Shorting the Dollar When Global Stock Markets Roar: The Equity Hedging Channel of Exchange Rate Determination

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Abstract

The equity hedging channel predicts that institutional investors' (IIs') hedging of their foreign equity position's FX exposure via foreign currency forward contracts leads to a positive relation between this position and IIs' supply of foreign currency forwards; in equilibrium, this prediction implies a negative relation between foreign equity prices and forward and spot rates. We use novel daily data on Israeli IIs' FX forward flows to test this equity hedging channel within a suitable Bayesian local projection model, finding strong evidence supporting a meaningful such channel.

JEL classification: E44,F3,F31,G15,G23

Keywords: Equity Hedging Channel; Foreign Currency Forward Flows; Forward Exchange Rate; Spot Exchange Rate; Global Stock Prices; Institutional Investors; Bayesian Local Projections.

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1 Introduction

The equity hedging channel of exchange rate determination speaks to the desire of investors with a foreign equity position to hedge an increase in FX risk resulting from a rise in the value of this position by selling foreign currency on the forward market. This selling puts downward pressure on the forward rate which in turn translates to a decline in the spot rate.[1] While the effects of equity markets on FX markets have been mainly studied via a portfolio rebalancing based mechanism taking place in the FX *spot* market (Hau and Rey (2004, 2006) and Camanho et al. (2022)), the equity hedging channel studied in this paper focuses on the effects of equity markets on the FX *forward* market which then spillover into the FX spot market. Given that institutional investors (IIs) tend to meaningfully apply FX hedges to their foreign equity positions (see Page 29 for evidence on this), the equity hedging channel has the potential of being a significant transmitter of global stock price movements into FX spot rates through an FX forward market based mechanism that is distinct from the usually considered portfolio-rebalancing-induced FX spot market mechanism.

Objective and Contribution of this Paper. The main objective of this paper is to study the existence and quantitative relevance of the equity hedging channel of exchange rate determination. Toward this end, utilizing novel daily data on FX forward flows of Israeli IIs for a recent (roughly) 13-year sample period that saw little variation in local and foreign monetary policy rates, we center our analysis around a straightforward litmus test for the importance of this channel. (For a discussion on the external validity of our analysis, which argues that our results are externally valid for a broader sample of economies, see Section 6.) This litmus test concerns the estimation of the effect of innovations in global stock prices on USD/NIS forward and spot flows of IIs as well as USD/NIS forward and spot rates along with spreads between U.S. and Israeli interest rates at various maturities.

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

[1] Even if the covered interest parity (CIP) condition fails to hold, it is still very much reasonable to expect a positive relation between forward and spot rates. See the model from Section 2 for more details.

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. Throughout this paper's terminology, since 84% and 81% of IIs' volume of FX forward and spot trades are done in dollars, respectively, we treat USD/NIS as the sole currency pair underlying IIs trades with the term 'dollar' and 'foreign currency' being equivalent in our terminology. (The remaining 16% and 19% shares of the flows are nevertheless included in our FX flows data and are translated into dollar terms.) Moreover, given the smallness of the local economy underlying the equity hedging channel, we treat the terms 'foreign' and 'global' as equivalent. We hence use them interchangeably throughout this paper's terminology.

Lastly, FX forward flows arise from two contract types: standard (one-leg) forward contracts and swap contracts.[2] As discussed and explained on Page 12, the data does not suggest a meaningful role for FX swaps in the equity hedging channel while supporting a meaningful such role for standard forward contracts; Hence, throughout this paper we treat the term 'standard (non-swap-linked) forward flows' as terminologically equivalent to 'forward flows', in line with our desire to streamline the exposition.

Underlying Framework. This part lays out a simple structural partial equilibrium model of the FX forward market. The backbone of the model is a local II that sells foreign currency forwards to hedge part of its foreign equity position, with these forwards sold to a local importer who desires to hedge its import purchases. This setting results in the following result: there is a perfectly elastic supply curve of foreign currency forwards which shifts rightward along the importer's downward-sloping demand curve when the II's foreign equity position's value rises. This downward pressure on the forward rate translates into a decline in the spot rate owing to a global arbitrager's activity which produces a positive equilibrium relation between forward and spot rates (albeit in tandem with a violation of the CIP condition).

The second part of the paper tests the model's prediction, i.e., that an increase in foreign stock prices leads to greater (lower) forward flows (forward and spot rates). This prediction is

[2]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 essence of the equity hedging channel of exchange rate determination.

Econometric Model. The second part of the paper studies the effect of increased foreign equity prices on aggregate USD/NIS forward and spot flows as well as USD/NIS forward and spot rates along with spreads between U.S. and Israeli interest rates at various maturities. We also estimate the response of USD/NIS cross-currency basis to ascertain the possible role of conditional CIP violations.

We measure foreign equity prices with the closely followed MSCI ACWI index which covers 23 developed economies and 25 emerging economies. We also have micro data on IIs' portfolios' regional weights that allows us to directly measure IIs' foreign equity returns but this data is only available from November 2015 onwards. Hence, we confirm that the baseline results are robust to using this data to measure foreign stock price innovations (see robustness check from Appendix B.1 from the online appendix to this paper) and, importantly, we also confirm that our MSCI return series is very strongly correlated with the latter micro-regional-weights based return series (aggregated using IIs' foreign equity shares). (The two series have a correlation of 98.2%).

We use a Bayesian local projection model which we present in Section 4.2.1. 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.

First, a one standard deviation innovation to MSCI induces significant selling of dollar forwards, peaking (in absolute terms) at 2 million dollars on impact and accumulating to 300 million dollars after about 1.5 years. Viewed through the lens of our structural model, this significant selling of dollar forwards implies a persistent rightward shift in the supply of USD/NIS forwards. The response of USD/NIS spot flows is much smaller in magnitude relative to that of forward flows. The smaller response in the spot market indicates that the bulk of the activity in the USD/NIS FX market following a rise in MSCI is taking place in the forward market, bolstering confidence in the interpretation of our results as being mainly driven by the equity hedging channel. Further reinforcing this confidence is the fact that for the pre-COVID sample the selling of spot dollars is not significant while that of dollar forwards continues to be significant, with the MSCI innovation explaining 35%-43% of the variation in the spot rate (even slightly higher than

the corresponding baseline variation shares). (The pre-COVID sample based results are shown in Appendix B.3 of the online appendix to this paper.)

Second, both USD/NIS forward and spot rates significantly and persistently decline following the MSCI innovation, with roughly 33% of their impact forecast error variation being accounted for by this innovation. Moreover, their decline is very similar and takes place in tandem with an economically negligible response of U.S. and Israeli interest rates, which accords with the insignificant estimated response of USD/NIS cross-currency basis we find for all benchmark forward contract horizons. That is, in accordance with our structural model, the MSCI innovation seems to produce a rightward shift in IIs' supply of dollar forwards which in turn results in lower forward and spot rates, where the positive conditional relation between these two rates embodies unchanging CIP deviations. (USD/NIS cross-currency basis is negative on average in our sample period. So the insignificant response of the USD/NIS cross-currency basis should be interpreted as implying that this basis is unchanged *conditional* on MSCI innovations.)

Related Literature. To the best of our knowledge, this paper constitutes the first empirical investigation of the equity hedging channel of exchange rate determination that uses daily FX forward flow data to quantify this channel. The daily frequency of this data allows us to quite cleanly identify this channel. We now turn to discuss the literature that motivates our work.

The determinants of exchange rate behavior have long alluded researchers (Meese and Rogoff (1983)), with the data offering only a weak connection between exchange rates and macroeconomic aggregates, thus leading to the coining of the term 'exchange rate disconnect puzzle' by Obstfeld and Rogoff (2000). Recently, meaningufl advancement has been made on resolving this puzzle by turning to the relation between equity and credit markets and FX markets. Lustig et al. (2011) were the first to produce empirical evidence supporting a global-risk-based view of exchange rate determination. Offering a post-GFC resolution to the exchange rate disconnect puzzle, Lilley et al. (2019) show that proxies for global risk appetite explain a significant share of currency returns after the GFC; the particular post-GFC element of Lilley et al. (2019)'s findings is possibly related to the findings from Avdjiev et al. (2019) which show that post-GFC CIP deviations are representative of risk-taking capacity in global capital markets and are accordingly systemat-

ically related to the dollar exchange rate. And Hau and Rey (2004) (using a VAR) and Camanho et al. (2022) (exploiting fund-level international equity allocations) provide significant empirical evidence for an equity portfolio rebalancing channel (whose theoretical underpinning is from Hau and Rey (2006)).

While the equity portfolio rebalancing channel focuses on the relation between foreign equity markets and FX *spot* markets, our paper studies the equity hedging channel of exchange rate determination and therefore focuses on the relation between foreign equity markets and FX *forward* markets. An additional noteworthy difference between the equity hedging channel we study and the portfolio rebalancing channel is that the underlying impulse of the former is a foreign equity innovation while that of the latter is an innovation to the equity return *differential* between foreign and local equity markets. There are two papers that are close to ours in studying the role of hedging in exchange rate determination, which we turn to discuss next.

The first is Melvin and Prins (2015), who assume that IIs' hedges are most typically adjusted once per month at the end of the month (around the 4 PM fix). Therefore, they use equity returns up until the second to last day of the month as a proxy for equity-price-induced hedging to test the relation between equity hedging and exchange rates for the 2004–2013 period for the eight most liquid currencies; they find a statistically significant negative relation, leading them to conclude that hedging demand plays a role in exchange rate determination. The second paper is Liao and Zhang (2020), which studies a debt hedging channel of exchange rate determination. They insightfully connect country-level measures of net external financial imbalances to exchange rates, while interpreting this channel as debt- rather than equity-based.

The main dimension along which our paper differs from Melvin and Prins (2015) is our daily data on IIs' FX forward flows which allows us to identify the equity hedging channel quite cleanly. (Our data shows that IIs do hedging trades not on one particular day as Melvin and Prins (2015) assume but rather quite dispersedly over the month.) This dimension also sets our paper apart from Liao and Zhang (2020)'s analysis but we also differ from them along three additional dimensions which we now turn to discuss.

First, their paper does not set out to study the equity hedging channel, focusing instead on a debt hedging channel while using data that excludes FX forward flows. As Sialm and Zhu (2022)

document, while 90% of U.S. international fixed income funds use FX forwards, they hedge, on average, only 18% of their FX exposure. Considering that regulatory FX hedging constraints on many local IIs do not differentiate between debt and equity instruments, and considering the available survey evidence on local IIs' significant foreign equity hedging practices (see Page 29 for more details on both points), the debt and equity hedging channels seem to stand on fairly equal grounds in terms of their underlying motivating evidence on local IIs' hedging practices.

Second, we do not view our channel as hinging on the direction of an economy's net external balances. Rather, as explained in Section 6, it hinges on meaningful foreign equity positions of local IIs that are in turn meaningfully hedged, with these IIs belonging to a sufficiently small economy so that a counteracting hedging mechanism from the world economy does not prevail and eliminate the local one. And, third, at the core of their debt hedging channel is a CIP-deviation-based mechanism stemming from global arbitrageurs' concave return from investment in non-swap related activity, an element which is omitted from our framework due to the negligible cross-currency basis response to MSCI innovations we find in the data (also see related discussion on Page 12).

Outline. The remainder of the paper is organized as follows. In the next section the theoretical motivation for this paper is laid out. The subsequent section provides institutional background of Israeli IIs' activity. Section 4 provides a description of the data and methodology used in this paper. Section 5 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). Section 6 discusses the external validity of our results. The final section concludes.

2 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. The framework is a partial equilibrium of the FX forward market consisting of two time periods (t and $t+1$) and three agents. The first is a local institutional investor (II) who sells foreign currency forwards so as to hedge its position in foreign equity markets. The second is a local importer (IM) who demands foreign

currency forwards for its import activity. And the third is a global arbitrageur (GA) whose activity produces violations from CIP that are unaffected by foreign equity prices, in line with our empirical evidence.

We start our depiction of the model with a presentation of the supply side of the forward market by presenting the local II's supply of foreign currency forwards. We then show demand for foreign currency forwards by the local IM followed by an exposition of GA's activity. We end the section by defining equilibrium and presenting the model's main prediction.

2.1 Supply of Foreign Currency Forwards

Local II's Hedging. We assume that the local II hedges a share h of the FX risk of its period t foreign equity position, which we denote by A_t. (This position can be thought of as the product of some fixed quantity of foreign stocks and the price of these shocks.) In particular, this hedging is done by the local II through the selling of $FCF_{t,II} = hA_t$ foreign currency forwards on the forward market to the IM at FX forward rate $F_{t,t+1}$.

Local II's Supply of Foreign Currency Forwards. $FCF_{t,II} = hA_t$ represents local II's supply of foreign currency forwards. Note that this supply is perfectly inelastic given that it has no dependence on $F_{t,t+1}$. Importantly, a positive shock to global stock prices induces a rightward shift in the supply of foreign currency forwards because it produces a rise in A_t.

