period t, conducting this trade entirely with the local II. Second, it sells forward $Q_{t,GA}S_t(1+i_{t+1,L})$ local currency units at forward rate $F_{t,t+1}$, where $Q_{t,GA}S_t$ is the local currency amount sold forward to the local II in the second leg of the associated GA-local II FX swap trade and $Q_{t,GA}S_t i_{t+1,L}$ represents the interest related amount sold forward in an outright forward trade the GA conducts with some (unmodeled) broker-dealer institution.

The rationale for the second part of the trade can be explained as follows. Using its predetermined arbitrage capital, the GA conducts CIP arbitrage as well as other arbitrage trades (whose depiction is deferred for now). Given its role as global arbitrageur, and since FX swaps trades do not perfectly align with CIP arbitrage as they exclude the interest proceeds element,[5] the GA additionally sells forward $Q_{t,GA}S_t i_{t+1,L}$ local currency units, where $Q_{t,GA}$ is the GA'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.)

We assume that the GA 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 GA's FX swap trade. In our setting it is viewed as the effective cost of the FX swap trade as we assume the GA funds this trade by borrowing the required funds in the cash market.) However, we assume that it faces frictions in FX swap market, as we now turn to explain.[6]

Haircut. Following Ivashina et al. (2015), we assume that a haircut is applied to GA's FX swap trade in the amount of $\kappa Q_{t,GA}$. That is, the GA's FX swap trade requires it to incur a linear haircut-induced cost through the depositing of share κ of its swap position to the local II.[7]

[5]While 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)). In our data, the median maturity for the universe of USD/NIS FX swap trades is 6 days. Interestingly, that for IIs is 54 days, pointing to an interesting maturity transformation task facing local commercial banks. The latter are IIs' sole counterparties, intermediating between IIs' relatively long-maturity-based FX swap demand and global financial institutions' short-maturity-based FX swap supply. (In our data, the latter's trades' median maturity is 3 days.) While this maturity transformation is an interesting avenue for future research, we abstract from it as it is beyond the scope of this paper.

[6]We are aware that our justification for measuring GAC in the empirical analysis with ease of global financial institutions' funding relies on the presence of frictions in the dollar cash market. (Also see related discussion from Footnote 4.) However, extending our model to account for a negative relation between GAC and the severity of such frictions is beyond our model's scope.

[7]For simplicity, we abstract from the opposing haircut facing the local II.

GA's Alternative Arbitrage Activity. By allocating $\kappa Q_{t,GA}$ for CIP arbitrage, the GA has to take these funds away from its pre-determined arbitrage capital A_t. In other words, $A_t - \kappa Q_{t,GA}$ represents the GA'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 $G(A_t - \kappa Q_{t,GA})$, where $G(:) > 0$, $G'(:) > 0$, $G''(:) < 0$, and $G'''(:) > 0$. [8]

These assumptions on $G(:)$ 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 ($G''(:) < 0$) in fact implies a positive third derivative ($G'''(:) > 0$) 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.

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

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

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

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

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 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.

[8] The 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 GA'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).

Relation between $Q_{t,GA}$ and $-b_t$. Minus of the cross-currency basis (i.e., $-b_t$) from FOC (2) is GA'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 GA's supply of FX swaps increases in $-b_t$. To show this formally, we differentiate $-b_t$ from FOC (2) with respect to $Q_{t,GA}$:

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

where the positive sign of Equation (3) comes from the assumed concavity of net return function $G(A_t - \kappa Q_{t,GA})$. 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 GA to supply more such swaps. Moreover, we can show that the slope of the GA's FX swap supply curve flattens (steepens) when initial arbitrage capital is higher (lower) by differentiating Equation (3) with respect to A_t:

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

This result clearly follows from the arguably weak assumption of $G(:)$'s positive third derivative (see related discussion on this assumption on Page 9). I.e., more (less) initial arbitrage capital induces less (more) rigidity in the willingness of the GA 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 GA 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

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

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

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

And the variance of local II's profit ($\mathbb{V}_t \Pi_{t+1,II}$) can be written as $\mathbb{V}_t \Pi_{t+1,II} = Q^2_{t,II} \mathbb{V}_t (1 + i_{t+1,FA})$, 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

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

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. In our empirical analysis we identify these shocks as the innovations in local IIs' FX swap flows that are orthogonal to a rich array of current and past values of variables that capture the other supply- and demand-side factors present in our model.

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

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

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 $-b_t$:

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

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}:

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

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

3.3 Model Equilibrium

We define equilibrium in the FX swap market as the equality $Q_{t,II} = Q_{t,GA} = Q_t$, 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 GAs' 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 $Q_{t,II} = Q_{t,GA} = Q_t$) to obtain the following equilibrium equation for b_t:

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

Second, we implicitly differentiate Equation (11) with respect to e^{ϵ_t} to obtain the effect of the latter on b_t:[9]

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

The positive sign of Equation (12) relies on the assumed concavity of G and the derived negative and positive 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:

$$\frac{\partial^2 b_t}{\partial e^{\epsilon_t}\partial A_t} = \frac{\kappa^2 G'''(:)\frac{\partial Q_{t,II}}{\partial e^{\epsilon_t}}(1-\kappa G''(:)\frac{\partial Q_{t,II}}{\partial b_t}) + \kappa^2 G''(:)\frac{\partial Q_{t,II}}{\partial e^{\epsilon_t}} G'''(:)\frac{\partial Q_{t,II}}{\partial b_t}}{\left(1-\kappa G''(:)\frac{\partial Q_{t,II}}{\partial b_t}\right)^2} = \tag{13}$$

$$\frac{\kappa^2 G'''(:)\frac{\partial^2 b_t}{\partial e^{\epsilon_t}}\left(1-G''(:)\frac{\partial Q_{t,II}}{\partial b_t}(\kappa^2-\kappa)\right)}{\left(1-\kappa G''(:)\frac{\partial Q_{t,II}}{\partial b_t}\right)^2} < 0.$$

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 and positive 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. Equations (12) and (13) formally demonstrate that a negative

[9] To 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.

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 GAC (A_t) is lower.

This prediction has strong economic intuition given that low initial GAC levels, by limiting the availability of funds for GAs' arbitrage activity, should make their FX swap supply more rigid and hence less 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 GAC-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 GAC-dependent FX swap demand channel. There are two noteworthy facts from this figure. First, to most vividly convey the crux of the GAC-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., high GAC state) and perfectly *inelastic* FX swap supply (rightward panel of the figure, i.e., low GAC state). While the precise manifestation of these cases in our model depends on what is assumed about the asymptotic behavior of $G''(:)$, one can view these cases as reasonable proxies for states of abundant versus scarce levels of initial GAC.

Second, Figure 1 reflects the fact that a low GAC state corresponds to both a steeper and a more leftward FX swap supply curve in our model. That is, having an initially lower GAC 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 daily 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,[10] and life insurance policies.[11] 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.[12] 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 (2021).

IIs' FX Swap and Spot Trading. To fund their foreign investments, IIs can either do spot trades where they sell NIS and buy USD or FX swap trades where they do opposing spot and forward 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 1/2/2008-12/31/2021. (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 cur-

[10] The 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.

[11] Mutual 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.

[12] These 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.

rency. 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/NIS.[13]

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.[14]

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 alternative of FX swaps surpasses the spot based alternative, with the accumulation of swaps reaching a peak of 77.7 Billion dollars on 12/23/2021 compared to a corresponding accumulated spot value of 52.3 Billion dollars.[15]

Sectoral Comparison of FX Swap Flows. Figure 3 shows the evolution of accumulated daily FX swap flows for 1/2/2008-12/31/2021 for four additional sectors on top of the II 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; banking sector, which includes the Israeli commercial banks; financial sector, which includes Israeli mutual funds' swap flow activity

[13] 85.9% 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%).

[14] While 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.

[15] Outright 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 (Nathan and Ben Zeev (2022)).

as well as Israeli IIs' such activity that is done on their own behalf rather than on behalf of the public's long-term investments (i.e., activity related to Israeli IIs' nostro (own) accounts); and foreign sector, which includes all foreign firms engaged in financial activity (i.e., foreign commercial banks, investment banks, hedge funds, and pension funds).[16]

This figure demonstrates that the sole effective buyers of dollar swaps among market participants are IIs, against which the two main sellers of dollar swaps are the foreign and local banking sectors. The significance of the foreign sector as sellers of dollar swaps is consistent with the modeling approach taken in the previous section which assumes that global GAs are IIs' counterparty, supplying IIs' their demanded FX swaps.

