

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

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## Abstract

This paper investigates the influence of global equity market shocks on institutional investors' (IIs') hedging behavior and the resulting effects on exchange rates. Employing unique daily data on Israeli IIs' foreign exchange (FX) forward flows, we find that a one standard deviation global equity market shock generates significant and persistent selling of US dollar forwards by IIs, as a hedge against heightened FX exposure, along with significant and persistent exchange rate appreciation. To reinforce the causal interpretation of our findings, we use both a granular instrumental variable estimation approach as well as a Bartik instrument one to show that IIs' hedging demand shocks induce significant exchange rate appreciation.

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

*Keywords:* Exchange Rate Determination; Equity Hedging Channel; Foreign Currency Forward Flows; Order Flow; Limits of Arbitrage; FX Dealers; Forward Exchange Rate; Spot Exchange Rate; Global Stock Prices; Institutional Investors; Granular Instrumental Variable; Bartik Instrument; Bayesian Local Projections.

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# 1 Introduction

We highlight a channel through which global equity market shocks influence exchange rate variation: the collective hedging of foreign exchange (FX) risk by institutional investors (IIs) such as pension and insurance funds. This equity hedging channel of exchange rate determination is driven by the need for investors with foreign equity positions to hedge against increased FX exposure resulting from a rise in the value of their foreign equity positions. They do this by selling foreign currency on the forward market. However, the purpose of their selling is not to rebalance their portfolios by changing their allocation of foreign and local equities, but rather to secure their foreign equity gains without selling the underlying foreign stocks. This in turn puts downward pressure on the forward rate, and consequently, leads to a decline in the spot rate.<sup>1</sup>

To investigate whether causality follows from the global equity shock to the hedging demands of IIs and then to the exchange rate, we use novel daily data on FX forward flows of Israeli IIs. Our dataset covers a recent (roughly) 10-year sample period that saw slight variation in local and foreign monetary policy rates. The MSCI All Country World Index (ACWI), a widely-followed measure of foreign equity prices that includes 23 developed and 25 emerging economies, is used to gauge global equity shocks.

**Main Results.** Our main findings can be summarized as follows. A one standard deviation innovation to the MSCI index leads to significant and highly persistent selling of dollar forwards by IIs, peaking on impact at 2.8 million dollars and accumulating to 338.8 million dollars after approximately 1.1 years (as shown in Figure 1). This striking collective sale of dollars in the forward market serves as a hedge against increased foreign exchange exposure. Second, both the USD/ILS spot and forward rates experience a significant and persistent decline following the MSCI innovation. This decrease is economically and statistically significant, standing at -0.23% on impact - with as much as 31%-32% of these variables' impact forecast error variation (FEV) being accounted for by this innovation, and is followed by a slow reversal over the next two years which is consistent with limits of arbitrage (see Section 6.6 for more details). The decrease in the spot and forward rates is very similar and coincides with a minimal response in U.S. and Israeli interest rates, as indicated by the insignificant estimated change in the USD/ILS cross-currency basis for all benchmark forward contract horizons.

**Ruling Out Other Potential Mechanisms.** Although our daily data provides us with confidence that we are identifying causal evidence, we exercise caution throughout the paper in ruling

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<sup>1</sup>Even if the covered interest parity (CIP) condition fails to hold, it is very reasonable to expect a positive relation between forward and spot rates. See the model from Section 3 for more details.

out other potential mechanisms that could explain the relationship we observe between shocks to the MSCI and the exchange rate.

**I. Causality Between Forward Flows and the Exchange Rate.** In order to ensure that our analysis is valid and to address potential concerns that hedging activities by IIs may not directly cause changes in forward rates but rather just occur concurrently with them, we investigate whether forward flows have an impact on the exchange rate in a general setting. That is, forward shocks that are not related to the MSCI shock (e.g., the need for some IIs to increase their hedging ratio.)

To do this, we exploit the granularity of our data and use a granular instrumental variable (GIV) estimation approach (Gabaix and Koijen (2020)) as well as the popularized and widely used Bartik (1991) instruments (also known as shift-share estimators) estimation approach. Specifically, we examine the exchange rate effects of the difference between the size- and inverse-variance-weighted average of idiosyncratic shocks to IIs' forward supplies (GIV shock) as well as the mean of these shocks (Bartik shock). To control for other factors that may affect the exchange rate, such as MSCI and local and foreign interest rates, we include them as controls in our granular estimation procedure.

We emphasize that the point of this exercise is not to compare the effect of the two shocks on the exchange rate, but rather to strengthen our conclusion that forward supply shocks can affect the exchange rate in the Israeli market. In fact, we hypothesize that the forward supply shock in this general setting would have a smaller effect on the exchange rate with a shorter persistence. This stems from the MSCI shocks displaying a sustained influence on the MSCI rate, akin to a random walk. Such shocks would likely elicit greater and longer-lasting hedging requirements than mere idiosyncratic hedging needs. The results agree with our hypothesis. Our GIV- and Bartik-based analyses, whose results are similar, show that forward supply shocks induce a statistically significant effect on the exchange rate. Per our hypothesis, the effect is weaker than the effect observed in response to an MSCI shock. And, we also observe a much weaker response of hedging by IIs following the GIV- and Bartik-based hedging shocks, which lasts only for 7 and 8 days for the GIV and Bartik shocks, respectively. This finding reinforces the importance of examining how hedging activities respond to MSCI shocks, as the latter elicit a continuing significant selling of forwards over the next year with a stronger effect on the exchange rate. Our GIV- and Bartik-based results further justify our choice of employing a dynamic model to capture these relationships effectively.

**II. Interest Rates and Cross-Currency Basis.** We rule out that it is changes in interest rates and/or cross-currency basis that drive our relationship. In particular, our dynamic analysis shows that the decrease in the spot and forward rates is very similar and coincides with a minimal response of U.S. and Israeli interest rates and an insignificant estimated change in the USD/ILS

cross-currency basis for all benchmark forward contract horizons.

**III. Debt Hedging.** The observed hedging that we see is not in response to a positive shock in the prices of bonds given the negative correlation typically observed between bonds and stocks. For instance, the daily correlation between the MSCI return series and a comparable global debt index return series is -26% in our sample. Moreover, variation in the latter debt index return series is very modest, both in absolute terms as well as relative to the MSCI return series, possessing a standard deviation of only 0.15% compared to 0.92% for the MSCI return series. This stark difference in variation serves as meaningful motivation for our focus on equity value shocks as important high-frequency impulses that drive the corresponding IIs' equity hedging.

**IV. Portfolio Rebalancing.** The channel we are capturing is conceptually distinct from the portfolio rebalancing channel (see, e.g., [Hau and Rey \(2004\)](#)) along three dimensions. First, their mechanism is silent about the role of FX hedging. Second, the portfolio rebalancing channel would not generate any expected FX *spot* flows in a scenario where two equity markets, local and foreign, perform similarly. However, even if both markets increase (or decrease) in value while the exchange rate remains constant, local investors could still encounter elevated (or reduced) foreign exchange (FX) exposure to the dollar in the equity hedging channel that we are studying. As a result, they might choose to hedge against this increased exposure (or lessen their hedge in case of decreased exposure). This decision in turn creates volatility in the FX market. And, third, as we formally show in Section 6.4, IIs tend to roll over foreign equity capital gains such that their hedging of these gains is funded by FX swaps rather than the spot selling of these gains. This institutional feature reinforces the notion that IIs' hedging flows are distinct from rebalancing-induced spot flows as the latter, by definition, involve the actual selling of the underlying foreign asset.

Importantly, our empirical findings provide crucial evidence that underscores the distinction between the portfolio rebalancing channel and the equity hedging channel, highlighting the latter's significance. Specifically, we observe that the baseline accumulated forward flow responses to an MSCI shock dwarf the accumulated spot flow responses across all horizons we analyze. Additionally, our pre-COVID sample reveals a statistically significant selling of dollar forward in response to MSCI innovation, while the selling of spot dollars is insignificant. These two results further emphasize the preeminent role played by the equity hedging channel in driving our results.

**V. Global Risk Appetite Shocks.** One might still be worried that the relation that we capture between the MSCI and the exchange rate is primarily driven by risk premiums. We show in Section 6.5 that global risk appetite shocks - a proxy for the risk premium - are not driving our results by re-estimating our model with current and lagged global risk appetite shocks controlled for in the identification of our MSCI shock. The results from this estimation exercise are very

similar to the baselines ones, bolstering confidence in the view that the equity hedging channel we find in the data is indeed driven by value shocks to MSCI and not merely coincide with changes in the risk appetite of investors that drive both the MSCI and the exchange rate.

**Robustness of Results.** We also perform a variety of robustness tests along four dimensions to further bolster confidence in our results. The first and second dimensions confirm the insensitivity of the results to the specific return series being used: the first uses micro data on IIs' regional portfolio weights to estimate the foreign equity innovation and the second replaces the MSCI return series with the S&P 500 index return series. The third dimension truncates the sample at 2/19/2020 to confirm that the results are robust to the omission of the COVID period. The fourth dimension 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, reinforcing confidence in the message of 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 as much as 36% of the variation in the spot rate, but it no longer generates significant selling of spot dollars as in the baseline case.

**External Validity.** We argue that the channel we document is not specific to the Israeli economy (For more information on the external validity of our analysis in other economies, see Section 7.). In fact, the recent OECD report "Pensions at a Glance 2021" shows that in 2020, pension funds in OECD countries had an average of 100% of assets in terms of GDP, up from 63% in 2010 (in Israel, Pension funds had assets equivalent to 68% of their GDP according to the same report). As these assets grow, pension funds often seek to invest abroad as they become quite large relative to their local financial markets. As evidence, the report states that out of a sample of 50 countries, these pension funds invested 35% of their assets in 2020, with some countries as high as 90% of their assets.

There is also survey evidence suggesting meaningful FX hedging of IIs in other economies. According to the OECD 2019 Survey of Investment Regulation of Pension Funds, minimal FX hedging 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%). Additionally, a survey conducted by Mercer (2020) in 2020 of 927 IIs in 12 countries, representing over 1.1 trillion in assets, found that 42% of the surveyed IIs hedge at least 60% of their FX exposure in listed equity portfolios. In conclusion, the results of these surveys suggest that the equity hedging channel identified in our paper may be relevant to a wide range of other countries.

**Objective and Contribution of this Paper.** The primary goal of this paper is to study the existence and quantitative relevance of the equity hedging channel of exchange rate determina-

tion. We center our analysis around a straightforward litmus test for the importance of this channel. This litmus test concerns the estimation of the effect of innovations in global stock prices on USD/ILS forward and spot flows of IIs as well as USD/ILS forward and spot rates corresponding to benchmark FX forward contracts.

To achieve our stated goal, this paper unfolds in two parts. The first section presents a clear conceptual framework that helps to clarify our ideas, motivates the use of the litmus test mentioned above, and provides a suitable foundation for the paper. The second part of the paper then carries out the litmus test itself. Before discussing these two sections, we will first briefly clarify some terminology to facilitate the exposition of the paper.

**Terminology.** In this paper, we use the terms “dollar” and “foreign currency” interchangeably to refer to the USD/ILS currency pair, as 84% and 81% of IIs’ FX forward and spot trades, respectively, are conducted in dollars. (The remaining 16% and 19% of these trades are included in our data and converted to dollar terms.) Additionally, since the local economy underlying the equity hedging channel is relatively small, we use the terms “foreign” and “global” interchangeably throughout the paper.

Finally, it is worth clarifying that FX forward flows can arise from two types of contracts: “standard” (single-leg) forward contracts and swap contracts.<sup>2</sup> Nonetheless, it is crucial to highlight the limited influence of FX swaps on exchange rate fluctuations. Although IIs use FX swaps to hedge (see, e.g., [Ben Zeev and Nathan \(2023\)](#)), as elaborated on page 12, FX swaps do not exert price pressure, given that an FX swap comprises both a spot and an opposing forward transaction, which ‘cancel’ each other and do not generate excess demand for the USD/ILS currency pair. This observation is further supported by our empirical findings. Consequently, for the purpose of simplicity and clarity, we consistently utilize the term “standard (non-swap-linked) forward flows” as equivalent to “forward flows” throughout this paper.

**Underlying Framework.** The first part of the paper 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 inelastic 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 arbitrageur’s activity which produces a positive equilibrium relation between forward and spot rates (albeit in tandem with an unconditional violation of the CIP condition).

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<sup>2</sup>FX Swap contracts consist of two legs, with the first being a spot transaction and the second being an opposite forward transaction of equal value.



The second part of the paper, to which we turn our attention next, tests the model's prediction that an increase in global stock prices leads to increased forward flows and lower forward and spot rates, which is the central idea behind the equity hedging channel of exchange rate determination.

**Econometric Model.** In this part we study the effect of increased foreign equity prices on aggregate USD/ILS forward and spot flows, USD/ILS forward and spot rates, and spreads between U.S. and Israeli interest rates at various maturities. We also estimate the USD/ILS cross-currency basis response to ascertain the possible role of conditional CIP violations.

As previously stated, we use the widely-followed MSCI ACWI index, which covers 23 developed and 25 emerging economies, to measure foreign equity prices. While we also have microdata on the regional weights of IIs' portfolios that allows us to measure their foreign equity returns directly, this data is only available from November 2015 onward. And there are additional noteworthy caveats to this data which we discuss in Appendix D.1 of the online appendix to this paper. Nevertheless, we also provide the important confirmation in this appendix that our baseline results are robust to using this data to measure foreign stock price changes, and we also confirm that our MSCI return series is highly correlated with the micro-regional-weights based return series (which is aggregated using IIs' foreign equity shares). The two series have a correlation of 98.2%.

In order to estimate our model, we utilize a Bayesian local projection model, which is described in Section 5.2.1. The technical details of this model's estimation and inference are provided in Appendix B of the online appendix. Our Bayesian estimation and inference procedure provides a convenient numerical way to produce confidence intervals that account for estimation uncertainty in both the step that estimates the MSCI shocks as well as the subsequent step that estimates the dynamic effects of these shocks on our variables of interest. (See discussion on Page 19 on why this two-step approach is preferable over a one-step estimation approach.) Our Bayesian approach is in the spirit of a long tradition in the literature on impulse response estimation (see, e.g., [Del Negro and Schorfheide \(2011\)](#)) that has recently also caught on in the local projections literature (see, e.g., [Miranda-Agrippino and Ricco \(2021\)](#) and [Ben Zeev \(2023\)](#)). We view our dynamic modeling choice as one of the strengths of our paper as it allows for studying the rich dynamics that occur after the MSCI shock.

As we previously mentioned, we find a significant and persistent selling of dollar forwards consistent with hedging by IIs, which takes place in tandem with a persistent appreciation of the spot and forward rates. Viewed through the lens of our structural model, this significant selling of dollar forwards implies a persistent rightward shift in the supply of USD/ILS forwards. The response of USD/ILS 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/ILS

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 (see the literature review for other possible channels). 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 as much as 36% of the variation in the spot rate (even moderately higher than the corresponding baseline 31% share). (The pre-COVID sample based results are shown in Appendix D.3 of the online appendix to this paper.)

The decline in exchange rates occurs in tandem with an economically negligible response of U.S. and Israeli interest rates, which accords with the insignificant estimated response of USD/ILS cross-currency basis we find for all benchmark forward contract horizons. That is, following 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 exchange rates embodies unchanging CIP deviations. (USD/ILS cross-currency basis is negative on average in our sample period. So the insignificant response of the USD/ILS cross-currency basis should be interpreted as implying that this basis is unchanged *conditional* on MSCI innovations.)

