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

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Abstract

Theory predicts that institutional investors' (IIs') hedging of their foreign equity asset positions' FX exposure leads to a positive relation between foreign equity returns and IIs' supply of foreign currency forwards; in equilibrium, this prediction implies a negative relation between foreign equity returns 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: D22,D24,E23,E32,E44

Keywords: Equity Hedging Channel; FX Forward Flows; Institutional Investors' Short FX Position; FX Forward Rate; FX Spot Rate; Stock Prices; Bayesian Local Projections.

*The views expressed in this paper are those of the authors and do not necessarily reflect the views of the Bank of Israel. All errors are our own.

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1 Introduction

The equity hedging channel of exchange rate determination speaks to the desire of investors with a foreign equity asset position to hedge the FX risk in this position by selling foreign currency on the forward market, thus putting 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 examined via a portfolio rebalancing based mechanism taking place in the FX *spot* market (Hau and Rey (2004, 2006) and Camanho et al. (2020)), 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 asset positions (see Page 26 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 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 local IIs' daily foreign equity portfolio returns 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 maturities corresponding to common FX forward contracts.

To accomplish our aforementioned objective, this paper unfolds in two parts. The first part lays out a simple conceptual framework which serves the purpose of fixing ideas, motivating the

[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.

aforementioned litmus test, and forming a suitable conceptual base for this paper. The second part of this paper conducts the aforementioned litmus test.

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 who 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 foreign equity'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).

Our second part of the paper tests the latter prediction, i.e., the relation between increased foreign stock market performance and greater (lower) forward flows (forward and spot rates). This prediciton is the essence of the equity hedging channel of exchange rate determination.

Econometric Model. The second part of the paper studies the effect of increased local IIs' foreign equity portfolio performance 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 maturities corresponding to common FX forward contracts. We also estimate the response of USD/NIS currency basis so as to ascertain the possible role of conditional CIP violations.

We measure IIs' foreign equity portfolio performance with a closely followed MSCI 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 2016 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 98.3%).

The model we use is a Bayesian local projection model whose details are given in Section 4.2.1. Our results can be summarized as follows.

First, a one standard deviation innovation to MSCI induces significant selling of forward dollars, 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. USD/NIS spot flows' response is much smaller in magnitude relative to forward flows' response magnitude. This indicates that the bulk of the action in the USD/NIS market following a rise in MSCI is taking place in the forward market, bolstering confidence in the interpretation of our results as being driven by the equity hedging channel.

Second, both USD/NIS forward and spot rates significantly and persistently decline following the MSCI innovation, with roughly 50% of their two-year forecast error variation being accounted for by the latter innovation. Moreover, their decline is very similar and takes place in tandem with a negligible response of U.S. and Israeli interest rates, which accords with the insignificant estimated response of USD/NIS currency basis we find for all common forward contract horizons. That is, in accordance with our structural model, the MSCI innovation seems to produce a rightward shift in the supply of dollar forwards which in turn results in a lower forward and spot rate, where the positive conditional relation between these two rates embodies unchanging CIP deviations. (USD/NIS currency basis is negative on average in our sample period. So the latter result 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 FX forward flow data to quantify this channel, with the daily frequency of this data allowing us to rather 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, some advancement has been made on resolving this puz-

zle by turning to the relation between financial and credit markets and FX markets. Offering a post-GFC resolution to the exchange rate disconnect puzzle, Lilley et al. (2019) show that proxies for global risk appetite, including returns on the S&P 500 index, explain a significant share of currency returns after the GFC. And Hau and Rey (2004) (using a VAR) and Camanho et al. (2020) (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 returns and FX *spot* markets, our paper studies the equity hedging channel of exchange rate determination and therefore focuses on the relation between foreign equity returns and FX *forward* markets. There are two papers that are close to ours, 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 and thus use equity returns up until the second to last day of the month 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), who studies a general hedging channel of exchange rate determination that insightfully connects 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 quite cleanly the equity hedging channel. (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 in that 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. Furthermore, as explained in Section 6, we do not view our channel as hinging on the direction of an economy's net external balances. Rather, it hinges on meaningful foreign equity asset 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.

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.[2] And the third is a global arbitrager (GA) whose activity produces violations from CIP that are unaffected by foreign equity returns, 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

[2]In practice, exporters also comprise part of the supply of foreign currency forwards and, together with the supply from IIs, form the aggregate supply of foreign currency forwards that equates importers' demand for such forwards in equilibrium (Alfaro et al. (2021)). We refrain from modeling the exporters' supply of foreign currency forwards given our focus on the equity hedging channel and the fact that such modeling would have no consequences for our model's main predictions. It is also noteworthy that a setting where supply of foreign currency forwards from exporters and IIs equals importers' demand for such forwards can also exist for an economy with positive net exports (as is the case for Israel); the reason for this is that import activity tends to be more strongly correlated with hedging than exports (Alfaro et al. (2021)). This stronger correlation is also apparent for Israel, as seen from Figure 6666666666666666666666 where the real sector as a whole is a significant seller for dollar forwards. (And this fact is also consistent with a report from the BOI for the years 2014-2017 which documented significantly larger FX purchases by large importers than FX sales by large exporters; and with a 2015 survey from the Israeli Export Institute indicates that only 14% of Israeli exporters hedge any of their export proceeds.)

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. 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 made in period $t+1$ (i.e., the 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

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

[3]Our assumption that the IM is the local II's counteprarty 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 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.

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 Arbitrager

We now introduce into the model a global arbitrager (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 $Q_{t,GA}$ local currency units in return for spot $\frac{Q_{t,GA}}{S_t}$ foreign currency units while simultaneously selling forward $Q_{t,GA}(1+i_{t+1,L})$ local currency units in return for $\frac{Q_{t,GA}}{S_t}(1+i_{t+1,W})$ foreign currency units at forward rate $F_{t,t+1}$ (with $i_{t+1,W}$ representing the foreign risk-free interest rate).

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 $\kappa\frac{Q_{t,GA}}{S_t}$, 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., $\kappa\frac{Q_{t,GA}}{S_t}i_{t+1,W}$). 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

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

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

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

where $\frac{S_t}{F_{t,t+1}}(1+i_{t+1,L})$ represents the synthetic, CIP-implied foreign risk free interest rate which is clearly higher than the actual one. In other words, Equation (6) implies a negative cross-currency basis that is caused by the swap trade's haircut-induced friction. 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 of the FX spot rate's response to changes in foreign stock market performance is the same as that of the forward rate.

[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))

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 princes) 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 (i.e., a rise (fall) in FCF_t ($F_{t,t+1}$)).

Moreover, Since FOC (6) implies a positive 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. Hence, in sum, we can deduce that a shock to global stock prices is predicted to reduce the FX spot 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, and life insurance

[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.

policies.[6] 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, in 2003 the Israeli government lowered this 70% threshold to 30%, thus 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.[7]

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 a hedge ratio (share of foreign assets' value which is hedged using forwards, swaps, and options) of 29% at the end of 2009.