2.2 Demand for Foreign Currency Forwards

General Setting. The demand side of the forward market is governed by a local importer (IM) who buys in period t $FCF_{t,IM} = P_{t,W}Q_{t,IM}$ foreign currency forwards at forward rate $F_{t,t+1}$ to fund the purchase of its imports of intermediate input quantity $Q_{t,IM}$ at foreign price $P_{t,W}$ (in foreign currency units).[3] It is effectively assumed here that the actual payment of this purchase will be

[3]Our assumption that the IM is the local II's counterparty is backed by both unconditional and conditional evidence shown later in the paper. For simplicity, we assume that the local IM funds its import purchases entirely through the forward market. While it is possible to extend this framework to allow for some of the purchases to be made at the realized future spot rate, the latter simplifying perfect hedging assumption is consistent with the fact that the real sector in Israel has bought on a net basis over our sample period six times more foreign currency on the forward market than on the spot market, indicating that most of importers' FX flow activity takes place on the forward (rather than spot) market.

made in period $t+1$ (i.e., the import deal is made with trade credit). The local IM's imported intermediate inputs are in turn used to produce and sell output quantity $M(Q_{t,IM})$ at local price $P_{t,L}$ (in local currency units) in the local economy, where $M(Q_{t,IM})$ is an increasing and concave function.

Local IM's Expected Profit. Given the setting described above, we can write local IM's profit as

$$\Pi_{t,IM} = P_{t,L}M(Q_{t,IM}) - P_{t,W}Q_{t,IM}F_{t,t+1}. \tag{1}$$

Optimal Demand for Foreign Currency Forwards. To derive the optimal demand for foreign currency forwards, we let the local IM maximize its expected profit from Equation (1) with respect to $Q_{t,IM}$. The solution to this maximization problem obtains local IM's optimal demand for imported intermediate inputs from which it is straightforward to compute the demand for foreign currency forwards $FCF_{t,IM} = P_{t,W}Q_{t,IM}$. The FOC of this problem is

$$P_{t,L}M'(Q_{t,IM}) = P_{t,W}F_{t,t+1}. \tag{2}$$

To see that the demand for foreign currency forwards is downward-sloping, we implicitly differentiate Equation (2) with respect to $F_{t,t+1}$ so as to obtain the first derivative of $Q_{t,IM}$ with respect to $F_{t,t+1}$ and then insert this derivative in the derivative of $FCF_{t,IM}$ with respect to $F_{t,t+1}$ to obtain the effect of the latter on the former:

$$\frac{\partial Q_{t,IM}}{\partial F_{t,t+1}} = \frac{P_{t,W}}{P_{t,L}M''(Q_{t,IM})} < 0, \forall Q_{t,IM}, \tag{3}$$

$$\frac{\partial FCF_{t,IM}}{\partial F_{t,t+1}} = \frac{\partial\left\{P_{t,W}Q_{t,IM}\right\}}{\partial F_{t,t+1}} = \frac{P_{t,W}^2}{P_{t,L}M''(Q_{t,IM})} < 0, \forall Q_{t,IM}, \tag{4}$$

where the assumed concavity of M was used to establish the negative relation between $F_{t,t+1}$ and $Q_{t,IM}$, which in turn ensures the downward-sloping nature of the demand for foreign currency forwards. This constitutes an important result because it allows us to interpret the effect of a rise in A_t on the supply of foreign currency forwards (discussed in Section 2.1) through the lens of

a demand-supply framework in which a perfectly inelastic supply curve intersects a downward-sloping demand curve in the forward market. In particular, the prediction that a shock to global stock prices will produce a rightward shift in the (perfectly inelastic) supply of foreign currency forwards can now be interpreted as happening along a downward-sloping demand curve and thus will lead in equilibrium in the forward market to a rise in foreign currency forward flows along with a decline in the FX forward rate.

2.3 Global Arbitrageur

We now introduce into the model a global arbitrageur (GA) that facilitates the determination of the FX spot rate, which we denote by S_t. This facilitation is an outcome of the following cross-currency swap. (While left unmodeled, the counterparty to this swap trade can be thought of as a broker-dealer institution.) The GA buys spot $Q_{t,GA}$ foreign currency units and sells spot $Q_{t,GA}S_t$ local currency units while simultaneously buying forward $Q_{t,GA}S_t(1+i_{t+1,L})$ local currency units and selling $Q_{t,GA}(1+i_{t+1,W})$ foreign currency units at forward rate $F_{t,t+1}$ (with $i_{t+1,L}$ and $i_{t+1,W}$ representing the local and foreign risk-free interest rates, respectively).

Haircut. We follow Ivashina et al. (2015) and Liao and Zhang (2020) and assume that a haircut is applied to GA's swap trade in the amount of $\kappa Q_{t,GA}$, with $0 < \kappa < 1$. That is, the GA is required to deposit a share κ of its swap position to its (unmodeled) broker-dealer counterparty. This initial margin requirement constitutes a cost for the GA that is equal the foregone interest earnings that it would be able to earn absent this requirement (i.e., $\kappa Q_{t,GA} i_{t+1,W}$). This haircut-induced cost has merit in producing a violation of CIP that accords with that we see in our data[4] in that it exists unconditionally but does not play a role in the equity hedging channel.

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

$$Q_{t,GA}\frac{S_t}{F_{t,t+1}}(1+i_{t+1,L}) - Q_{t,GA}(1+i_{t+1,W}) - \kappa Q_{t,GA} i_{t+1,W}. \tag{5}$$

[4]This violation is of course not specific to our data given the robust finding from the post-GFC sample for various currencies on negative cross-currency basis with respect to the dollar (see, e.g., Du et al. (2018)).

The FOC that results from maximizing the profit from Equation (5) with respect to $Q_{t,GA}$ is

$$\frac{S_t}{F_{t,t+1}}(1 + i_{t+1,L}) = 1 + i_{t+1,W} + \kappa i_{t+1,W}, \tag{6}$$

where $\frac{S_t}{F_{t,t+1}}(1 + i_{t+1,L})$ represents the synthetic, CIP-implied foreign (gross) risk-free interest rate which is clearly higher than the actual one owing to the haircut-induced cost. In other words, Equation (6) implies a negative cross-currency basis that is caused by the swap trade's haircut-induced friction with this basis unaffected by A_t. Also noteworthy is the fact that this equation implies a positive relation between the FX spot rate and the FX forward rate; this is important for our purposes as it implies that in our model the sign (as well as magnitude in percentage terms) of the FX spot rate's response to changes in foreign equity prices is the same as that of the forward rate.

2.4 Model Equilibrium

We define equilibrium in the FX forward market as the equality $FCF_{t,II} = FCF_{t,IM} = FCF_t$, with FCF_t denoting the equilibrium level of FX forward flows and where $FCF_{t,II} = hA_t$ and $FCF_{t,IM} = P_{t+1,W}F_{t,t+1}Q_{t,IM}$. The latter two equations, integrated with the equilibrium condition $FCF_{t,II} = FCF_{t,IM} = FCF_t$, join the FOCs of the local IM's, and GA's problems (i.e., Equations (2), and (6)) in forming a system of four equations in four unknowns (FCF_t, $Q_{t,IM}$, $F_{t,t+1}$, and S_t) which represents our model's equilibrium.[5]

Relation Between A_t and FCF_t, $F_{t,t+1}$, and S_t. A rise in A_t (as a result of a shock to global stock prices) implies a rightward shift in the perfectly inelastic supply of foreign currency forwards that takes place along a downward-sloping corresponding demand curve, where the latter is not affected by either A_t or h. This implies in turn that in equilibrium there must be a rise (fall) in quantity (price) of foreign currency forwards (i.e., a rise (fall) in FCF_t ($F_{t,t+1}$)).

Moreover, Since FOC (6) implies a positive and proportional relation between S_t and $F_{t,t+1}$ which is not dependent on A_t, the equilibrium prediction just noted for $F_{t,t+1}$ must also carry over to S_t (and in a one-to-one relation in percentage terms). Hence, in sum, we can deduce that a shock

[5] It is noteworthy that a proof that relies on a fixed-point argument for the existence and uniqueness of a solution to this four-equation system is available upon request from the authors.

to global stock prices is predicted to reduce the spot rate in the same magnitude (in percentage terms) as it does the forward rate.

3 Institutional Background

This section lays out information about the IIs in Israel and the environment in which they operate.

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,[6] and life insurance policies.[7] IIs are important players in the Israeli financial market, managing 607.7 billion dollars on behalf of the public as of December 2020, which is 44% of the public's entire financial asset portfolio and 141% 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.[8]

[6]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.

[7]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 excluded from the list of entities that comprises our sample.

[8]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.

It was only by the end of 2009 that Israeli IIs reached a double-digit level of foreign asset holdings as a share of their total assets. In tandem with this landmark, they began to hedge their foreign investments more aggressively, recording an FX hedge ratio (share of foreign assets' value which is hedged using forwards, swaps, and options) of 29% at the end of 2009.

Basis for Abstraction from FX Swaps. The previous section's theoretical framework centers the equity hedging channel around forward contracts between IIs and importers, where the latter posses downward-sloping demand curves for foreign currency forwards. An alternative framework for the equity hedging channel would center around FX swap contracts between IIs and global arbitrageurs, where the latter have a concave net return from their alternative non-swap-related investment activities which in turn produces for them a downward-sloping demand for foreign currency forwards. Such frictional FX swap setting is used in Ivashina et al. (2015) to study the effect of non-U.S. banks' credit quality shocks on these banks' capacity to lend in dollars relative to euro; and in Liao and Zhang (2020) to study a *debt* hedging channel. At the core of this frictional FX swaps setting is a deviation from CIP, i.e., non-zero cross-currency bias; hence, a decline in the forward rate in this setting occurring in response to a rightward shift in IIs' supply of foreign currency swap-linked forwards is equivalent to a decline in cross-currency basis. (Equation (2) from Ivashina et al. (2015) is a formal demonstration of this equivalence.)

In our econometric analysis we have found that USD/NIS cross-currency basis does not meaningfully move in response to foreign equity innovations. And we also confirmed this finding for several other economies whose institutional background seems conducive to a meaningful equity hedging channel (see Section 6.2). Hence, the data rejects a meaningful role for FX swaps in the equity hedging channel while favoring a meaningful such role for standard, one-leg forward

contracts between IIs and importers.[9]

IIs' Exposure to FX Risk. To gain an understanding of the unconditional behavior of IIs' foreign assets as a share of total assets, foreign equities as a share of foreign assets, the FX hedge ratio, and the USD/NIS exchange rate, Figure 1 plots these variables in monthly frequency for the monthly sample of 2011:M4-2021:M8, which corresponds to the daily sample of non-II sectors' forward flows data shown at the end of this section. A salient feature of this figure lies in the broadly steady rise in the share of total assets being allocated to foreign assets (solid line), which peaks in June 2021 at 31.7%. By contrast, and not surprisingly given foreign equities values' relatively large fluctuations, foreign equities as share of foreign assets (round dotted line) exhibit much less stability; especially notable are the periods 2015:M7-2016:M4 and 2020:M3, for which the foreign equites share in foreign assets declined considerably owing to significant U.S. stock market sell-offs. Nevertheless, the latter share is considerable for the whole sample period recording a mean of 47% and even surpassing the 50% mark toward the end of the sample.

This high reliance of IIs on foreign assets in general and foreign equities in particular necessitates some hedging of these positions' FX risk. Accordingly, there is an average FX hedge ratio (square dotted line) of 36.8% for the sample, i.e., IIs on average hedge 37% of their FX-sensitive positions, which represents meaningful hedging on the part of IIs. While one might expect that the USD/NIS spot rate (dashed line) would move in opposite direction to that of the FX hedge ratio, i.e., IIs would be more prone to hedging in an appreciating USD/NIS spot rate environment, Figure 1 does not conclusively show this to be the case. E.g., while in 2011-2014 these two variables do seem to move in opposite directions, from 2015 onwards the general appreciation trend of the

[9]The real sector in Israel is a minor (and net seller, not buyer, of swap-linked forwards) player in the swap market, indicating that importers do very little hedging via FX swaps. IIs' *net* swap average daily volume activity amounts to 133.7 million dollars (11.4% of the entire swap market), relative to a 62.2 million dollar non-swap-linked forward volume activity (25.7% of the entire forward market). (The *net* swap number is the absolute value of the difference between swap trades that are long on the dollar (i.e., those whose first leg is a selling of spot dollars and second leg is a buying of forward dollars) and those that are short on it (i.e., those whose first leg is a buying of spot dollars and second leg is a selling of forward dollars).) The accumulation of the raw values of these net swap trades amounts to -61.2 billion dollars, which is lower than the -77.8 billion dollars resulting from the accumulation of raw non-swap-linked forward dollar trades. This meaningful difference indicates that IIs' selling of non-swap-linked forward dollars is a more dominant hedging tool for IIs than the selling of swap forward dollars.

USD/NIS spot rate coexists with a mostly falling trend of the FX hedge ratio.

IIs' FX Trading. As noted above, IIs hedge a considerable portion of their foreign asset position. Such hedging can be done with either non-swap-linked and swap-linked FX forwards or FX options. (In accordance with our discussion from Page 12, the forward flow data we present below abstracts from swap-linked forward flows and simply refers to 'non-swap-linked forward flows' as 'forward flows', in line with the terminology used in the rest of this paper.) In Israel the latter hedging device is a negligible hedging trading tool and we therefore abstract from them in both the descriptive analysis shown here and the empirical analysis that follows this section.[10] Alongside their hedging related trading activity, Israeli IIs also trade on the FX spot market. Figure 2 shows the evolution of accumulated daily forward (solid line) and spot (dashed line) flows for 4/26/2011-8/18/2021. (This sample is chosen to accord with the non-II sectors' forward flows data availability shown below.) Negative accumulated flows' values represent the accumulated selling of foreign currency; positive values represent the accumulated buying of foreign currency.