**Outline.** The remainder of the paper is organized as follows. In the next section we provide a literature review. In Section 3 the theoretical motivation for this paper is described (to save space, the full depiction of the associated model is deferred to Appendix A of the online appendix to this paper). The subsequent section provides institutional background of Israeli IIs' activity. Section 6.4 demonstrates an important institutional feature of IIs regarding the way they fund the settlement of their forward contracts and which in turn supports the interpretation of our findings. Section 5 provides a description of the data and methodology used in this paper. Section 6 presents the baseline results and briefly discusses additional robustness checks (the results of which are shown in Appendix D of the online appendix to this paper). Section 7 discusses the external validity of our results. The final section concludes.

## 2 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 literatures that motivate our work.



**Exchange Rate Determinants.** 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). Understanding which forces drive exchange rates is crucial given their central role in global capital allocation (Maggiori et al. (2020)) and open economies’ macroeconomic fluctuations (Schmitt-Grohé and Uribe (2016)).

Recently, meaningful advancement has been made in resolving the ‘exchange rate disconnect puzzle’ by two relevant literatures to our work. First, by turning to order flow data, a growing body of work has demonstrated that currency order flow can provide insight into explaining exchange rate excess returns. For example, Evans and Lyons (2002), Froot and Ramadorai (2005), and Menkhoff et al. (2016) have found that changes in currency order flow can help explain a significant amount of the fluctuations in the exchange rate.

Second, another body of literature has turned to investigating 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 systematically 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)), with a 7.1 billion dollars equity U.S. outflow (induced by foreign equity returns) resulting in a 1% dollar depreciation.

While the equity portfolio rebalancing channel studied by Hau and Rey (2004, 2006) and Camanho et al. (2022) 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. A critical distinction between the equity hedging channel we examine and the portfolio rebalancing channel lies in the underlying impulse driving each channel. In the equity hedging channel, the primary impulse is a foreign equity innovation, whereas in the portfolio rebalancing channel, the impulse stems from an innovation in the equity return *differential* between foreign and local equity markets.

To illustrate this difference, consider a scenario where both US and European stocks generate 10% returns in a given year and that the USD/EUR remained relatively unchanged. According to the portfolio rebalancing channel, no FX flows would be expected in this situation. However, in

the equity hedging channel we emphasize, European investors would still experience increased FX exposure to the dollar and might want to hedge against this exposure, thereby leading to fluctuations in the FX market.

**Hedging and Exchange Rates.** There are two additional papers that are relevant 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.

Our paper differs from [Melvin and Prins \(2015\)](#) in several crucial aspects. First, they assume that IIs hedge only in response to the relative outperformance of returns, an assumption we find unnecessary and do not adopt. Second, the granularity and high-frequency nature of our data enables us to identify the equity hedging channel more clearly. (Our data indicates that IIs execute hedging trades not on one specific day, as [Melvin and Prins \(2015\)](#) assume, but rather sporadically throughout the month with an effect that lasts for two years which is made possible by our dynamic analysis.) This aspect also distinguishes our paper from [Liao and Zhang \(2020\)](#)'s analysis. However, we also diverge from their study in three additional ways, which we will now 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 36 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. Moreover, as documented in [Du and Huber \(2023\)](#), pension funds have a non-negligible amount they invest in US denominated equities and also a non-negligible hedging ratio.

Second, we do not view our channel as hinging on the direction of an economy's net external balances. Rather, as explained in Section 7, it hinges on meaningful foreign equity positions of local IIs that are in turn meaningfully hedged, with these IIs belonging to a sufficiently small econ-

omy 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).

**Intermediaries and Asset Pricing.** Last, we also contribute to the extant literature investigating the many ways in which intermediaries affect financial markets (Greenwood and Vayanos (2010), Ellul et al. (2011), He and Krishnamurthy (2013), He et al. (2017), O' Hara et al. (2018), He and Krishnamurthy (2018), Klingler and Sundaresan (2019), Hendershott et al. (2020), Jiang et al. (2021), Koijen and Yogo (2022), Greenwood et al. (2023), and Pinter (2023) among others). We add to this literature by showing how hedging demand by IIs (an important form of intermediaries) through FX forwards affects exchange rates.

### 3 Theoretical Motivation

In Appendix A of the online appendix to this paper 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.

The central prediction of the model is that an increase in the value of the II's foreign equity position causes an increase (decline) in the equilibrium quantity (price) of foreign currency forwards; this appreciation of the forward rate leads to an identical (in percentage change terms) appreciation of the spot rate. The intuition for this prediction is simple. The rise in the II's foreign equity position prompts it to increase its hedging of this now enlarged position. Hence, the II's supply of foreign currency forwards shift rightward along the unchanged IM's downward-sloping forward demand curve, thus generating an increase in the equilibrium quantity of forwards along with a decrease in their price. Through the GA's arbitrage activity, this forward rate appreciation translates into an equivalent spot rate appreciation (in percentage change terms).

## 4 Institutional Background

This section lays out information about the IIs in Israel and the environment in which they operate. We first start with a description of the liquidity in the Israeli FX market.

**Liquidity of the Israeli FX market.** According to the latest BIS triennial survey of 51 countries, as of April 2022, Israel's daily average turnover in the forward market was 779 million dollars, half the size of the spot market's daily average turnover of 1,491 million dollars. This places Israel in the third quartile of the 51 countries for this relative measure, alongside other major FX markets like the U.S., the U.K., and Switzerland, indicating the forward market is a liquid market relative to the spot market for the ILS. Compared to other countries, Israel's daily average turnover in the forward market is similar to Belgium's (807 million dollars) and Norway's (708 million dollars). The interquartile range and median daily forward market turnover for the 51 countries are 373 and 1,407 million dollars, respectively. Israel's total daily average turnover in the FX market, including spot, forwards, FX swaps, and options, is approximately 10 billion dollars. This data suggests that Israel's forward FX market is vibrant and liquid.

**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,<sup>3</sup> and life insurance policies.<sup>4</sup> 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

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<sup>3</sup>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.

<sup>4</sup>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.

workers, further increasing the portfolio managed by IIs while pushing them to seek alternatives to their investments in Israel.<sup>5</sup>

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.

**Hedging FX Exposure.** IIs have several methods to hedge their FX risk that arises from making profits through international investments. One approach is to sell appreciated foreign equities and immediately convert the earnings into local currency (e.g., portfolio rebalancing). Another method — central to our paper — involves purchasing the local currency in the FX forward market in the desired amount as to hedge the profit. This selling strategy ensures that IIs will not incur losses on the amount of profits they hedged due to future fluctuations in the dollar's value. Moreover, it offers benefits compared to merely selling an asset. When the forward contract reaches maturity, IIs can fund it without necessarily having to sell the asset, which in practice they often do using FX swaps (see Section 6.4).

**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 possesses 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 basis; 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.)

With regards to an effect on the FX rate, it is crucial to understand that an FX swap has two opposing legs. A long (short) spot transaction and a short (long) forward transaction. These transactions cancel each other in terms of the effect of excess demand on the exchange rate. In our econometric analysis we have found that USD/ILS cross-currency basis does not meaningfully

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<sup>5</sup>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.

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 7.2). 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.<sup>6</sup>

Notwithstanding the irrelevance of FX swaps to the mechanism of our equity hedging channel, Section 6.4 exploits the transaction-level FX swap and forward data available to us to establish that IIs tend to unconditionally roll over their foreign asset positions by having the bulk of their forward dollar selling funded by their buying of FX swap-linked spot dollars. Such FX swap buying is a substitute for selling foreign asset positions as a way to fund maturing forward contracts' payments and thus its dominant role in funding the latter payments serves as meaningful support for our argument that IIs' forward selling of dollars is not done to rebalance their portfolios but rather to hedge their foreign equity profits without selling foreign stocks.

**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/ILS exchange rate, Figure 2 plots these variables in monthly frequency for the monthly sample of 2011:M4-2021:M8, which corresponds to the daily sample of our forward flows 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 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 equities 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

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<sup>6</sup>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 USD/ILS 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/ILS spot rate environment, Figure 2 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/ILS 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. Moreover, since FX options are a negligible hedging trading tool in Israel, we abstract from them in both the descriptive analysis shown here and the empirical analysis that follows this section.<sup>7</sup>

Alongside their hedging related trading activity, Israeli IIs also trade on the FX spot market. Figure 3 shows the evolution of accumulated daily forward (solid line) and spot (dashed line) flows for 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.

There are two noteworthy facts that are borne out by Figure 3. First, Israeli IIs conduct meaningful trading 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. 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 4 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 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

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<sup>7</sup>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.

sectors. It is noteworthy that the more central buyer of dollar forwards throughout the bulk of the sample is the real sector. These buying and selling activities are intermediated by FX dealers (local banks) who provide liquidity to the market and are central in the determination in exchange rates (see, e.g., [Gabaix and Maggiori \(2015\)](#) and [Itskhoki and Mukhin \(2021\)](#)); only at the end of the sample do local banks accumulate dollar forward purchases that are quantitatively comparable to those of the real sector.<sup>8</sup> 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 IIs' counterparties in their forward selling trades. In the empirical analysis we will demonstrate the role of the real and banking sectors as counteparties to IIs' forward selling *conditional* on a shock to global stock prices.

## 5 Methodology

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

### 5.1 Data

Our data is daily and covers the period 4/26/2011-8/18/2021. The specific starting and ending points of this approximate 10-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.

#### 5.1.1 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.

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<sup>8</sup>Notice that local banks only started buying in the beginning of the COVID-19 crisis when global prices of equities collapsed. This created a surge in the selling of forwards by IIs which banks had to absorb on their balance sheet.

**Forward 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.

**Data for GIV- and Bartik-Based Estimation.** Our GIV- and Bartik-based identification approaches from Section 6.3 come from our ability to observe the universe of transaction-level forward flows for individual IIs. There is a total of 14 such IIs on which we base our GIV- and Bartik-based identification procedures. These IIs are the universe of asset managers in Israel managing its public's long-term savings and comprise of investment banks and insurance companies. The long-term savings industry in Israel is quite concentrated, as reflected by an average Herfindahl-Hirschman Index of 0.33 for IIs' (absolute) forward flows.

It is reasonable to expect only modest correlation among our 14 IIs' forward flows given the high-frequency (daily) nature of our data. This expectation is borne out by the data with an average absolute pairwise correlation among the 14 IIs of 7.3% and a corresponding standard deviation of 6.1%. Importantly, by removing the effects on these flows of various common drivers, our GIV- and Bartik-based estimation procedures are capable of materially reducing these numbers to 1.7% and 1.7%, respectively. I.e., the high-frequency nature of our data along with the suitability of Section 6.3's GIV- and Bartik-based estimation procedures facilitate the extraction of daily idiosyncratic II-level forward supply shocks whose GIV- and Bartik-based constructions provide valid IVs for reinforcing the causal interpretation of this paper's results on the equity hedging channel.

**Spot 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.

### 5.1.2 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.

### 5.1.3 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 (4/26/2011-8/18/2021). 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/ILS Spot.** The USD/ILS spot rate is our measure of the spot exchange rate.

**USD/ILS Forward.** We use 1-, 3-, 6-, and 12-month USD/ILS 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.

## 5.2 Estimation

We estimate a daily frequency Bayesian 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.

### 5.2.1 Econometric Model

**Specification.** We estimate the system

$$\Delta MSCI_t = B_1 \Delta MSCI_{t-1} + B_2 \Delta MSCI_{t-2} + \dots + B_p \Delta MSCI_{t-p} + B_c + u_t, \quad (1)$$

$$y_{t+h} - y_{t-1} = \alpha_h + \Xi_h \hat{u}_t + \epsilon_{t+h}, \quad (2)$$

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;<sup>9</sup>  $B_c$  is a constant; and  $u_t \sim i.i.d. N(0, \sigma_u^2)$  is the foreign stock price innovation where  $\sigma_u$  is its standard deviation;  $\hat{u}_t$  is the estimated residual from Equation (1), normalized to have unit variance;  $\alpha_h$  is an horizon-specific intercept, with  $h$  being regression's rolling horizon ( $h = 0, \dots, 500$ );  $\Xi_h$  is the effect of a one standard deviation MSCI index shock on the relevant outcome variable at horizon  $h$ ;<sup>10,11</sup> and  $\epsilon_{t+h}$  is the residual of Equation (2).

Let the stacked  $(p+1) \times 1$   $B = [B_1, \dots, B_p, B_c]'$  matrix represent the coefficient matrix from Equation (1) such that  $B$  and  $\sigma_u$  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 (2) and  $\sigma_{\epsilon,h}$  represent the standard deviation of the residual from Equation (2) (for each horizon  $h$ ). Hence, the parameters to be estimated from Equation (2) can be summarized by the coefficient matrix  $Q_h$  and residual variance  $\sigma_{\epsilon,h}^2$ . (These nomenclatures will be used in Appendix B of the online appendix to this paper to facilitate this appendix's detailed depiction of the inference and estimation procedure for Equations (1) and (2).)

**Estimation Method.** We estimate Equation (1) jointly with Equation (2) 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 (1) and the second contains Equation (2). As shown in Zha (1999), this kind of block separation along with the standard as-

<sup>9</sup>AIC, HQIC, and BIC criteria tests recommend 25, 18, and 18 lags. Our 20 baseline lag choice reflects the average of these recommended lags. We show the robustness of our results to alternative lag choices in online appendix's Section B.4.

<sup>10</sup>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 and spot and forward flows are stationary according to the Augmented Dicky-Fuller test and hence entered into the rolling regressions in levels. The Mann-Kendall test (modified to account for autocorrelation) for trend detection indicated that one can not reject the null of trend absence in the spot and forward flow series. Notwithstanding the robustness of our baseline results for these two variables to the inclusion of a time trend in their associated local projections, the result from the Mann-Kendall test - which accords with what one deduces from eyeballing these series - led us to only include a constant in the said local projections.

<sup>11</sup>Note that results from estimating the response of the MSCI index from Equation (2) are similar to those obtained from iteration of the AR coefficients from Equation (1) 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.

sumption 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 B of the online appendix to this paper.)

**Two- Versus One-Step Estimation.** It is noteworthy that it is asymptotically equivalent to estimate System (1)-(2) as a single equation by replacing  $\hat{u}_t$  in Equation (2) 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 (1)-(2) 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 (1) just  $p = 20$  observations earlier than the start of Equation (2)'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 (1) on the *same* sample for all sectoral FX flows variables considered in the estimation of Equation (2) 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.



## 6 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.<sup>12</sup>

### 6.1 MSCI and FX Market Variables

**MSCI index.** The first sub-figure of Figure 7 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 0.81% to its own innovation and is persistently higher than its pre-shock value, leveling off at a 0.47% 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 USD/ILS 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 6.2.)

**USD/ILS Spot and Forward Rates.** The first sub-figure of Figure 8a gives the response of the USD/ILS spot exchange rate while the following 4 sub-figures show the responses of the 1-, 3-, 6-, and 12-month USD/ILS 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. This response troughs on impact at -0.23% for all exchange rates (spot and forward); it then gradually begins to decay until reaching at the two-year mark -0.07% for the spot and 1- and 3-month forward rates, -0.08% for the 6-month forward rate, and -0.09% for the 12-month forward rate. The gradual decay is consistent with limits of arbitrage (Shleifer and Vishny (1997)), an hypothesis which we explore formally in Section 6.6.

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<sup>12</sup>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.

The effectively identical responses of spot and forward rates are consistent with the negligible responses of interest rates from Figure 7 (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/ILS 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 8b show the FEV of the USD/ILS 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 29% of the impact variation in the spot and forward rates, with this share rising quickly to peak at 31% and 32% of the variation in spot and forward rates, respectively. To further validate the importance of our channel, we now turn to the quantity side of the forward market while also showing the behavior of spot flows for completeness.