Theoretical Basis for Abstraction from FX Swaps. In our econometric analysis from swaps due to their null theoretical role in the equity hedging channel. (We also abstract from options due to their negligibility in IIs' FX trades.) 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 amount. While IIs' *net* swap daily volume activity amounts to 133.7 million dollars (11.4% of the entire swap

[6]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. 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.

[7]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.

market),[8] relative to a 62.2 million dollar forward volume activity (25.7% of the entire forward market), 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 forward dollar trades. This meaningful difference indicates that IIs' selling of non-swap forward dollars is a more dominant hedging tool for IIs than the selling of swap forward dollars.

More importantly, this swap activity is done against foreign and local banks - the real sector is a minor (and net seller, not buyer, of swap-linked forwards) player in the swap market - and therefore faces a perfectly elastic demand for swaps which in turn implies that the equity hedging channel does not operate through a swaps-based mechanism. This contrasts the pure forward contract activity of IIs whose major counterparty are importers with the theory supporting their possessing of a downward-sloping demand for forwards. See Section 2.2 for a formalization of the latter argument. And see Section 3 for a formalization of the former argument related to the perfectly elastic demand for swaps of an arbitrager that trades in FX swaps, which is the theoretical basis for our abstraction from swaps in our econometric analysis. (The trade from section 's setting also contains a pure forward contract that covers the foreign interest rate proceeds. But this is immaterial to the perfectly elastic forward demand argument as it is clear that such demand is borne out from this setting regardless of whether these proceeds are covered or uncovered.)

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 hedge ratio, and the USD/NIS exchange rate, Figure 1 plots these variables in monthly frequency where the monthly sample corresponds to the daily sample we use in our econometric analysis (whose time coverage is governed by our daily FX forward flow data). 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 at the end of the sample at 31.7%. By contrast, and not surprisingly given foreign equities

[8]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 forward dollar trades. This meaningful difference indicates that IIs' selling of non-swap forward dollars is a more dominant hedging tool for IIs than the selling of swap forward dollars.

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 46.8% 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 hedge ratio (square dotted line) of 36.8% for the sample, i.e., IIs on average hedge 36.8% of their FX-sensitive positions, which represents meaningful hedging on the part of IIs. While one might expect that the USD/NIS rate (dashed line) would move in opposite direction to that of the hedge ratio, i.e., IIs would be more prone to hedging in an appreciating USD/NIS 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 USD/NIS rate coexists with a mostly falling trend of the 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 FX forwards or FX options. 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.[9] 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 in our baseline sample of 4/26/2011-8/18/2021. Negative accumulated flows' values represent the accumulated selling of foreign currency; positive values represent the accumulated buying of foreign currency. (Since about 77% of IIs' FX trades are done in dollars, throughout this paper's terminology we treat USD/NIS as the sole currency pair underlying IIs trades. The remaining 23% non-dollar trades are nevertheless included in our data and their values are translated into dollar terms.)

There are two noteworthy facts that are borne out by Figure 2. First, Israeli IIs conduct hedging

[9]Not even a single option trade was done 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.

predominantly through selling forward dollars, as reflected by the significant accumulation of IIs' forward dollars sold which reaches a peak of 77.8 Billion dollars at the end of the sample. (The accumulation of the selling of foreign currency 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 forward dollars 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 in our baseline sample of 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; local banks sector, which includes the Israeli commercial banks; financial sector, which includes the forward flow activity of Israeli IIs that is done on their own behalf rather than on behalf of the public's long-term investments (i.e., activity related to their 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 sector and local banks. 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 sector and local banks 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 31/10/2008-8/18/2021. (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 micro data we have on FX flows of Israeli IIs. Israeli IIs include all entities that manage the public's long-term savings, including pension funds, provident funds (both investment provident funds and severance pay provident funds), advanced training funds (an investment instrument from which savers can withdraw the entire amount after six years), and life insurance policies.[10] We begin our data description by providing details on IIs' micro data after which we turn to discuss the other variables we utilize in our empirical analysis.

4.1.1 IIs' FX Flows Micro Data

We have proprietary daily micro data at the Israeli II level 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 10 for a theory-based explanation for our abstraction from swap flows in our econometric analysis.

Since roughly 77% of IIs' FX trades are done in dollars, throughout this paper's terminology 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 approximate 23% of the flows are nevertheless included in our FX flows data and are translated into dollar terms.)

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

[10] It is noteworthy that commercial banks are not allowed to manage long-term saving schemes and hence Israel's entire long-term savings are effectively run by investment banks and insurance companies.

this variable for a given observation when an II was a net seller of forward dollars on the corresponding day. Since the equity hedging channel we seek to study is macroeconomic in nature, we sum this variable across all IIs in our sample in the time series model and look at the response of the resulting aggregate forward net transaction variable.

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. As in the case of the forward flows variable, we sum this variable across all IIs in our sample and look at the response of the resulting aggregate spot net transaction variable.

4.1.2 Other Sectors' FX Flows Micro 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; local banks sector, which includes the Israeli commercial banks; financial sector, which includes the forward flow activity of Israeli IIs that is done on their own behalf rather than on behalf of the public's long-term investments (i.e., activity related to their 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).

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) is our measure of foreign stock price performance, the focal impulse underlying the equity hedging channel of exchange rate determination. This widely quoted index covers 9,200 securities, 23 developed markets, 27 emerging markets, and 99% of the investable global

equity market. The leading countries in terms of market weight in this index are the U.S. (42.5%), Japan (10%), UK (6.8%), China (6%), and France (3.8%); the leading sectors by market weight are Financials (28.8%), Information Technology (10.6%), Industrials (9.2%), Consumer Discretionary (8.8%), Health Care (8.6%), Communication Services (7.4%), and Energy (7.2%).

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

Forward USD/NIS. 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 Libor interest rates 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;[11] B_c is a constant; and $u_t \sim i.i.d.\ N(\mathbf{0}, \sigma^2_{sp})$ is the foreign stock price innovation where σ_{sp} is its standard deviation; $\hat{u}_t$ is the estimated residual from Equation (7), normalized to have unit variance);α_h is the intercept of outcome variable $y_{t+h} - y_{t-1}$, with h being regression's rolling horizon ($h = 1, ..., 500$);[12, 13] Ξ_h is the effect of a one standard deviation MSCI index shock on the relevant outcome variable at horizon h; 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 (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

[11] 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.

[12] Stock prices (logged MSCI) and spot and forward rates are all entered in cumulative differences 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 and hence entered into the rolling regression in levels. Spot and forward flows, because of their trend-stationarity, 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.

[13] 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 latter effectively remain constant as the horizon progresses whereas the former 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.

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.)

Two- Versus One-Step Estimation. It is noteworthy that it is asymptotically equivalent to estimate System (7)-(8) as a single equation by replacing $\hat{\epsilon}_t$ 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.[14]

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 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.)