As also discussed in Footnote 5, IIs' FX swaps trades' maturities tend to be much shorter (having a median of 54 days) than the other market participants, with the median maturity for the entire universe of trades being 6 days. The median maturities for the foreign and local banking sector are 3 and 7 days, respectively. IIs conduct all of their FX swap trades against local banks which in turn face the interesting task of maturity transformation when intermediating between IIs and foreigners (i.e., rolling over FX swap trades from foreigners to match the maturity of the FX swap trades these banks conduct with IIs). However, such intermediation only reflects part of local banks' FX swap activity, as evidenced by their open long position which is comparable to that of foreigners, thus raising the concern that not controlling for this non-intermediation related activity might contaminate our results.[17]

To avoid this contamination and properly identify the GAC-dependent FX swap demand channel, we will impose in our empirical analysis on our FX swap demand shock to move IIs' swap flows in exactly opposing magnitude with respect to foreigners' swap flows. This restriction ensures that our shock does not capture an innovation to the behavior of non-II local sectors while capturing the crucial element of our structural model regarding the correspondence between local IIs and foreigners as demanders for and suppliers of FX swaps, respectively, conditional on the FX swap demand shock. .

[16]The foreign real sector's FX swap volume is negligible and is therefore excluded from Figure 3.

[17]E.g., one driver of the willingness of local banks to take on a long FX swap position is an influx of dollars coming from capital inflows, making it more appealing for local banks to sell FX swaps to IIs. This type of FX swap supply shock is a possible contaminator of our results if left uncontrolled for.

Cross-Currency Basis. We end this section with an exposition of the cost of FX swaps, as measured by 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. Figure 4 shows the evolution of the 1-, 3-, 6-, and 12-month USD/NIS cross currency bases, where the underlying interest rate, spot rate, and forward rate data are from Bloomberg.[18]

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 means of the considered bases are -49.8, -54.2, -50, and -41.9 basis points, respectively. These meaningful averages also embody significant volatility, with bases actually being positive early on in the sample but then starting to become negative in early 2009 and remaining in this negative territory throughout the sample except for a brief positive spell in 2012-2013.

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 is daily and covers the period 1/2/2008-12/31/2021. The specific starting and ending points of this 14-year period are dictated by the availability of the Bank of Israel (BOI) proprietary FX swap data and the illiquidity measure from Hu et al. (2013), respectively. We begin our data description by providing details on IIs' data after which we turn to discuss the other variables we utilize in our empirical analysis.

[18] Potentially, one could try to construct bases from spot and forward data underlying IIs' swap trades by using our micro-level swap trade dataset. However, this is not possible owing to lack of spot rate data for the micro-level swap trades. Hence, we stick to the standard approach of using Bloomerg spot and forward rate data for the construction of the bases.

5.1.1 FX Swap Flows Data

We have proprietary daily micro-level data for Israeli IIs and foreign financial institutions (foreigners). We also have such data for other sectors but, as explained below, in our empirical analysis we only make use of FX swap flow data for these two sectors. We construct from this micro data aggregate FX swap flow series for IIs and foreigners. We restrict attention to USD/NIS 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%).)

IIs' FX Swap Flows. This variable measures (in dollars) the daily net change in IIs' open swap position. This position is calculated from the net transaction flows from IIs' 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 when an II was a net buyer (seller) of swap-linked dollars on the corresponding day. While 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.

The median maturity of IIs' FX swap trades is 54 days; the 95th maturity percentile is 198 days; and the maximal maturity is 2,348 days (roughly 6.4 years). As discussed on Page 17 as well as in Footnote 5, there is a significant maturity gap between IIs, the sole short dollar swap position holder, and the foreign sector which is one of the two major long dollar swap position holders (the other being the local banks). Local banks, who are market makers in the USD/NIS FX swap market against which IIs conduct their swap trades, face the task of managing the risk from this maturity mismatch.

Foreign Sector's FX Swap Flow Data. We also have micro-level FX swap flow data for the foreign sector (i.e., changes in foreigners' open swap position), which includes all types of foreign economic units engaged in financial activity.[19] The median maturity of foreigners' FX swap trades is 3 days; the 95th maturity percentile is 70 days; and the maximal maturity is 4,989 days (roughly 13.7 years). In the empirical analysis we orthogonalize our FX swap demand shock with respect to current and lagged value of the sum of IIs and foreigners' FX swap flows, thus ensuring that our shock only represents exogenous variation in IIs' swap demand that is in turn met by GAs' FX swap supply. This restriction aligns with our structural model and removes the possibility of our identification capturing non-II local sector FX swap demand and supply shocks.

5.1.2 Macro-Financial Data

We use several daily frequency macro-financial variables in our analysis, both foreign and local, all of which cover the baseline empirical sample of 1/2/2008-12/31/2021. Apart from the illiquidiy series from Hu et al. (2013) which is taken from Jun Pan's webpage,[20] all of the macro-financial variables are taken from Bloomberg and their values are end-of-day quotes.

GAC Measure. Building on the insight from Anderson et al. (2021) that GAC is inherently dependent upon wholesale funding, we proxy for GAC using the daily funding index (FI) series developed by the Office of Financial Research (OFR) which measures how easily financial institutions can fund their activities. FI is a sub-index of OFR's broader financial stress index and is computed as a weighted average of the following 7 indicators of wholesale funding ease: spread between 3-month USD London Interbank Offered Rate (Libor) and USD overnight index swap (OIS); spread between 3-Month USD Libor and 3-month treasure bill yield (TED Spread); spread between 3-Month Euro interbank offered rate (Euribor) and Euro Overnight Index Average (Eonia); spread between 3-month JPY Libor and JPY OIS; 2-year USD/EUR and USD/JPY cross-currency basis; and 2-year U.S. swap spread. The weights are estimated with a dynamic

[19] While we do not use this data in the empirical analysis, we also have FX swap flow data for three additional sectors: real sector, which represents the net FX flows from swap transactions involving Israeli exporters and importers; banking sector, which includes the Israeli commercial banks; and financial sector, which includes Israeli mutual funds' forward flow activity as well as Israeli IIs' such activity that is done on their own behalf rather than on behalf of the public's long-term investments (i.e., activity related to Israeli IIs' nostro (own) accounts). Use of this data was made in the previous section when we conducted a sectoral comparison of FX swap flows (Figure 3).

[20] https://en.saif.sjtu.edu.cn/junpan/.

factor model in the spirit of Bai and Ng (2008) and Stock and Watson (2011).[21]

USD/NIS Cross-Currency Bases. We construct the USD/NIS cross-currency bases for the 1-, 3-, 6-, and 12-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). 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.)

VIX. The VIX is a volatility index 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 regression that identifies the FX swap demand shock 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 regression that identifies the FX swap demand shock 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 the largest 500 and 35 companies in U.S. and Tel-Aviv Stock Exchanges, respectively. We include current and lagged values of the return differential between these two indices in the regression that identifies the FX swap demand shock so as to ensure that our shock does not capture endogenous demand variation due to differential stock market performance across the U.S. and Israeli stock markets. (As also discussed in Footnote 24, our structural model could be extended to include

[21] For the FI data and more details regarding it, the reader is referred to https://www.financialresearch.gov/financial-stress-index/.

a role for local equity returns in addition to foreign ones, in which case the associated return differential would be present as a demand shifter.)

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 regression that identifies the FX swap demand shock. We compute these bases correspondingly to how we compute the USD/NIS ones, taking the 1- and 12-month Euribor rates as the risk-free rates for the Euro. As explained in Footnote 26, 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.

Illiquidity Measure. We use the first-difference of the noise measure from Hu et al. (2013) in the regression that identifies the FX swap demand shock to control for global illiquidity shocks. Hu et al. (2013) put forward the daily average dispersion of a properly fitted yield curve for treasury bonds as a measure of illiquidity. Since lack of sufficient GAC limits the force of arbitrage and hence allows assets' prices to trade significantly away from their fundamental values, one can argue that Hu et al. (2013)'s noise measure can also be considered as a measure of GAC. However, we view its capacity to accomplish this to be more limited than the funding index. The reason for this is that time variation in shorting costs is likely picked up by this noise measure, in addition to constraints in GAC, because times of financial distress and illiquidity are also associated with rising shorting costs (10.2307/42002587). As discussed on Page 20, we follow the reasoning from Anderson et al. (2021) that the ease with which global banks obtain their funding should proxy well for GAC and therefore use the funding index which precisely captures the level of this ease.