**USD/ILS Spot and Forward Flows.** The 6th and 7th sub-figures of Figure 8a present the raw and accumulated raw responses of USD/ILS spot flows, respectively, while the 8th and 9th sub-figures show the raw and the minus of the accumulated raw responses of ILS/USD forward flows. Negative responses imply a selling of spot and forward dollars. Spot and forward flows drop significantly for 158 and 219 trading 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 accumulating to a peak value of 72.4 million dollars after 256 trading days and the former's corresponding value standing at 4.7 times larger than that at 338.8 million dollars after 277 days.

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.) It is noteworthy that we also show the accumulated response of forward flows 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.<sup>13</sup>

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<sup>13</sup>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.

That the accumulated forward flow responses dwarf the accumulated spot flow responses at all horizons stresses the dominant role of the equity hedging channel in driving the significant and immediate exchange rate appreciation from the first sub-figure of Figure 8a. In Section 6.7 we discuss how the pre-COVID sample based results (shown in Appendix D.3 of the online appendix 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 as much as 36% of the variation in the spot rate (even moderately higher than the baseline 31% share). Taken together, the baseline 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 8b present the FEV of ILS/USD spot and forward flows that is attributable to the MSCI index innovation. At the impact horizon, the latter innovation accounts for only 0.8% of the variation in spot flows while explaining 4.5% 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 MSCI index innovation effects are propagated primarily through the forward market. This point is also vividly shown in the 8th and 9th sub figures of Figure 8b, which show the FEV shares for the accumulated spot and forward flow variables, respectively. While 53.6% of the two-year variation in the accumulated forward flows variable is accounted for by the MSCI innovation, a corresponding much less significant 19.2% is accounted for by the MSCI innovation for the accumulated spot flows variable.

**Other Sectors' USD/ILS Spot and Forward Flows.** Figure 9 shows spot and forward flows' responses of four additional sectors:<sup>14</sup>) 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.

Figure 9 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

<sup>14</sup>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.)

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 corresponding significant buying of such dollars on the part of the other participants for which we have such data, indicates that the BOI is acting as a major 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 10 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 D.3 of the online appendix to this paper, this role has only been relevant for the post-COVID period; considering only a pre-COVID sample 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 3.

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 9 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).

## 6.2 Interest Rates and Cross-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 7 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 11 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 2.7 basis points for the 3-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.

**ILS/USD Cross-Currency Basis.** While the structural model from Section 3 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 11 depict the response of 1-, 3-, 6-, and 12-month CIP deviations to an MSCI innovation.<sup>15</sup> It is clear that the response of CIP deviations (i.e. USD/ILS 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/ILS cross-currency basis (see Footnote 15), deviations from CIP *conditional* on the MSCI innovation do not appear to be a meaningful propagation mechanism for the equity hedging channel.

### 6.3 Inspecting the Mechanism Through the Lens of Forward Supply Shocks

**GIV- and Bartik-Based Estimation.** One concern that may still arise from our empirical evidence is that MSCI innovations' effect on the exchange rate is not intrinsically rooted in a causal relation between forward flows and the exchange rate. To alleviate this concern and bolster confidence in the existence of such casual-based equity hedging channel, we estimate a daily frequency

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<sup>15</sup> 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/ILS, 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)).

Bayesian local projection model whose core lies in the granular instrumental variable (GIV) approach from [Gabaix and Koijen \(2020\)](#) as well as the [Bartik \(1991\)](#) instrument approach. (Also known as shift-share estimators, Bartik instruments constitute an established and widely used identification approach in economics (see, e.g., [Blanchard and Katz \(1992\)](#), [Autor et al. \(2013\)](#), [Adão et al. \(2019\)](#), [Goldsmith-Pinkham et al. \(2020\)](#), and [Borusyak et al. \(2021\)](#))).) The estimation proceeds in two steps.

In the first step, we identify idiosyncratic forward supply shocks from 14 micro-level regressions of our IIs' forward flows on their own raw lag as well as current and lagged value of MSCI returns and U.S. and Israeli interest rates.<sup>16</sup> This rich specification ensures that the micro-level innovations to the IIs' forward flow series from the micro-level regressions (i.e., the first step of our estimation) represent well idiosyncratic forward supply shocks. Based on numerous conversations we have had with FX market traders from two local banks, the microstructure of the USD/ILS forward market is such that IIs' forward flows are IIs-initiated transactions. I.e., these flows represent seller-initiated forward orders placed by IIs with market making local banks. Hence, after appropriately controlling for potential exogenous drivers of these flows such as MSCI and interest rates, the remaining variation in these seller-initiated forward flows constitutes a valid measure of idiosyncratic II-level forward supply shocks.

In the second step of our estimation, we run local projection regressions of spot and forward rates as well as IIs' aggregate forward and spot flows on the GIV and Bartik shocks, thus allowing us to estimate the dynamic effects of forward supply shocks on our main outcome variables. We now discuss the construction of each shock.

The GIV shock is constructed as the difference between the size-weighted- and inverse-variance-weighted-average of the 14 idiosyncratic micro-level forward supply shocks from the first estimation step, where the size weights are calculated from the share of forward flows average volume of each II in total IIs' average volume. As shown in [Gabaix and Koijen \(2020\)](#), this GIV construction is optimal in the sense that the resulting estimation possesses the highest precision. Moreover, it provides an aggregate shock to IIs' forward supply in line with [Gabaix and Koijen \(2020\)](#). In particular, it alleviates the concern that each of the idiosyncratic forward supply shocks still contains some common component (e.g., variation coming from contemporaneous forward rate variation) because the gap between the size-weighted- and inverse-variance-weighted-average of these shocks removes any potential remaining such common variation and hence produces a shock (shifter) to IIs' aggregate forward supply.

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<sup>16</sup>While there are 175 funds in our sample, they are managed by only 14 investment banks and insurance companies. Two funds managed by the same firm are governed by the same investment strategy and policy, including those pertaining to hedging practices. Hence, to obtain a meaningfully distinct enumeration of IIs, it is vital to resort to looking at the aforementioned list of 14 IIs.



As in [Gabaix and Koijen \(2020\)](#), we define the Bartik instrument shock as the cross-sectional mean (equally-weighted-average) of our 14 IIs' idiosyncratic shocks. [Gabaix and Koijen \(2020\)](#) define and compare the Bartik instrument in relation to their GIV instrument and emphasize that the two instruments should be viewed as complementary identification approaches. Specifically, while the GIV approach seems to be the natural and preferable method for identification when there are large idiosyncratic shocks driving the aggregate, the Bartik instrument may be more suitable when there are no such large shocks. It is therefore of value to confirm that both identification approaches yield similar results. To summarize, the second step of our estimation allows us to estimate the dynamic effects of the GIV- and Bartik-based forward supply shocks on our main outcome variables.

**Specification.** We estimate the following two-step model:

$$FF_{i,t} = \alpha_{i,0} + \beta_{i,1}FF_{i,t-1} + \dots + \beta_{i,p_i}FF_{i,t-p_i} + C_{i,0}Z_t + \dots + C_{i,p_i}Z_{t-p_i} + \xi_{i,t}, \quad (3)$$

$$y_{t+h} - y_{t-1} = \alpha_{2,h} + \Phi_h \hat{\omega}_t + v_{t+h}, \quad (4)$$

where  $i$  and  $t$  index IIs and time at daily frequency;  $\alpha_{i,0,L}$  is the fixed effect;  $FF_{i,t}$  is II  $i$ 's forward flows;  $p_i$  denotes the number of lags for II  $i$ 's equation;<sup>17</sup>  $Z_{t-s}$  are  $9 \times 1$  variable vectors whose components are the log-first-differences of MSCI and the levels of U.S. and Israeli interest rates at the 1-, 3-, 6-, and 12-month maturities;  $\xi_{i,t} \sim i.i.d. N(0, \sigma_{i,\xi}^2)$  is Equation (3)'s residual (i.e., true idiosyncratic forward supply shock for II  $i$ ) where  $\sigma_{i,\xi}$  is its standard deviation;  $b_t$  is IIs' cross-currency basis;  $h$  is Regression (4)'s rolling horizon ( $h = 0, \dots, H$ ); for the GIV case  $\hat{\omega}_t = \sum_{i=1}^{14} w_i \hat{\xi}_{i,t} - \sum_{i=1}^{14} v_i \hat{\xi}_{i,t}$  is the difference between the size-weighted- and inverse-variance-weighted-average of estimated residuals from Equation (2) while for the Bartik case  $\hat{\omega}_t = \sum_{i=1}^{14} \frac{1}{14} \hat{\xi}_{i,t}$  (both the GIV and Bartik shocks are normalized to have unit variance), i.e.,  $\hat{\omega}_t$  is the estimated aggregate IIs' forward supply shock, where the weights  $w_i$  are calculated from the share of forward flows' average volume of each II in total IIs' average volume and  $v_i$  is the share of  $\hat{\xi}_{i,t}$ 's inverse variance in the sum of estimated residuals' inverse variances; and  $v_{t+h} \sim i.i.d. N(0, \sigma_{v,h}^2)$  is Equation (4)'s residual where  $\sigma_{v,h}$  is its standard deviation, where Equation (4) in turn possesses the same structure of Equation

<sup>17</sup>We compute the AIC, corrected AIC, BIC, and HQIC lag length criteria tests for each II  $i$ 's regression. Our general inclination is to choose the number of lags for each micro-level regression by taking the average lag specification across the latter four considered tests for each II-level regression. Nevertheless, we also take note of the minimal number of lags needed to produce a white noise residual from Equation (3), according to the Ljung-Box Q-test for residual autocorrelation, to ensure our identified shocks are not serially correlated. Accordingly, whenever the average lag specification across our four considered tests was below this minimal lag threshold, we took the latter threshold as our lag choice. (This was the case for 7 of our 14 II-level regressions.) The ultimate average lag across the different II-level specifications is 9.9 with a standard deviation of 6.2.

(2). (The estimation and inference procedure for Equations (3) and (4) is shown in Appendix C of the online appendix to this paper.)

The coefficient of interest is  $\Phi_h$ , whose estimate provides the impulse response of our outcome variable of interest to the aggregate forward supply shock. We consider  $h$  up to the 10th horizon as significance of the effects of the latter shock dies out by this horizon.

**Rationale Behind Identification.** By purging II-level forward flow variation of innovations to MSCI and interest rates, the estimated II-level residuals from Equation (3) provides a valid measure of II-level forward supply shocks. One can structurally interpret this shocks as arising from exogenous, discretionary behavior on the part of IIs' FX traders or the investment committees that guide these traders. And any potentially remaining common variation in our 14 idiosyncratic shocks is likely removed owing to our GIV approach which subtracts the inverse-variance-weighted-average of the shocks from the size-weighted one. While the Bartik approach does not do this subtraction and merely takes the simple mean of the idiosyncratic shocks, the fact that the average absolute pairwise correlation among these shocks is so low (standing at 1.7% - this number is further discussed below) indicates that the Bartik shock also provides a valid aggregate forward supply shock.

A crucial element of our econometric model is that we allow for all of the coefficients in Equation (3) to vary with  $i$ . Technically, this implies that we separately estimate this equation for each of our 14 IIs. Substantively, this heterogeneous coefficient setting allows us to remove common variation in IIs' forward supply arising not only from the common variables in Equation (3) but also from the *way* by which IIs' respond to these variables. This is important because in addition to time-invariant differences across IIs' forward supply (captured by fixed effect  $\alpha_{i,0}$ ) there are also time-varying such differences stemming from heterogeneous sensitivities of IIs' to both lagged II-specific forward flows and common forward market drivers. The latter heterogeneity is what our heterogeneous coefficient setting precisely accounts for, resulting in a panel of 14 idiosyncratic demand shocks that exhibit a mere average absolute pairwise correlation of 1.7% with a standard deviation of 1.7%.

**Results.** Our identified IIs' GIV- and Bartik-based forward supply shocks, which generate similar results, can be used to examine the causal relation between forward flows and the exchange rate and to shed light on the mechanism underlying the equity hedging channel uncovered by this paper. Toward this end, Figures 12 and 13 show the responses of spot and forward rates and flows to the GIV and Bartik forward flow shocks from Equation (3) for 10 horizons, respectively. (Since negative forward flow values reflect IIs' selling of forward dollars, we multiply all impulse responses by -1 so that they represent responses to shocks that increase IIs' hedging demand (i.e., reduce forward flows).) Figures 12 and 13 confirm a causal relation between forward flows and

the exchange rate. Spot and forward rates all significantly decline (by effectively identical magnitudes) on impact in response to both forward flow shocks. The impact responses stand at -0.058% and -0.054% for the GIV and Bartik cases - which are 25.4% and 23.6% of the corresponding baseline magnitude of the response to the MSCI innovation - and significance only lasts for 8 and 9 days, respectively. To understand this stark difference with respect to the baseline exchange rate response to the MSCI innovation, we now turn to the response of the forward flow variable.

Forward flows decline significantly following the shock for only 7 and 8 days for the GIV and Bartik shocks, respectively, reaching accumulated responses at these respective horizons of -164.5 and -189.9 million dollars. The notably weak persistence of these response are dwarfed by the corresponding baseline one for MSCI innovations which stands at 219 horizons. And at the latter horizon the baseline MSCI innovation's cumulative effect on forward flows stands at -255.4 million dollars, significantly exceeding the GIV- and Bartik-based forward supply shocks' -164.5 and -189.9 million dollars effects. Considering the reasonable viewpoint that FX market makers are forward looking, it is therefore unsurprising that the exchange rate response to the MSCI innovation is considerably greater than the corresponding response to the forward flow shock. (Spot flows activity exhibits an insignificant response for nearly all horizons following the GIV shock, indicating a null role for the spot market in transmitting the identified GIV shock. The Bartik shock generates a significant (albeit quite modest) buying of spot dollars for 5 days after the shock, which is possibly consistent with IIs' desire to increase foreign asset positions as they exogenously decide to increase their hedging.)

**Summary.** In sum, we view this section's results as bolstering confidence in the validity of the equity hedging channel based interpretation of the previously shown empirical evidence. There are two reasons for this view. First, Figures 12 and 13 establish a causal relation between forward flows and exchange rates and thus provide a crucial support for the causal interpretation of our baseline empirical evidence. Second, the juxtaposition of the responses of forward flows to the GIV and Bartik forward supply shocks and its response to the MSCI innovation sheds valuable light on the mechanism underlying the strong equity hedging channel we uncover in the data. In particular, the persistence and associated magnitude of the forward flow response to the MSCI innovation appears to play a meaningful role in amplifying the equity hedging channel as forward looking FX market makers internalize this when setting prices conditional on an MSCI innovation.

## 6.4 Are Forward Flows Distinct from Rebalancing-Induced Spot Flows?

A relevant concern regarding this paper's story is that IIs' forward selling of dollars merely acts as rebalancing-induced spot dollar selling as opposed to acting as a hedging device against their

foreign equity positions' capital gains. I.e., one may worry that what we are picking up in the data in this paper is mainly a portfolio rebalancing mechanism where forward dollar selling substitutes spot dollar selling in the presence of foreign equity capital gains. This section's goal is to alleviate this concern in a twofold manner. (Ideally, we would want to remove this concern by looking directly at foreign equity holdings of IIs. However, we lack this data and hence turn to what we consider is a second-best way of accomplishing this goal.)

First, we emphasize the relatively long maturities typically characterizing IIs' forward contracts. Second, as prefaced in the previous section on Page 13, this section turns to inform us about whether IIs - when faced with the imminent need to obtain dollars to fund their maturing forward contracts - tend to roll over their foreign equity positions or rather realize the capital gains which are normally accrued to these positions. Understanding which is done is important to us because the latter alternative is consistent with a portfolio rebalancing framework while the former alternative implies that IIs use a different funding option for settlement of forward contracts and is therefore inconsistent with a meaningful portfolio rebalancing framework.

