Dollar Asset Holdings and Hedging around the Globe*

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Abstract

We collect and analyze detailed filings from global institutional investors to estimate foreign investors' U.S. dollar (USD) security holdings and currency hedging. Over two decades, foreign USD holdings grew sixfold, while hedge ratios rose by 15 percentage points after the 2008–2009 crisis. Currency hedging across mutual funds, pensions, and insurance reached $2 trillion by 2019. Hedging demand varies across investors, currency areas, and banking systems. We show that expected FX returns, beyond variance minimization, drive currency exposure in portfolios. Finally, we demonstrate and quantify how aggregate hedging demand affects hedging costs in the presence of constrained intermediaries. (*JEL* F21, F31, G11, G15, G22, G23)

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The U.S. dollar (USD) is the predominant currency in cross-border security holdings, and foreign investment in USD-denominated securities has been steadily increasing. However, USD asset holdings do not necessarily imply full exposure to USD currency risk, because foreign investors can hedge that risk using foreign exchange (FX) derivatives. In this paper, we compile and analyze a comprehensive set of sector- and company-level filings from global institutional investors, providing the first detailed estimates of foreign investors' USD security holdings and their currency hedging practices. Our analysis distinguishes between the demand for USD-denominated assets and the demand for USD currency exposure, shedding light on the economic drivers of currency risk management.

According to the Bank for International Settlements' (BIS) triennial FX derivatives survey, average daily turnover in FX derivatives reached $5.4 trillion in 2022, with 88% involving USD-linked currency pairs. Thus, foreign investors wishing to hedge their currency risk in USD investments can readily access a vast and liquid derivatives market. Yet little is known about the actual FX hedging behavior of foreign institutional investors. In the absence of clear evidence, the existing international finance literature assumes that foreign asset demand is either fully unhedged (e.g., Koijen and Yogo 2020) or fully hedged for bonds but unhedged for equities (e.g., Camanho, Hau, and Rey 2022). Likewise, models on the demand for safe assets do not separate the demand for USD exposure from the demand for underlying assets (e.g., Jiang, Krishnamurthy, and Lustig 2021, 2024). While recent studies document the currency exposure of U.S.-domiciled mutual funds (e.g., Sialm and Zhu 2024) and link hedging demand to exchange rate dynamics (e.g., Liao and Zhang 2025), a comprehensive cross-country analysis of USD holdings and hedging remains absent.

Our first contribution is to construct the first systematic portrait of foreign USD security holdings and the associated FX hedging. Unlike centralized reporting systems, such as

Treasury International Capital (TIC), which report *aggregate U.S.* cross-border liabilities, we adopt a bottom-up approach that tracks holdings of *USD* securities by sector and relative to investor portfolios.[1] We focus on seven sectors: the official sector, banks, insurance companies, pension funds, mutual funds, nonfinancial corporations and households, and hedge funds. In 2020, these seven sectors held about 75% of TIC-reported foreign-held U.S. securities and around 60% of our estimated total foreign-held USD securities.

We also construct a novel data set on how foreign investors manage the currency risk of their USD portfolios. Because standardized cross-country data on FX hedging are unavailable, we hand-collect company filings and sector statistics to generate the first sector- and country-level estimates of USD currency hedging demand for mutual funds, insurance companies, and pension funds. Our findings reveal approximately $2 trillion in outstanding USD hedges across those three sectors by the end of 2019. We complement our estimated FX hedging demand with an estimate of the hedging supply, particularly the short-term dollar funding provided by global banks. This effort uncovers new facts about foreign investors' hedging of USD securities, offering fresh insights into the role of the dollar in international portfolio allocation.

Our second contribution is to investigate the drivers and implications of FX hedging using this new data. Building on the existing literature, we start from a mean-variance portfolio choice framework and extend it to emphasize not only return covariances, as in Campbell, de Medeiros, and Viceira (2010), but also expected FX return arising from deviations from uncovered interest parity (UIP) and covered interest parity (CIP). We empirically confirm that, in both the cross-section and time series, investors' USD exposures respond not only

[1]The IMF's Coordinated Portfolio Investment Survey (CPIS) reports cross-border holdings by country, but its data are insufficient for our analysis for several reasons. First, overall USD holdings are understated due to voluntary reporting and the absence of country-level breakdowns. Second, many countries do not categorize U.S. investments by holder sector. Third, CPIS does not include data on allocation or hedging.

to variance-covariance terms but also to expected currency returns. Aggregate hedging demand, in turn, affects equilibrium hedging costs when intermediated by constrained financial institutions. We derive and validate the prediction that cross-currency variation in hedging cost is strongly positively correlated with variation in FX hedging amounts, confirming an upward-sloping supply curve for the hedges financial intermediaries provide. Furthermore, using granular data on Japanese insurers, we causally identify the positive effect of aggregate hedging demand on hedging costs. These findings provide novel evidence of the limited risk-bearing capacity of financial intermediaries.