There are two noteworthy facts that are borne out by Figure 2. First, Israeli IIs conduct hedging predominantly through selling dollar forwards, as reflected by the significant accumulation of IIs' dollar forwards sold which reaches a peak of 77.8 Billion dollars at the end of the sample. (The accumulation of the selling of dollar forwards on the part of IIs represents a building up of the FX short position associated with this selling.) Second, IIs also appear to be quite active on the spot market, purchasing an accumulated amount of 54.2 Billion dollars over the sample. But this buying of spot dollars is smaller than the selling of dollar forwards which points to the centrality of the latter in the way IIs trade in FX.

Sectoral Comparison of Forward Flows. Figure 3 shows the evolution of accumulated daily forward flows for 4/26/2011-8/18/2021 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 forward transactions involving Israeli exporters and importers; banking sector, which includes

[10] Not even a single option trade was done by IIs in 78.6% of the sample's trading days. And even when IIs do trade in options, the role that these trades plays in hedging appears null with a daily average notional flow value of only -0.1 millions dollars.

the Israeli commercial banks; 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); and foreign sector, which includes all types of foreign economic units.

This figure demonstrates that the sole effective sellers of dollar forwards among market participants are IIs, against which the two main buyers of dollar forwards are the real and banking sectors. It is noteworthy that the more central buyer of dollar forwards throughout the bulk of the sample is the real sector; only at the end of the sample do local banks accumulate dollar forward purchases that are quantitatively comparable to those of the real sector. The centrality of the real sector as buyer of dollar forwards is consistent with the modeling approach taken in the previous section which assumes that importers are the II's counterparty in their forward selling trades. In the empirical analysis we will demonstrate the role of the real and banking sectors as counteprarties to IIs' forward selling *conditional* on a shock to global stock prices.

4 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.

4.1 Data

Our data is daily and in general covers the period 10/31/2008-8/18/2021. (There are a few exceptions to this coverage related to FX flows of non-II sectors which we specify below when discussing these specific series.) The specific starting and ending points of this approximate 13-year period are dictated by the availability of the Bank of Israel (BOI) proprietary data we have on FX flows of Israeli IIs. 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.

4.1.1 IIs' FX Flows Data

We have proprietary daily data for Israeli IIs on FX flows by type (spot, forward, swap, and option). Since option trades are rather rarely made by IIs in Israel, in our econometric analysis we focus on spot and forward flows where the latter is our main variable of interest given its focal role in the equity hedging channel of exchange rate determination. And see Page 12 for an explanation for our abstraction from swap flows in our econometric analysis.

Forward FX Flows. This variable measures (in dollars) the daily net transaction flow from buying and selling U.S. dollars on the FX forward market. The raw data has a negative value for this variable for a given observation when an II was a net seller of dollar forwards on the corresponding day. Nearly all of IIs' forward contracts have maturities of up to 4 months, with 65% of them having maturities of up to 1 month.[11]

Spot FX Flows. This variable measures (in dollars) the daily net transaction flow from buying and selling dollars on the FX spot market. The raw data has a negative value for this variable for a given observation when an II was a net seller of spot dollars on the corresponding day.

4.1.2 Other Sectors' FX Flows Data

We also have forward and spot flow data for four additional sectors: real sector, which represents the net FX flows from forward transactions involving Israeli exporters and importers; banking sector, which includes the Israeli commercial banks; 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); and foreign sector, which includes all types of foreign economic units. The starting date for this sample for these sectors is 4/26/2011 and therefore their coverage (4/26/2011-8/18/2021) is smaller than that of the II sector (10/31/2008-8/18/2021).

[11] The average maturity of IIs' forward contracts is 41.6 days while that of the real sector's forward contracts is 98.4 days. This maturity gap between the two major short and long dollar position holders speaks to the fact that local banks, being market makers in the USD/NIS FX market (i.e., the intermediaries doing the forward trades with these two sectors), face the task of managing the risk from this maturity mismatch.

4.1.3 Macro-Financial Data

We use several daily frequency macro-financial variables in our analysis, both foreign and local, all of which cover the IIs' FX flows' sample (10/31/2008-8/18/2021). All of these variables are taken from Bloomberg and their values are end-of-day quotes.

MSCI ACWI IMI Index. The MSCI All Countries World Index Investable Market Index (MSCI ACWI IMI; henceforth MSCI) is our measure of foreign stock prices, the focal impulse underlying the equity hedging channel of exchange rate determination. This widely quoted index covers 23 developed markets and 25 emerging markets (roughly 85% of the investable global equity market). The leading regions in terms of market weight in this index are the U.S. (51.6%), Europe (22.2%), Asia (13.3%), BRIC (5.1%), and Canada (3.1%) (these are average annual weights over 2011-2021, reflecting the time-varying nature of this index's regional weights).

USD/NIS Spot. The USD/NIS spot rate is our measure of the spot exchange rate.

USD/NIS Forward. We use 1-, 3-, 6-, and 12-month USD/NIS forward rates in our analysis. Each of these time horizons corresponds to the future horizon at which the relevant FX flow will change hands at the specified forward rate.

Interest Rates. In accordance with the time horizons for the forward rate data, we also look at the responses of the 1-, 3-, 6-, and 12-month London Interbank Offered Rate (Libor) as our measure of foreign risk-free interest rates; and the 1-, 3-, 6-, and 12-month Tel Aviv Inter-Bank Offered Rate (Telbor), which are based on interest rate quotes by a number of commercial banks in the Israeli inter-bank market, as our measure of local risk-free interest rates.

4.2 Estimation

We estimate a daily frequency Byesian local projection model that consists of two blocks. The first contains an auto-regressive (AR) equation in the log-first-difference of the MSCI index variable.

And the second contains local projection regressions of an outcome variable of interest on the MSCI shock from the latter AR equation.

4.2.1 Econometric Model

Specification. We estimate the system

$$\Delta MSCI_t = B_1 \Delta MSCI_{t-1} + B_2 \Delta MSCI_{t-2} + ... + B_p \Delta MSCI_{t-p} + B_c + u_t, \tag{7}$$

$$y_{t+h} - y_{t-1} = \alpha_h + \Xi_h \hat{u}_t + v_{t+h}, \tag{8}$$

where t indexes time at daily frequency; $\Delta MSCI_t$ is log-first-difference of the MSCI index; B_i are scalar coefficients; p denotes the number of lags, which we set to 20 in accordance with lag length criteria tests;[12] B_c is a constant; and $u_t \sim i.i.d.\ N(\mathbf{0}, \sigma_u^2)$ is the foreign stock price innovation where σ_u is its standard deviation; $\hat{u}_t$ is the estimated residual from Equation (7), normalized to have unit variance; α_h is an horizon-specific intercept, with h being regression's rolling horizon ($h = 1, ..., 500$); Ξ_h is the effect of a one standard deviation MSCI index shock on the relevant outcome variable at horizon h;[13,14] and v_{t+h} is the residual of Equation (8).

For future reference, let the stacked $(p+1)$x1 $B = [B_1, ..., B_p, B_c]'$ matrix represent the coefficient matrix from Equation (7) such that B and σ_u correspond to the parameters to be estimated from this equation. And let $Q_h = [\Xi_h, \alpha_h]'$ matrix represent the coefficient matrix from Equation

[12] AIC and HQIC criteria tests recommend 20 lags while BIC recommends 18 lags. We show the robustness of our results to alternative lag choices in online appendix's Section B.4.

[13] Stock prices (logged MSCI) and spot and forward rates, whose non-stationarity could not be rejected by the Augmented Dicky-Fuller test, are all entered in cumulative differences (i.e., $y_{t+h} - y_{t-1}$) so as to remove any potential stochastic trends and thus make the data stationary, which is necessary for validating the local projections estimation and inference approach undertaken in this paper. Interest rates are stationary according to the Augmented Dicky-Fuller test and hence entered into the rolling regression in levels. Spot and forward flows, because of their trend-stationarity as indicated by the Augmented Dicky-Fuller test, are also entered in levels but also with a trend term being added in each rolling regression so as to account for their trending behavior.

[14] Note that results from estimating the response of the MSCI index from Equation (8) are similar to those obtained from iteration of the AR coefficients from Equation (7) at short horizons but the iterated impulse responses effectively remain constant as the horizon progresses whereas the local projection ones show some decay. The difference between the two impulse response objects speaks to the finite-sample result from Plagborg-Møller and Wolf (2021) that iterated finite-order VAR impulse responses do not coincide with local projection based impulse responses at horizons that are longer than the VAR's order. Nevertheless, for internal consistency, we report the local projection based impulse responses for the MSCI index instead of the VAR-based ones.

(8) and $\sigma_{\epsilon,h}$ represent the standard deviation of the residual from Equation (8) (for each horizon h). Hence, the parameters to be estimated from Equation (8) can be summarized by the coefficient matrix Q_h and residual variance $\sigma^2_{\epsilon,h}$.

Estimation Method. We estimate Equation (7) jointly with Equation (8) 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 (7) and the second contains Equation (8). 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 (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.)

Two- Versus One-Step Estimation. It is noteworthy that it is asymptotically equivalent to estimate System (7)-(8) as a single equation by replacing $\hat{u}_t$ in Equation (8) by $\Delta MSCI_t$ and adding as explanatory variables the lagged log-first-differences of the MSCI index. And results are expectedly very similar across the two- and one-equation formulations. However, formulating our model in the former two-step estimation setup puts forward two general advantages relative to the one-equation setup.

First, the two-step estimation procedure allows to estimate the MSCI innovation in a coherent

manner across all considered outcome variables by not imposing on the two samples underlying Equations (7)-(8) to be the same. This in turn also allows to increase efficiency in the estimation of the MSCI innovation through the facilitation of greater sample size for this estimation. While for the IIs' FX flows data this is not crucial as we begin the sample underlying Equation (7) just $p = 20$ observations earlier than the start of Equation (8)'s sample, for the other sectors' FX flows data this coherency and efficiency related advantage is much more prominent as the latter data starts roughly 2.5 years later than the IIs' FX flows data. While the one-step procedure would require us to lose this roughly 2.5-year long sample, the two-step estimation approach enables us to estimate Equation (7) on the *same* sample for all sectoral FX flows variables considered in the estimation of Equation (8) and thus have the benefit of greater coherency and efficiency.

Second, and related to the first advantage, the two-step procedure's computational burden is considerably lower than that of the one-step procedure through the former's conservation on degrees of freedom. In particular, given that $p = 20$ and the rolling horizon goes up to 500, the one-step procedure requires estimating 10,000 more coefficients than the two-step procedure.

5 Empirical Evidence

This section presents the main results of the paper. All impulse responses are computed in response to a one standard deviation innovation to the MSCI index. In all considered figures, solid lines represent the median responses of the corresponding variable to a one standard deviation size innovation to the MSCI index while dashed lines depict 95% posterior confidence bands; 500 daily horizons are considered, i.e., impulse responses are shown for roughly two years after the shock (there are approximately 250 trading days in a calendar year). To further our understanding of the quantitative importance of the equity hedging channel, we also present forecast error variance (FEV) decomposition results for our FX market variables.[15]

[15]For the FEV estimation, we utilize the general FEVD formula from Gorodnichenko and Lee (2020) (termed in their paper as 'LP-A') for FEV decomposition estimation in the local projections framework, which was shown by Gorodnichenko and Lee (2020) to be asymptotically valid and to perform well in small samples. While this formula does not ensure that the estimated FEV share be below one, the only variable for which the estimated FEV share exceeds one (and doing this only at long horizons) is the accumulated forward flows variable. Hence, for this variable we apply the 'LP-B' formula from Gorodnichenko and Lee (2020) which prevents this exceedance from happening.

5.1 MSCI and FX Market Variables

MSCI index. The first sub-figure of Figure 4 presents the response of the MSCI index to its own innovation (of one standard deviation size). As is clear from this sub-figure, the MSCI index jumps on impact by 0.9% to its own innovation and is persistently higher than its pre-shock value, leveling off at a roughly 0.55% higher value after two years. This immediate and persistent response of the MSCI index is the driving impulse of the equity hedging channel. We now turn to learn what this impulse does to the NIS/USD FX market, in terms of both spot and forward quantities and prices. (The discussion on the responses of the remaining variables of this figure (local and U.S. interest rates) is deferred to Section 5.3.)

USD/NIS Spot and Forward Rates. The first sub-figure of Figure 5a gives the response of the spot USD/NIS exchange rate while the following 4 sub-figures show the responses of the 1-, 3-, 6-, and 12-month USD/NIS forward rates. For both the spot and forward rates, the innovation to the MSCI index produces an immediate and significant appreciation of the shekel against the dollar which troughs on impact at -0.28% and then gradually begins to decay reaching -0.14% after 2 years.