**IIs' Forward Contracts' Maturity Distribution.** To emphasize that the channel we identify does not merely serve as another method for investors to rebalance their portfolio through forward markets, we present in Table 1 IIs' forward contracts' maturity distribution. Encouragingly, this table shows that the volume-weighted average and median maturity of forward contracts in our sample are 52 and 25 days, respectively. If IIs were simply using the forward market as a convenient means of rebalancing when the foreign equity market appreciates instead of simply selling in the spot market, we would expect to see a majority of forward contracts with close-to-zero maturity, as there would be no real incentive to wait almost a month to sell the asset.<sup>18</sup>

**FX Swaps as a Central Funding Tool for Forward Contracts' Settlement.** Investing abroad presents risks for IIs. They face FX risk because of the currency mismatch due to their liabilities being in the local currency while holding a portion of their assets in foreign currency. International investors such as IIs can mitigate potential losses by hedging against the FX risk. For instance, let's consider a foreign investor who invested in the S&P 500 in 2020, which saw a 16% increase. However, the US broad dollar index weakened by 3% during the same period. Without hedging the FX risk, the investor would have experienced approximately a 20% loss when converting their investment into their local currency.

IIs employ various strategies to hedge their FX risk. One approach - the focus of our paper - involves selling their dollar profits and purchasing the local currency through the FX forward market. By selling the profits in the forward market, investors safeguard themselves against potential

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<sup>18</sup>Conversations with market practitioners confirm that selling in the forward market and rolling over the forward contract is a common operational approach.

losses arising from future fluctuations in the value of the dollar. This approach offers an additional crucial advantage compared to simply selling the asset in the spot market which also differentiates our paper from the previous literature: it allows the investors to *maintain* their exposure to the foreign asset without the FX exposure. When the forward contract matures, its settlement can get funded with an FX swap, eliminating the immediate need to sell the underlying asset. This allows for continuous full hedging, ensuring ongoing protection against FX risk.

The ideal way to test the validity of our proposed mechanism is using daily foreign equity holdings of IIs which is unfortunately not available to us. However, our mechanism does offer a testable implication: we anticipate a negative relationship between the amount of dollars being bought or sold in the FX forward and the amount of dollars being bought or sold in the FX swap around the maturity of the forward contract.

Consider the following hypothetical example. On 01/01/2020, an II sells dollars in the forward market for one million dollars, with a maturity date of 31/01/2020. This transaction implies that the II will need to supply one million dollars around the end of January. Consequently, the II has three funding options available to him on or around the maturity date: tapping into the FX swap market by purchasing swap-linked dollars; tapping into the spot market by purchasing spot dollars; and rebalancing its foreign asset portfolio positions by selling foreign assets. Given our data availability, we can estimate the meaningfulness of the first two of these funding options while using their quantification to learn about the relevance of the third option.

**Econometric Specification.** To rigorously examine the relationship between FX swaps and forward contracts, we employ a panel regression analysis at the fund level, utilizing our granular (transaction-level) dataset comprising of 175 funds. The dependent variable in our regression is the daily amount of dollars bought or sold in the FX swap market by fund  $i$  at time  $t$  ( $FX\_SWAP_{i,t}$ ), while the independent variable is the corresponding amount of dollars bought or sold by fund  $i$  in the forward market at maturity time  $t$  ( $FF_{i,t}$ ) and the surrounding leads and lags (indexed by  $l$  below). The regression equation can be formally expressed as follows:

$$FX\_SWAP_{i,t} = \alpha_i + \sum_{l=-7}^{l=7} \beta_l FF_{i,t+l} + \epsilon_{i,t}. \quad (5)$$

To examine the FX spot funding option, we merely replace the outcome variable from Equation (5) with the daily amount of dollars bought or sold by IIs in the FX *spot* market at time  $t$ .

**Results.** Our findings for FX swaps, displayed in Figure 5, reveal notable point estimates pertaining to the maturity of the forward contract. Specifically, as anticipated, the estimates for the day prior to maturity (-1 on the x-axis), the day of maturity (0 on the x-axis), and the day after

maturity (1 on the x-axis) all exhibit statistical significance and negative values, aligning with our initial expectations. Remarkably, these estimates cumulatively amount to approximately -0.78, suggesting that nearly 80% of forward contracts' settlement is funded by IIs' tapping into the FX swap market. This empirical evidence substantiates our hypothesis that IIs do not engage in actual foreign stock sales but rather maintain exposure to the assets when using FX forwards. Furthermore, it is important to highlight that the estimates for the days preceding and following the maturity date are in close proximity to zero, indicating their non-significance. This outcome serves as a placebo test, further reinforcing the validity of our proposition.

What accounts for the remaining 20%? One possibility is that IIs acquire the remaining exposure by purchasing dollars in the spot market. However, when we conduct the same regression analysis as in Equation (5), employing the amount of dollars bought or sold in the spot market as the dependent variable (Figure 6), we do not observe any discernible pattern. This suggests that the 20% may originate from alternative sources, such as IIs' utilization of their dollar reserves - with foreign equity portfolio rebalancing being one possible such utilization. Be that as it may, this relatively small 20% share represents a modest upper bound for the importance of foreign equity rebalancing as a way for settling forward contracts on the part of IIs.

This section has revealed valuable information on the institutional details of IIs' hedging. Given that IIs play a significant role in global financial markets, such revelation and studying of the institutional details of how these investors operate is crucial because their investment strategies and decision-making processes can significantly impact market dynamics and financial stability (see, e.g., Greenwood and Vayanos (2010), Klingler and Sundaresan (2019), and Czech et al. (2021)).<sup>19</sup> Hence, considering that FX swaps produce off-balance sheet debt - or 'missing dollar debt' (Borio et al. (2022)), our results about IIs' tendency to fund the settlement of their forward contracts with FX swaps may potentially have implications for such stability issues.

## 6.5 Are Risk Appetite Shocks Driving Our Results?

An additional concern regarding our results that is worth addressing is that global risk appetite shocks are driving our results. This concern is especially important to address given the literature's evidence on the relation between investors' risk-bearing capacity and exchange rates (see, e.g., Lustig et al. (2011) and Lilley et al. (2019)). Specifically, one may be worried that favorable

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<sup>19</sup>A recent example includes the significant turmoil in September 2022 in the UK sovereign bonds market brought about by pension funds as one of their methods to hedge their duration mismatch was through the use of interest rate swaps. When yields rose sharply in the UK, they were met with margin calls which threatened to destabilize their bond market. Policymakers and regulators can use this institutional knowledge to design rules and regulations that promote market stability and protect investors.



global risk shocks are being picked up by our MSCI innovations, thereby confounding our interpretation of our results as being driven by the equity hedging channel.

To address this concern, we repeat the estimation of Equations (1) and (2) only that now we augment the former equation with the current and lagged values of the *daily* excess bond premium (EBP) shock variable from Gilchrist et al. (2021) who construct a high-frequency EBP version of their original series from Gilchrist and Zakrajšek (2012) by using micro-level data to construct a U.S. corporate credit spread index which they decompose into a component that captures firm-specific information on expected defaults and a residual component that they term as EBP. In particular, they use the structural “distance to default” model based on the seminal work of Merton (1973) to purge micro-level credit spread data of their endogenous default risk component and interpret the residual component (EBP) as a credit supply shock that represents exogenous movements in the pricing of risk.<sup>20</sup> As such, this shock provides a valid measure of global risk appetite shocks.

The results from our augmented estimation exercise are shown in Figure 14, where for conciseness we only show the FX market responses. (The impact MSCI response is very similar to the baseline one but persistence is diminished with a 0.3% response after 500 days relative to a 0.5% corresponding baseline response.) All responses are both qualitatively and quantitatively similar to the baseline ones with the spot rate response even moderately higher (in absolute terms) at -0.26%. These findings reinforce the notion that this paper’s results are capturing the equity hedging channel rather than a risk-appetite-induced exchange rate mechanism.

## 6.6 Limits of Arbitrage and Exchange Rate Response Persistence

The slow reversal of the exchange rate (both spot and forward) response in our baseline results is consistent with the presence of limits of arbitrage (LOA) as the absence of which would generate a faster return of the exchange rate to its pre-shock value owing to investors’ arbitraging of the emergence of any such slow mean-reverting behavior. Further and formally exploring the validity of this LOA-based argument can serve the important goal of advancing our understanding of the mechanism driving our observed strong persistence of the exchange rate response.

Toward this end, we augment Equation (2) with the global financial institutions’ equity capital measure from He et al. (2017) (normalized to have a zero mean and unit variance) and, importantly, the interaction between our MSCI innovation and the normalized He et al. (2017) equity

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<sup>20</sup>The permanent link for this daily excess bond premium series is <https://www.atlantafed.org/research/publications/policy-hub/2021/09/24/12-term-structure-of-excess-bond-premium> It is in daily frequency and covers our baseline sample period. We are grateful to Bin Wei for sending us an updated series.

capital variable. This variable is a reasonable proxy for LOA as higher values in it imply more available equity for global financial institutions to implement arbitrage activities. Hence, the sum of the estimated coefficient on the MSCI innovation and that on the interaction between this innovation and the He et al. (2017) equity capital ratio variables provides an estimate for a state in which there are no meaningful LOA. This in contrast to the estimate of the coefficient on the MSCI innovation which provides the average, or linear, effect which in turn embodies LOA.

The results from this estimation exercise appear in Figure 15, where we show the linear (first column) and no-LOA state (second column) effects of the MSCI innovation on the spot rate, forward flows, and accumulated forward flows. The no-LOA state effect effectively shows the response of the relevant outcome variable to the MSCI innovation when the He et al. (2017) equity capital variable is one standard deviation above its mean. In the third column we also show the difference between the no-LOA state effect and the linear effect (i.e., the third column shows the interaction effect).

These results demonstrate that, in the absence of LOA, the spot rate appreciates on impact by one -0.08% in response to the MSCI innovation and that this appreciation's significance lasts for only 272 days. By contrast, the impact appreciation for the linear case is -0.18% and this appreciation's significance lasts for 474 days. The interaction effect itself is significantly positive for a total of 490 days. Overall, these results indicate that LOA are likely a meaningful element underlying the mechanism that drives this paper's results.<sup>21</sup>

## 6.7 Robustness Checks

Appendix D of the online appendix to this paper examines the robustness of the baseline results from Sections 6.1 and 6.2 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

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<sup>21</sup>It is noteworthy that, while the linear impact effect from Figure 15 is lower than the baseline one of -0.23%, the impact LOA state effect (not shown in Figure 15 and simply equal to the linear effect minus the interaction effect) is -0.28%. I.e., when LOA is present, the MSCI innovation produces a larger effect than the linear baseline effect. This observation is important to recall given the significant negative skewness of the He et al. (2017) equity capital ratio variable, which stands at -0.17. This negative skewness can in turn potentially explain why our linear baseline effect is lower than the one from Figure 15: the baseline -0.23% effect appears to be driven more so by periods of considerable LOA than by periods with no LOA, in accordance with the former periods being more likely than the latter periods.

shares of the aggregate IIs' foreign equity position.<sup>22</sup> 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 2/19/2020 so as to confirm that the baseline results are robust to omission of the COVID period.<sup>23</sup> 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 as much as 36% 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.

We end this section with a brief discussion on why our findings are not capturing a debt hedging channel (refer to the literature review in Section 2). The conditional hedging activities we observe in our analysis are not aimed at hedging against changes in international bond prices. The driving impulse of our channel is a shock to global equity markets and our empirical shock captures exactly this driving impulse rather than a shock to global debt markets. Since bonds and stocks are typically negatively correlated (e.g., the correlation between the MSCI return series and a comparable global debt index return series is -27.2%), the notable hedging behavior we report

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<sup>22</sup>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.

<sup>23</sup>Global stock markets reached a peak on 2/19/2020, after which the COVID-induced bear market began to take place.

can be viewed as the net outcome of the *rise* in hedging from global equity price increases and the *decline* in hedging from global debt price decreases induced by the driving global equity shock. In other words, the equity hedging channel we find in the data is not overstated due to a debt hedging mechanism. If anything, it is understated on account of it.

## 7 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.

### 7.1 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.<sup>24</sup>

**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.<sup>25</sup> 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

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<sup>24</sup>These three conditions do not include the obvious condition of having a flexible exchange rate regime in place.

<sup>25</sup>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.

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.<sup>26</sup> 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 10.9% 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 3. 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 possess 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.

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<sup>26</sup>The fifth sub-figure from Figure 9 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 0.66%), this innovation clearly does not generate meaningful hedging from foreign financial intermediaries.

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.<sup>27,28</sup> 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.

## 7.2 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

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<sup>27</sup>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 its economy's relatively large size), 8 Euro area member economies, and Denmark whose exchange rate is fixed to the Euro.

<sup>28</sup>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 (1) and (2) 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 16a presents these variables' impulse responses and Figure 16b 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/ILS spot rate from Figure 8a. (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 9.6% - and the highest of them taking place for Mexico (USD/MXN) - peaking at 72%.

**Results for Cross-Currency Basis.** Figure 17 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,<sup>29</sup> 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 -0.46 basis points. This small 1-month basis response (which is in annual terms) implies that the Colombian forward rate appreciates on impact by only  $\frac{0.0046\%}{12} \approx 0.00038\%$  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 0.00038% more than the CIP-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 7.1.

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<sup>29</sup>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.

## 8 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/ILS forward and spot rates that embodies an inconsequential response of USD/ILS 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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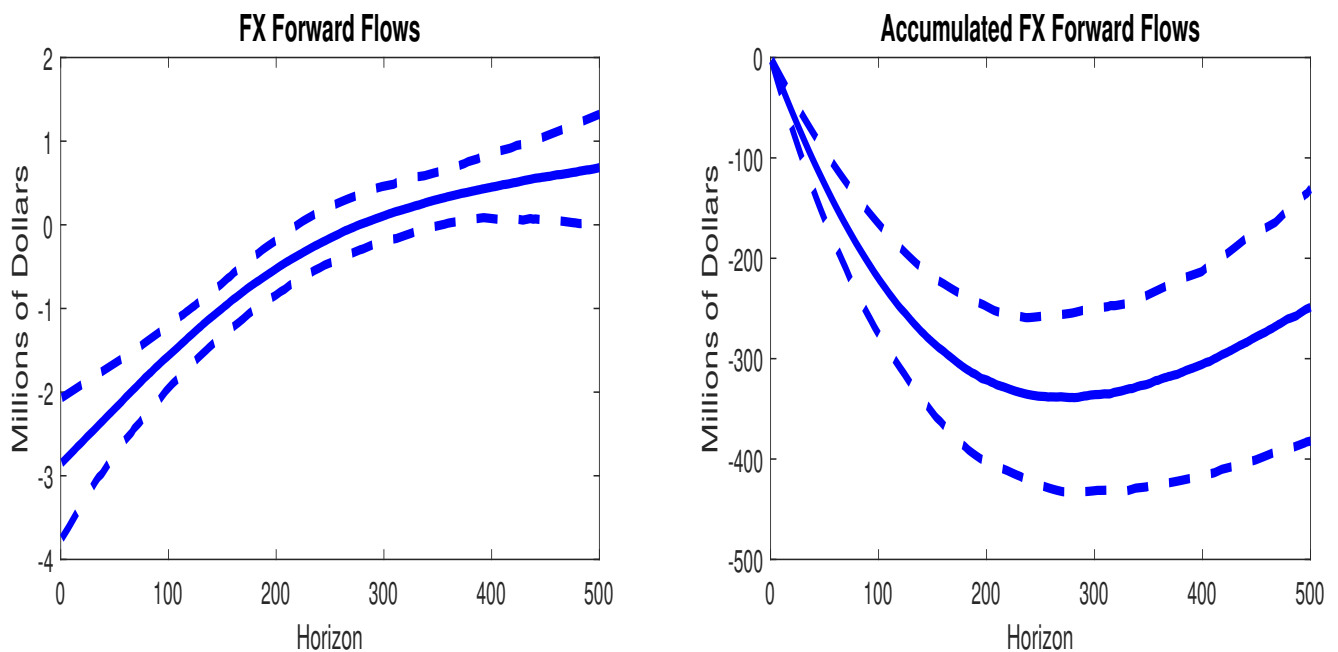