We start the paper by describing our data sources and methodology. We then present four stylized facts about foreign investors' USD holdings and hedging practices. First, we find that foreign investors have increasingly tilted their portfolios toward USD assets over the past two decades. The size of foreign USD securities holdings increased sixfold, from \$5.5 trillion in 2002 to approximately \$33.4 trillion in 2021. This increase is not solely due to larger foreign wealth: post-GFC, mutual funds, insurance companies, and pension funds raised the share of USD securities in their overall portfolios by 7.7 percentage points and increased the share of USD securities in their nondomestic investments by 6.6 percentage points.

Second, the large increase in USD securities holdings does not fully translate into higher USD currency exposure. Foreign investors in actively managed sectors hedge a substantial amount of their USD currency risk post-GFC. The USD hedge ratios for insurance companies, pension funds, and mutual funds were 43%, 35%, and 21%, respectively, in 2020. Collectively, these three sectors generated nearly \$2 trillion in annual hedging demand. On average, hedge ratios in these sectors increased by 14.7 percentage points post-GFC compared to pre-GFC levels. Elevated and fluctuating deviations from CIP post-GFC increased the cost of hedging:

we estimate that, between 2017 and 2020, hedging costs due to short-term CIP deviations averaged \$2.6 billion per annum for just the insurance and pension sectors.

Third, we document significant heterogeneity in foreign investors' hedging practices across currency areas. We find suggestive evidence that investors hedge USD bonds at higher ratios than they hedge equities, consistent with the prediction of Campbell, de Medeiros, and Viceira (2010). But even within the same sector, where portfolio allocation to bonds and equities is more similar, USD hedge ratios still vary considerably in the cross-section.

Fourth, we examine how foreign institutional investors' demand for USD FX hedges is accommodated within global financial markets. The direct counterparties for institutional investors hedging their currency risk are FX derivatives dealers, who are typically affiliated with large global banks. These global banks meet hedging demand either by matching institutional investors with other clients that have offsetting FX derivative needs or by directly supplying hedges, effectively providing short-term dollar funding through their own balance sheets. Using banking data from the BIS, we find that global banks, in aggregate, provide a substantial volume of FX hedges via their balance sheets. However, there are substantial cross-country differences in dollar funding business models: some banks are net suppliers of USD FX hedges, while others use FX hedging as a means of funding their own USD operations.

Having documented key facts about foreign investors' USD hedging practices, we next investigate the drivers of optimal currency exposure and the implications of hedging for FX derivatives pricing. We model and study both sides of the FX derivatives market in turn. On the demand side, FX hedging arises from a mean-variance foreign investor's optimal currency exposure, conditional on their portfolio allocation between USD and domestic securities.[2] In our model, the investor considers not only the variance of portfolio return, as in Campbell, de Medeiros, and Viceira (2010), but also the expected level of returns, which can be influenced by expected currency returns due to UIP violations or by FX hedging costs stemming from CIP deviations. The model offers predictions for how deviations from UIP and CIP shape currency exposure, for which we find strong support in the data. Overall, investors' observed FX exposures are substantially better rationalized when expected FX returns are considered in addition to return variances and covariances. Also, consistent with the model, we find that sectoral differences in hedging practices and foreign currency exposure are aligned with differences in effective risk tolerance.

We then model the net supply of hedging services as coming from FX intermediaries. These intermediaries, constrained by balance sheet size, require CIP deviations as compensation for supplying the short-term USD funding needed to meet FX hedging demands. Consistent with Ivashina, Scharfstein, and Stein (2015), the model predicts that CIP deviations, or the costs of FX hedging, widen in the amount of hedging intermediaries must supply. In a world where intermediaries' balance sheets are segmented across currencies, shocks to local hedging demand give rise to cross-sectional variation in CIP deviations. Consistent with an upward-sloping FX hedges supply, we find that the cross-sectional R-squared between hedging volume and CIP deviations is .73. We then exploit the granular firm-level data from Japanese insurers to causally identify the relationship between aggregate FX hedging and CIP deviations. Our results underscore the role of financial intermediation frictions in FX markets and highlight the relevance of institutional hedging behavior for understanding banks' currency-specific intermediation activities.

[2] We do not solve for the mean-variance optimal portfolio allocation between USD and domestic securities, as the literature extensively documents the role of home bias and other frictions (e.g., French and Poterba 1991). However, such frictions do not necessarily influence the optimal currency exposure decision.

1 Related Literature

Our paper contributes to the literature on institutional investors' portfolio allocation. Whereas previous studies focus primarily on variance-covariance as the motive for currency hedging (e.g., Campbell and Viceira 2002; Campbell, de Medeiros, and Viceira 2010), our model emphasizes the additional role of deviations from UIP and CIP (Anderson and Danthine 1980, 1981). Importantly, we exploit our unique data to establish the empirical relevance of these mean-variance drivers in FX hedging. By documenting the USD asset holdings and hedging practices across a broad set of non-U.S. investor types, our work relates to several strands of research on international portfolio allocation.[3] In particular, two related papers examine FX derivative use by U.S. mutual funds investing abroad (Sialm and Zhu 2024, Opie and Riddiough 2023). In contrast, we investigate the currency management across a broad cross-section of non-U.S. investors and characterize the drivers of their optimal FX exposure. On average, we find that non-U.S. investors maintain higher hedge ratios than U.S. investors. Given the generally negative covariance between the strength of the USD and global risky asset returns, U.S. investors arguably face amplified risk exposure through both currency and asset returns. This dynamic should, in principle, strengthen the motive for currency hedging among U.S. investors, but is at odds with their limited use of currency hedging, suggesting the importance of drivers beyond return covariance.