Israel's five-year CDS. To control for changes in the perceived riskiness of the Israeli economy, we include the first-difference of Israel's five-year credit default swap (CDS) price in the regression that identifies the FX swap demand shock. The underlying asset of this CDS price is 5-year Israeli government dollar bonds. Controlling for this variable ensures that our FX swap demand shock does not capture the endogenous response of IIs' demand to variation in local riskiness nor does it capture the endogenous response of foreigners' FX swap supply to such variation.

5.2 Estimation

We estimate a daily frequency Bayesian state-dependent local projection model. The model has two equations. In the first equation, we identify the FX swap demand shock from a regression of IIs' swap flows on their own raw lags, the interactions of their current and lagged values with the one-day lagged value of the funding index, and a rich array of controls which capture FX swap supply- and demand-side factors. This rich specification ensures that the innovation to the IIs' FX swap series from the first equation represents well an FX swap demand shock. We think about this shock in terms of our structural model from Section 3, i.e., as representing changes in IIs' geographical portfolio preferences. (Also see related discussion in Footnote 2.) In the second equation, we run local projection regressions of cross-currency basis on the estimated shock from the first equation as well as on the interaction between this shock and the one-day lagged funding index. This allows us to estimate the GAC-dependent dynamic effect of the FX swap demand shock on the basis.

5.2.1 Econometric Model

Specification. We estimate the following two-equation model:

$$\begin{aligned}
\Delta SP_t &= \alpha_{0,L} + \alpha_{1,L}\mathbb{T}_t + \beta_{1,L}\Delta SP_{t-1} + \cdots + \beta_{p,L}\Delta SP_{t-p} \\
&+ FI_{t-1}\left(\alpha_{0,I} + \alpha_{1,I}\mathbb{T}_t + \beta_{0,I}\Delta SP_t + \cdots + \beta_{p,I}\Delta SP_{t-p}\right) \\
&+ A_1 V_{t-1} + ... + A_L V_{t-p} + C_0 Z_t + ... + C_p Z_{t-p} + \epsilon_t, \qquad (14)
\end{aligned}$$

$$b_{t+h} - b_{t-1} = \alpha_{2,L,h} + \Xi_{L,h}\hat{\epsilon}_t + FI_{t-1}\left(\alpha_{2,I,h} + \Xi_{I,h}\hat{\epsilon}_t\right) + \gamma_h(SP_{t+H} - SP_{t-1}) + u_{t+h}. \qquad (15)$$

where t indexes time at daily frequency; ΔSP_t is IIs' FX swap flows (i.e., the first-difference of IIs' open FX swap position); FI_{t-1} is the deviation of the OFR's funding index variable at $t-1$ from its mean divided by this variable's standard deviation; $\mathbb{T}_t$ is a time trend; p denotes the number of lags, which we set to 15 in the baseline case;[22] A_i ($i = 1, ..., p$) are $1{\times}4$ coefficient vectors and V_{t-i} are $4{\times}1$ variable vectors whose components are detailed below; C_s ($s = 0, ..., p$) are $1{\times}11$ coefficient vectors and Z_{t-s} are $11{\times}1$ variable vectors whose components are detailed below; $\epsilon_t \sim i.i.d.\ N(\mathbf{0}, \sigma_\epsilon^2)$ is Equation (14)'s residual (i.e., true FX swap demand shock) where σ_u is its standard deviation; b_t is cross-currency basis (for either the 1-, 3-, 6-, or 12-month maturity; h is Regression (15)'s rolling horizon ($h = 1, ..., H$); $\hat{\epsilon}_t$ is the estimated residual from Equation (14) (normalized to have unit standard deviation), i.e., the estimated FX swap demand shock; SP_{t+H} and SP_{t-1} are IIs' open FX swap positions for periods $t + H$ and $t - 1$, respectively, constructed as $\sum_{j=1}^{t+H} SF_i$ (i.e., the sum of IIs' FX swap flows up to period $t + H$) and $\sum_{j=1}^{t-1} SF_i$ (i.e., the sum of IIs' FX swap flows up to period $t - 1$, which correspondingly represents IIs' open FX swap position at time $t - 1$);[23] 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.

Identification. To be internally consistent, we identify the FX swap demand shock 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 funding index 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 lagged funding index and the current value of IIs' swap flows ensures that the identified shock does not erroneously capture the interaction of the true shock with the one-day lagged funding index. And we separately control for the

[22] This lag specification reflects effectively three weeks of past data in terms of calendar days. The corrected AIC, AIC, BIC, and HQIC lag length criteria tests suggest 11, 17, 3, and 17 lags, respectively. Our general inclination is to follow the recommendation from the corrected AIC test given its ability to avoid the tendency of AIC and HQIC to overfit as well as that of BIC to underfit. However, we have found that the minimal number of lags needed to produce a white noise residual from Equation (14), according to the Ljung-Box Q-test for residual autocorrelation, is 15. Hence, as a reasonable compromise, we opted for this lag specification in the baseline case. We show the robustness of our results to alternative lag choices in online appendix's Section B.1.

[23] While we do not have the starting level of IIs' open FX swap 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.

one-day lagged funding index to ensure that our identified shock does not erroneously pick up the effects of higher/lower GAC.

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. Variable vector V_{t-i} consists of the first-differences of the 1-, 3-, 6-, and 12-month cross-currency bases, which we control for to purge from our identified shock any variation related to the past dynamics of currency bases' changes. And variable vector Z_{t-s} includes the following variables: differentials between S&P 500 and TA-35 returns and 1- and 12-month Libor and Telbor rates, the inclusion of which ensures that relative equity price and interest rate changes are not driving our results;[24,25] log-first-difference of VIX and broad dollar index, the controlling of which ensures our identified shock is unrelated to global uncertainty and risk appetite shocks, respectively; first-differences of USD/EUR 1- and 12-month cross-currency bases,[26] the controlling of which removes the possibility that our identified shock captures shocks to frictions in the global FX swap market; first-differences of the illiquidity series from Hu et al. (2013), whose inclusion ensures illiquidity shocks in the central U.S. treasury market are not driving our results;[27] first differences of the funding index, whose inclusion assures our identified shock is not picking up *changes* in GAC; the first difference of the credit default swap price for 5-year Israeli government dollar bonds, the inclusion of which ensures our identified shock is unrelated to changes in the Israeli's economy riskiness as perceived by global as well as

[24] While our structural model implies only the presence of foreign equity returns as a driver of FX swap demand, one could extend our setting to allow for local equity investment which would in turn produce the presence of a *relative* equity return variable as a demand driver. Such extension would complicate the exposition while leaving the main message of the model unchanged. Hence, we refrain from it.

[25] While results are robust to including the 3- and 6-month interest rate differentials, these variables have 90% and 91% correlations with the 12-month rate differential and hence carry no meaningful additional information beyond that contained in the latter variable. Hence, for efficiency reasons, we only include the 1- and 12-month interest rate differentials. (The correlation between these two variables is 60%.)

[26] While results are robust to including the first-differences of the 3- and 6-month EUR/USD 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%.)