Table 1: **Summary Statistics of IIs' Forward Contracts' Maturity Distribution.**

Volume-Weighted Mean	Median	25th Percentile	75th Percentile	Min	Max
52	25	3	64	0	1767

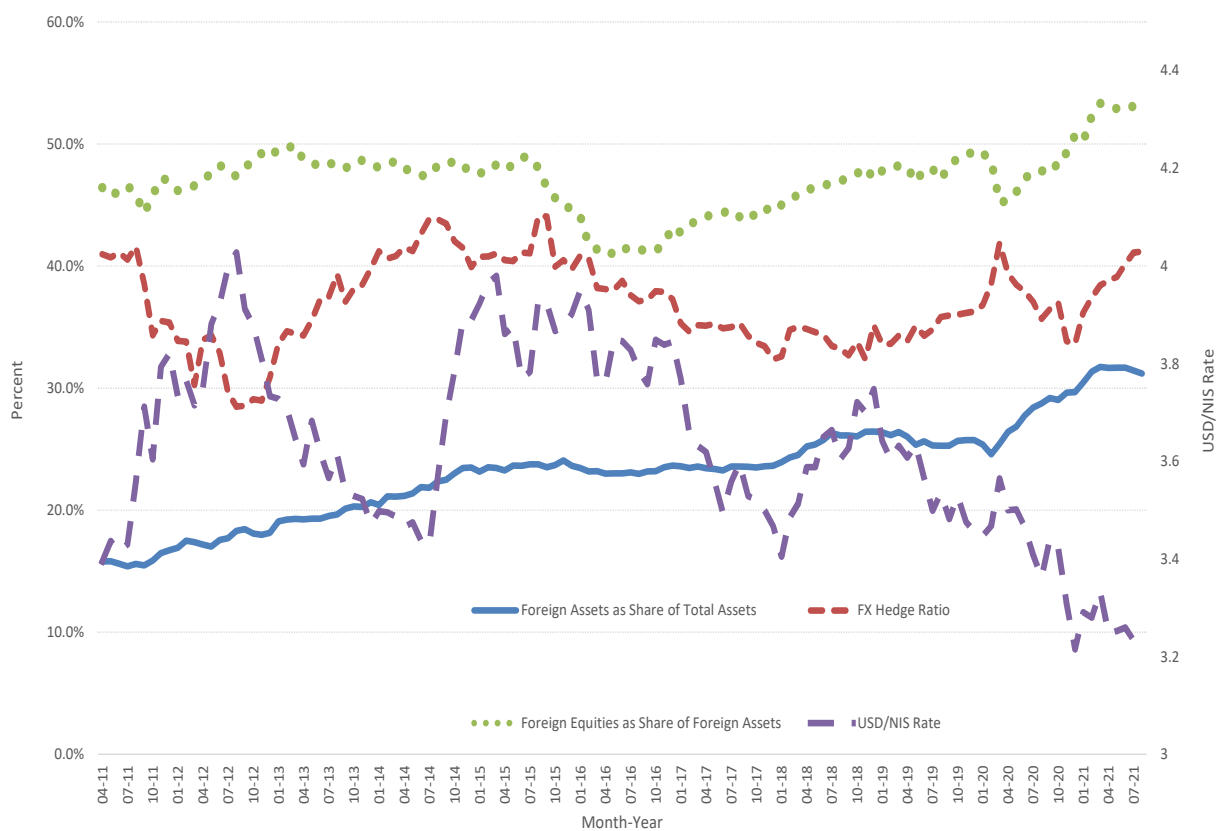
*Notes:* This table shows the volume-weighted mean, median, and upper and lower percentiles for IIs' transaction-level forward contracts' maturities in our sample, covering the baseline period from 4/26/2011 to 8/18/2021.

Figure 1: **Impulse Responses to a One Standard Deviation MSCI Index Innovation: Forward Flows.**



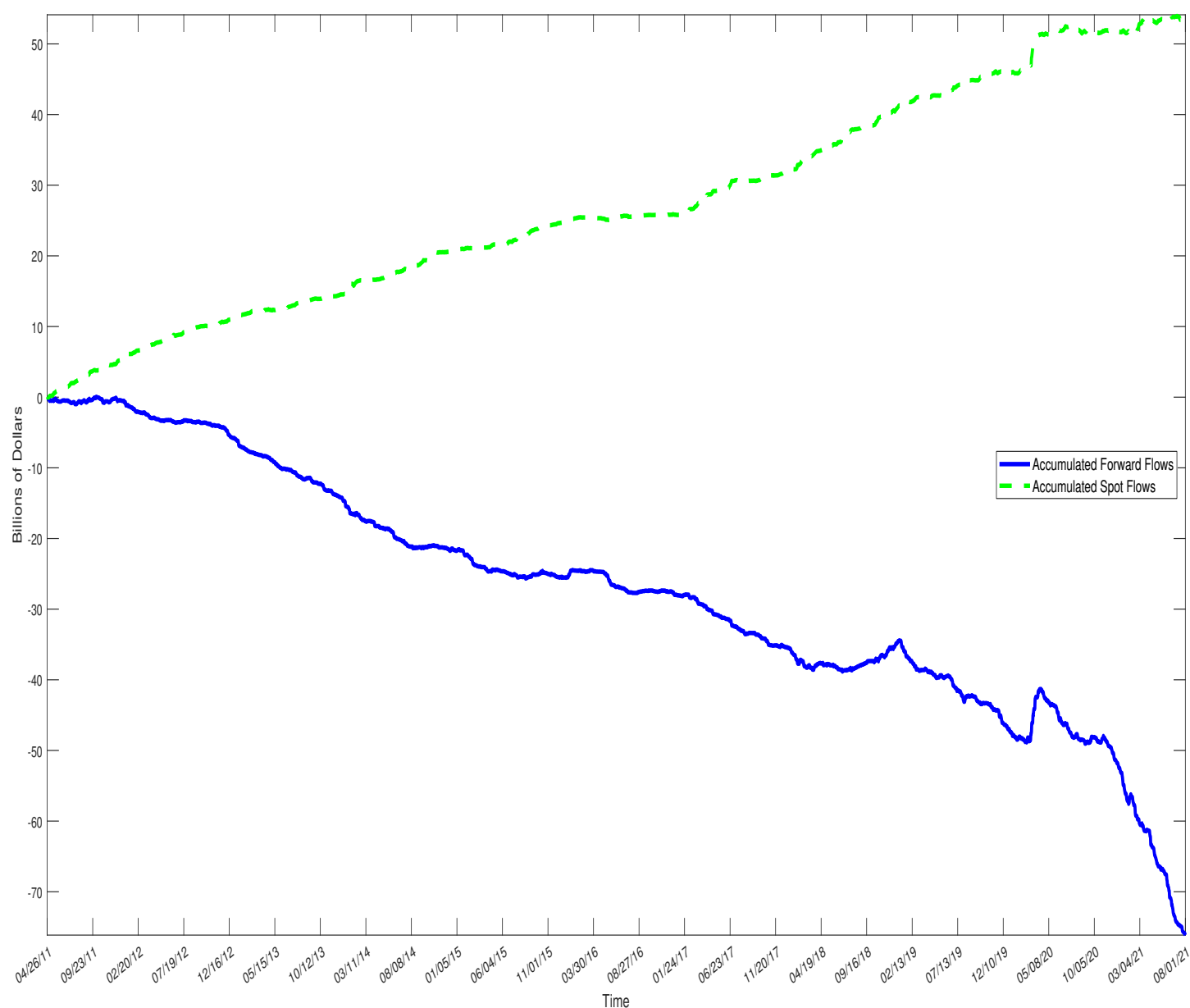
*Notes:* This figure presents the raw and accumulated impulse responses of forward flows to a one standard deviation MSCI index innovation from the model described by Equations (1) and (2). Responses are in terms of deviations from pre-shock values (in millions of dollars). Horizon (on x-axis) is in days.

**Figure 2: Time Series of IIs' Foreign Assets, Foreign Equities, FX Hedge Ratio, and USD/ILS Spot Rate.**



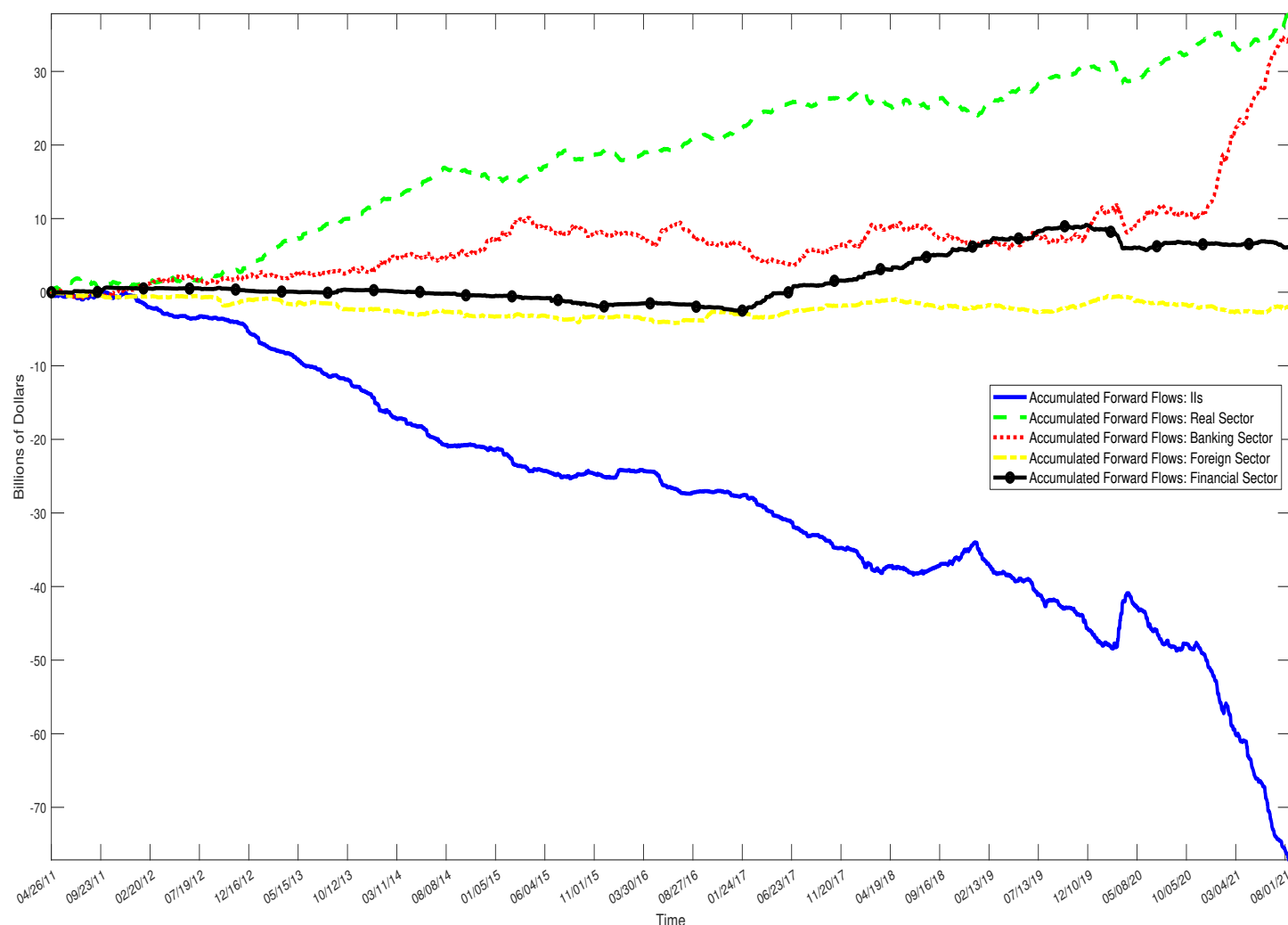
*Notes:* This figure presents the time series of the monthly shares of IIs' foreign assets in their total assets (solid line) and foreign equities in total foreign assets (round dotted line), IIs' FX hedge ratio (squared dotted line) (the share of foreign assets that is hedged against FX risk using forwards, swaps, and options), and the USD/ILS 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/ILS rate is on the right y-axis.

Figure 3: Time Series of Accumulated FX Forward and Spot Flows.



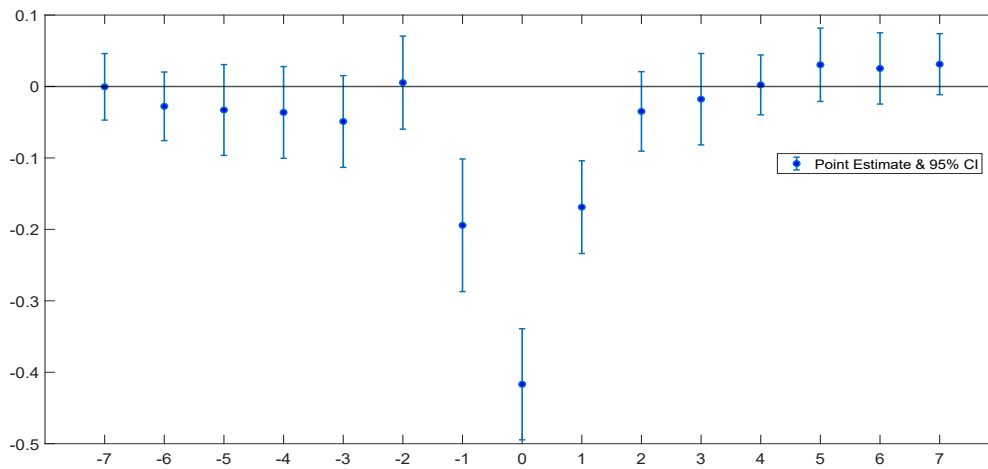
*Notes:* This figure presents the time series of IIs' accumulated daily FX forward (solid line) and spot (dashed line) flows. Negative accumulated flows values represent the accumulated selling of dollars; positive values represent the accumulated buying of dollars. Data are from the BOI and cover 4/26/2011-8/18/2021.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

Figure 4: Time Series of Accumulated FX Forward Flows by Sector.



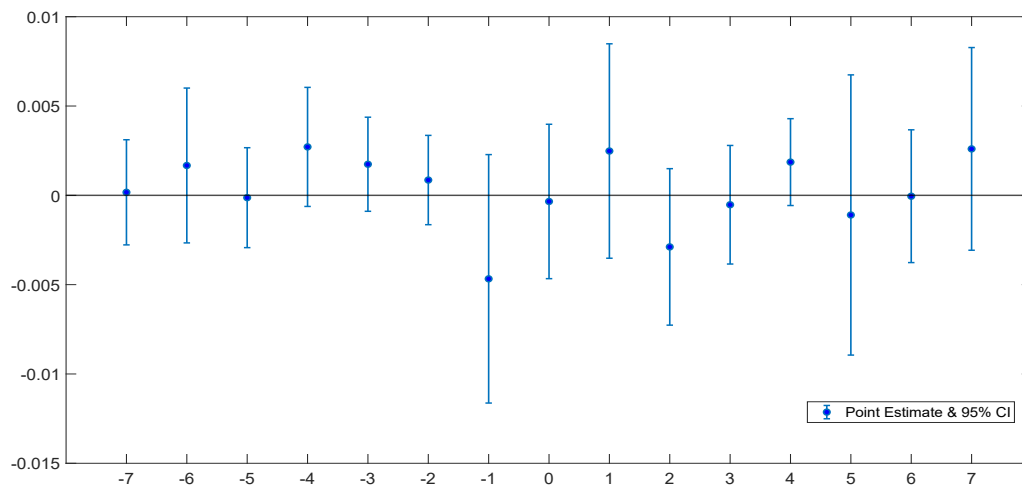
*Notes:* This figure presents the time series of accumulated daily FX forward flows by sector. On top of the IIs sector (which, for completeness, is also included in the figure and is represented by the solid line), this figure includes four additional sectors: real sector (dashed line), which represents 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 5: The Relation between FX Forwards and FX Swaps.