Our paper also contributes to the growing literature on the impact of asset demand on exchange rates.[4] Our paper is most closely related to Liao and Zhang (2025),, who devel-

[3] Examples include public investment funds (e.g., Mitchell, Piggott, and Kumru 2008; Lucas and Zeldes 2009), mutual funds (e.g., Maggiori, Neiman, and Schreger 2020), European investors (e.g., Faia, Salomao, and Veghazy 2022), and sovereign debt (e.g., Fang, Hardy, and Lewis 2025).

[4] Earlier work linking exchange rate dynamics to order flows includes Evans and Lyons (2002) and Froot and Ramadorai (2008).

ops a model linking currency hedging with exchange rate dynamics and tests implications of the model for both spot exchange rates and CIP deviations. Building on the conceptual framework in Liao and Zhang (2025), we highlight and empirically verify the expected currency return as an important driver of currency risk exposure beyond portfolio variance minimization. In addition, rather than approximate hedging demand using countries' net dollar foreign debt holdings as in Liao and Zhang (2025), we compile a broader set of data to construct direct measures of currency exposure and hedging demand. Our data allow us to investigate the economic drivers of the pronounced cross-sectional heterogeneity in hedging practices across currencies and sectors.

Our work is complementary to Bräuer and Hau (2022) and Dao, Gourinchas, and Itskhoki (2025), who study the relationship between the FX derivatives positions and the spot exchange rate.[5] Rather than modeling spot exchange rate dynamics, we focus on the equilibrium interaction between hedging demand, intermediary balance sheets, and CIP deviations. Our findings inform models of asset demand that equate the currency and asset exposure, implicitly assuming no FX hedging (e.g., Koijen and Yogo 2020; Jiang, Krishnamurthy, and Lustig 2021). More generally, by showing that FX hedging demand widens CIP deviations, we highlight intermediaries' limited risk-bearing capacity, which connects asset demand to asset prices in the FX market and beyond (An and Huber 2024).

Finally, our work further expands the active literature on CIP deviations. The persistence and cross-sectional variation in CIP deviations underscore the role of intermediaries' regulatory constraints in shaping asset prices (Du, Tepper, and Verdelhan 2018; Du, Hébert, and Huber 2022). This paper illuminates two outstanding questions. First, we demonstrate

[5]Using hedging data from one single country or region, several other recent studies also explore the connection between hedging demand and FX prices. For example, Ben Zeev and Nathan (2024) study Israeli institutional investors' hedging. Kubitza, Sigaux, and Vandeweyer (2025) and Hacioglu Hoke et al. (2026) study European investors' hedging using the EMIR regulatory reports.

that although CIP deviations are small in magnitude, they impose substantial financial costs on investors due to the sheer scale of hedging demand.[6] Second, we provide evidence that investors' hedging demand helps explain the puzzling cross-sectional variation in CIP deviations. In a fully arbitrageable world, such cross-sectional differences would be eliminated. Our paper advances the understanding of these deviations by introducing hedging supply from intermediaries with segmented balance sheets.[7] Similar to Borio et al. (2016), we link CIP deviations to global banks' USD funding imbalance. However, we depart from prior work by estimating banks' currency-specific hedging provision directly from institutional investors' hedging demand, rather than inferring it from the currency mismatch of banks in specific regions—for example, using European banks' positions to approximate the provision of EUR-USD hedges. Our approach allows banks to intermediate transactions denominated in currencies beyond their home jurisdictions. Empirically, we find that hedging demand correlates with CIP deviations across a wide range of currencies, including those of emerging economies.

2 Methodology and Data Construction

In this section, we describe the methodology used to construct the data analyzed in this paper. First, we outline our approach to estimating foreign holdings and hedging of USD securities, with detailed procedures available in Appendix A. Next, we define the cross-currency basis, which serves as our measure of deviations from covered interest-rate parity (CIP). Finally, we summarize the additional data used and outline the currency areas included in our

[6] Dávila, Graves, and Parlatore (2024) explore the social welfare implications of arbitrage violations, including CIP deviations.

[7] Diamond and Van Tassel (2026) explain the cross-section of CIP deviations using market-specific option-implied box rates, with implications for market segmentation.

sample for the analysis of portfolio allocations and hedging.