The effectively identical responses of spot and forward rates are consistent with the negligible responses of interest rates from Figure 4 (to be discussed in the next section) as well as the conditional inviolability of CIP (also discussed in that section). And that such a persistent and significant exchange rate appreciation takes place in the USD/NIS forward market following an MSCI index innovation constitutes a necessary condition for a meaningful equity hedging equity channel of exchange rate determination.

The first 5 sub-figures of Figure 5b show the FEV of the USD/NIS spot and forwards rates that is attributable to the MSCI index innovation. These FEV results serve the purpose of ascertaining the importance of the equity hedging channel for explaining variation in exchange rates. We can see from these results that the MSCI index innovation accounts for about 34% of the impact variation in the spot and forward rates, with this share rising quickly to peak at about 42% towards the end of the two-year mark. To further validate the importance of this channel, we now turn to the quantity side of the forward market while also showing the behavior of spot flows for

completeness.

USD/NIS Spot and Forward Flows. The 6th and 7th sub-figures of Figure 5a present the raw and accumulated raw responses of USD/NIS spot flows, respectively, while the 8th and 9th sub-figures show the raw and the minus of the accumulated raw responses of NIS/USD forward flows. Negative responses imply a selling of spot and forward dollars. Spot and forward flows drop significantly for 125 and 248 days straight after the MSCI index innovation, respectively. In quantitative terms, the selling of dollar forwards is much larger than that of spot dollars with the latter being only 0.34 million dollars and the former standing at nearly 7 times larger than that at 2.3 million dollars. That the increased selling of dollar forwards is rather persistent speaks to an apparent desire on the part of IIs to smooth out hedging over time rather than to increase hedging immediately with full force. Understanding the theoretical basis for this conditional smoothing of IIs' hedging can be an interesting avenue of future research. (One possible explanation for this smoothing is informational rigidity that induces IIs to gradually increase their hedging as they learn about the nature and persistence of the MSCI innovation.)

The last sub-figure of Figure 5a presents the accumulated response of FX forward flows. We also show the accumulated response as it gives an additional quantitative measure of the persistence of IIs' hedging in response to the MSCI innovation in providing a rough measure of the build up of IIs' short position on the dollar given that each sold dollar forward adds to this short position.[16] As shown in this last sub-figure, a very significant and persistent short position on the dollar is built up by the IIs in response to a rise in MSCI, peaking at 296.3 million dollars after roughly 330 horizons (at which point the accumulated spot flow response is only -38.1 million dollars). The accumulated forward flow responses dwarf the accumulated spot flow responses at all horizons, stressing the dominant role of the equity hedging channel in driving the significant and immediate exchange rate appreciation from the first sub-figure of Figure 5a. In Section 5.3 we discuss how the pre-COVID sample based results (shown in Appendix B.3 of the online appendix

[16]This is not a precise measure of their short position's response because this impulse response accumulation does not take into account the expiry of sold dollar forwards' contracts which in turn reduces the short position. Nevertheless, this accumulated impulse response function can be interpreted as representing the *gross* additions to IIs' short position conditional on the MSCI innovation.

to this paper) strengthen this claim by showing that there is no longer significant selling of spot dollars while the selling of dollar forwards continues to be significant, this in tandem with the MSCI innovation accounting for 35%-43% of the variation in the spot rate (even slightly higher than the baseline variation shares). Taken together, the post- and pre-COVID sample results point to a clear dominance of the forward flows response over the spot flows one, which in turn provides important reassurance that this paper's results are not driven by the FX-*spot*-market-based portfolio rebalancing mechanism from Hau and Rey (2004, 2006) and Camanho et al. (2022).

The 6th and 7th sub-figures of Figure 5b present the FEV of NIS/USD spot and forward flows that is attributable to the MSCI index innovation. At the impact horizon, the latter innovation accounts for less than 0.4% of the variation in spot flows while explaining 3.4% of the variation in forward flows. While these shares are both small, the still significant gap between them is consistent with the response differences for these variables and is an additional testament to the notion that the MSCI index innovation effects are propagated primarily through the forward market. This point is more vividly shown in the 8th and 9th sub figures of Figure 5b, which show the FEV shares for the accumulated spot and forward flow variables, respectively. While 52.6% of the two-year variation in the accumulated forward flows variable is accounted for by the MSCI innovation, a corresponding mere 6.7% is accounted for by the MSCI innovation for the accumulated spot flows variable.

Other Sectors' USD/NIS Spot and Forward Flows. Figure 6 shows spot and forward flows' responses of four additional sectors:[17]) real sector, which represents the net FX flows from forward transactions involving Israeli exporters and importers; banking sector, which includes the Israeli commercial banks; 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); and foreign sector, which includes all types of foreign economic units.

[17]These sectors, together with the II sector, household sector, and the BOI effectively comprise the universe of FX market participants. The household sector is abstracted from in this figure given its negligible role in the FX market. The BOI is abstracted from due to lack of access to its daily FX spot flows. (The BOI does not trade on the forward market.)

Figure 6 indicates a statistically and economically insignificant role for the foreign and financial sectors as counterparties to IIs conditional on an innovation to MSCI. By contrast, the banking sector significantly raises its buying (selling) of forward (spot) dollars and the real sector significantly raises its buying of dollar forwards while insignificantly changing its spot flows. (The selling of spot dollars on the part of the local banks and IIs, without any significant buying of such dollars on the part of the other participants for which we have such data, indicates that the BOI is the buyer of these sold spot dollars.)

To better understand the role of the banking sector and real sector as the holders of the long FX position that opposes the corresponding IIs' short FX position, Figure 7 presents the difference between raw and accumulated (in absolute terms) responses of IIs' forward flows and the summed responses of the banking and real sectors' raw and accumulated forward flows, respectively. (For completeness, responses themselves (both raw and accumulated) for all three sectors are also shown in the figure.) These results indicate that the banking and real sectors function as counterparties to IIs in building up a long position on the dollar which is insignificantly different (at all horizons) from the corresponding accumulated short position of IIs.

Israeli Local banks act as market makers in the FX market and hence their role as opposing long position holders to IIs is somewhat surprising. However, as shown in Appendix B.3 of the online appendix to this paper, this role has only been relevant for the post-COVID period; truncating the sample at the end of February 2020 renders the response of banking sector's forward flows insignificant and leaves the real sector as the only significant holder of long position that quantitatively corresponds to IIs' short position in the presence of an MSCI innovation. This robust and significant role of the real sector as opposing long position holder to IIs is consistent with the simple model from Section 2.

We end this section with a discussion on the possibility that this paper's results are driven by the insightful mechanism from Dahlquist et al. (2022), where a favorable U.S. risk appetite shock induces a rise in global stock markets in tandem with a depreciation of the dollar exchange rate by increasing (decreasing) the global supply of (demand for) U.S. goods. A testable implication of this expenditure-switching-based mechanism being a driver of our results is for our real sector to be meaningfully *selling* spot and/or forward dollars. As Figure 6 clearly shows, the real sector's

FX activity rules out the possibility that Dahlquist et al. (2022)'s mechanism is driving this paper's results given that this sector is insignificantly trading in spot dollars and is actually significantly *buying*, rather than selling, forward dollars (in line with our channel's narrative).

5.2 Interest Rates and Currency Basis

Interest Rates. Since differences between local and foreign interest rates represent the most basic and conventional mechanism of exchange rate determination, it is important to confirm that our analysis does not confound the equity hedging channel with this interest-rate-spread based textbook mechanism. Toward this end, the second to ninth sub-figures of Figure 4 depict the responses of the 1-, 3-, 6-, and 12-month Libor (U.S.) and Telbor (Israeli) interest rates; and the first 4 sub-figures of Figure 8 present the differences between responses of the Libor and Telbor rates, where each difference corresponds to one of the four considered interest rate time horizons.

These results clearly indicate a negligible role for interest rate spreads across the U.S. and Israeli economies as a propagation mechanism for the foreign stock price innovation. Both U.S. and Israeli interest rates' responses are economically negligible, resulting in their associated spreads being also immaterial with the largest response difference standing at only -1.6 basis points for the 12-month spread after 2 years. All in all, the main takeaway from these results is that the fact that most of the sample period considered in our analysis saw constant interest rates glued to their effective zero lower bounds facilitates our analysis by ruling out a meaningful interest rate spread based mechanism being present after an MSCI index innovation.

NIS/USD Cross-Currency Basis. While the structural model from Section 2 allowed for a haircut-cost-induced deviation from CIP, this deviation was not a function of IIs' foreign equity position and therefore cross-currency basis (deviation from CIP) had a null role in the model's equity hedging channel. We now confirm that the data supports this theoretical prediction. Toward this end, the last 4 sub-figures of Figure 8 depict the response of 1-, 3-, 6-, and 12-month CIP

deviations to an MSCI innovation.[18] It is clear that the response of CIP deviations (i.e. USD/NIS cross-currency basis) to the MSCI index innovation is both statistically and economically insignificant at all considered horizons. That is, notwithstanding the unconditionally meaningful negative USD/NIS cross-currency basis (see Footnote 18), deviations from CIP *conditional* on the MSCI innovation do not appear to be a meaningful propagation mechanism for the equity hedging channel.

5.3 Robustness Checks

Appendix B of the online appendix to this paper examines the robustness of the baseline results from the previous two sections along four dimensions. The first estimates the foreign equity innovation from micro data on IIs' regional portfolio weights. In particular, we construct each II's foreign equity portfolio return using its regional weights (available from only November 2015 onwards) and then aggregate the micro II-level returns into an aggregate return using IIs' foreign equity shares of the aggregate IIs' foreign equity position.[19] We then estimate our model using the latter aggregate return series instead of the MSCI return series. (We also report in the context of this robustness check that the correlation between these two return series is 98.3%, indicating that our baseline MSCI return series is an excellent measure of the actual aggregate return of IIs' foreign equity portfolio.

The second robustness check replaces the MSCI return series with the S&P 500 index return series. The purpose of this exercise is to further confirm the insensitivity of the baseline results to the specific return series being used. (The correlation between the S&P 500 index return series and

[18] CIP deviation is computed here in the standard way as the difference between the actual U.S. interest rate and the CIP-implied synthetic one. For USD/NIS, it is noteworthy that this deviation is not zero in our sample and is in fact quite meaningful with a mean of -41.47, -53.60, -61.70, and -69.66 basis points for the 1-, 3-, 6-, and 12-month deviations, respectively. (The corresponding standard deviations for these means are also quite large at 147.23, 134.73, 130.75, and 126.69 basis points.) Hence, unconditionally, we have a meaningful violation of CIP which is in accordance with other such violations observed for various other currencies with respect to the dollar since the GFC (see, e.g., Du et al. (2018) and Du and Schreger (2022)).

[19] While regional weights reflect the regional dispersion of investment in all foreign asset types, not just foreign equity, under the assumption that IIs' regional allocation of investment in non-equity foreign assets is similar to the regional allocation of foreign equity investment, the regional foreign asset weights we use should be a good proxy for the sought after regional foreign equity weights. While we concede that this is somewhat of a crude assumption, the latter similarity can still be argued to be sufficient for the validity of the robustness check associated with the micro-based foreign equity return series.

the micro-based return of IIs' foreign equity portfolio is 98.2%. And the correlation between the former series and the baseline MSCI return series is 90%.) The third robustness check truncates the baseline sample at 2/28/2020 so as to confirm that the baseline results are robust to omission of the COVID period. And the last robustness check estimates the model for two alternative lag specifications in the AR process underlying the MSCI return series equation.

The results from these four robustness checks are similar to the baseline ones, bolstering confidence in this paper's message about a meaningful equity hedging channel. It is noteworthy that for the pre-COVID sample the MSCI innovation continues to produce significant selling of dollar forwards, while accounting for 35%-43% of the variation in the spot rate, but it no longer generates significant selling of spot dollars as in the baseline case. (Recall that for the baseline case IIs' selling of dollar forwards increases by 5 times more than the selling of spot dollars in response to the MSCI innovation, albeit the latter selling being significant.) This strengthens our argument that what we pick up in the data is mostly coming from an equity hedging channel rather than a portfolio-rebalancing-induced spot market based mechanism.

6 External Validity

This section discusses the issue of our analysis's external validity, i.e., whether we can infer a broader conclusion regarding the equity hedging channel we uncover in Israel for other economies as well. We first lay out three necessary conditions for a meaningful equity hedging channel along with some survey evidence supporting the likely relevance of these conditions for a broad sample of economies. Then, we provide estimates of exchanges rate and cross-currency basis responses to an MSCI innovation for six economies which appear to belong to the latter sample.

6.1 Conditions for a Meaningful Equity Hedging Channel

An important question arising from this paper's analysis is whether its obtained results can be considered as externally valid for broader sample of economies. While the answer to this question can not be unconditionally affirmative, in what follows we discuss three conditions which are met by a large sample of economies and whose possession by an economy is vital for there to be a

meaningful equity hedging channel of exchange rate determination in this respective economy.[20]

Smallness. For a meaningful equity hedging channel of exchange rate determination, the economy at hand needs to be sufficiently small such that foreign IIs' FX exposure to this economy's currency is negligible and hence does not motivate foreign IIs to pursue the same hedging activity that is done by these economies' IIs.[21] This is an important condition because, under the fairly reasonable assumption of comovement across foreign and local stock markets, not meeting the smallness condition would facilitate a counteracting equity hedging channel that is coming from anchor currencies' large economies.