[14]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 variables. Hence, for this variable we apply the 'LP-B' formula from Gorodnichenko and Lee (2020) which prevents this exceedance from happening.

NIS/USD 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 NIS/USD 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 -0.26% and then gradually begins to decay reaching -0.15% 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 forward NIS/USD markets 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 NIS/USD 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 over 30% of the impact variation in the spot and forward rates, with this share rising quickly to about 37% for the rest of the horizons. To further validate the importance of this channel, we now turn to the quantity side of forward market while also showing the behavior of spot flows for completeness.

NIS/USD Spot and Forward Flows. The 6th and 7th sub-figures of Figure 5a present the raw and accumulated raw responses of NIS/USD 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 roughly 200 and 300 days straight after the MSCI index innovation, respectively. In quantitative terms, the selling of forward dollars is much larger than that of spot dollars with the latter being only 0.4 million dollars and the former standing at 5 times larger than that at 2 million dollars.

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 position.[15] 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 300 million dollars after roughly 350 horizons (at which point the accumulated spot flow response is only -40 million dollars). The accumulated forward flow responses dwarfs 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.

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 0.5% of the variation in spot flows while explaining 3.5% 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 S&P 500 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 over 50% of the two-year variation in the accumulated forward flows variables is accounted for by the MSCI innovation, a corresponding mere 10% is accounted for by the MSCI innovation for the accumulated spot flows variable.

[15] 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 forward dollars' contracts which in turn reduces the short position. (Since the most common forward contract used by IIs has an horizon of 3 months, such expiry implies that the actual short position's response can be thought of as being lower than that from Figure 5a's last sub-figure (starting from the 3-month response horizon) by the amount of the latter's 3-month-lagged response.) Nevertheless, this accumulated impulse response function can be interpreted as representing the *gross* additions to IIs' short position conditional on the MSCI innovation.

Other Sectors' NIS/USD Spot and Forward Flows. Figure 6 shows spot and forward flows' responses of four additional sectors:[16]) 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 the forward flow activity of Israeli IIs that is done on their own behalf rather than on behalf of the public's long-term investments (i.e., activity related to their nostro (own) accounts); and foreign sector, which includes all types of foreign economic units.

Figure 6 indicates an economically and 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 forward dollars 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) response 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 local banks' forward flows

[16]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 their daily FX spot flows. (The BOI does not trade on the forward market.)

insignificant and leaves the real sector as the only significant holder of long position that quantitatively corresponds to IIs' short position. 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.

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 -2.5 basis points for the 1-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 S&P 500 index innovation.[17] It is clear that the response of CIP deviations (i.e. NIS/USD cross-currency basis) to the MSCI index innovation is statistically insignificant at all considered horizons. That is, notwithstanding the unconditionally meaningful negative NIS/USD cross-currency basis (see Footnote 17), deviations from CIP *conditional* on this innovation are not a meaningful propagation mechanism for the behavior of NIS/USD forward flows and rates.

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 return 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 2016 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. 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 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 various alternative

[17] 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 NIS/USD, 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 bases, 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 (2021)).

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.

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 rates' 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.[18]

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 these economies' currencies is negligible and hence does not motivate foreign IIs to pursue the same hedging activity that is done by these economies' IIs.[19] This is an important condition because, under the fairly reasonable assumption of comovement across global and local stock markets, not meeting the smallness condition would facilitate a counteracting equity hedging channel that is coming

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

[19]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.

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 then U.S. pension funds' position (or any other large economy's pension funds 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. And clearly this condition is met by a large sample of economies.

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 10.8% 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 of the previous section. 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.[20,21] And Alfaro et al. (2021) reports 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

[20] 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.

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

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 exchange rates with respect to the dollar in response 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.

Towards this end, we estimate Equations (7) and (8) using as outcome variables for the latter equation the spot rates for these six economies relative to the dollar. Figure 9a presents the these variables impulse response and Figure 9b presents the share of their forecast error variance that is attributable to the MSCI innovation. For all six economies, a significant and persistent appreciation takes place, mirroring the response observed for the USD/NIS spot rate from Figure 5a. FEV shares are meaningful in general, with the lowest of them taking place for Chile (USD/CLP) - peaking at a little below 10% - and the highest of them taking place for Mexico (USD/MXN) - peaking at 65%.

Notwithstanding their suggestive nature, given the lack of hedging data for these economies, the results from these 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 and persistent response of IIs' selling of forward dollars in response to an MSCI index innovation, along with a significant decline in USD/NIS forward and spot rates that embodies a insignificant response of USD/NIS currency basis. This set of findings can therefore be viewed as representing evidence in favor of a meaningful equity hedging channel:

a rise in foreign stock market performance produces a rightward shift in the 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.