2.1 Estimating foreign holdings and hedging of USD securities

We estimate foreign holdings and hedging of USD securities from two complementary perspectives. On the one hand, we leverage TIC and BIS statistics to provide the first systematic estimate of all USD securities held by foreign investors. On the other hand, we conduct a bottom-up data collection effort to estimate foreign USD securities holdings across seven major sectors and use portfolio-level data to assess FX hedging in three actively managed sectors.

2.1.1 Overall foreign holdings of USD securities.

We begin with total foreign holdings of securities issued by U.S. *residents*, available from TIC, and make several adjustments to derive total foreign holdings of U.S. *dollar*-denominated securities. First, we subtract foreign holdings of securities issued by U.S. residents that are not denominated in USD. Second, we augment this estimate by including foreign-held USD securities issued by non-U.S. residents. Specifically, we use BIS international debt securities statistics to estimate cross-border USD issuance and subtract securities held by U.S. residents.[8] Detailed estimation procedures are provided in Appendix A.1. In

[8] We adjust for debt securities only, as equities are generally denominated based on the place of issuance.

summary, our estimation is as follows:

$$\begin{aligned}
&\text{Total foreign holding of USD securities} \\
&= \text{Foreign USD holding of U.S. issuers} + \text{Foreign USD holding of non-U.S. issuers} \\
&= (\text{TIC foreign holding of U.S. securities} - \text{TIC foreign holdings of non-USD securities}) \\
&+ (\text{USD securities outstanding outside the United States} - \text{U.S. investors' cross-border USD holdings}).
\end{aligned}$$

2.1.2 Sector-specific USD securities holdings and hedging.

We identify seven sectors with significant investments in USD securities and collect country- and sector-level portfolio allocations for USD bonds and equities. These sectors include insurance companies, pension funds, mutual funds, banks, hedge funds, nonfinancial corporations and households, and the official sector. Our sector-specific data account for 60% of our estimated aggregate foreign holdings in 2020 (see Figure 4). The remaining 40% reflects both incomplete coverage of these seven sectors and potentially significant holdings by other groups, such as separately managed accounts of institutional investors and high-net-worth individuals.[9]

Of these seven sectors, three actively manage FX risks: insurance companies, pension funds, and mutual funds. We focus our hedging analysis on these three sectors. Notably, FX risk management outside these sectors is not directly comparable. For example, banks typically hedge nearly all FX risk due to the high regulatory capital charges on unhedged positions.[10] The official sector, by contrast, generally conducts minimal FX hedging, as

[9]High-net-worth individuals command substantial wealth. Forbes estimates that non-U.S. billionaires held $8 trillion in wealth in 2022 (Forbes Wealth Team 2022), much of which is tied to company stocks.

[10]See Appendix B for a discussion of how FX derivatives interact with bank regulations and for evidence that banks hedge nearly all FX risk.

its objectives include maintaining foreign currency liquidity for balance of payments and potential interventions.[11] In contrast, FX hedging by insurance companies, pension funds, and mutual funds reflects investor preferences. For instance, mutual funds are not required to maintain specific FX exposures but design hedging strategies to attract investors with varying degrees of FX risk tolerance. While some pension and insurance investors face foreign investment limits, few countries impose binding limits on USD securities; see Table A1.

Table 1 summarizes the sectors and currency areas in our analysis, along with the main data sources. We provide full estimation details in Appendix A.2; below, we will briefly outline our approach, starting with the insurance sector. In Japan and Taiwan, among other regions, insurers play a major role in retirement savings and are significant holders of investment securities. For Japan, we manually collect statutory filings from all active insurers since 2004. In Taiwan, we digitize physical copies of the Central Bank of the Republic of China's monthly life insurance reports and supplement these with annual reports from the six largest Taiwanese life insurers. For Denmark and Sweden, we use central bank data; for the broader European Economic Area, we obtain aggregate data from the European Insurance and Occupational Pensions Authority (EIOPA). For Israel, we use monthly data from the Bank of Israel. For each region, we collect information on overall portfolio size and USD securities holdings. For all but countries covered by EIOPA, we are able to estimate the USD hedge ratio, defined as the share of USD investments with hedged FX risk. Appendix A.2.1 contains estimation details.

For the pension sector, we focus on countries with the largest pension assets,[12] classifying

[11] Official sector holdings may include sovereign wealth funds. While little is known about their currency hedging practices, the Norwegian Sovereign Wealth Fund, the largest globally, does not hedge FX risk on its foreign investments (Du and Viceira 2024).

[12] See the OECD's "Pension funds' assets" data (last accessed June 26, 2026,

them by structural concentration. Japan, the Netherlands, and Canada have highly concentrated markets, so we analyze filings from their largest pension funds. In contrast, Australia, Switzerland, and the United Kingdom have more fragmented systems, so we rely on sector-level data from national authorities. Additional countries studied include Denmark, Sweden, Israel, Chile, and nine other Latin American countries that are FIAP members.[13] For each country, we collect data on total pension assets and USD investments. We estimate the USD hedge ratio for all countries except the United Kingdom and the nine non-Chile Latin American countries, due to data limitations. See Appendix A.2.2 for further details.