U.S. pension funds seem to have a limited position in world equities, holding only 16.7% of their total investment funds (i.e., indirect investment) in foreign (non-U.S.) equity funds (Yazdani (2020)). Making the reasonable assumption that U.S. pension funds are less inclined to make direct investment in foreign equities than they are with respect to domestic ones, the latter 16.7% is likely to go down when computing it in terms of U.S. pension funds' total investment (i.e., direct and indirect (through investment funds) investment). But even if this number were much higher, so long that the economy at hand is small, U.S. pension funds' position (or any other large economy's pension funds' position for that matter) in that economy's equities would represent a negligible share of their total assets and thus would be unlikely to warrant hedging of this position's FX exposure on the part of U.S. pension funds. Israel is a small economy that does not belong to a large monetary union and therefore meets the smallness condition.[22] And clearly this condition is met by a large sample of economies.

[20]These three conditions do not include the obvious condition of having a flexible exchange rate regime in place.

[21]Note that this smallness condition is not necessarily implied by the smallness of an economy in real terms (e.g., in GDP terms) as a small economy that belongs to a large monetary union such as the Euro area would not meet this condition.

[22]The fifth sub-figure from Figure 6 formally supports this assertion in demonstrating a statistically and economically insignificant response of foreigners' forward flows following an MSCI innovation. While this innovation was found to (as expected) increase the Israeli stock market in results not shown here (specifically by 0.64%), this innovation clearly does not generate meaningful hedging from foreign financial intermediaries.

Meaningful Foreign Equity Position. IIs in the economy at hand also need to hold a meaningful share of their assets in foreign equities so that their FX exposure would be sufficient to warrant hedging and so that this resulting hedging would also produce meaningful FX forward flows. Israeli IIs hold on average 10.9% of their assets in foreign equities over our sample period. Given the global nature of IIs' investments across the world, comparable values are expected to hold for the typical small economy. A recent report from Yazdani (2020) corroborates this reasonable expectation, documenting a 18.5% average share of foreign equities in total pension funds' assets across several small economies (Australia, Canada, Chile, Colombia, Denmark, Mexico, New Zealand, Norway, Peru, South Korea, Sweden, and Switzerland) along with a moderate standard deviation of 8%.

Hence, the foreign equity condition seems to be relevant for a broad sample of economies which includes as its subset the sample of economies adhering to the smallness condition. And the foreign equity condition is likely to become all the more applicable to the latter sample over time as IIs in small economies around the world are becoming more global in their investment strategies.

Meaningful Hedging. Clearly, IIs need to hedge a meaningful part of their foreign equity position for there to be a meaningful equity hedging channel of exchange rate determination. This third condition is also formalized in the motivating model from Section 2. While direct data on hedging-related FX flows of IIs is quite scarce (with Israel and Chile being notable exceptions), we view this hedging condition as intertwined with the second one and we therefore expect economies possessing the foreign equity condition to also posses the hedging one. (It is not uncommon for some minimal hedging of pension funds' FX exposure to be required by government regulation in the form of a minimal currency match ratio between FX liabilities and assets. E.g., according to the OECD 2019 Survey of Investment Regulation of Pension Funds, such minimal ratios are required for pension funds in Chile (50%), Colombia (50%-85%), Denmark (80%), Mexico (70%-100%), Norway (70%), Sweden (80%-100%), and Switzerland (70%).)

In accordance with this expectation, Mercer (2020) provides survey evidence for 2020 from 927 IIs across 12 countries (with a total asset value of over 1.1 trillion dollars) indicating that 42% of

the surveyed IIs hedge over 60% of their FX exposure in listed equity portfolios.[23,24] And Alfaro et al. (2021) report that Chilean pension funds are the largest holders of gross positions of FX derivatives, having the largest net short FX derivatives position and, at times, being the only net suppliers of U.S. dollars in the forward market. By the end of 2018, they held 41.3 billions of U.S dollars in FX derivatives, which is equivalent to 30% of the commercial banking credit and 15% of GDP.

6.2 Suggestive Evidence for External Validity

Economies that meet the three conditions laid out in the previous section should see their exchange rates appreciate in the presence of a rise in global stock prices. This prediction is a litmus test for the validity of these three conditions as requisites for a meaningful equity hedging channel. (Since we lack data on forward flows for economies outside of Israel, showing this exchange rate appreciation is only suggestive evidence for the presence of a meaningful equity hedging channel in the studied economies.)

The survey evidence from the previous section illuminates six economies that appear to meet that section's three conditions: Switzerland, Norway, Chile, Sweden, Colombia, and Mexico. While we do not have forward flow data for these economies, it is still of value to estimate the response of these economies' dollar exchange rates to an MSCI innovation. The reason for this is that finding a significant appreciation for their exchange rates would be suggestive for and consistent with a meaningful equity hedging channel in these economies as well as a testament to the generic relevance of these three conditions as requisites for a meaningful equity hedging channel. An additional exercise we conduct is looking at these economies' cross-currency basis to make sure that the conditional exchange rate appreciation we find in their spot rates is not meaningfully coming from a CIP-deviation-based mechanism in line with this paper's focus on non-swap-linked (rather than swap-linked) forward contracts as the underlying hedging tool of

[23] 2 countries out of the 12 that were surveyed meet the smallness condition and have a floating exchange rates (Norway, and Switzerland), with the remaining economies consisting of the UK (which violates the smallness condition owing to it economy's relatively large size), 8 Euro area member economies, and Denmark whose exchange rate is fixed to the Euro.

[24] Also see Melvin and Prins (2015) for a good summary of additional survey evidence on IIs' foreign equity portfolio hedging practices.

the equity hedging channel. (Also see related discussion from Page 12.) Towards this end, we re-estimate Equations (7) and (8) using as outcome variables for the latter equation the spot rates and cross-currency basis for these six economies relative to the dollar.

Results for Spot Rates. Figure 9a presents the these variables' impulse responses and Figure 9b presents the share of their FEV that is attributable to the MSCI innovation. For all six economies, a significant and persistent appreciation takes place, qualitatively mirroring the response observed for the USD/NIS spot rate from Figure 5a. (While the appreciation of the Swiss exchange rate (USD/CHF) is very persistent, in results not shown here- which extend the estimation beyond the 500th horizon - its response was found to bottom out shortly after the latter horizon.) FEV shares are meaningful in general, with the lowest of them taking place for Chile (USD/CLP) - peaking at 8.3% - and the highest of them taking place for Mexico (USD/MXN) - peaking at 65.8%.

Results for Cross-Currency Basis. Figure 10 presents the response of the 1-month cross-currency basis of the said six economies. It is apparent that cross-currency basis does not respond meaningfully for all economies regardless of the responses' sign. Specifically, keeping in mind that a negatively responding basis is consistent with a CIP-deviation-based mechanism that competes with an equity-hedging-channel based one,[25] it is clear that such competing mechanism for the said six economies is not borne out by the data. The largest *negative* impact basis response is recorded by Colombia (USD/CLP), standing at -0.55 basis points. This small 1-month basis response (which is in annual terms) implies that the Colombian forward rate appreciates on impact by only $\frac{0.0055\%}{12} \approx 0.00046\%$ more than the corresponding spot rate (after accounting for interest rate differential behavior), representing an economically insignificant deviation from CIP. (I.e., the actual forward rate for Colombia appreciates on impact by only 0.00046% more than the CIP-

[25] This point is related to the discussion on Page 12. Specifically, the competing CIP-deviation-based mechanism speaks to an environment where the II hedges its foreign equity position via an FX swap trade against a global arbitrageur which possesses a downward-sloping demand curve for dollar swap-linked forwards. The imperfect elasticity of this demand curve owes to the arbitrageur's concave return from its non-swap-related investments. The underlying deviation from CIP in this environment declines in the swap trade amount. Hence, a rise in foreign equity prices which in turn generates more swap-induced hedging would shift the II's supply of dollar swap-linked forwards along the corresponding downward-sloping demand curve, producing a decline in the forward rate and a rise in swap activity. The latter rise is tantamount to a declining cross-currency basis.

implied one following the MSCI innovation.)

Summary. Notwithstanding their suggestive nature (given the lack of IIs' hedging data for these economies), the results from the above-presented figures are consistent with the claim that this paper's results can be viewed as externally valid for a broader sample of economies which meet the three conditions laid out in Section 6.1.

7 Conclusion

This paper documents a significant response of IIs' selling of dollar forwards in response to an MSCI index innovation, along with a significant decline in USD/NIS forward and spot rates that embodies an inconsequential response of USD/NIS currency basis and interest rate differentials. This set of findings can be viewed as representing evidence in favor of a meaningful equity hedging channel: a rise in foreign stock markets produces a rightward shift in IIs' supply of dollar forwards that is neutral to CIP deviations and that is meaningful for exchange rate determination.

We hope this paper's results can advance our understanding of how exchange rates are determined in shedding light on the relation between IIs' foreign equity positions, their hedging, and exchange rates' determination. 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 satisfy the conditions of being sufficiently small so as to avoid inducing a counteracting equity hedging channel from the world economy and of having IIs with a meaningful foreign equity position whose FX exposure is meaningfully hedged.

Lastly, this paper's results have potentially meaningful policy implications. A quantitatively important equity hedging channel may render it optimal for policymakers looking to combat an exchange rate appreciation to consider outright FX intervention in the forward, rather than spot, market. An additional potentially relevant policy tool can involve limiting the use of IIs' hedging through taxation or quantitative restrictions. Studying the normative aspect of the employment of such policy tools in the presence of a meaningful equity hedging channel is a potentially fruitful avenue for future research.

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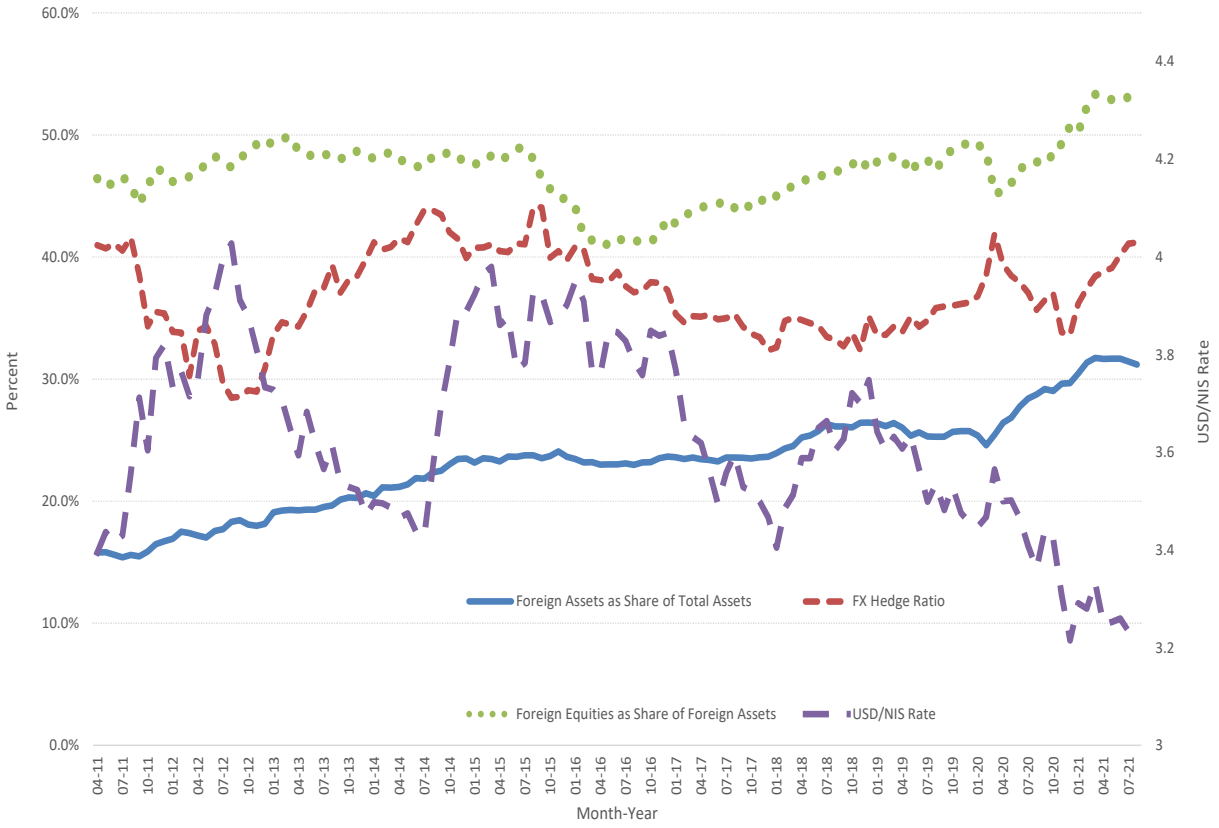
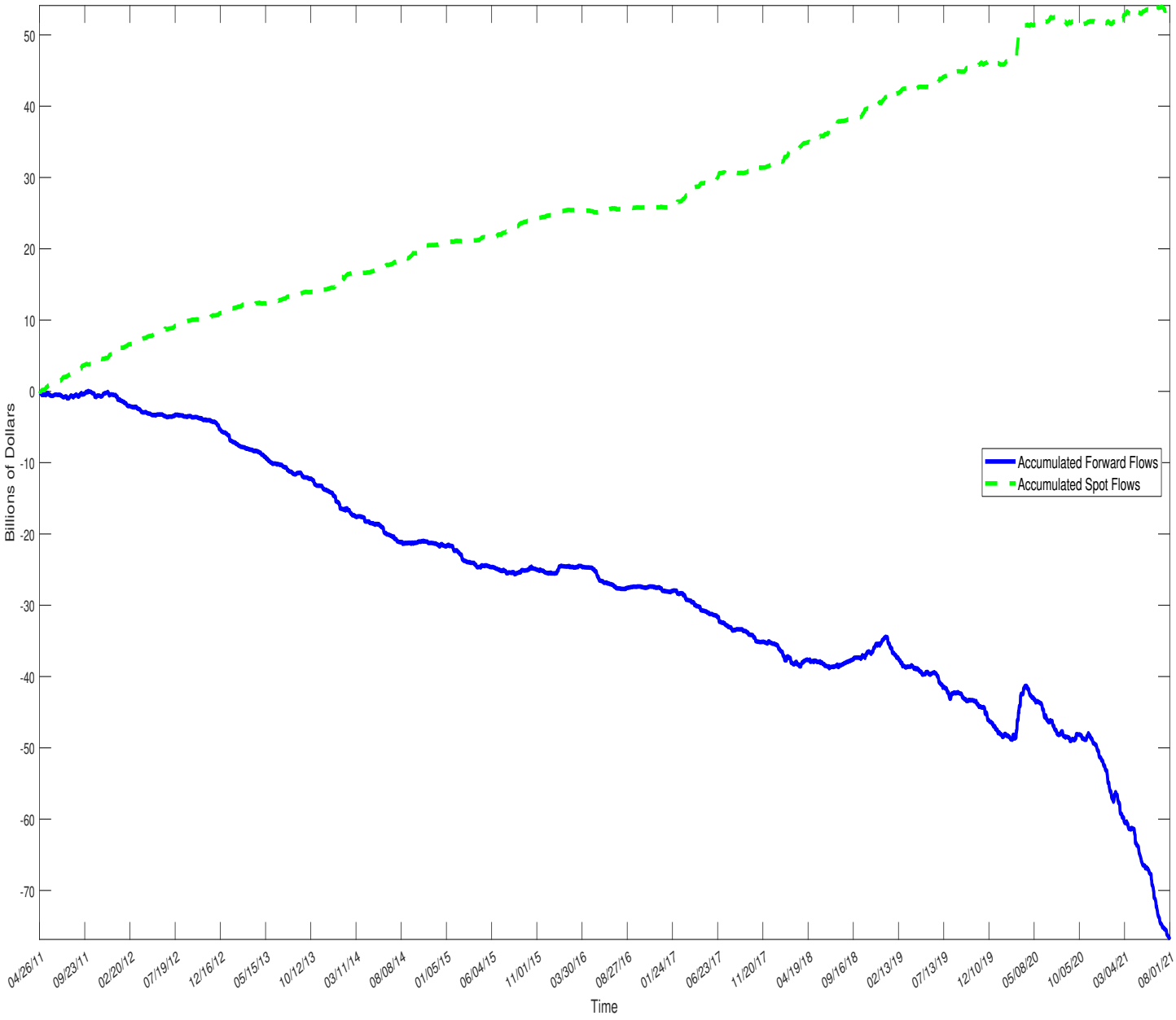
Figure 1: **Time Series of IIs' Foreign Assets, Foreign Equities, FX Hedge Ratio, and USD/NIS Spot Rate.**