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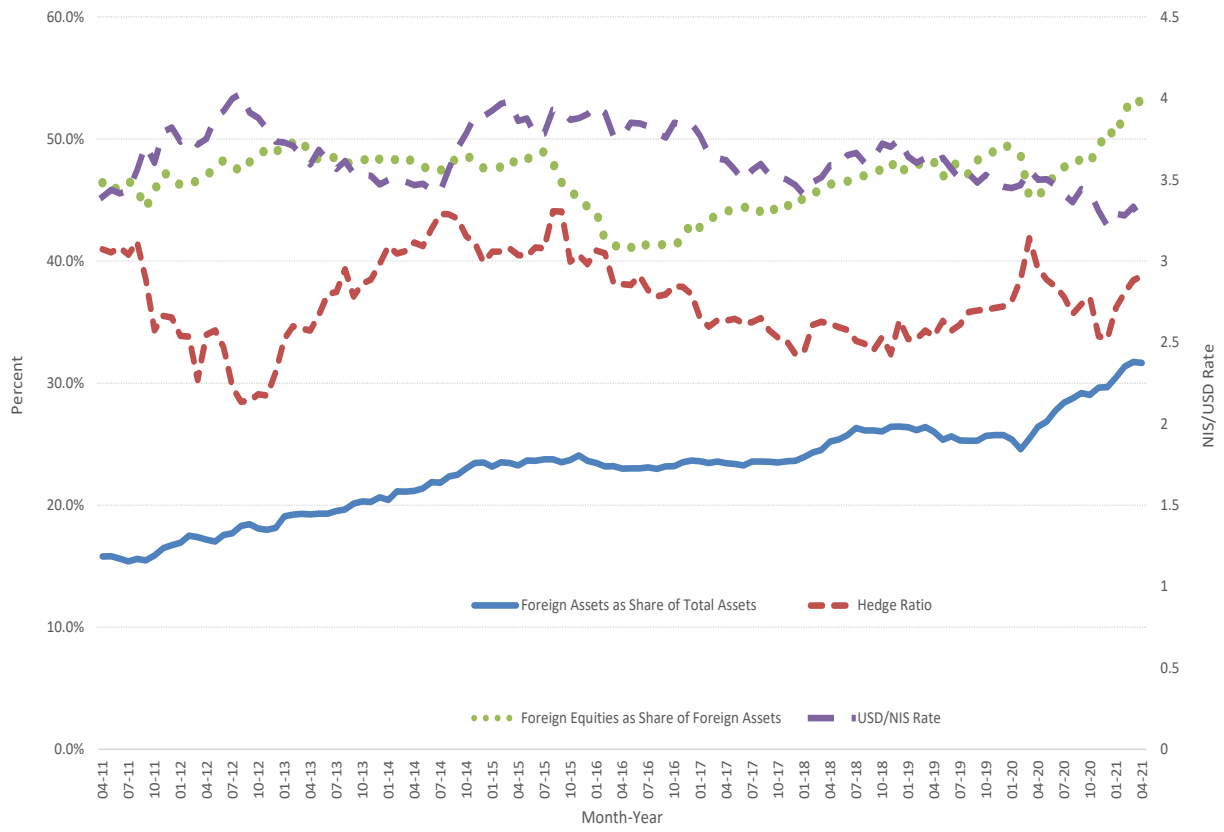
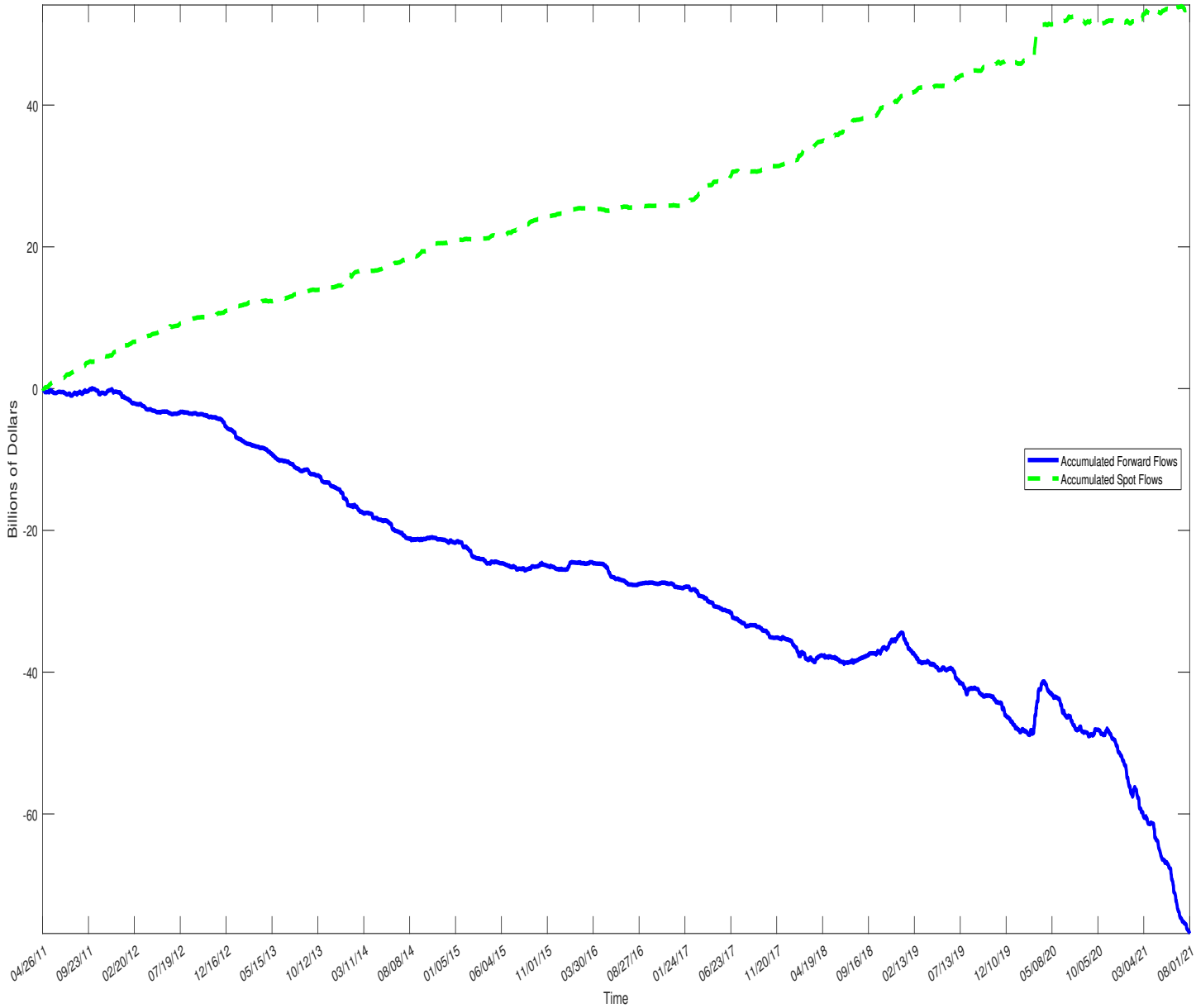
Figure 1: **Time Series of Institutional Investors' Foreign Assets, Foreign Equities, and Hedge Ratio and USD/NIS Rate.**