[27] This noise series arguably also captures movements in GAC but we view its capacity to accomplish this to be more limited than the funding index. The reason for this is that time variation in shorting costs is likely picked up by this noise measure, in addition to constraints in GAC, because times of financial distress and illiquidity are also associated with rising shorting costs (10.2307/42002587). As discussed on Page 20, we follow the reasoning from Anderson et al. (2021) that the ease with which global banks obtain their funding should proxy well for GAC and therefore use the funding index which precisely captures the level of this ease.

local investors; and the sum of IIs' FX swap flows and foreigners' FX swap flows, the inclusion of which ensures that our identified shock is unrelated to shocks to other domestic sectors' FX swap flows, i.e., it captures the essence of our structural model that the FX supply side is governed by global arbitrageurs who meet IIs-driven demand changes in equilibrium.[28]

The coefficients of interest are $\Xi_{L,h}$ and $\Xi_{I,h}$ from Equation (15). Building on the conceptual base provided by our structural model, we construct the effects of a one standard deviation FX swap demand shock in the low and high GAC states on cross-currency basis at horizon h as $\Xi_{L,h} + 2\Xi_{I,h}$ and $\Xi_{L,h} - 0.8\Xi_{I,h}$, respectively, where the low GAC state is defined by the funding index being 2 standard deviations higher than its mean while the high GAC state is defined by the funding index being lower by -0.8 than its mean. The latter definition stems from the considerable right skewness of the funding index: the -0.8 value is the 6.8th percentile of the funding index's distribution and 2 corresponds to the symmetric 93.2th percentile of this distribution. (The minimal value of the funding index is -0.92, i.e., the variable does not even experience a -1 standard deviation realization in our baseline sample.) Interpreted through the lens of our model's conceptual framework, $\Xi_{L,h} + 2\Xi_{I,h}$ and $\Xi_{L,h} - 0.8\Xi_{I,h}$ capture the effects of an FX swap demand shock conditional on the supply curve of FX swaps being significantly rigid and elastic, respectively.

To ensure that our results are not driven by differential persistence of the demand shock across the two states, we control for the accumulated difference in IIs' open FX swap position from period $t-1$ to period $t+H$ in Equation (15). This control imposes on the effect of the demand shock on IIs' open FX swap position in both states to die out after H periods and hence imposes on this shock's persistence to be similar across states. Our choice for H in the analysis ($H = 140$, i.e., roughly 7 calendar months) is governed by the fact that the significance of the effects on cross-currency bases begins to die out around this horizon. It is noteworthy that our results are robust to the exclusion of this persistence restriction. But excluding this restriction results in the demand shock in the low GAC state having a more persistent effect on IIs' open FX swap position than its corresponding effect in the high GAC state, thus making the state-dependent effects on the cross-currency bases incomparable. Our persistence restriction resolves this issue by putting the state-dependent effects on common grounds.

[28]The merit of Specification 14 is borne out by its high R^2 of 76.8%.

For future reference, let the stacked $(3 + 17 * p + 11)$x1 $B = [\alpha_{0,L}, ..., C_p]'$ and 5x1 $Q_h = [\alpha_{2,L,h}, ..., \gamma_h]'$ 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 matrix B and residual variance σ^2_ϵ for Equation (14) and coefficient matrix Q_h and residual variance $\sigma^2_{u,h}$ for Equation (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, 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 (2020), 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) GAC-dependent impulse responses to compute the GAC-dependent FEV contributions of our swap demand shock as follows:

$$\mathbb{C}_{LGAC,h} = \frac{\mathbb{V}(\hat{\epsilon}_t \mid LGAC)\left(\hat{\Xi}_{L,0} + 2\hat{\Xi}_{I,0}\right)^2 + ... + \left(\hat{\Xi}_{L,h} + 2\hat{\Xi}_{I,h}\right)^2}{\mathbb{V}(b_{t+h} - b_{t-1} \mid LGAC)}, \tag{16}$$

$$\mathbb{C}_{HGAC,h} = \frac{\mathbb{V}(\hat{\epsilon}_t \mid HGAC)\left(\hat{\Xi}_{L,0} - 0.8\hat{\Xi}_{I,0}\right)^2 + ... + \left(\hat{\Xi}_{L,h} - 0.8\hat{\Xi}_{I,h}\right)^2}{\mathbb{V}(b_{t+h} - b_{t-1} \mid HGAC)}, \tag{17}$$

where $\hat{\Xi}_{L,h}$ and $\hat{\Xi}_{I,h}$ are the estimated linear and nonlinear (interaction-term) impulse response coefficients from Equation (15); $LGAC$ and $HGAC$ correspond to the low and high GAC states, respectively; $\mathbb{V}(b_{t+h} - b_{t-1} \mid LGAC)$ and $\mathbb{V}(b_{t+h} - b_{t-1} \mid HGAC)$ represent the variances of the cross-currency bases' accumulated differences conditional on the low and high GAC states, respectively; and, similarly, $\mathbb{V}(\hat{\epsilon}_t \mid LGAC)$ and $\mathbb{V}(\hat{\epsilon}_t \mid HGAC)$ are the estimated swap demand shocks' variances conditional on the low and high GAC states, respectively.

Operationally, we define these states as the groups of observations where the funding index series values are above or equal to the funding index series's 86.4th percentile (low GAC state) and below or equal to the funding index series's 13.6th percentile (high GAC state). The rationale for these definitions is based on the fact that the low (high) GAC state is defined by the funding index being equal to its 93.2th (6.8th) percentile value. (The funding index's 2 and -0.8 standard deviation values correspond to its 93.2th and 6.8th percentiles.) Hence, we define the variances conditional on these states as the variances that result from considering observations that closely and symmetrically surround the low and high GAC state values but at the same time deliver a sufficient number of observations for FEV estimation.

6 Empirical Evidence

This section presents the main results of the paper. In all considered figures, solid lines represent the median GAC-dependent responses of the corresponding variable to a one standard deviation FX swap demand shock while dashed lines depict 95% posterior confidence bands; 140 daily horizons are considered, i.e., impulse responses are shown for 140 trading days (roughly 7 calendar months) after the shock. (As noted also on Page 26, results' significance dies out beyond the 140-day mark.) To further our understanding of the quantitative importance of the GAC-dependent FX swap demand channel, we also present forecast error variance (FEV) decomposition results for our cross-currency basis variables. After showing the results for currency bases, we turn to the results for the IIs' open FX swap position variable.

6.1 Currency Bases' Impulse Responses

Figure 5 shows the GAC-dependent effects of a one standard deviation FX swap demand shock on the 4 considered cross-currency bases. The figure contains four rows and three columns. Each row corresponds to a specific cross-currency basis variable. The first two columns of the figure present the low- and high-GAC-dependent effects of the shock, respectively. The third column of the figure shows the difference between the low- and high-GAC-dependent impulse responses.

The results demonstrate a significant and persistent widening of the basis in response to the swap demand shock in the low GAC state. There is a significant widening of the bases on impact for all considered maturities, with the 1-, and 3-, 6-, and 12-month bases widening on impact by 3.5, 2.3, 2, and 2.1 basis points, respectively. And the effects for these bases maintain their significance for 126, 85, 134, and 140 trading days, respectively.

In contrast to the low-GAC-dependent responses, the high-GAC-dependent responses are both economically and statistically insignificant for all considered horizons. Therefore, the magnitude and the persistence of the differences between the low- and high-GAC-dependent responses are similar to those observed for the low-GAC-dependent responses. Response differences across the two states for the 1-, 6-, and 12-month bases remain significant for 124, 95, and 140 trading days, respectively. Those for the 3-month basis are marginally significant for more than 90 days. (The theory-consistent hypothesis test we should focus on is one-tailed, i.e., that the cross-currency basis widens (falls) relative to being unchanged. As such, the significance level for the one-tailed tests underlying Figure 5 is 2.5%. While the 3-month basis's response is not significantly negative at the latter significance level, it is significant at the 5% and 10% levels for 58 and 92 trading days, respectively.)

In sum, the results from Figure 5 support the story from our structural model. When GAC is low, FX swap supply is sufficiently rigid such that a favorable FX swap demand shock causes a significant widening of the basis. And our dynamic framework allows us to uncover a significant persistence to this GAC-dependent mechanism. By contrast, when GAC is high, FX swap supply is sufficiently elastic (effectively perfectly elastic according to the results) so as to prevent from such the favorable FX swap demand shock to widen the basis. We now turn to the FEV results.

6.2 Cross-Currency Bases' FEVs

Figure 6 shows the GAC-dependent contributions of the FX swap demand shock to the FEV of the four considered cross-currency bases. The FX swap demand shock's peak contributions to the 1-, 3-, 6-, and 12-month bases' FEVs in the low GAC state are 31%, 13.4%, 17.6%, and 23.2%, respectively, taking place at the 114th, 33th, 33th, and 20th horizons. That the swap demand shock accounts for these meaningful FEV shares indicates that the GAC-dependent FX swap demand channel we uncover in this paper is quantitatively important for explaining cross-currency bases' variation.