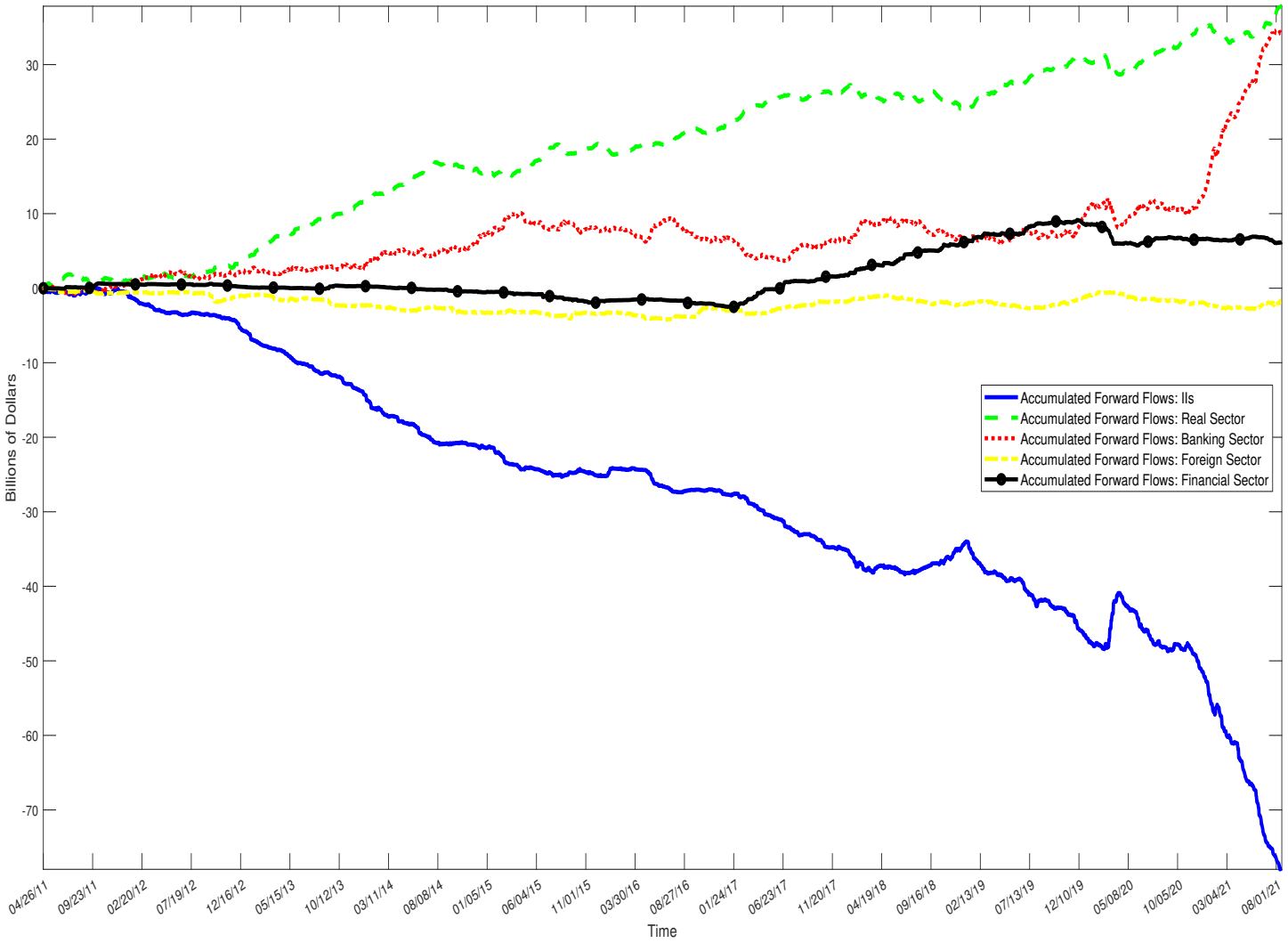
Notes: This figure presents the time series of the monthly shares of IIs' foreign assets in their total assets (solid line) and foreign equities in total foreign assets (round dotted line), IIs' FX hedge ratio (squared dotted line) (the share of foreign assets that is hedged against FX risk using forwards, swaps, and options), and the USD/NIS spot rate (dashed line). Data are from the BOI and cover 2011:M4-2021:M8. Time (monthly dates)is on the x-axis. IIs' variables are on the left y-axis; USD/NIS rate is on the right y-axis.

Figure 2: **Time Series of Accumulated FX Forward and Spot Flows.**



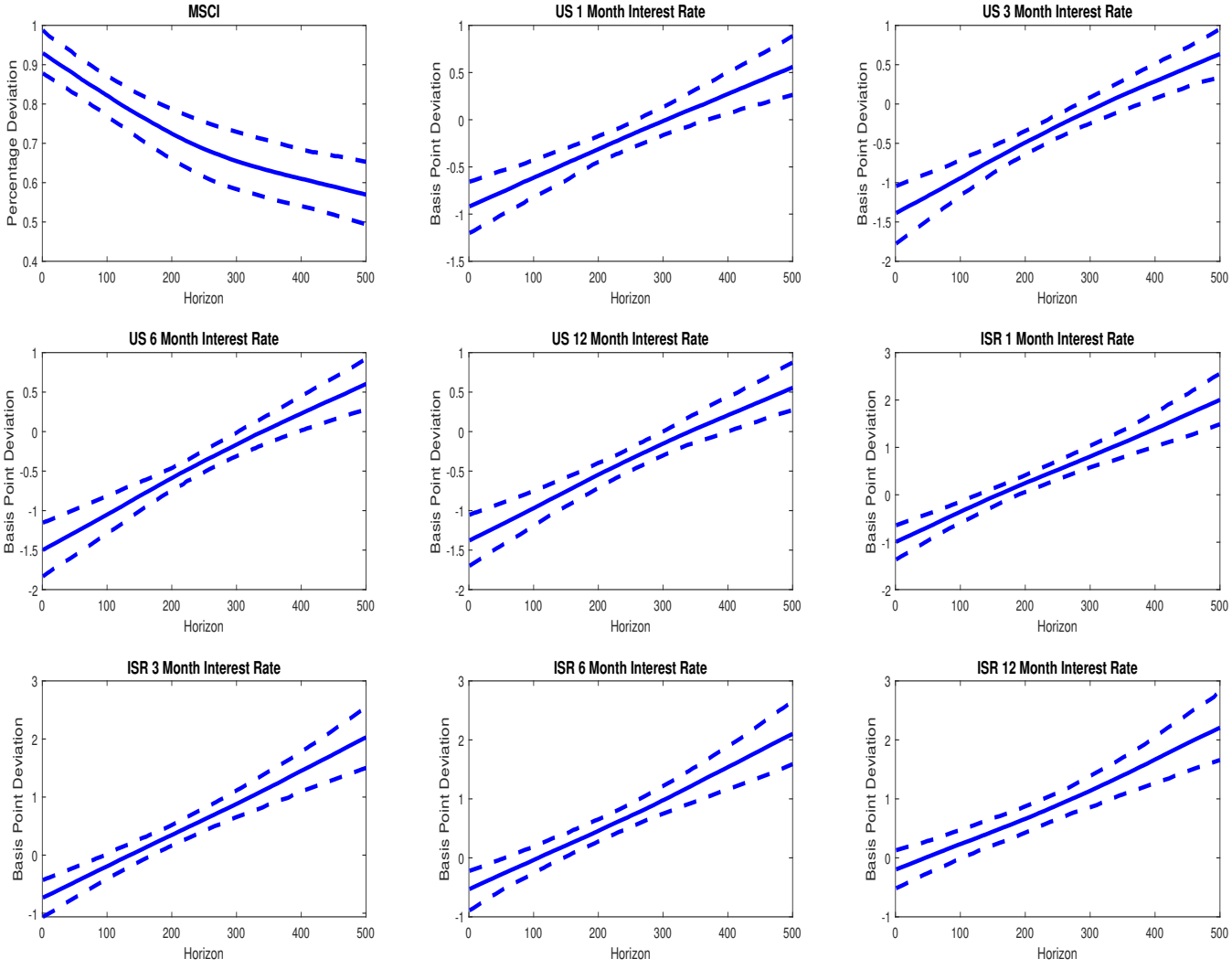
Notes: This figure presents the time series of IIs' accumulated daily FX forward (solid line) and spot (dashed line) flows. Negative accumulated flows values represent the accumulated selling of dollars; positive values represent the accumulated buying of dollars. Data are from the BOI and cover 4/26/2011-8/18/2021. Date is on the x-axis. Values are in billions of dollars.