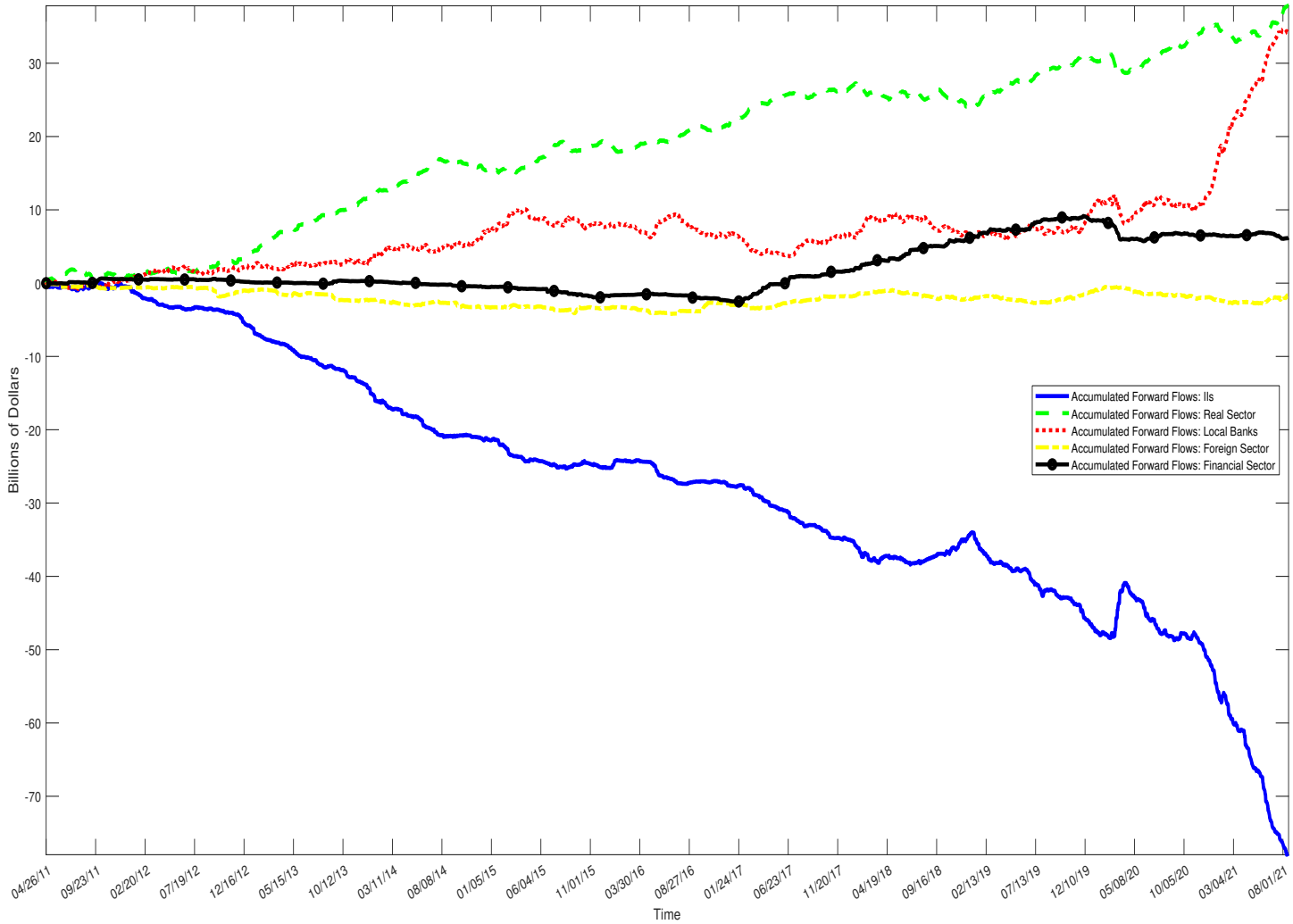
Notes: This figure presents the time series of the monthly shares of institutional investors' foreign assets in their total assets and foreign equities in total foreign assets (round dotted line), institutional investors' hedge ratio (squared dotted line)(the share of foreign assets that is hedged against FX risk using forwards and option), and the USD/NIS (spot) rate (dashed line). Data are from the BOI and cover 2011:M4-2021M4. Time is on the x-axis. Institutional investors' 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.**



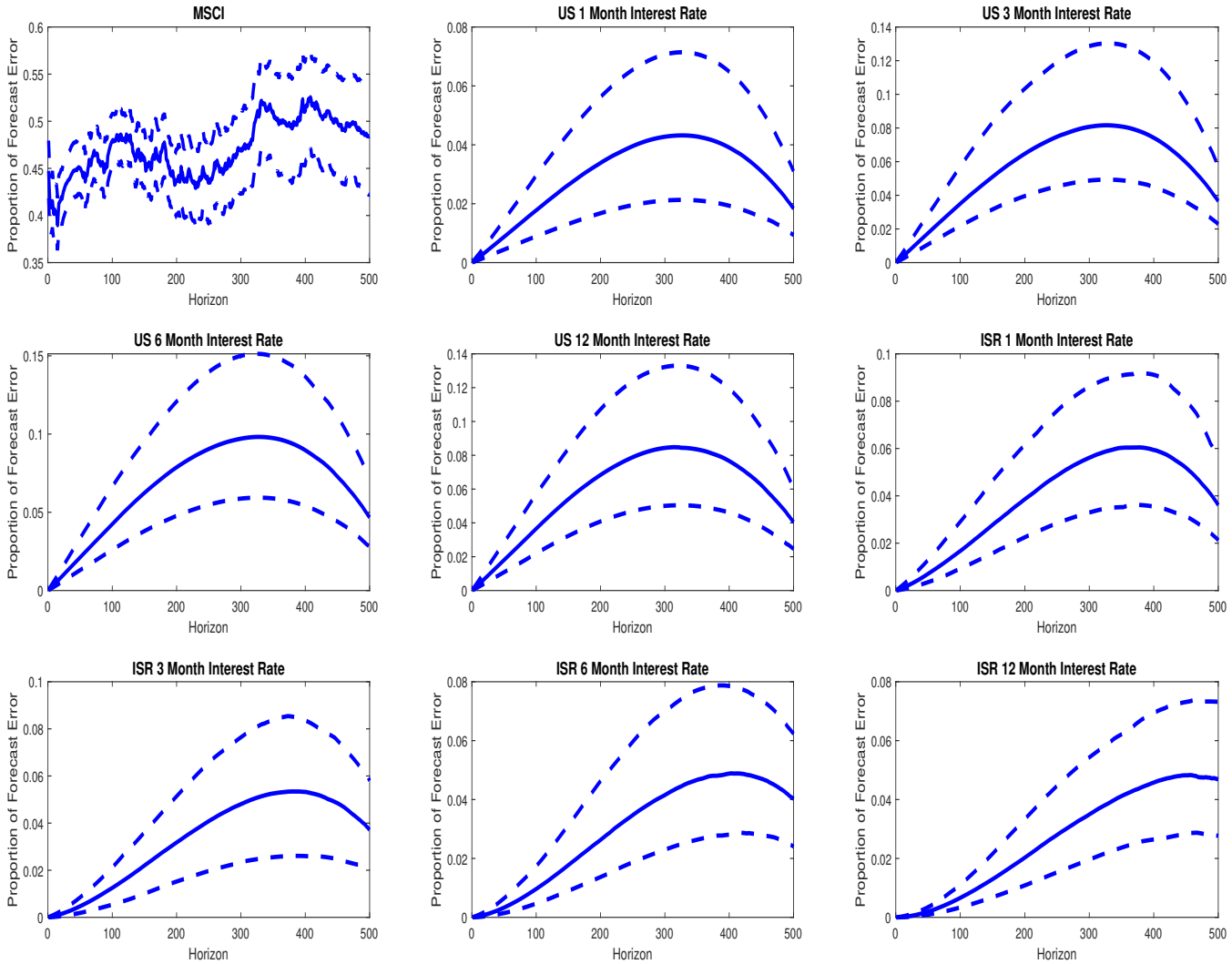
Notes: This figure presents the time series of IIs' accumulated daily FX forward (solid line)and spot (dashed line) flows. Negative accumulated flows' values represent the accumulated selling of dollars; positive values represent the accumulated buying of dollars. Data are from the BOI and cover 4/26/2011:8/18/2021.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