For mutual funds, we use Morningstar data covering open-ended and exchange-traded funds (ETFs) domiciled in 64 non-U.S. countries. This data set provides security-level holdings data similar to those used in Maggiori, Neiman, and Schreger (2020) and Coppola et al. (2021). We estimate USD bond holdings by aggregating all USD-denominated bonds and derive USD equity holdings from each fund's allocation to U.S. equities. Hedge ratios are estimated at the share-class level, using a combination of disclosure (e.g., "fully hedged") and benchmark choice (e.g., "U.S. Corporate Bond EUR Hedged"). See Appendix A.2.3 for discussion of limitations.

Finally, we estimate foreign USD holdings for banks, hedge funds, nonfinancials, and the official sector. For banks, we use BIS Locational Banking Statistics (LBS) and focus on debt holdings; banks do not hold much positions in equity because the associated capital requirement is much higher. We estimate foreign banks' USD debt holdings as proportional to the difference between total USD assets and USD loans. For hedge funds, we use 13F reports, which require institutional investment managers with over $100 million assets un-

https://doi.org/10.1787/d66f4f9f-en).

[13]FIAP (Federación Internacional de Administradoras de Fondos de Pensiones) members include Argentina, Bolivia, Colombia, Costa Rica, Chile, El Salvador, Mexico, Peru, the Dominican Republic, and Uruguay.

der management (AUM) to disclose quarterly U.S. equity holdings. For nonfinancials, we conservatively estimate their USD holdings from holdings of U.S. securities, as reported to IMF's Coordinated Portfolio Investment Survey (CPIS) data. Of the 81 countries reported as having investments in U.S. securities, 56 provide nonfinancial sector breakdowns. For the official sector, we rely on U.S. securities holdings reported in TIC. Full details are provided in Appendix A.2.4.

2.2 Deviations from covered interest-rate parity

We measure deviations from CIP using the cross-currency basis. Following Du, Tepper, and Verdelhan (2018), we define the τ-month cross-currency basis of foreign currency c vis-à-vis the USD as:

$$X_{t,\tau}^{c,\$} = \frac{R_{t,\tau}^{\$}}{R_{t,\tau}^{c}} \left(\frac{F_{t,\tau}}{S_t} \right)^{\frac{12}{\tau}} - 1,$$

and the log version as:

$$x_{t,\tau}^{c,\$} = \ln\left(1 + X_{t,\tau}^{c,\$}\right). \tag{1}$$

Here, $R_{t,\tau}^{c}$ and $R_{t,\tau}^{\$}$ are the annualized gross τ-month risk-free interest rates in currency c and USD, respectively. Exchange rates are expressed in units of foreign currency per USD, so an increase in the spot exchange rate S_t reflects a depreciation of the foreign currency and an appreciation of the USD. The forward exchange rate at time t for a τ-month tenor is denoted $F_{t,\tau}$.

If CIP held, $x_{t,\tau}^{c,\$} = X_{t,\tau}^{c,\$} = 0$, meaning that the forward exchange rate is priced solely based on the interest rate differential. A more negative cross-currency basis indicates higher costs for non-U.S. investors to hedge USD exposure: when the cross-currency basis $x_{t,\tau}^{c,\$}$ is negative, the forward exchange rate is priced too low relative to the prevailing interest rates, reducing the proceeds from selling USD forward.

We measure R using IBOR rates across countries and focus on the 3-month tenor. This choice reflects the prevailing hedging practice of continuously rolling over short-term hedges. Moreover, because a 3-month contract appears on the quarter-end balance sheet regardless of when within the quarter it is initiated, its pricing does not exhibit the quarter-end spikes observed for shorter-dated contracts (Du, Tepper, and Verdelhan 2018). We source daily IBOR rates, as well as spot and forward FX rates, from Bloomberg using London closing rates.

2.3 Other data and sample currencies

We supplement our core data with several additional series. From the BIS, we obtain the Triennial Central Bank Survey on Foreign Exchange and Derivatives Market Activities (2001–2022), the Debt Securities Statistics, and the Locational Banking Statistics. From the World Bank, we gather data on public equity market capitalization. From Preqin, we obtain AUM data for U.S. and global private equity funds. SIFMA provides data on outstanding U.S. debt securities, compiled from Bloomberg, the Federal Reserve, U.S. Agencies, and the U.S. Treasury.

From Bloomberg, we also obtain historical yields on 10-year government bonds and major equity indices in the United States and 12 other currency areas. These data are used to study the empirical correlations between asset and currency returns. The 12 currency areas included in our analysis are Australia (AUD), Canada (CAD), Switzerland (CHF), Denmark (DKK), Germany (EUR), the United Kingdom (GBP), Japan (JPY), Norway (NOK), Sweden (SEK), Chile (CLP), Israel (ILS), and Taiwan (TWD). These areas form the core of our sample, as each provides mutual fund hedging data and at least one of insurance or pension hedging data. Our sample includes nine advanced economies and three emerging economies.