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



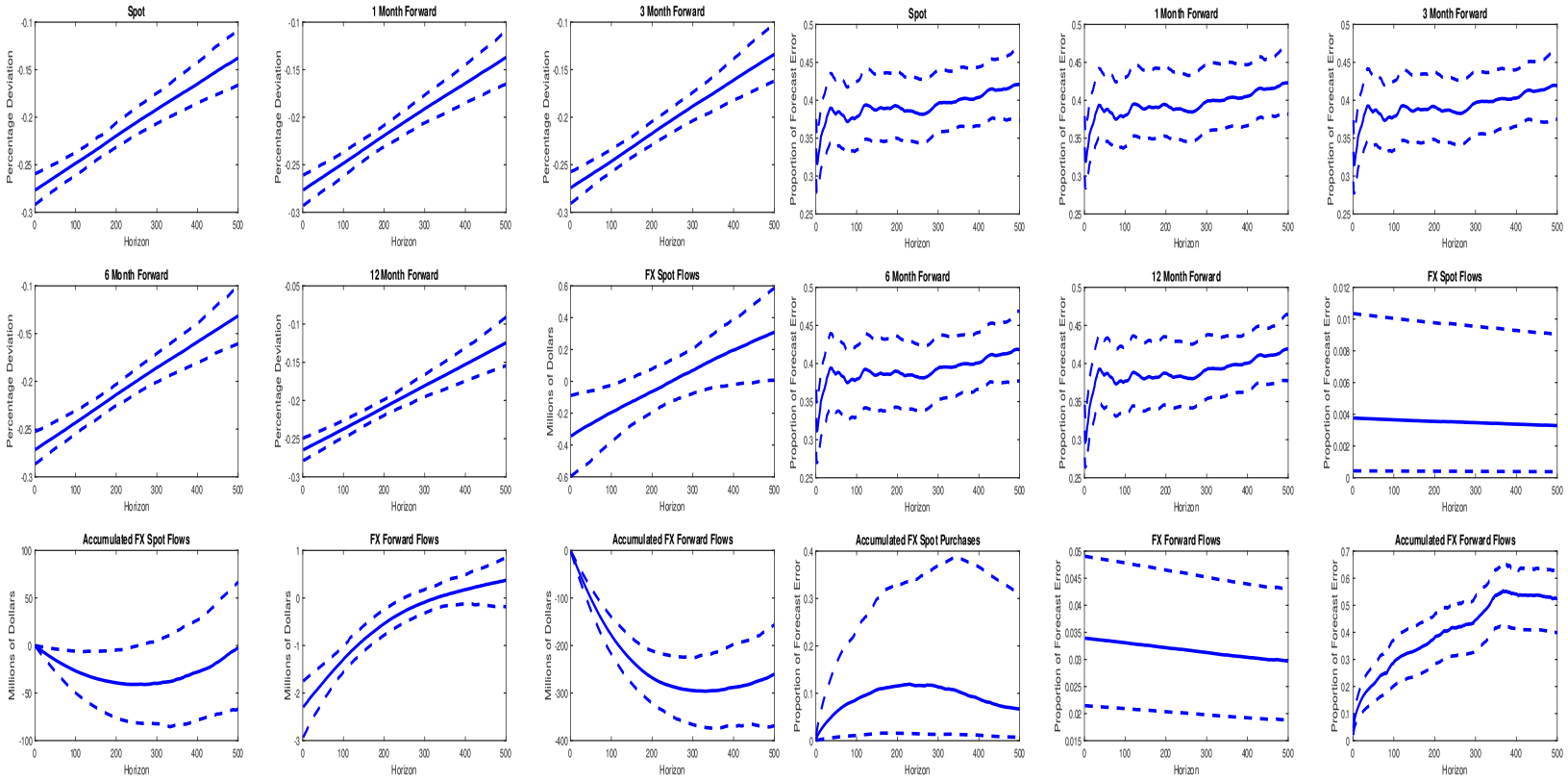
Notes: This figure presents the time series of accumulated daily FX forward flows by sector. On top of the II sector (which, for completeness, is also included in the figure and is represented by the solid line), this figure includes four additional sectors: real sector (dashed line), which represents the net FX flows from forward transactions involving Israeli exporters and importers; banking sector (dotted line), which includes the Israeli commercial banks; foreign sector (dash-dotted line), which includes all types of foreign economic units; and financial sector (solid line with circle markers), 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). Negative accumulated flows' values represent the accumulated selling of dollar forwards; positive values represent the accumulated buying of dollar forwards. Data are from the BOI and cover 4/26/2011-8/18/2021. Time is on the x-axis. Values are in billions of dollars.

Figure 4: **Impulse Responses to a One Standard Deviation MSCI Index Innovation: MSCI and Interest Rates**.



Notes: This figure presents the impulse responses of MSCI and 1-, 3-, 6-, and 12-month U.S. (Libor) and Israeli (Telbor) interest rates to a one standard deviation MSCI index innovation from the model described by Equations (7) and (8). Responses are in terms of deviations from pre-shock values (percentage deviation for MSCI and basis point deviation for interest rates). Horizon (on x-axis) is in days.

Figure 5: **FX Market Prices and Quantities: (a) Impulse Responses; (b) FEVs**.

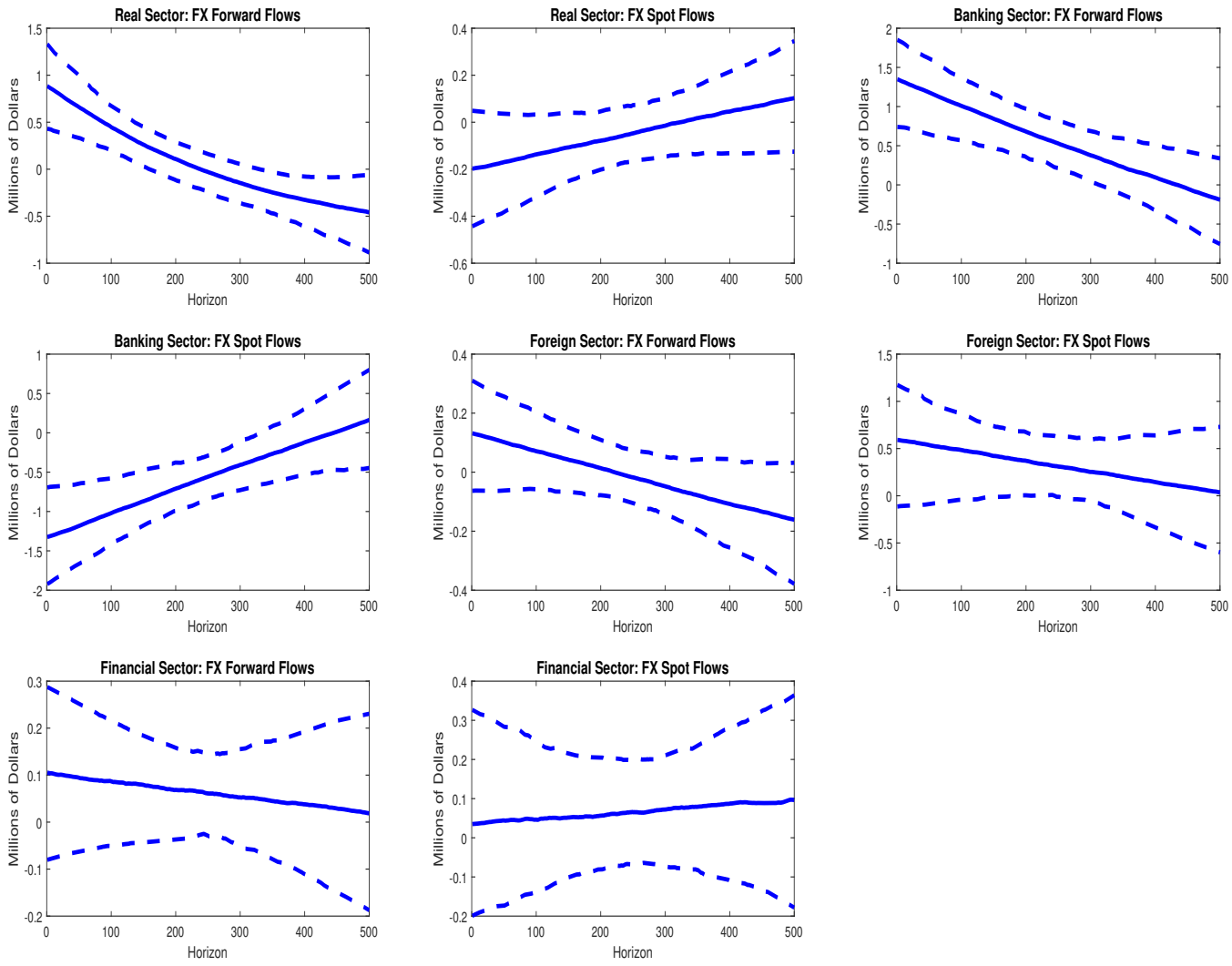


(a) Impulse Responses of FX Market Prices and Quantities to a One Standard Deviation MSCI Index Innovation.

(b) FEV of FX Market Prices and Quantities Attributable to MSCI Index Innovation.

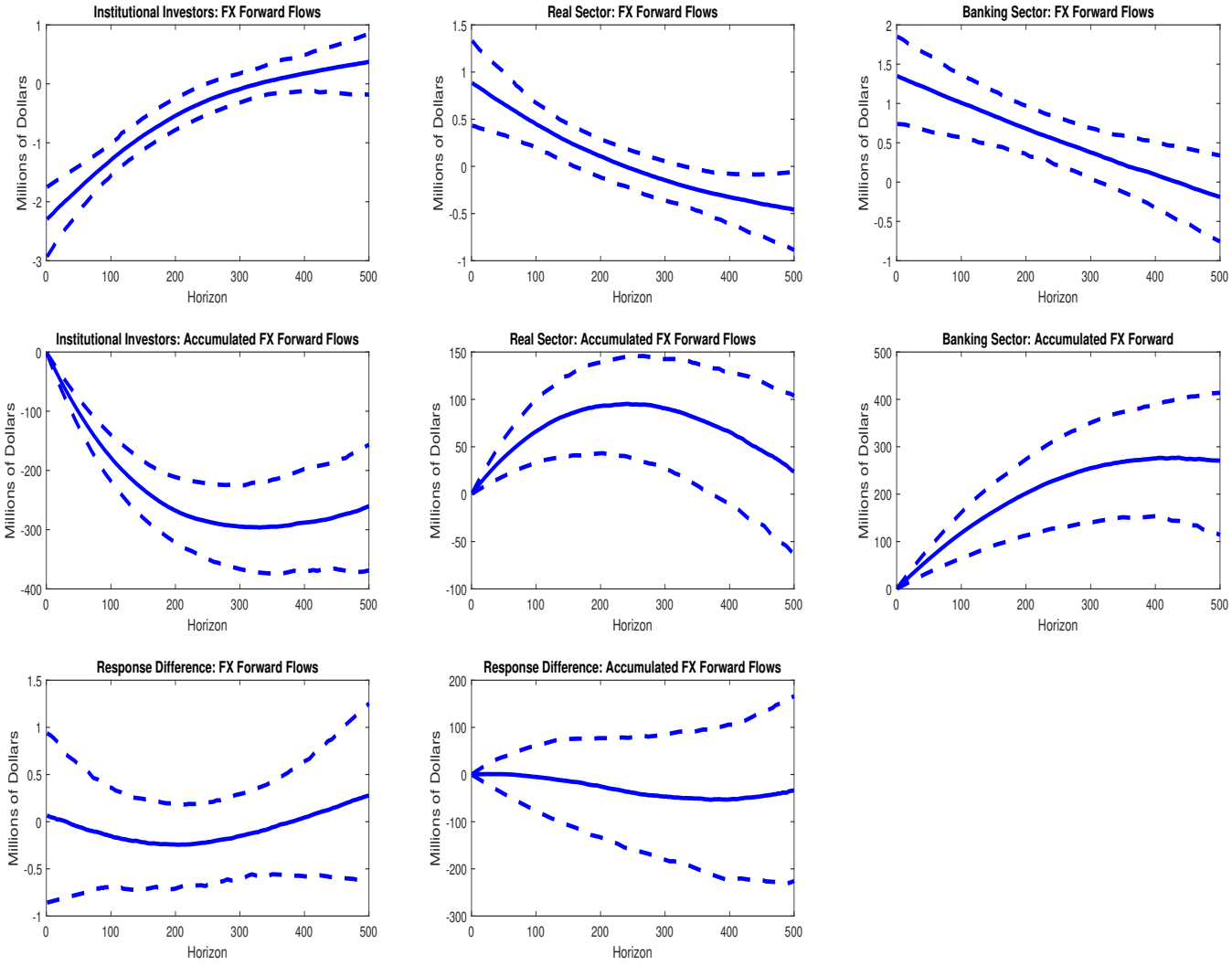
Notes: Panel (a): This figure presents the impulse responses of the spot and forward rates and quantities to a one standard deviation MSCI index innovation from the model described by Equations (7) and (8). Responses are in terms of deviations from pre-shock values (percentage deviation for spot and forward rates and Millions of dollars for spot and forward flows' raw and accumulated responses). Horizon (on x-axis) is in days. Panel (b): This figure presents the FEV share of the spot and forward rates and quantities that is attributable to the MSCI index innovation from the model described by Equations (7) and (8). Horizon is in days.

Figure 6: **Impulse Responses to a One Standard Deviation MSCI Index Innovation: Non-II Sectors' Spot and Forward Flows**.