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



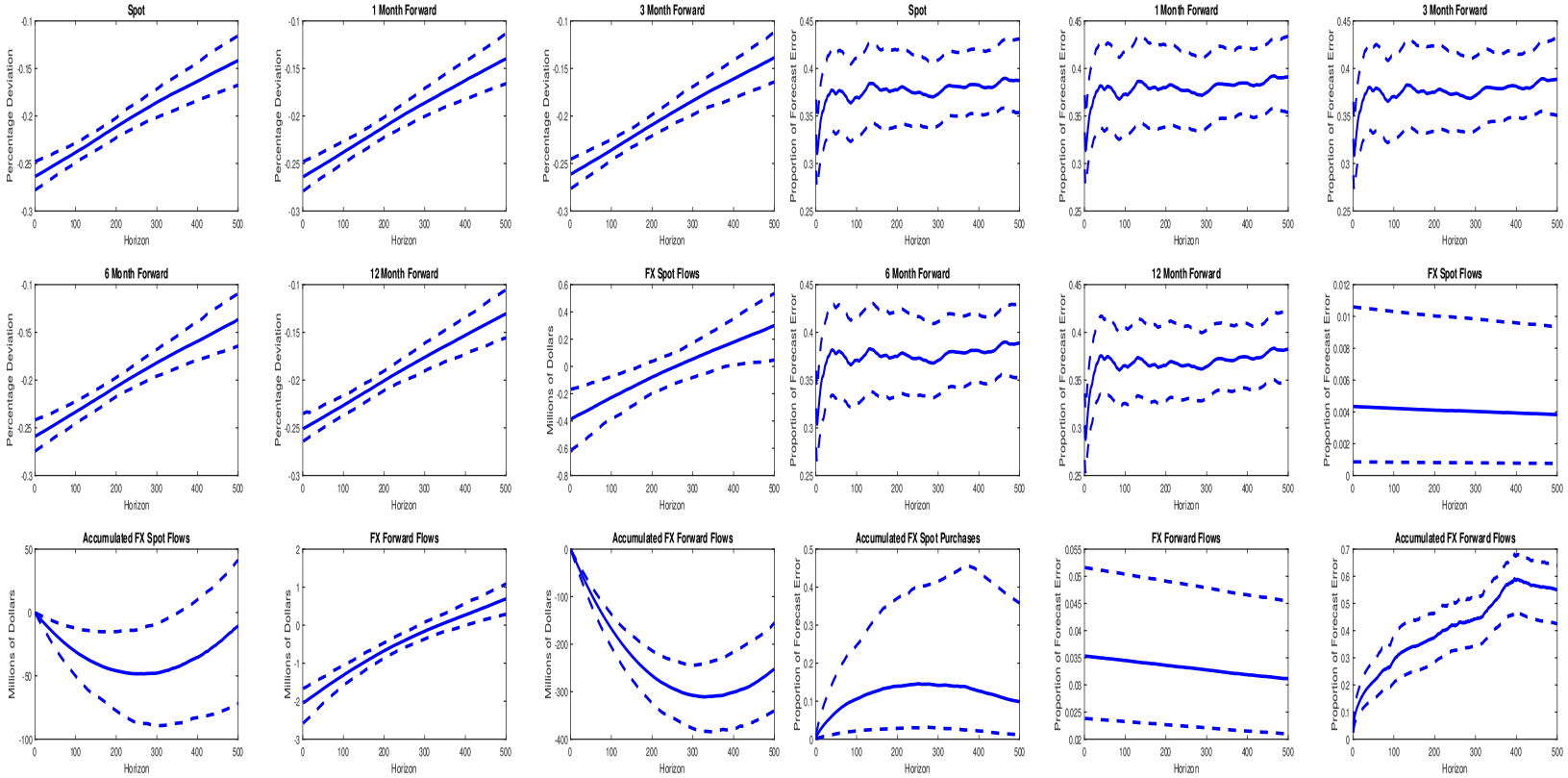
Notes: This figure presents the time series of accumulated daily FX forward flows by sector. On top of the II sector (which, for completeness, is also included in the figure and is represented by the solid line), this figure includes four additional sectors: real sector (dashed line), which represents the net FX flows from forward transactions involving Israeli exporters and importers; local banks 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 the forward flow activity of Israeli IIs that is done on their own behalf rather than on behalf of the public's long-term investments (i.e., activity related to their nostro (own) accounts). Negative accumulated flows' values represent the accumulated selling of forward dollars; positive values represent the accumulated buying of forward dollars. 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 stock prices and basis point deviation for interest rates). Horizon (on x-axis) is in days.

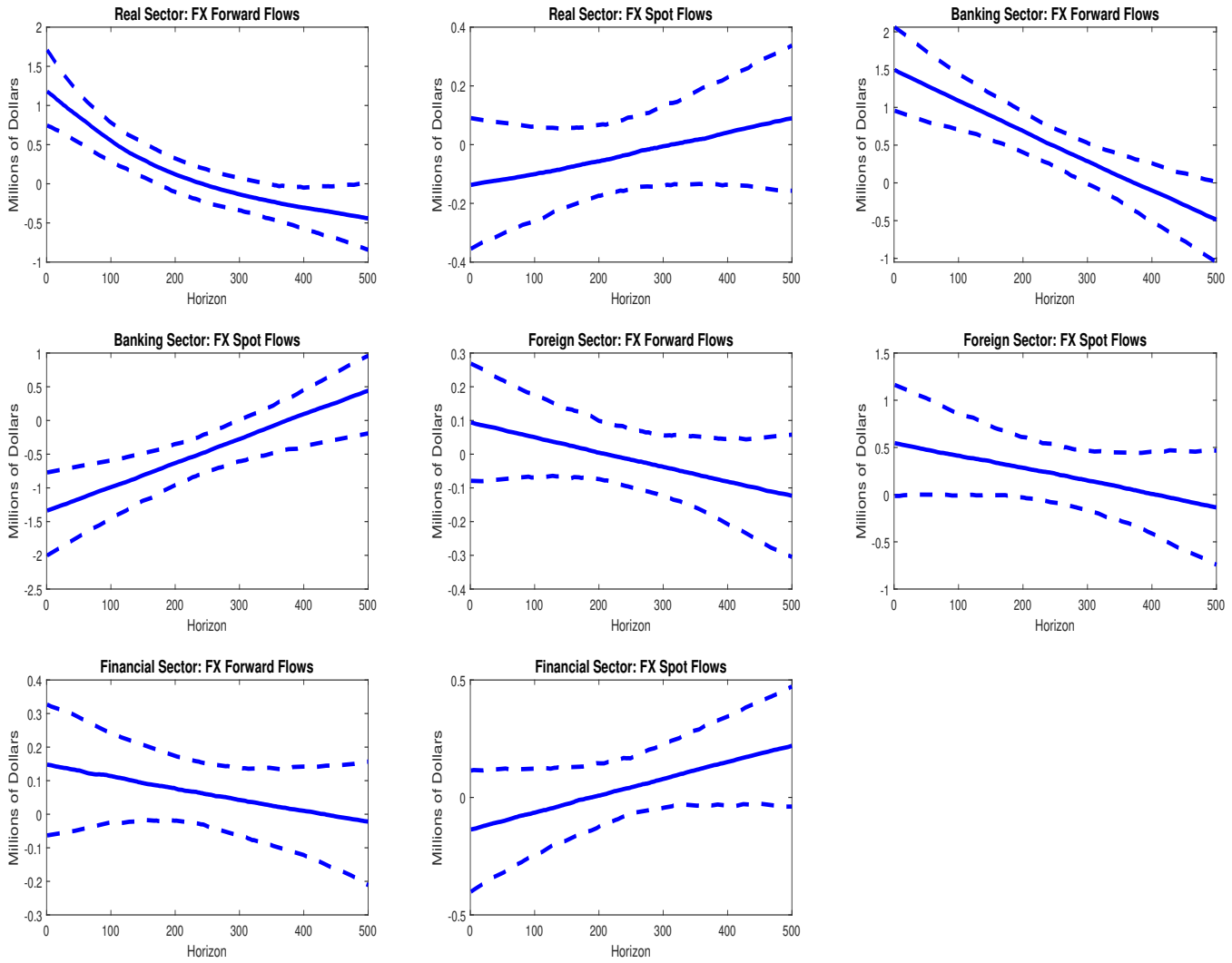
Figure 5: **FX Market Prices and Quantities: (a) Impulse Responses; (b) FEVs.**