*Notes:* This table presents the point estimates obtained from a panel regression with fixed effects, following the specification of Equation (5). The x-axis represents days relative to the forward contract. To calculate standard errors, we employ Driscoll and Kraay (1998) standard errors with 7 lags (this standard error procedure accounts for arbitrary serial and spatial correlation of panel regression's residual). The regression analysis includes data from 175 funds, covering the period from 4/26/2011 to 8/18/2021.

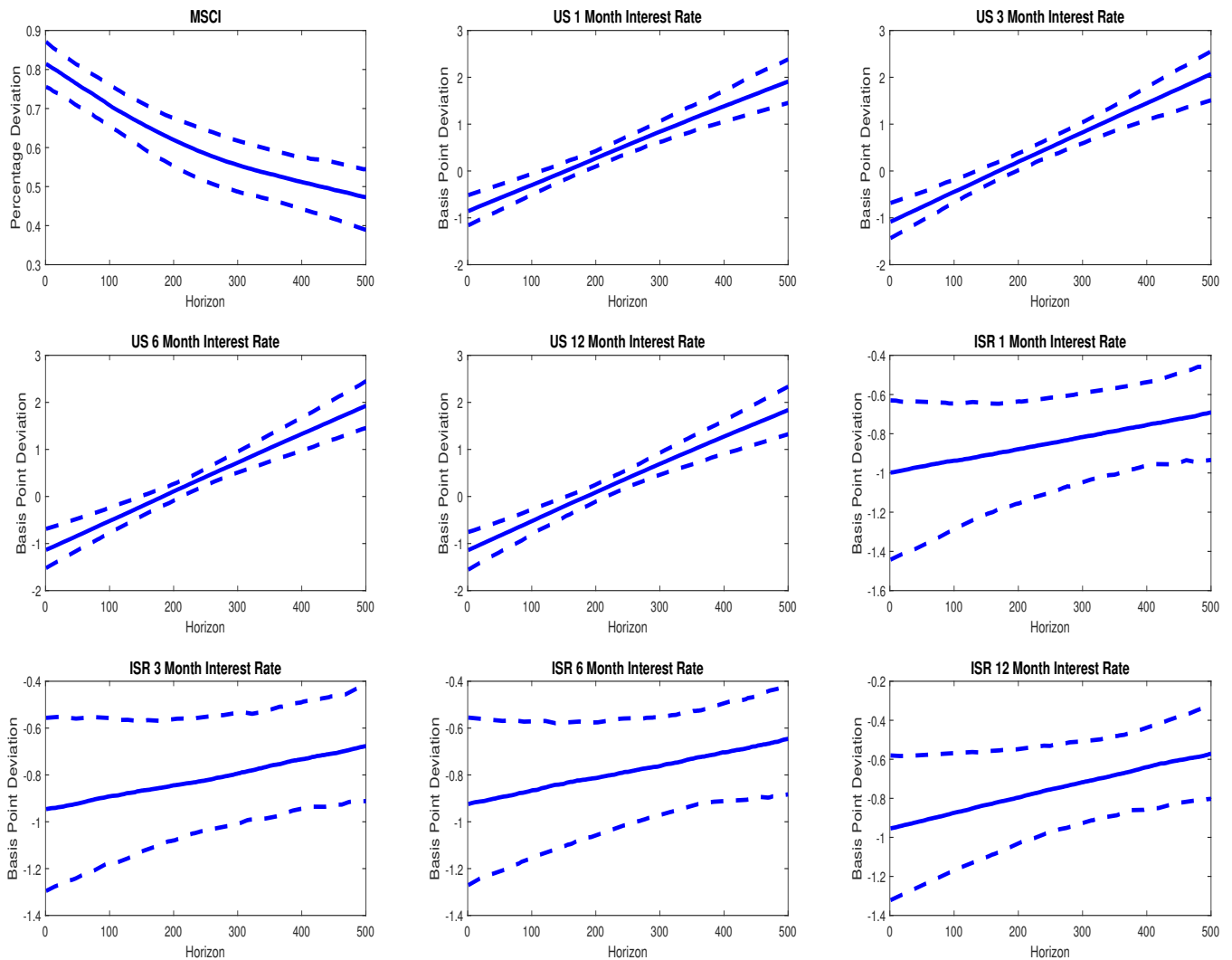
Figure 6: The Relation between FX Forwards and FX Spots.



*Notes:* This table presents the point estimates obtained from a panel regression with fixed effects, following the specification of Equation (5) but replacing the FX swap outcome variable with the FX spot one. The x-axis represents days relative to the maturity of the forward contract. To calculate standard errors, we employ Driscoll and Kraay (1998) standard errors with 7 lags (this standard error procedure accounts for arbitrary serial and spatial correlation of the panel regression's residual). The regression analysis includes data from 175 funds, covering the period from 4/26/2011 to 8/18/2021.

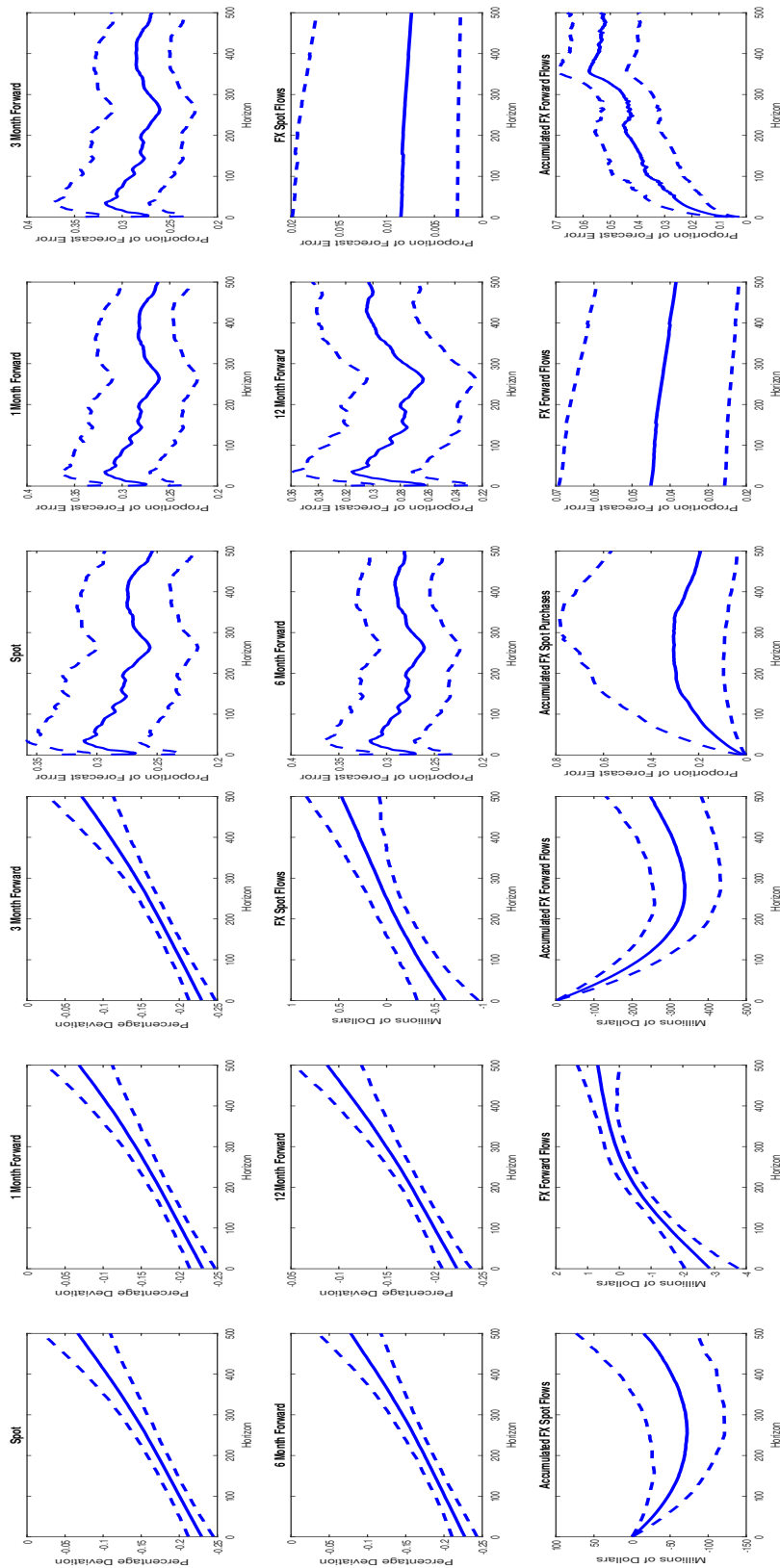


**Figure 7: Impulse Responses to a One Standard Deviation MSCI Index Innovation: MSCI and Interest Rates.**



*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 (1) and (2). 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.

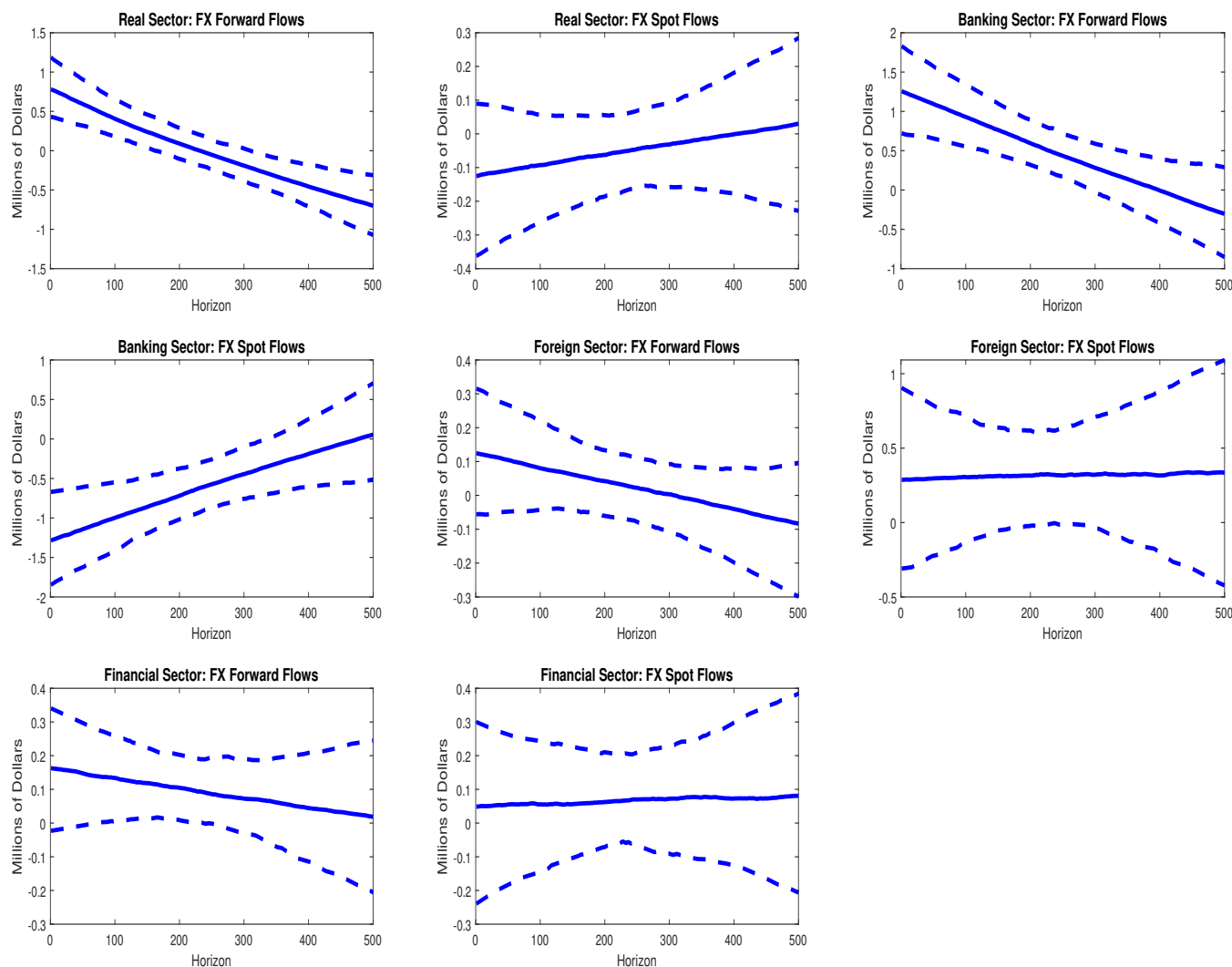
Figure 8: FX Market Prices and Quantities: (a) Impulse Responses; (b) FEVs.



(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.

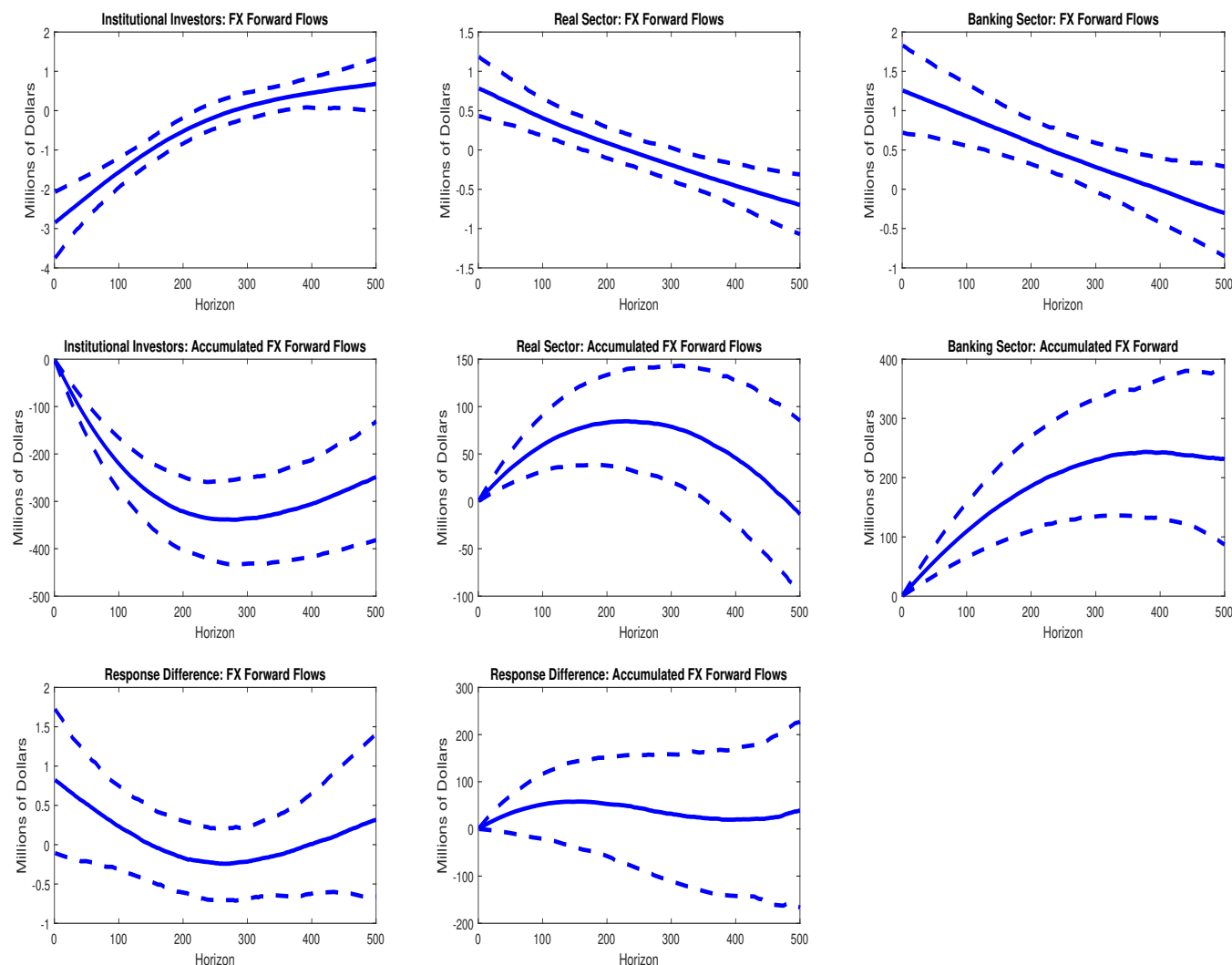
Notes: Panel (a): This figure presents the impulse responses of the spot and forward rates and quantities to a one standard deviation MSCI index innovation from the model described by Equations (1) and (2). Responses are in terms of deviations from pre-shock values (percentage deviation for spot and 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 (1) and (2). Horizon is in days.