3 Stylized Facts on Foreign USD Holdings and Hedging

In this section, we present four stylized facts about foreign investors' aggregate USD holdings and currency hedging patterns.

Fact 1: Foreign investors increasingly tilt their portfolios toward USD securities.

Figure 1 shows that foreign holdings of USD securities reached $33.4 trillion by mid-2021. Our estimate exceeds the comparable figure from TIC due to the inclusion of substantial amounts of USD debt issued by non-U.S. residents. It is also nearly double the estimate from CPIS, which relies on reporting countries to categorize their cross-border holdings by either country or currency. We estimate that total foreign holdings of USD securities have increased sixfold since 2002 (from $5.5 trillion). This remarkable growth occurred during a period when global GDP (excluding the United States) expanded by less than threefold.

The increase in foreign USD holdings is broad-based across both bonds and equities. In aggregate, foreign investors hold approximately two-thirds of their USD securities in bonds and one-third in equities (Figure 2, panel A. Foreign holdings represent a larger share of total USD bonds outstanding compared to U.S. equities (panel B).[14] Importantly, the share of foreign holdings has been rising in both asset classes.

Figure 3 illustrates the evolution of portfolio allocations to USD securities across three

[14]We estimate total outstanding USD debt as the sum of U.S. fixed-income securities and USD-denominated cross-border debt issued by non-U.S. residents. Total outstanding USD equities are estimated as the market capitalization of U.S.-listed stocks and AUM of U.S. private equity funds.

sectors: insurance companies (panel A), pension funds (panel B), and mutual funds (panel C). The portfolio allocation to USD assets, defined as the ratio of USD bonds and equities to total assets (hereafter, "USD asset allocation"), has been steadily increasing. For many investors, the USD asset allocation has nearly doubled over the sample period.[15]

To assess whether this rise in USD allocation reflects a broader increase in foreign investors' nondomestic investments or a reallocation toward USD assets within investors' foreign portfolios, we examine portfolio allocations using panel data in Table 2. Columns 1 and 2 show that, in the post-GFC period, investors in our 12 sample currency areas (9 advanced economies and 3 emerging economies; see Section 2.3) increased their USD asset allocation by an average of 7.7 percentage points relative to the pre-GFC period.[16] This growth follows a linear trend of 0.23 percentage points per quarter. In addition, the share of USD securities in investors' nondomestic investments increased by 6.6 percentage points post-GFC (column 3).[17] The robust, though slightly smaller, growth trend in USD share within nondomestic investments (column 4) suggests that rising USD allocation reflects both greater foreign investment and more active rebalancing toward USD assets.

Fact 2: Substantial hedging in actively managed sectors post-GFC despite rising hedging costs.

Although foreign investors have large and growing holdings of USD securities, they do not retain all the associated USD currency exposure. As of June 2020, we estimate that the USD

[15]Our USD asset allocation focuses on USD securities and excludes real estate and infrastructure. Anecdotal evidence suggests that USD exposure in these categories has also risen, further increasing total USD portfolio exposure.

[16]We define the pre-GFC period as on or before June 30, 2007; the GFC period as July 1, 2007, through June 30, 2010; and the post-GFC period as after July 1, 2010.

[17]Appendix Figure A1 shows the share of USD bonds in the global bond market and the share of U.S. equities in the global equities market. Neither share significantly increased post-GFC, suggesting that rising USD allocation is not simply driven by changes in supply.

hedge ratios, the proportion of USD securities hedged against FX risk, were 43%, 35%, and 21% for insurance companies, pension funds, and mutual funds, respectively. Collectively, these three sectors generated more than $2 trillion in hedging demand by 2019. Figure 4 provides a snapshot of hedging practices across sectors.

Table 3 uses our microdata to examine time-series trends in USD hedging and currency exposure. Columns 1 and 2 show that USD hedge ratios rose significantly post-GFC. Controlling for sector-by-currency fixed effects, average hedge ratios increased by 14.7 percentage points. Aggregate data on FX derivatives trading corroborates this trend. FX hedging is primarily conducted through forward or swaps,[18] and Appendix Figure A2 shows that daily average turnover in these instruments rose sharply between 2001 and 2022, outpacing growth in spot FX transactions. This trend holds when looking at only transactions involving institutional investors, such as insurance companies, pension funds, and mutual funds.[19]

Despite rising hedge ratios, foreign investors' total portfolio exposure to unhedged USD currency risk has continued to grow, as USD asset allocation outpaced the increase in hedging. Columns 3 and 4 of Table 3 show that post-GFC, investors' unhedged USD exposure increased by 5.8 percentage points overall, and by 6.7 percentage points for a given investor type in a given currency area.

This combination of higher hedge ratios and rising USD asset allocations has led to a surge in the *volume* of USD hedging. Yet the CIP condition, which should govern the pricing of the FX forwards and swaps used for hedging, has exhibited large and fluctuating deviations since the GFC. For many currencies, the cross-currency basis has been persistently negative,

[18] Appendix Figure A3 shows that nonforward and nonswap FX derivatives constitute a small and stable-to-declining share of the market since the GFC.