(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.**

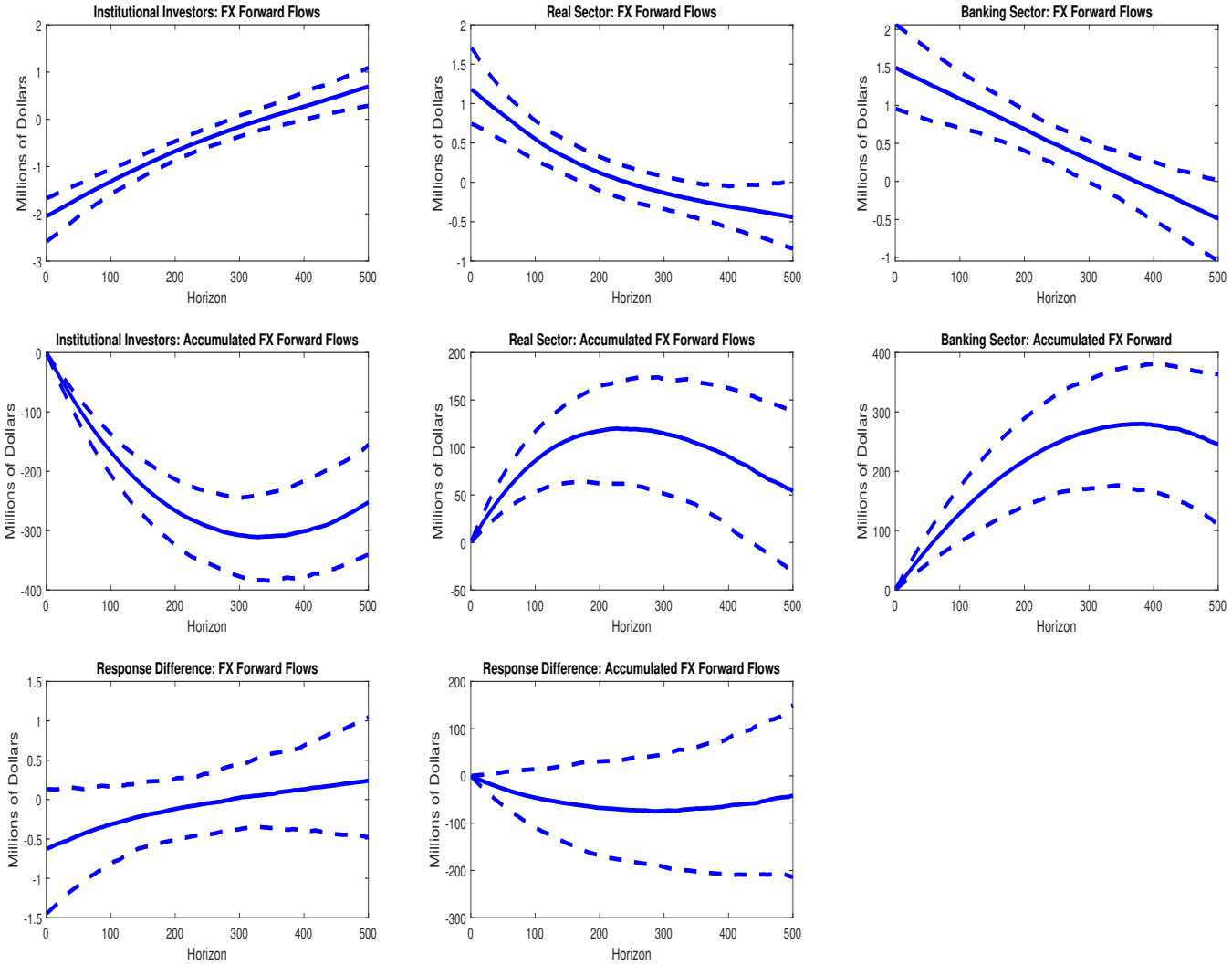
Notes: Panel (a): This figure presents the impulse responses of the spot and forward rates and quantities to a one standard deviation MSCI index innovation from the model described by Equations (7) and (8). Responses are in terms of deviations from pre-shock values (percentage deviation for spot and forward rates and Millions of dollars for spot and forward flows, spot-flows-induced accumulated spot FX purchases, and forward-flows-induced accumulated short position). 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**.