In contrast to the low GAC state, the second column of Figure 6 shows that FEV contributions in the high GAC state are negligible, peaking at 0.9% (110th horizon), 1.3% (140th horizon), 1% (140th horizon), and 2.2% (140th horizon). These unimportant FEV shares are consistent with the view that our high GAC state captures an effectively perfectly elastic FX swap supply curve. The third column of Figure 6 confirms that the economically large differences between the FEV shares across the two states are also statistically significant, showing significant differences for all 140 horizons for the 1-month basis; 32 horizons for the 3-month basis (64 at the 5% significance level); 119 horizons for the 6-month basis (all 140 horizons at the 5% significance level); and 71 horizons for the 12-month basis (138 at the 5% significance level).

6.3 IIs' open FX Swap Position

To further bolster confidence in the interpretation of our results as evidence for a meaningful GAC-dependent FX swap demand channel, it is important to confirm that IIs' open FX swap position's differential response across the two states accords with the latter channel. Specifically, if this channel is truly driving our results for the currency bases, then we should expect to see IIs' open FX swap position respond more strongly to the swap demand shock in the high GAC state than in the low GAC state.

Figure 7 shows the GAC-dependent impulse responses of IIs' open FX swap position. These responses are obtained from replacing the cross-currency basis accumulated difference outcome variable in Equation (15) with the accumulated difference in IIs' open FX swap position (i.e., $SP_{t+h} - SP_{t-1}$).[29] The results from Figure 7 accord well with those from Figure 5: IIs' open FX swap position increases significantly more in the high GAC state than in the low one, reaching a significantly greater impact response of 249.6 million dollars in the former compared to only 44 million dollars in the latter. (Response differences are significant for a total of 113 horizons.) This nearly 6-fold greater impact response in the high GAC state supports the interpretation of our results as being driven by a GAC-dependent FX swap demand channel where the high (low) GAC state identifies an elastic (inelastic) FX swap supply curve.

6.4 Robustness Checks

Appendix B of the online appendix to this paper examines the robustness of the baseline results from the previous three sections along three dimensions. The first excludes the COVID-ridden period by truncating the sample at February 28, 2020. The second excludes the GFC period by omitting from the sample 2008 and 2009. And the last robustness check examines results' sensitivity to different lag choices 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 GAC-dependent FX swap demand channel.

7 Conclusion

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

[29] We also add to the RHS of Equation (15) a time trend, both separately as well as interacted with FI_{t-1}, so as to control for possible trending behavior of $SP_{t+h} - SP_{t-1}$. This trend inclusion accords with that done in Equation (14), whose outcome variable is simply $SP_{t+h} - SP_{t-1}$ for $h = 0$, and removes the concern that this paper's results are possibly driven by a trending behavior of IIs' FX swap flows.

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 posses a developed FX swap market in which local IIs are central demanders for dollars.

Lastly, this paper's results have potentially meaningful policy implications. A quantitatively important GAC-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 GAC-dependent FX swap demand channel is a potentially fruitful avenue for future research.

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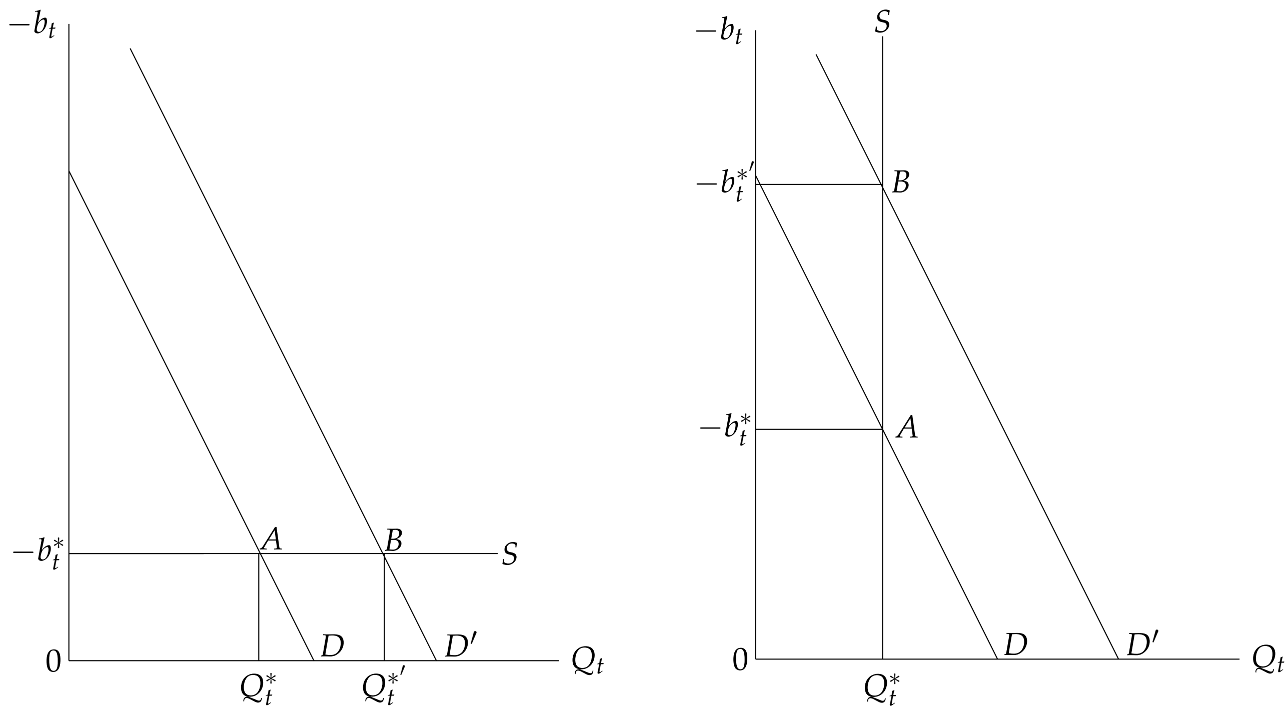
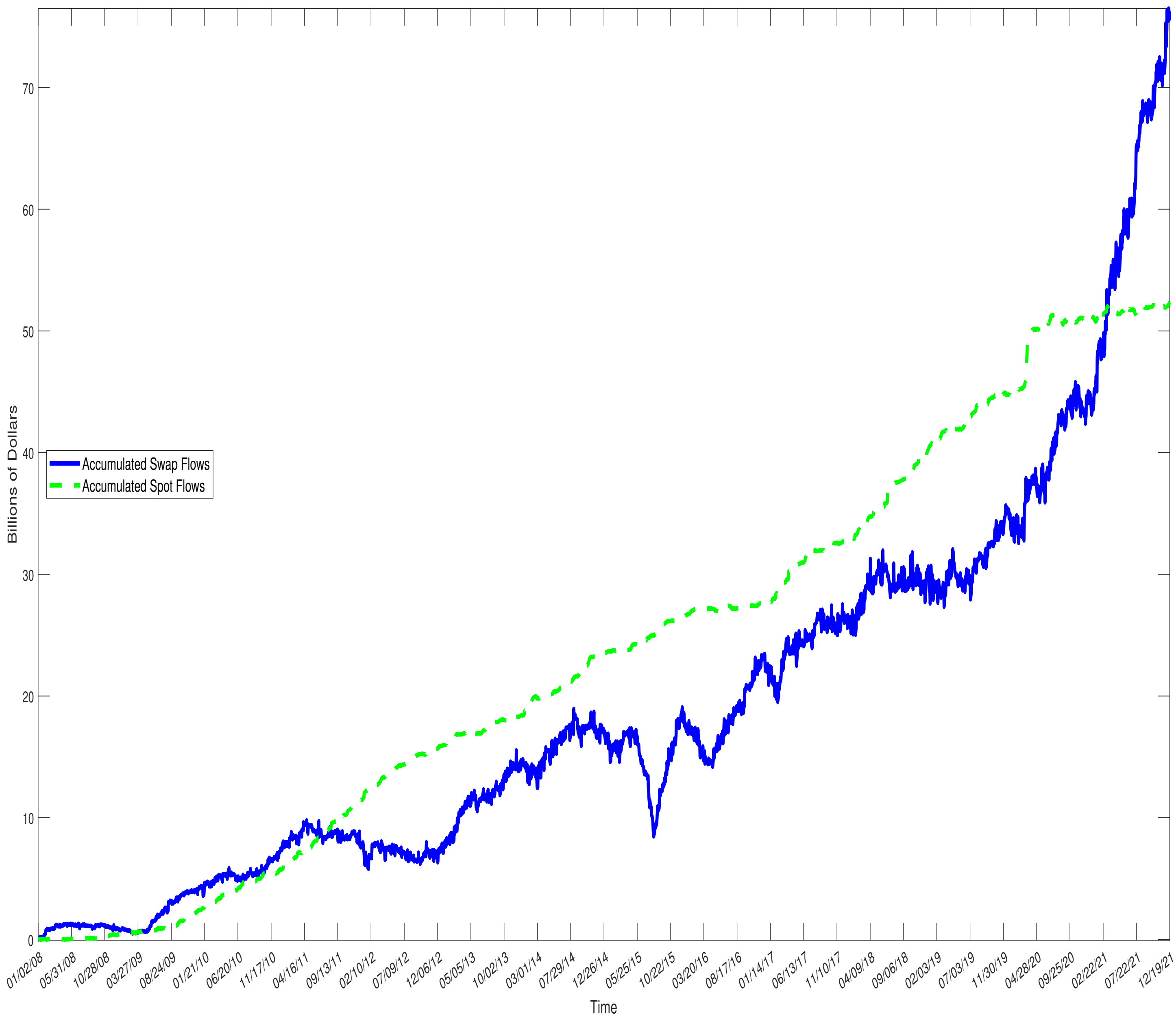
Figure 1: **Diagramtic Depiction of GAC-Depenendent FX Swap Demand Channel**.