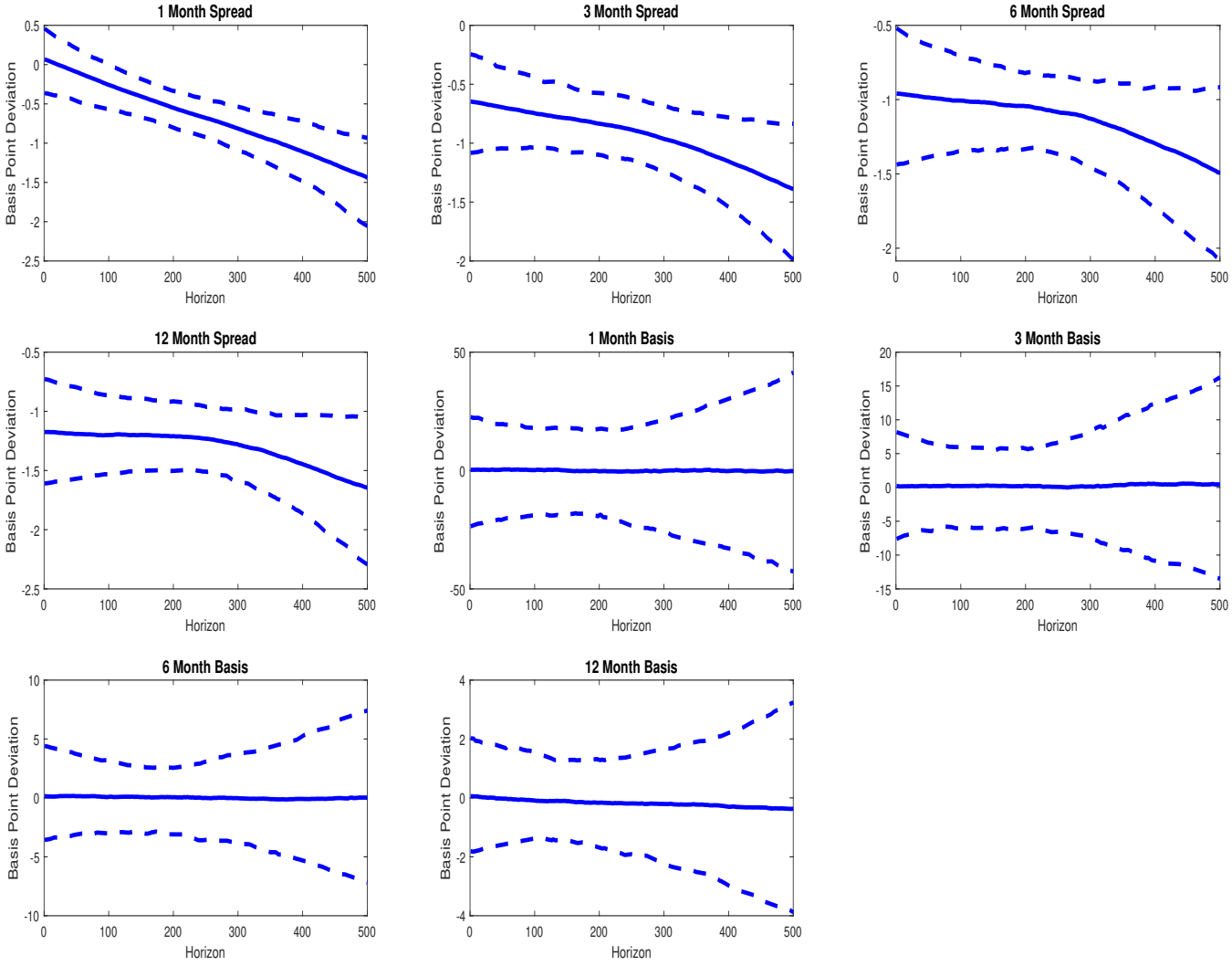
Notes: This figure presents the impulse responses of spot and forward flows of the real, banking, foreign, and financial sectors to a one standard deviation MSCI index innovation from the model described by Equations (7) and (8). Responses are in terms of deviations from pre-shock values (in million of dollar terms). Horizon (on x-axis) is in days.

Figure 7: **Impulse Responses to a One Standard Deviation MSCI Index Innovation: Banking and Real Sectors' Forward Flows Versus IIs' Forward Flows**.



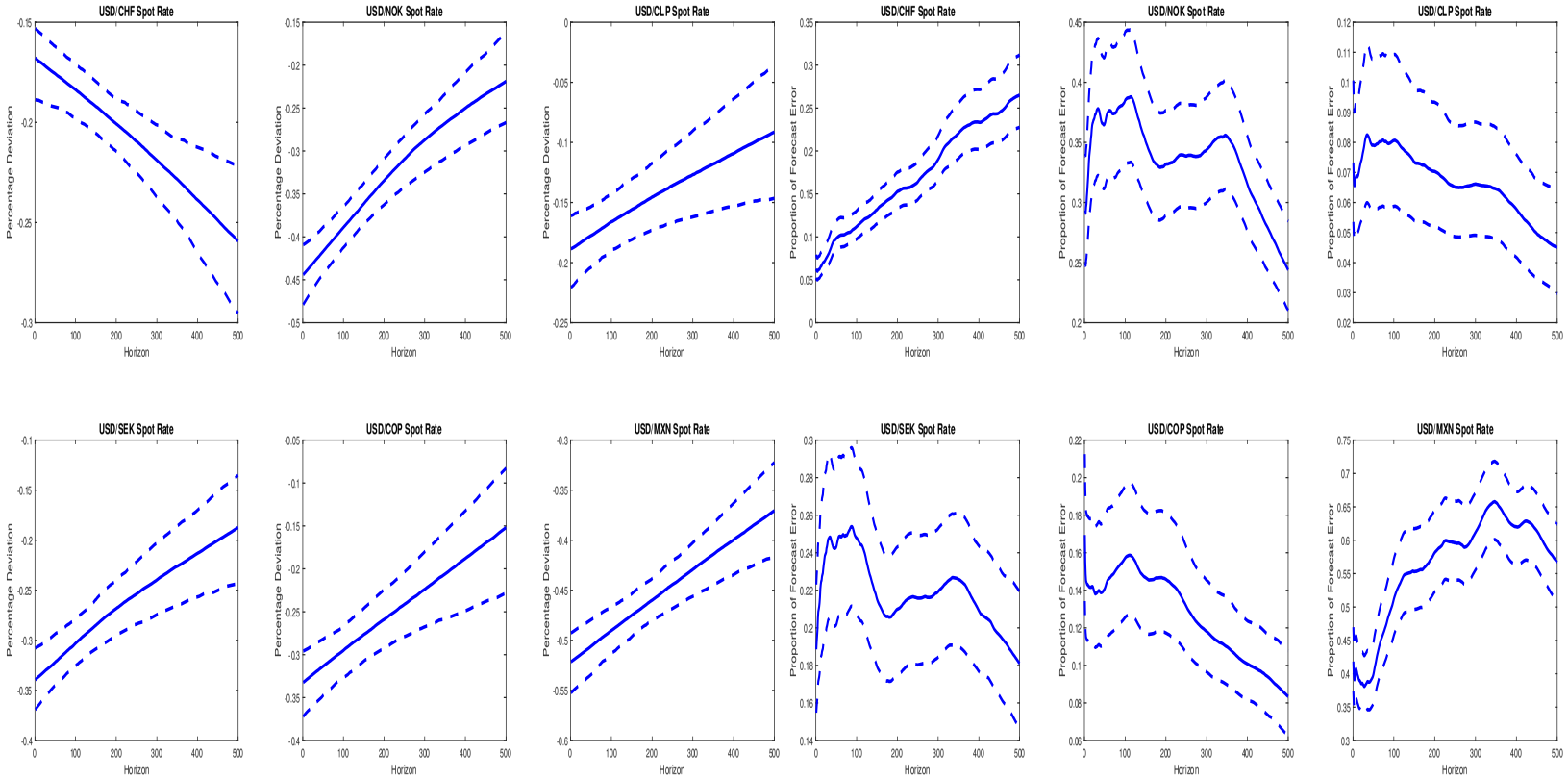
Notes: This figure presents the difference between raw and accumulated (in absolute terms) response of IIs' forward flows and banking and real sectors' raw and accumulated forward flows, respectively, to a one standard deviation MSCI index innovation from the model described by Equations (7) and (8). (For completeness, responses themselves (both raw and accumulated) for all three sectors are also shown in the figure.) Responses are in terms of deviations from pre-shock values (in million of dollar terms). Horizon (on x-axis) is in days.

Figure 8: **Impulse Responses to a One Standard Deviation MSCI Index Innovation: Interest Rate Spreads and Cross-Currency Basis.**



Notes: This figure presents the impulse response differences across U.S. (Libor) and Israeli (Telbor) interest rate responses and the associated USD/NIS cross-currency basis responses to a one standard deviation MSCI index innovation from the model described by Equations (7) and (8). Responses are in terms of basis point deviation from pre-shock values. Horizon is in days.

Figure 9: **Spot Exchange Rates for Other Economies: (a) Impulse Responses; (b) FEVs**.

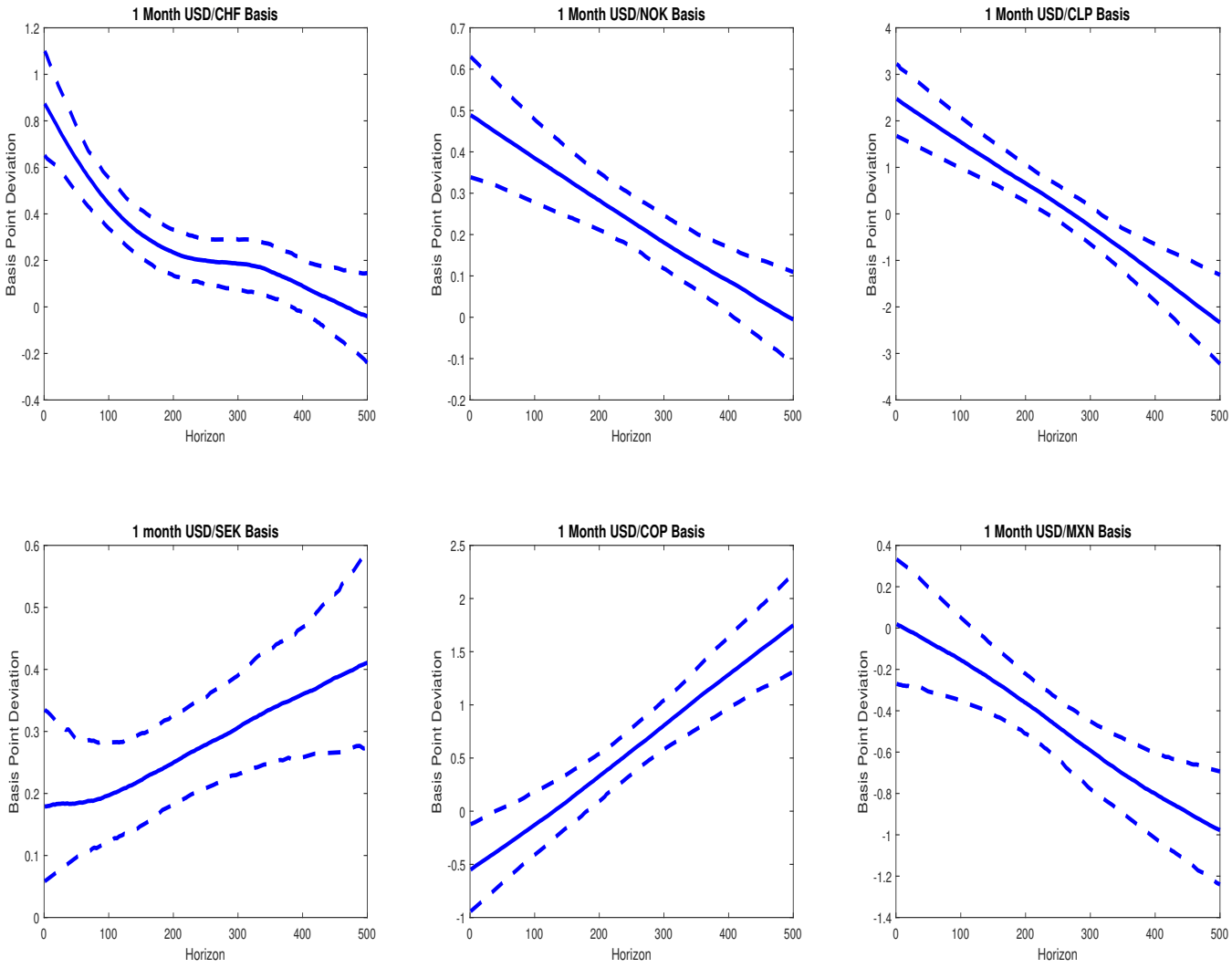


(a) Impulse Responses of Spot Exchange Rates for Other Economies to a One Standard Deviation MSCI Index Innovation.

(b) FEV of Spot Exchange Rates for Other Economies Attributable to MSCI Index Innovation.

Notes: Panel (a): This figure presents the impulse responses of Swiss (USD/CHF), Norwegian (USD/NOK), Chilean (USD/CLP), Swedish (USD/SEK), Colombian (USD/COP), and Mexican (USD/MXN) spot rates (relative to the dollar) to a one standard deviation MSCI index innovation from the model described by Equations (7) and (8). Responses are in terms of deviations from pre-shock values (in percentage deviation terms). Horizon (on x-axis) is in days. Panel (b): This figure presents the FEV share of the six considered spot rates that is attributable to the MSCI index innovation from the model described by Equations (7) and (8). Horizon is in days.

Figure 10: **Cross-Currency Basis for Other Economies**.



Notes: This figure presents the impulse responses of the cross-currency basis for Swiss (CHF), Norwegian (NOK), Chilean (CLP), Swedish (SEK), Colombian (COP), and Mexican (MXN) with respect to the USD to a one standard deviation MSCI index innovation from the model described by Equations (7) and (8). Responses are in terms of deviations from pre-shock values (in basis point deviation terms). Horizon (on x-axis) is in days.