**Figure 9: Impulse Responses to a One Standard Deviation MSCI Index Innovation: Non-II Sectors' Spot and Forward Flows.**



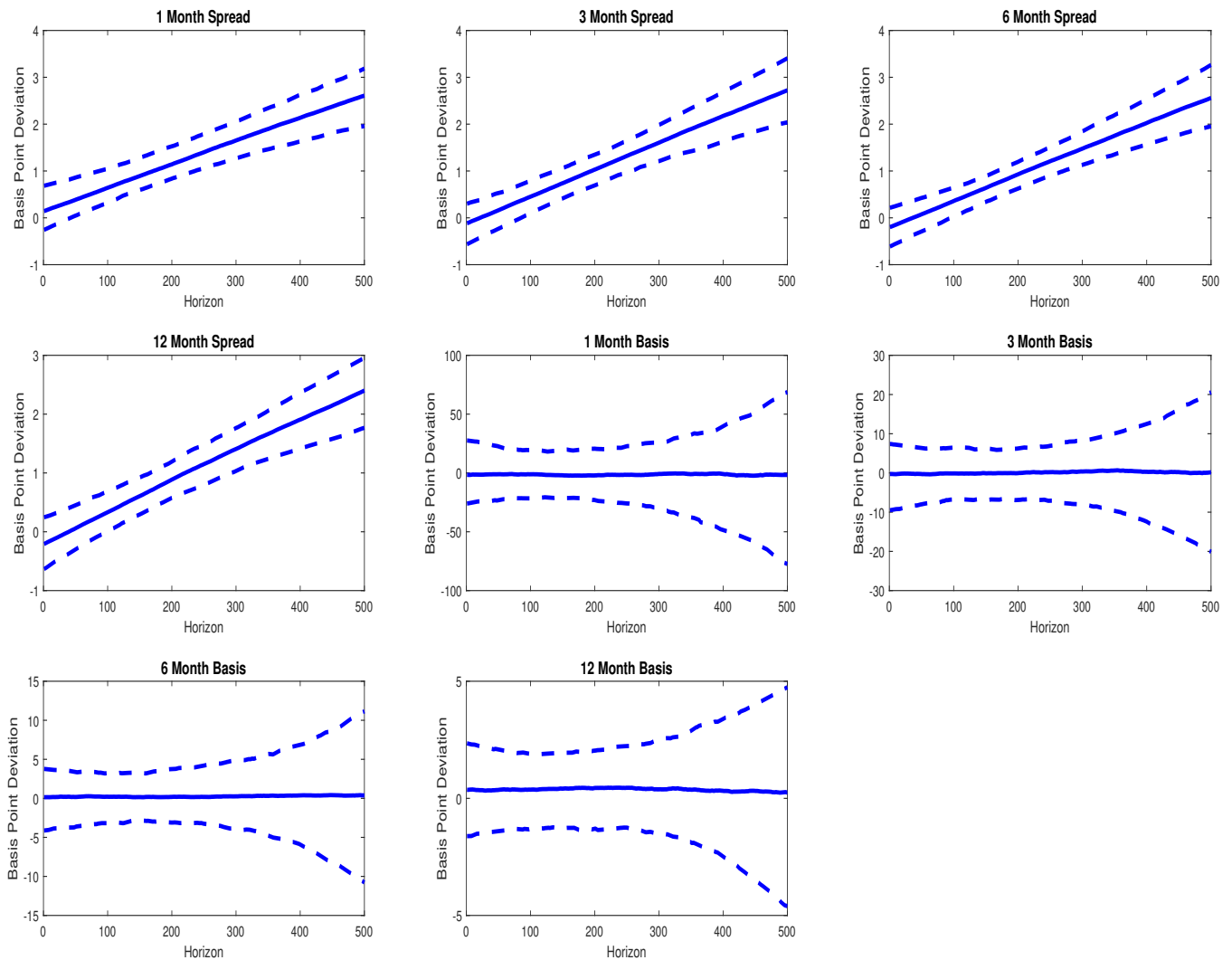
*Notes:* This figure presents the impulse responses of spot and forward flows of the real, banking, foreign, and financial sectors to a one standard deviation MSCI index innovation from the model described by Equations (1) and (2). Responses are in terms of deviations from pre-shock values (in million of dollar terms). Horizon (on x-axis) is in days.

**Figure 10: Impulse Responses to a One Standard Deviation MSCI Index Innovation: Banking and Real Sectors' Forward Flows Versus IIs' Forward Flows.**



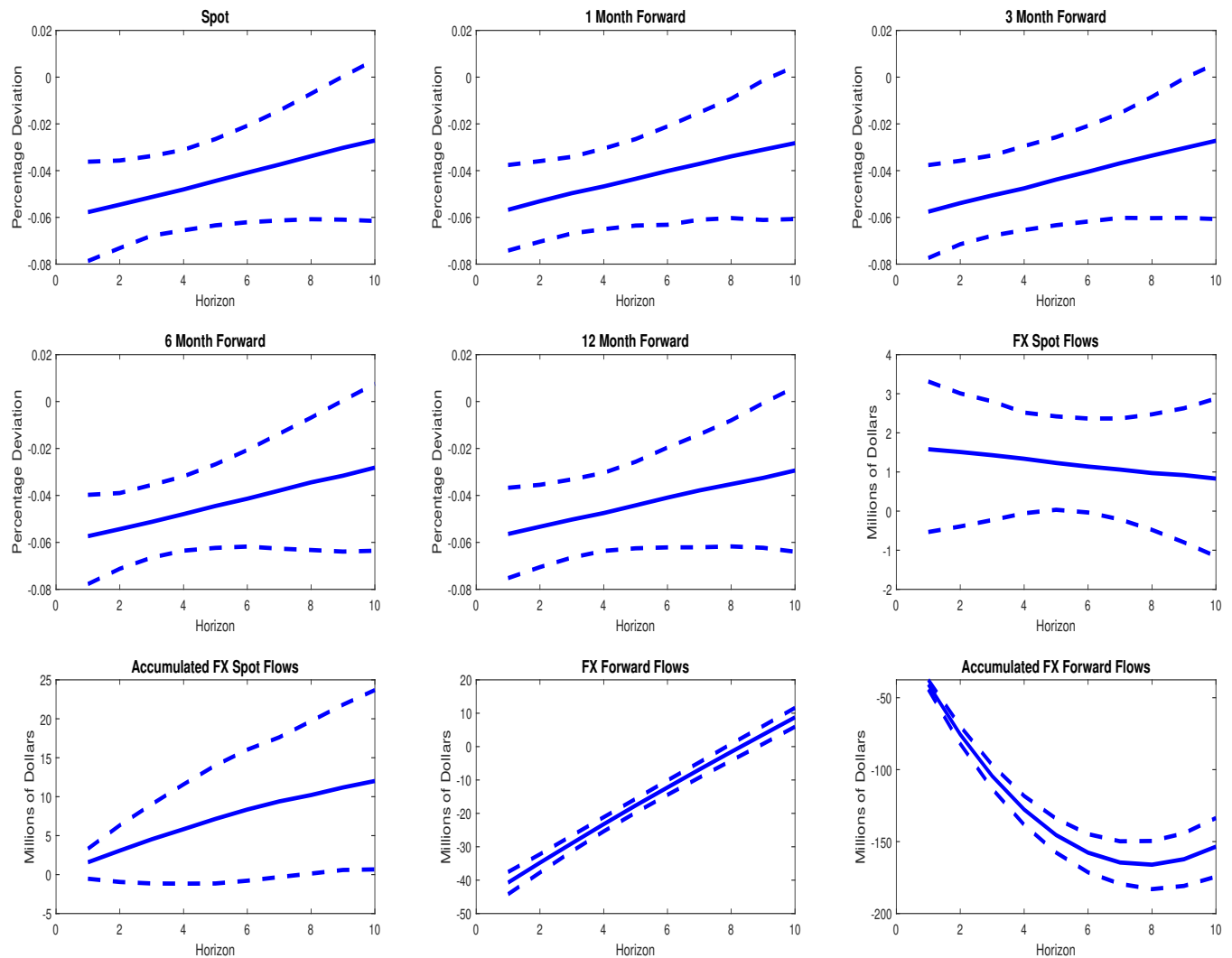
*Notes:* This figure presents the difference between raw and accumulated (in absolute terms) response of IIs' forward flows and banking and real sectors' raw and accumulated forward flows, respectively, to a one standard deviation MSCI index innovation from the model described by Equations (1) and (2). (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 11: 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/ILS cross-currency basis responses to a one standard deviation MSCI index innovation from the model described by Equations (1) and (2). Responses are in terms of basis point deviation from pre-shock values. Horizon is in days.

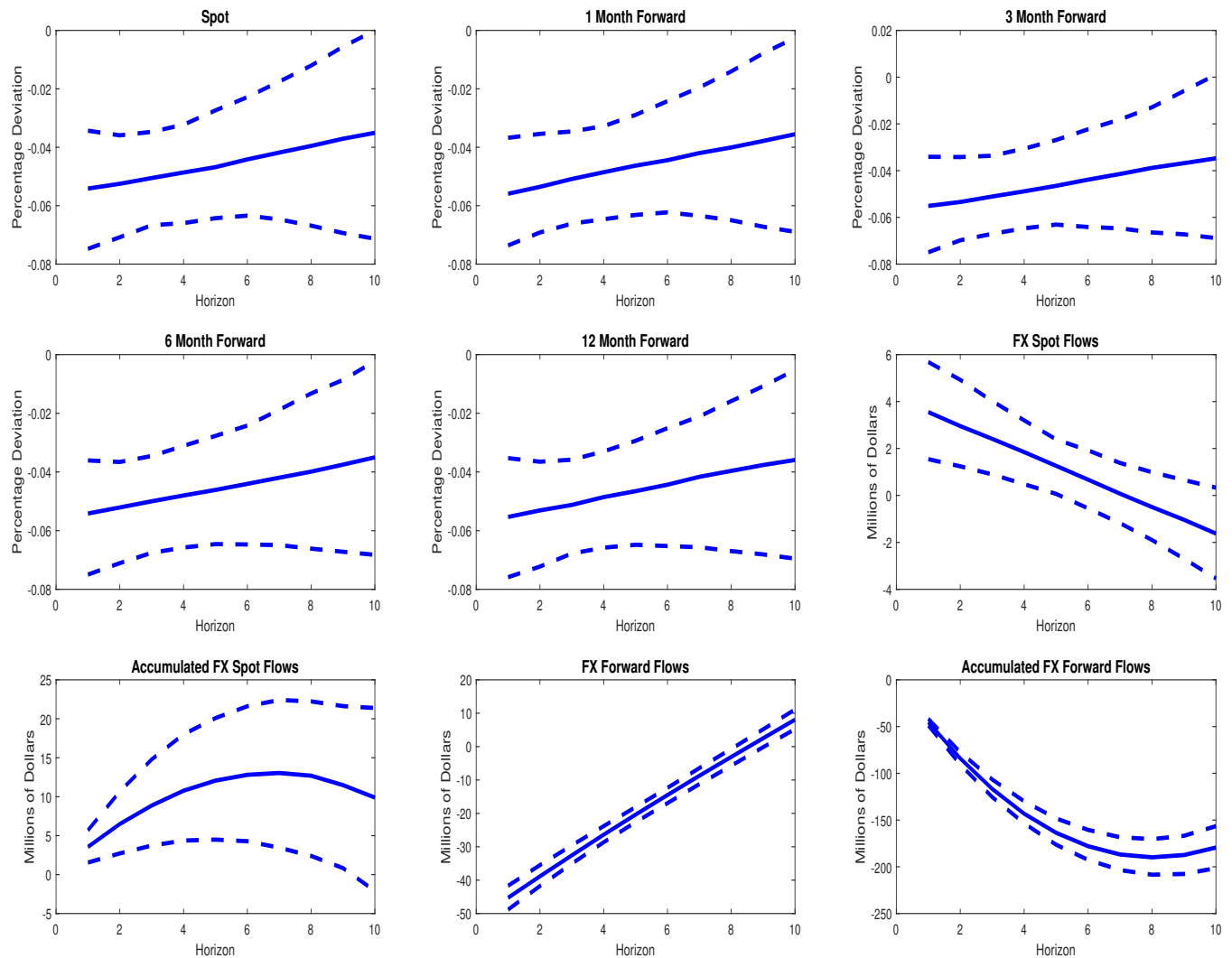
**Figure 12: Impulse Responses to a One Standard Deviation GIV-Based Forward Flow Shock: FX Market Prices and Quantities.**



*Notes:* This figure presents the impulse responses of the spot and forward rates and quantities to a one standard deviation GIV-based forward supply shock from the model described by Equations (3) and (4). 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.