FX Swap Market: High GAC State. **FX Swap Market: Low GAC State**.



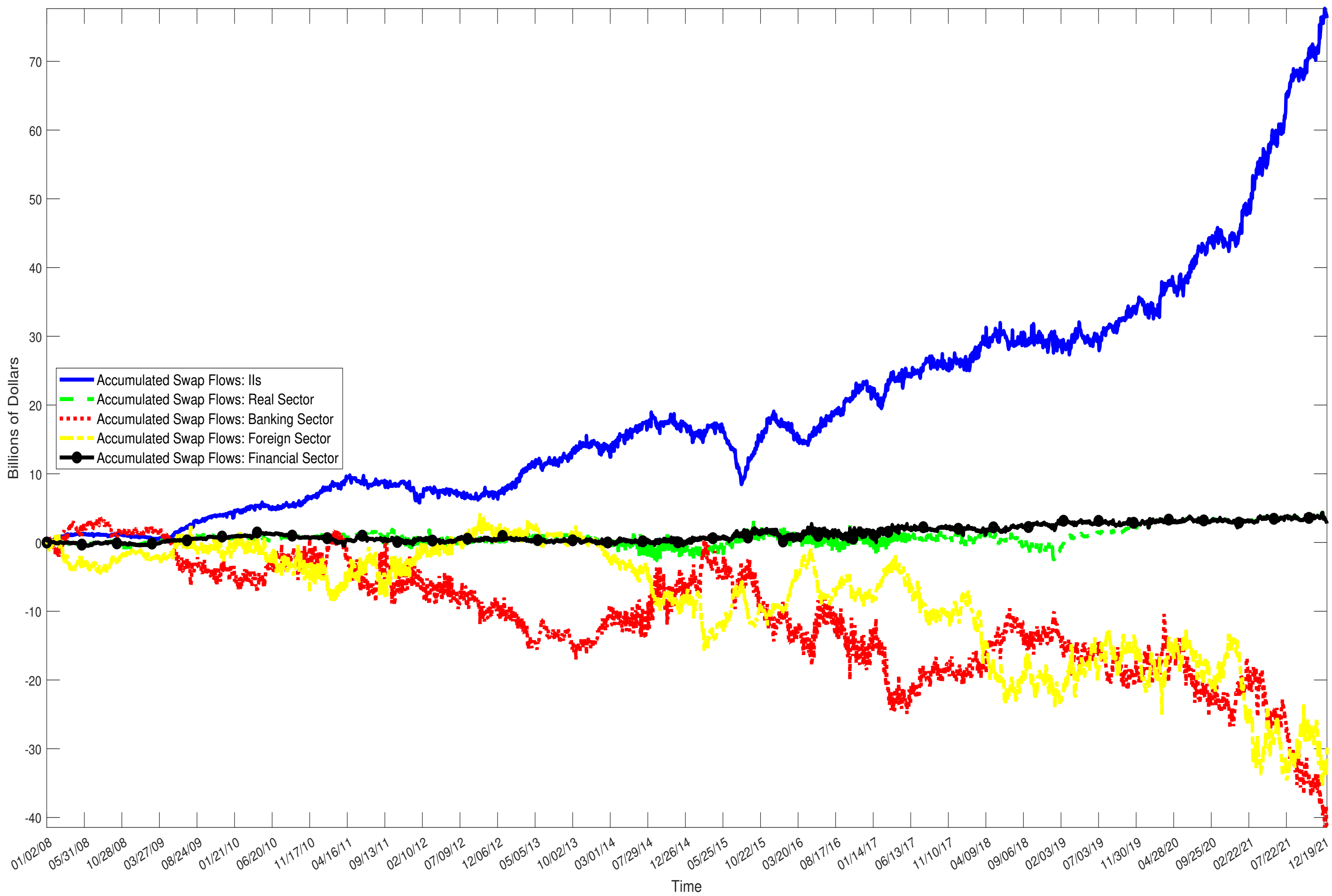
Notes: This figure provides a qualitative depiction of the GAC-dependent FX swap demand channel underlying the structural model from Section 3. The high (low) GAC state represents the state in which the level of A_t, i.e., global banks' arbitrage capital, is high (low). b_t is cross-currency basis defined 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., high GAC state) and perfectly *inelastic* FX swap supply (rightward panel of the figure, i.e., low GAC 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 global 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.**



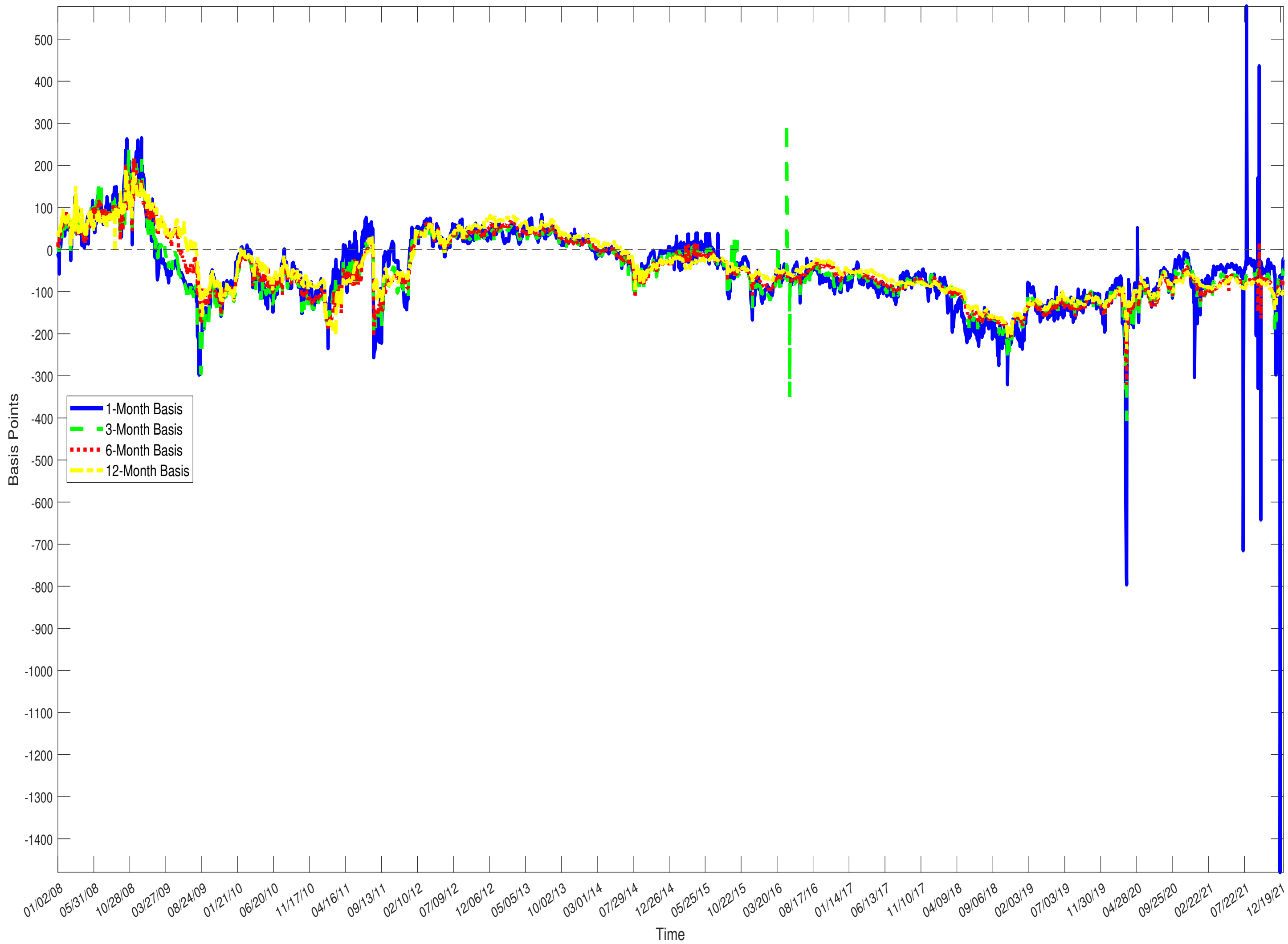
Notes: This figure presents the time series of the accumulated daily flows of IIs' FX swap (solid line) and spot (dashed line) trades in the NIS/USD currency pair. Since FX swap flows are changes in IIs' open FX swap position, their shown accumulated series can be viewed as IIs' open FX swap position. 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 01/02/2008-12/31/2021. 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.**