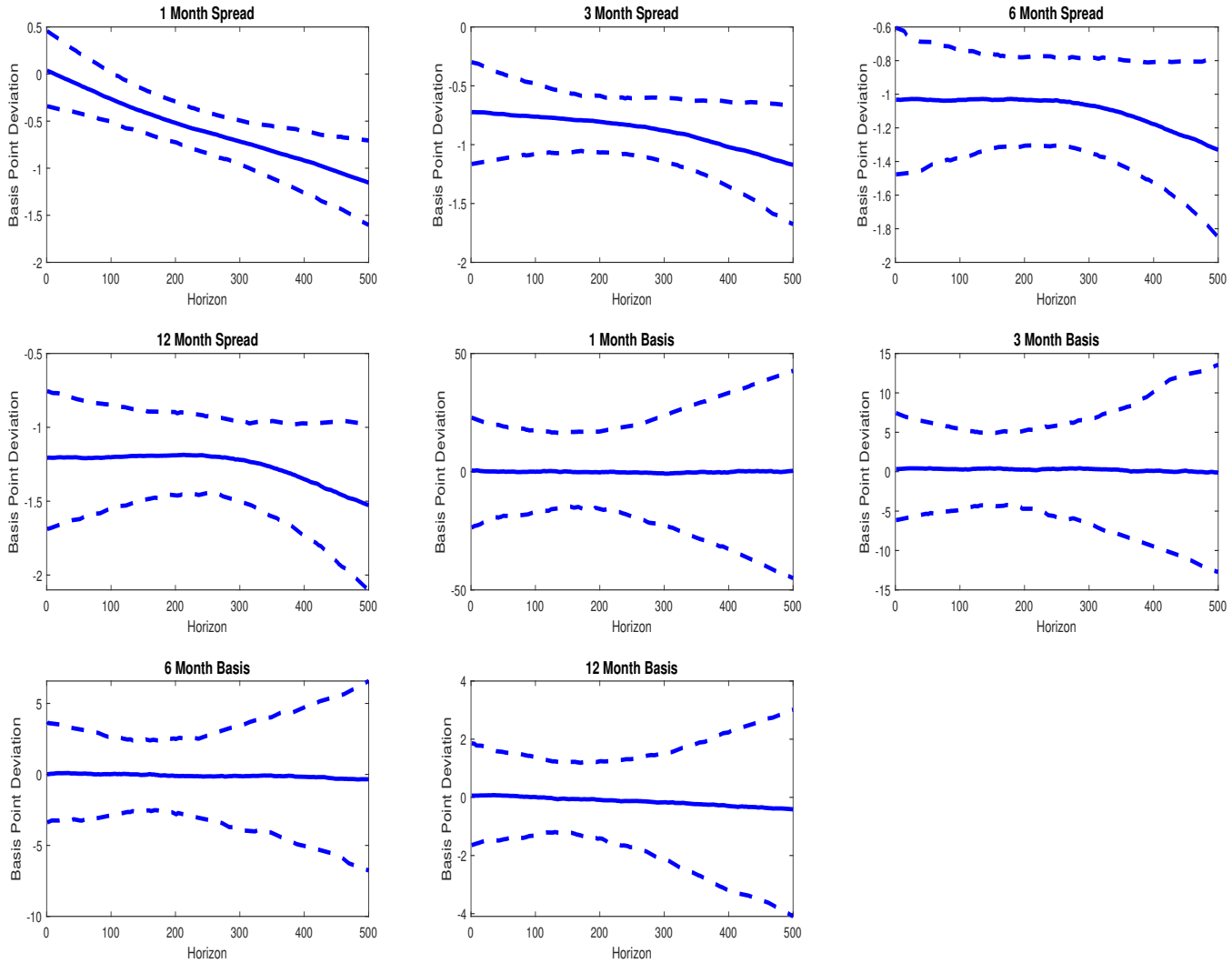
Notes: This figure presents the impulse responses of spot and forward flows of the real, banking, foreign, and financial sectors to a one standard deviation MSCI index innovation from the model described by Equations (7) and (8). Responses are in terms of deviations from pre-shock values (in million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



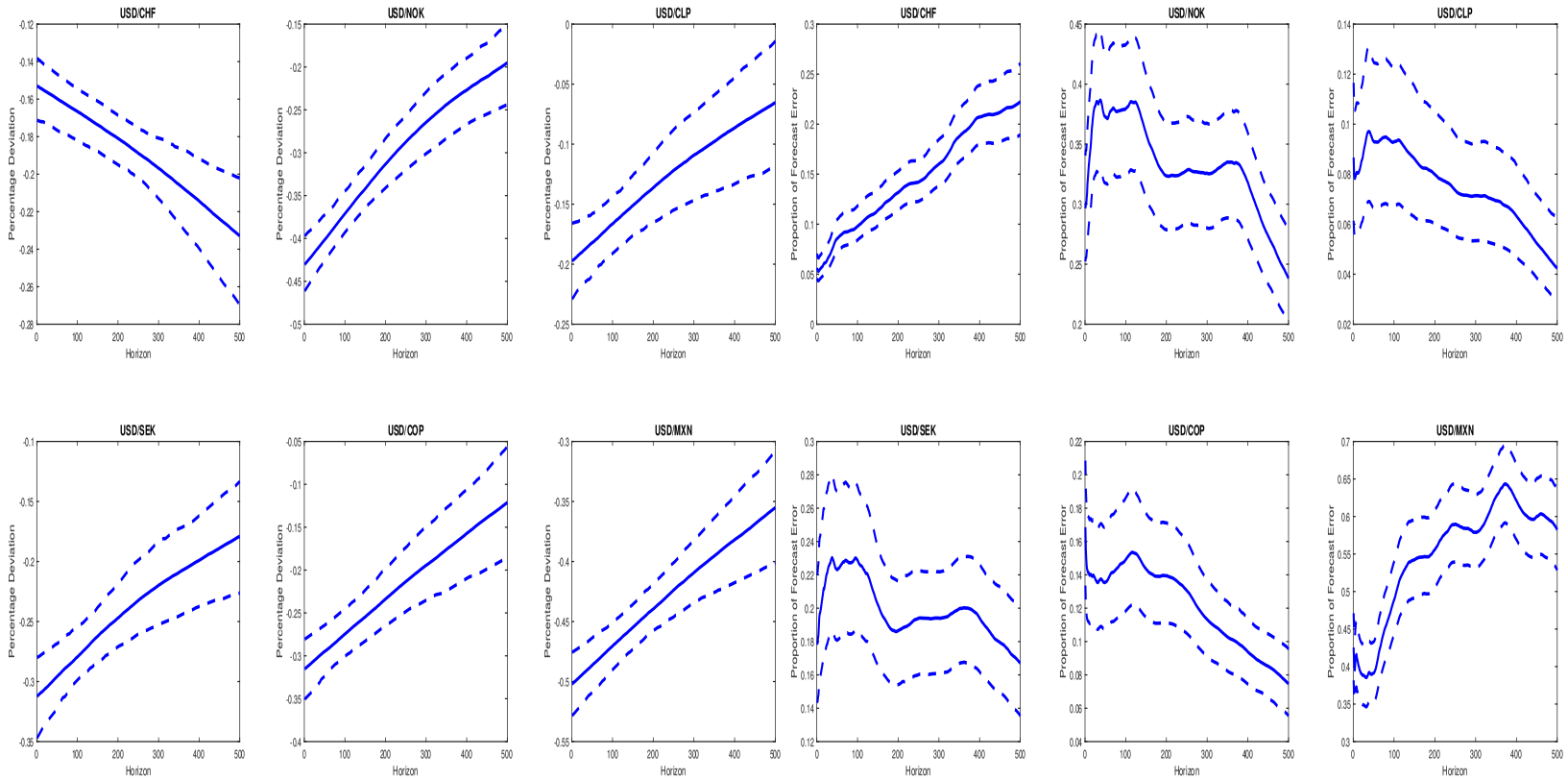
Notes: This figure presents the difference between raw and accumulated (in absolute terms) response of IIs' forward flows and the summed responses of the banking and real sectors' raw and accumulated forward flows, respectively, to a one standard deviation MSCI index innovation from the model described 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 NIS/USD 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.