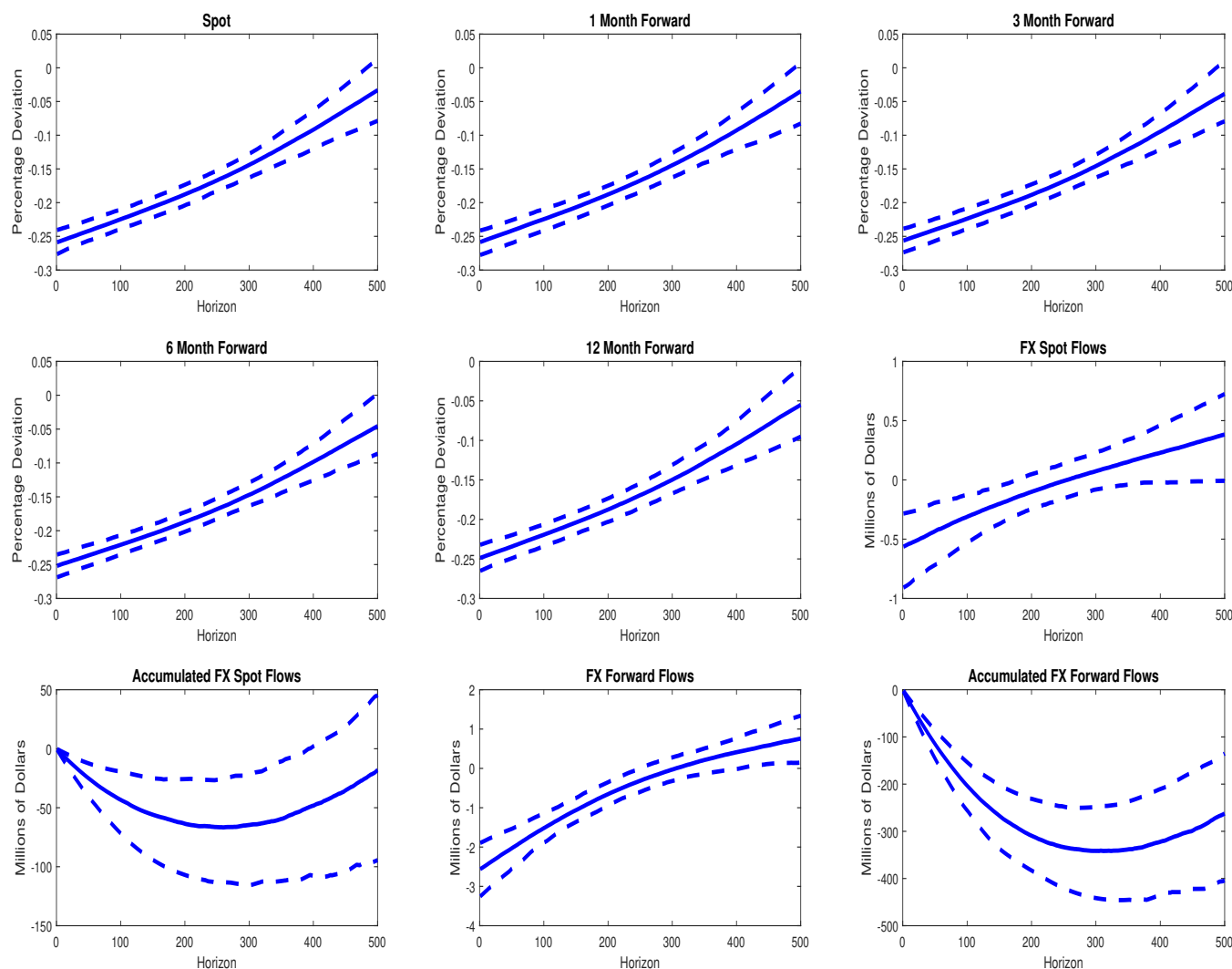


**Figure 13: Impulse Responses to a One Standard Deviation Bartik-Based Forward Flow Shock: FX Market Prices and Quantities.**



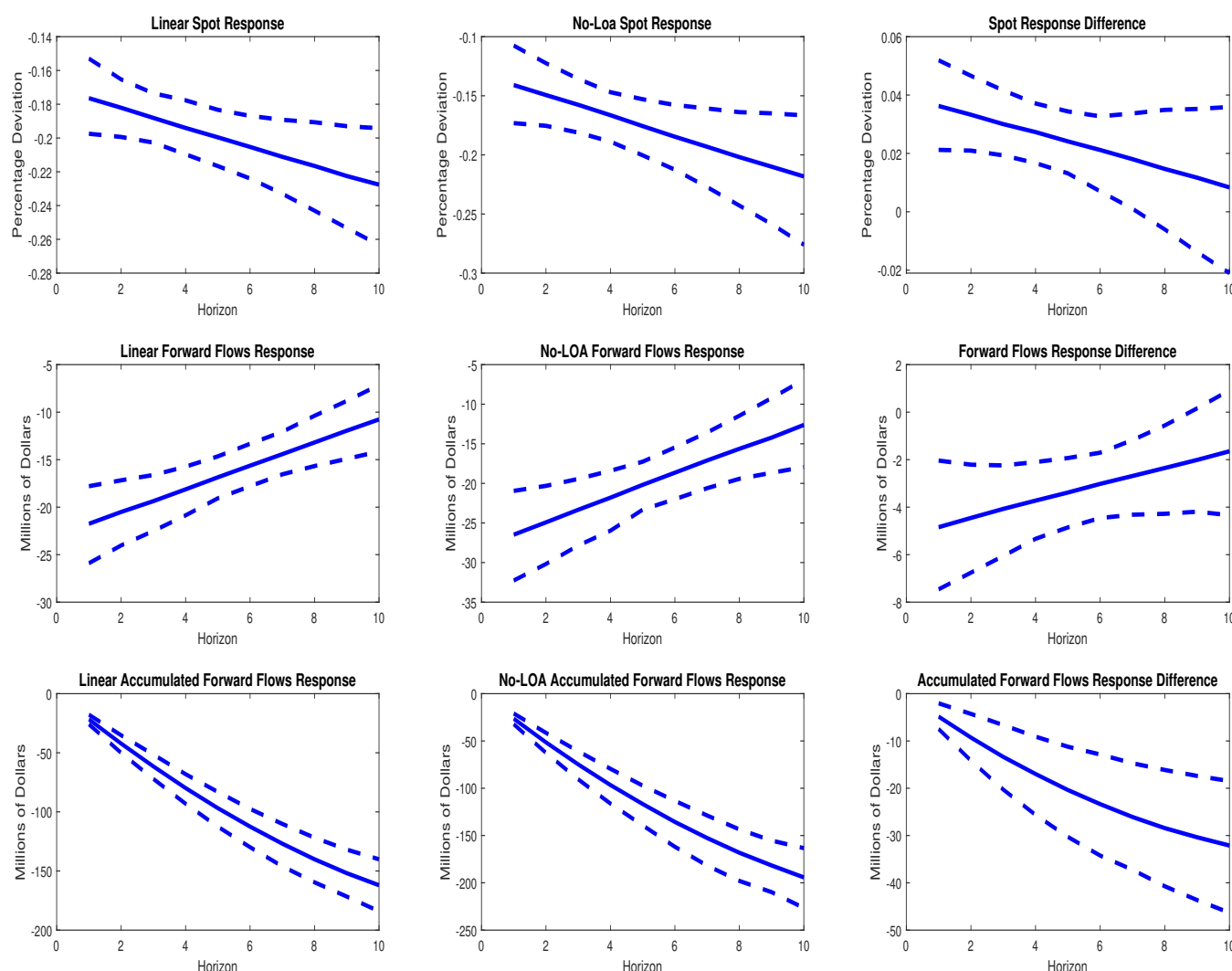
*Notes:* This figure presents the impulse responses of the spot and forward rates and quantities to a one standard deviation Bartik-based forward supply shock from the model described by Equations (3) and (4). Responses are in terms of deviations from pre-shock values (percentage deviation for spot and forward rates and Millions of dollars for spot and forward flows' raw and accumulated responses). Horizon (on x-axis) is in days.

**Figure 14: Impulse Responses to a One Standard Deviation MSCI Index Innovation Orthogonalized with Respect to Risk Appetite Shocks: FX Market Prices and Quantities.**



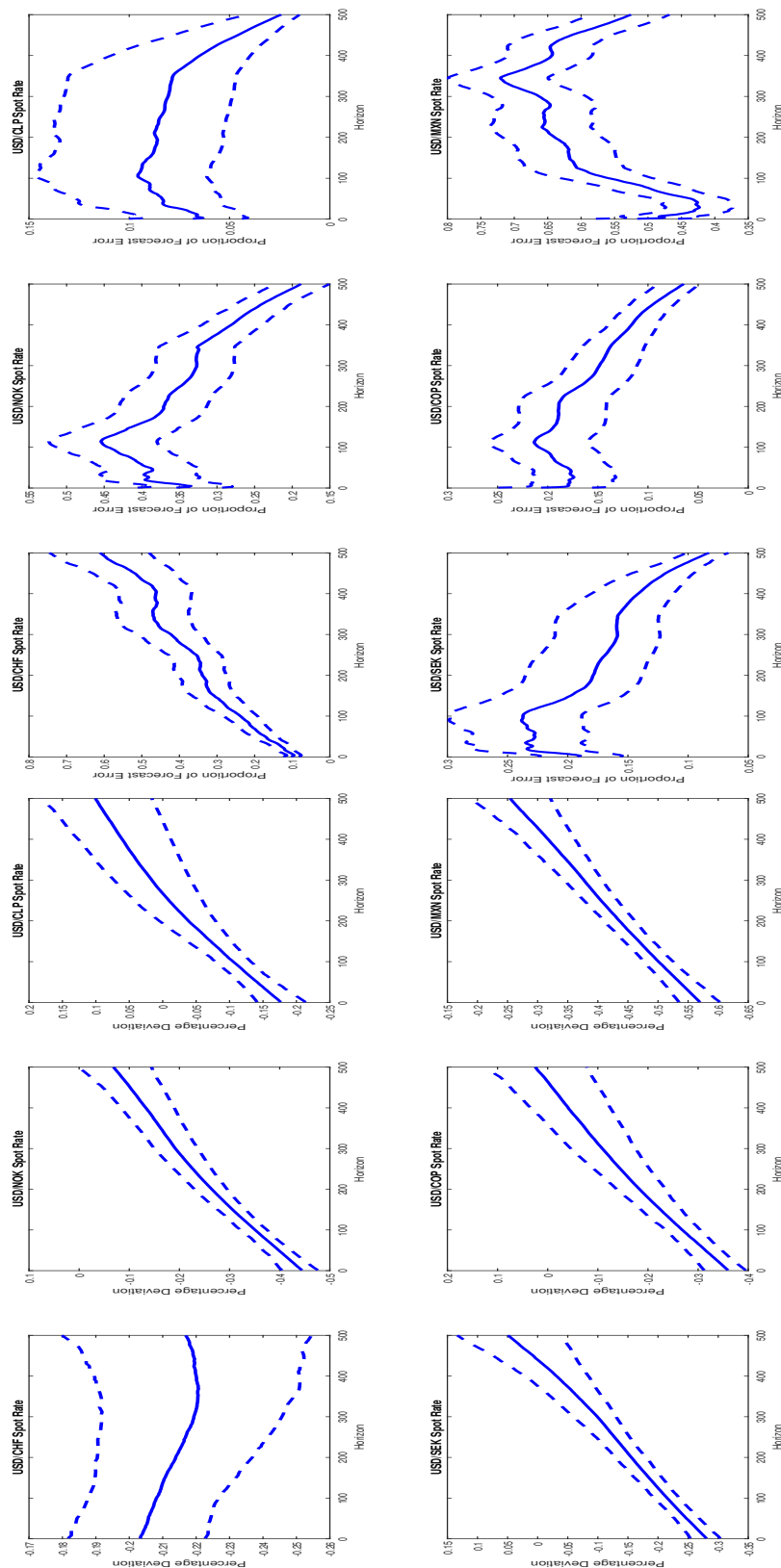
*Notes:* This figure presents the impulse responses of the spot and forward rates and quantities to a one standard deviation MSCI innovation from an augmented version of the model described by Equations (1) and (2) where current and lagged values of the daily EBP series from Gilchrist et al. (2021) are added to the RHS of Equation (1). 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.

Figure 15: LOA-Dependent Impulse Responses to a One Standard Deviation MSCI Index Innovation: FX Market Prices and Quantities.



Notes: This figure presents the LOA-dependent impulse responses of the spot rate and raw and accumulated forward flows to a one standard deviation MSCI innovation from an augmented version of the model described by Equations (1) and (2) where we add to the RHS of Equation (2) the global financial institutions' equity capital measure from He et al. (2017) (normalized to have a zero mean and unit variance) and the interaction between the latter variable and our MSCI innovation. The figure shows the linear (first column) and no-LOA state (second column) effects of the MSCI innovation. The no-LOA state effect effectively shows the effect of the MSCI innovation when the He et al. (2017) equity capital variable is one standard deviation above its mean. In the third column we also show the difference between the no-LOA state effect and the linear effect (i.e., the third column shows the interaction effect). Responses are in terms of deviations from pre-shock values (percentage deviation for the spot rate and Millions of dollars for forward flows' raw and accumulated responses). Horizon (on x-axis) is in days.

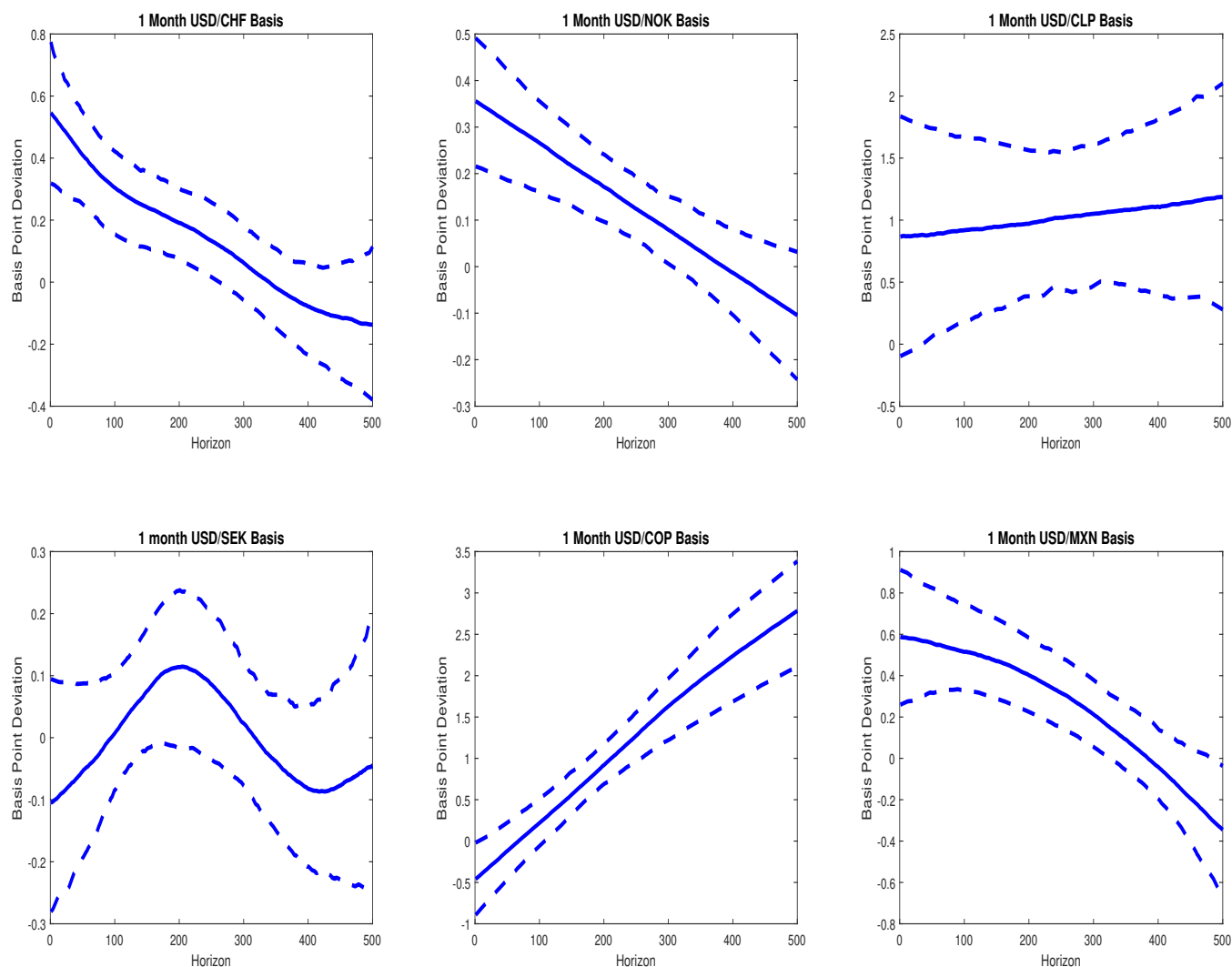
Figure 16: Spot Exchange Rates for Other Economies: (a) Impulse Responses; (b) FEVs.



(a) Impulse Responses of Spot Exchange Rates for Other Economies Attributable 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 (1) and (2). 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 (1) and (2). Horizon is in days.

Figure 17: 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 (1) and (2). Responses are in terms of deviations from pre-shock values (in basis point deviation terms). Horizon (on x-axis) is in days.