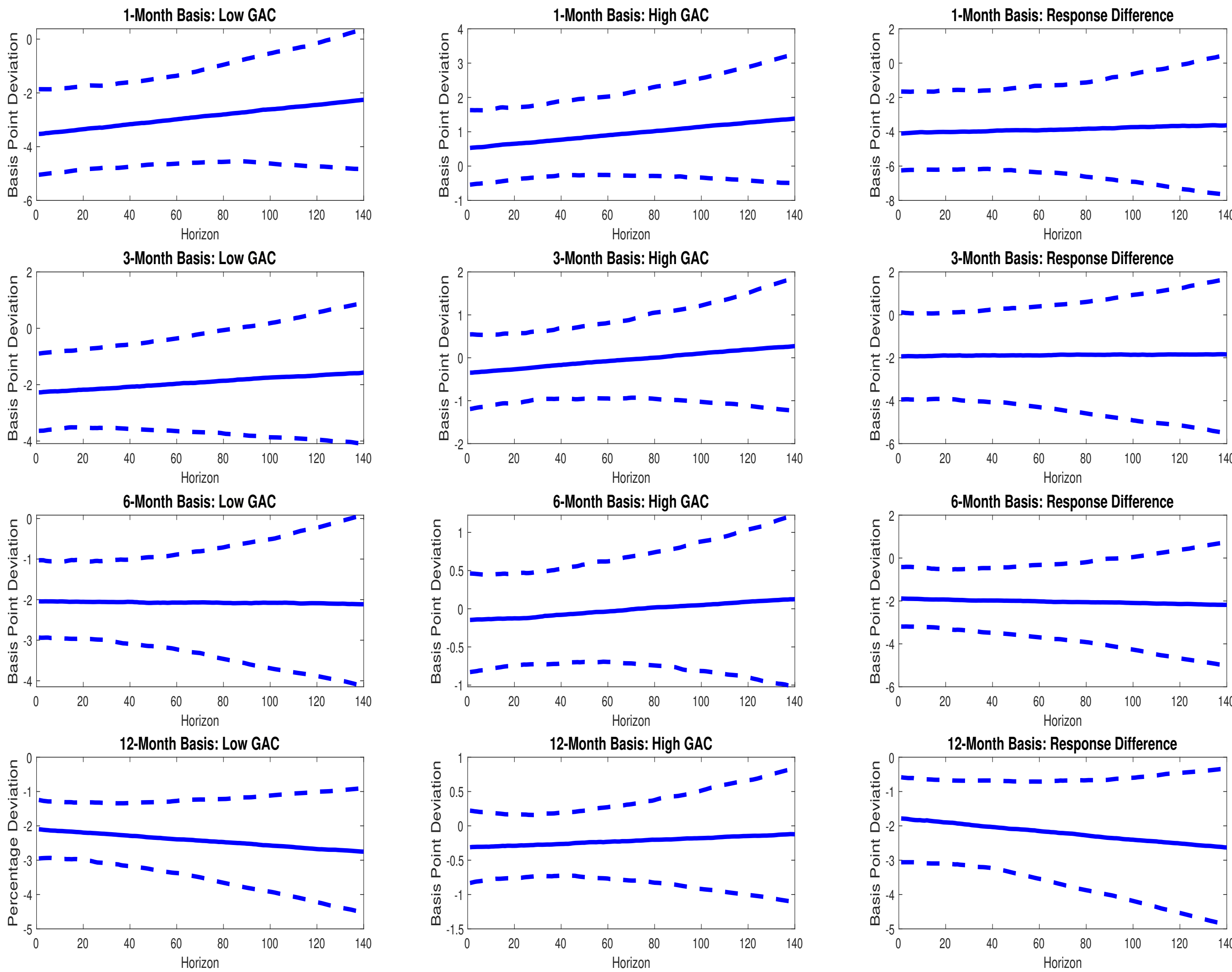
Notes: This figure presents the time series of accumulated daily FX forward flows by sector. Since FX swap flows are changes in the corresponding sector's open FX swap position, their shown accumulated series can be viewed as the corresponding sector's open FX swap position with positive (negative) values representing an open FX swap short (long) position. On top of the II sector (which, for completeness, is also included in the figure and is represented by the solid line), this figure includes four additional sectors: real sector (dashed line), which represents the net FX flows from swap transactions involving Israeli exporters and importers; banking sector (dotted line), which includes the Israeli commercial banks; foreign sector (dash-dotted line), which includes all foreign firms engaged in financial activity; and financial sector (solid line with circle markers), which includes Israeli mutual funds' swap flow activity as well as Israeli IIs' such activity that is done on their own behalf rather than on behalf of the public's long-term investments (i.e., activity related to Israeli IIs' nostro (own) accounts). Negative accumulated flows' values represent the accumulated selling of swap dollars; positive values represent the accumulated buying of swap dollars. Data are from the BOI and cover 1/2/2008-31/12/2021. Time (daily dates) is on the x-axis. Values are in billions of dollars.