[19] Data on total FX derivatives trading come from the BIS Triennial Central Bank Surveys. BIS defines "institutional investors" to include mutual funds, pension funds, insurance and reinsurance companies, and endowments. They typically engage in FX trading for hedging, investing, and risk management purposes. BIS refers to this group as "real money investors" BIS (2022).

meaning that hedging USD exposure is costly for foreign investors (see also Section 2.2). We estimate that, between 2017 and 2020, hedging cost measured as the product of hedging volume and the negative of the cross-currency basis, reached approximately $2-$4 billion per annum for the insurance companies and pension funds in our sample.[20] The average annual hedging cost over this period was $2.6 billion, or about 0.1% of USD securities held by these two sectors. We note that our estimates likely understate the true cost of FX hedging, as the cross-currency basis implied in Bloomberg rates reflects interdealer quotes; dealer market power means that investors may pay more (Hau et al. 2021).

Fact 3: Hedging behavior exhibits heterogeneity across currencies.

Most countries and sectors have increased their USD FX hedging, but substantial variation remains in hedge ratios across currencies. Table 4 presents a snapshot of USD securities holdings and hedge ratios at the end of 2019. The average USD hedge ratio across mutual funds, pension funds, and insurance companies ranges from 10% in Canada to 57% in Denmark (Column "Hedge Ratio").

One explanation for this variation is that investors adopt different hedging strategies based on portfolio composition. Campbell, de Medeiros, and Viceira (2010) argue that investors in advanced economies should hedge bonds more than equities due to covariance between returns on asset and returns on FX exposure. In downturns in which U.S. equities perform poorly, flight-to-safety flows tend to appreciate the dollar and increase the return on Treasury bonds. Therefore, dollar exposure offers a natural hedge for U.S. equity returns, but amplifies the risk on Treasury bond returns. We find suggestive evidence consistent with

[20] We use quarterly snapshots of hedging volumes and average 3-month cross-currency basis, assuming continuous rollover of short-term forwards. For countries covered by EIOPA (excluding Denmark and Sweden), we use the sector average hedge ratio. For U.K. pensions, we use the 2016Q1–2020Q4 average from Czech et al. (2022).

this mechanism from those investors in our sample who separately report hedge ratios for bonds and equities. In Figure 5, fixed-income mutual funds hedge significantly more than equity mutual funds (panel A); Australian and Dutch pensions also hedge bonds at higher ratios (panel B).

Yet even within the same sector, where investors have broadly similar allocations between bonds and equities, hedge ratios still vary widely. Figure 6 illustrates the time series of USD hedge ratios across sectors. Among pensions (panel B), hedge ratios range from 5% in Japan to 80% in Denmark in 2020. Mutual funds (panel C) show the narrowest range, but even here, ratios vary from near 0% to nearly 30%. These patterns highlight the need for a systematic framework to understand the determinants of hedging behavior across sectors and currency areas.

Moreover, although our data sets focus on non-U.S. investors, comparing them with U.S. investors reveals important differences. Sialm and Zhu (2024) show that U.S.-domiciled international fixed-income mutual funds maintain an average hedge ratio of just 18%. Similarly, Chen and Zhou (2025) find that these funds often hold negative hedge ratios against emerging market currencies, indicating that U.S. funds sometimes use FX derivatives to increase their currency exposure. These relatively low hedge ratios among U.S. investors challenge the notion that hedging is purely driven by return covariance. Since the USD tends to appreciate when global risky asset returns decline, currency exposure increases the volatility of foreign asset returns, strengthening the case for U.S. investors to hedge. This suggests that factors beyond return covariance play an important role in shaping hedging behavior.

Fact 4: Global banks are net suppliers of USD FX hedges.

We now examine how foreign institutional investors' demand for USD FX hedges is accommodated within global financial markets. FX intermediaries, such as global banks, match those who demand FX forwards and swaps (e.g., institutional investors) with those who can supply (e.g., nonfinancial corporations, hedge funds). When customer-supplied FX hedges are insufficient, banks step in to clear the market. Because hedging demand essentially represents a need for short-term USD funding, supply of FX hedges by banks hinges on their ability to source such funding via deposits or wholesale borrowings. Conversely, banks may also demand FX hedges themselves, seeking synthetic USD funding for their own USD-denominated assets.

As FX derivatives are predominantly traded over-the-counter, comprehensive data on global banks' FX activities are limited. Following Borio et al. (2016) and Borio et al. (2018), we construct a "dollar funding gap" as an empirical proxy for non-U.S. banks' net supply of USD FX hedges. This gap is defined as the difference between on-balance-sheet USD assets and liabilities. Under the assumption that banks use off-balance-sheet FX derivatives to cover their on-balance-sheet dollar funding gap, a positive gap indicates net USD borrowing through FX derivatives, while a negative gap reflects net USD lending. We estimate these gaps using BIS Locational Banking Statistics (LBS).[21]

U.S. banks have a distinct advantage in providing USD funding due to their extensive access to USD deposits. For U.S. banks, we infer net dollar lending as the difference between foreign-currency assets and liabilities, assuming that any open on-balance-sheet FX positions

[21] Where consolidated statistics are available, we use aggregated positions of all bank branches headquartered in a given country. Consolidated data are available for Canada, Japan, Sweden, Switzerland, the United Kingdom, and six EU countries (Belgium, France, Germany, Italy, Netherlands, and Spain). For countries without consolidated data, we approximate the dollar funding gap using aggregate positions of all bank branches located in the respective country.

are hedged off-balance-sheet using FX derivatives.