Figure 4: **Time Series of USD/NIS Cross Currency Basis.**



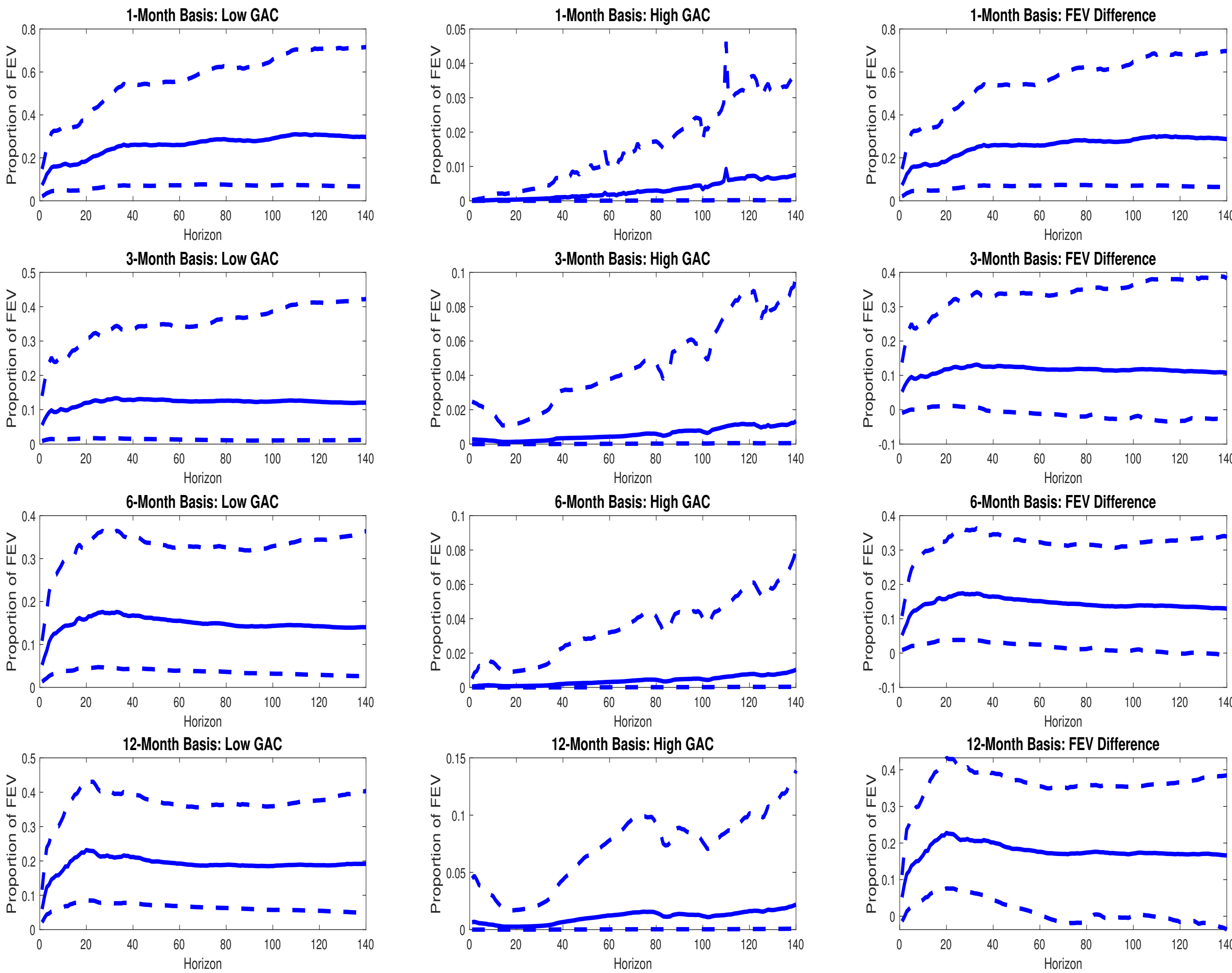
Notes: This figure presents the time series of daily USD/NIS cross currency basis for the 1- (solid line), 3- (dashed line), 6- (dotted line), and 12-month (dash-dotted line) horizons. The bases are computed as the difference between Libor dollar rates and CIP-implied dollar rates. Data are from Bloomberg and cover 1/2/2008-31/12/2021. Time (daily dates) is on the x-axis. Values are in basis point terms.

Figure 5: **GAC-Dependent Impulse Responses of Cross-Currency Bases to a One Standard Deviation FX Swap Demand Shock**.



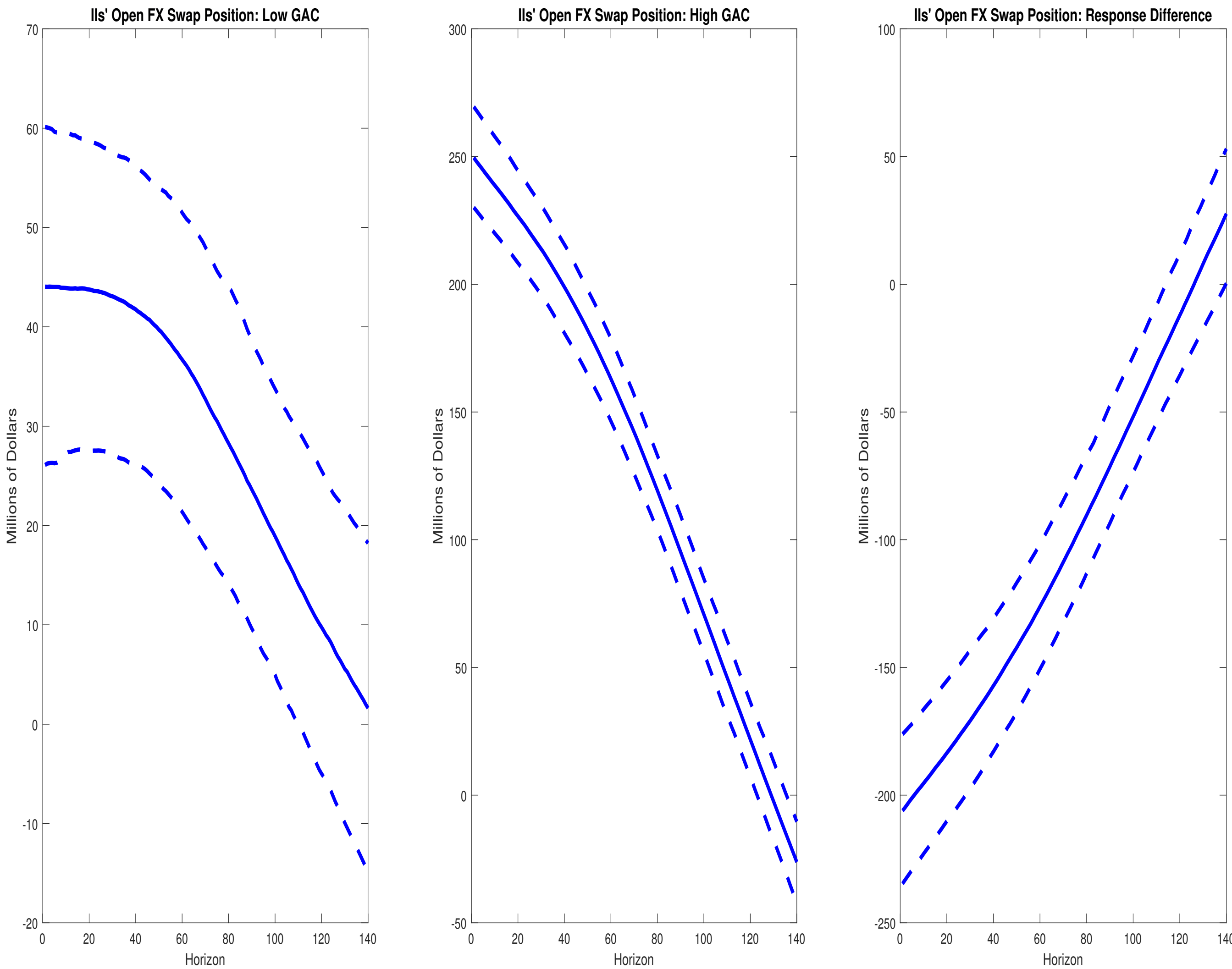
Notes: This figure presents the GAC-dependent impulse responses of the 1-, 3-, 6-, and 12-month cross currency bases to a one standard deviation FX swap demand shock from the model described by Equations (14) and (15). The first and second columns show the responses in the low and high GAC states, respectively; and the third column shows the response differences across the two states. Responses are in terms of deviations from pre-shock values (basis point deviations). Horizon (on x-axis) is in days.

Figure 6: **GAC-Dependent FEV Shares of Cross-Currency Bases Attributable to FX Swap Demand Shock**.



Notes: This figure presents the FEV share of cross-currency bases that is attributable to the FX swap demand shock from the model described by Equations (14) and (15). The first and second columns show the FEV contributions in the low and high GAC states, respectively; and the third column shows the FEV contribution differences across the two states. Horizon (on the x-axis) is in days and the FEV share is on the y-axis.

Figure 7: **GAC-Dependent Impulse Responses of IIs' Open FX Swap Position to a One Standard Deviation FX Swap Demand Shock**.



Notes: This figure presents the GAC-dependent impulse responses of IIs' open swap position to a one standard deviation FX swap demand shock from the model described by Equations (14) and (15) where the outcome variable in the latter equation is now replaced by the accumulated difference in IIs' open FX swap position (i.e., $SP_{t+h} - SP_{t-1}$). The first and second columns show the responses in the low and high GAC states, respectively; and the third column shows the response differences across the two states. Responses are in terms of deviations from pre-shock values (in millions of dollars terms). Horizon (on x-axis) is in days.