Table 4 presents the net supply of USD FX hedges by banking jurisdictions. A negative (positive) value in the "Bank Hedging" column indicates net supply (demand). The data reveal considerable heterogeneity in funding models across jurisdictions. For instance, Japanese banks exhibit a strong positive net demand for USD hedges, totaling $305 billion in 2019. In contrast, banks in Australia, the euro area, the United Kingdom, and the United States collectively supplied approximately $410 billion. In total, global banks supplied $333 billion in 2019, highlighting that their role extends well beyond pure intermediation.

Finally, while dollar funding gaps capture the overall volume of USD funding banks supply, they do not reveal the specific currencies against which these USD FX hedges are provided. In addition, inferring FX hedging positions from BIS banking statistics is subject to measurement limitations. For example, while the BIS LBS provide a full decomposition of cross-border positions by currency, USD positions booked locally in the United States or in other jurisdictions may be underreported or omitted, likely leading to an underestimation of the supply of USD hedging by global banks. We return to this point in Section 5, where we use institutional investors' FX demand to approximate the currency-level allocation of banks' USD hedge provision.

4 FX Exposure for Mean-Variance Investors

On the whole, foreign investors meaningfully hedge the FX exposure associated with their USD securities holdings. But there is substantial heterogeneity across hedging practices. In this section, we use a mean-variance framework to examine the drivers of investors' demand for unhedged USD exposure. We then empirically test the model's predictions and find robust support for our theoretical framework.

4.1 Portfolio asset and currency returns

We assume that the investor has access to investment opportunities at home and in n other countries, each using a different currency. We define the spot and forward exchange rates, S_t and F_t, as units of home currency per foreign currency. An increase in S_t or F_t corresponds to an appreciation of the foreign currency.[22] For simplicity, we assume that only one asset exists in each country. Following Viceira and Shen (2023), we let $\boldsymbol{\omega}_t$ denote a $(n+1)\times 1$ vector of portfolio asset weights, where ω_c is the portfolio share of asset in country (currency) c, with $c = 1$ representing the home country (currency). Moreover, let $\boldsymbol{\theta_t}$ denote a $(n+1)\times 1$ vector of FX hedging done, expressed in portfolio shares, with $\theta_1 = 0$. Therefore, $\boldsymbol{\psi_t = \omega_t - \theta_t}$ is a $(n+1)\times 1$ vector of investor's true exposure to foreign currencies, also expressed in portfolio shares.

We assume that the investor does not have direct access to foreign short-term rates, so currency hedging must be done via the FX derivatives market, namely, FX forwards and swaps. We allow for a wedge in the CIP condition between the home currency and foreign currency c,

$$F_t^c = S_t^c \frac{1 + i_t^1}{1 + i_t^c}(1 + X_t^c),$$

where i_t^1 and i_t^c denote one-period domestic and foreign money market rates, F_t^c is the one-period forward exchange rate known at time t, and X_t^c is the cross-currency basis. In log form, the CIP deviation is given by:

$$x_t^c = (i_t^c - i_t^1) + (f_t^c - s_t^c),$$

[22] This definition is consistent with that in Section 2.2, where S_t and F_t were defined as units of foreign (non-USD) currencies per USD. In this section, USD is one potential foreign currency for the investor.

where $f_t^c = \log(F_t^c)$, $s_t^c = \log(S_t^c)$, and $x_t^c = \log(1 + X_t^c)$. In other words, investors can synthetically access the foreign short-term rate by swapping the local short-term rate $i_t^c - x_t^c = i_t^1 - (f_t^c - s_t^c)$.

Finally, we measure the violation of uncovered interest parity (UIP) with the expected return of going long in foreign currency c:

$$\xi_t^c = (i_t^c - i_t^1) + \mathbb{E}_t \Delta s_{t+1}^c,$$

where $\mathbb{E}_t \Delta s_{t+1}^c$ is the expected foreign currency appreciation. If UIP holds, the expected appreciation of the foreign currency should exactly offset the interest rate differential. However, on average, high-interest-rate currencies do not depreciate enough against low-interest-rate currencies relative to their interest rate differentials (e.g., Lustig and Verdelhan 2007; Lustig, Roussanov, and Verdelhan 2011; Hassan and Mano 2019). Therefore, on average, there are positive excess returns from going long in high-interest-rate currencies and shorting low-interest-rate currencies.

With these definitions, we define the hedged portfolio return as:

$$R_{h,t+1} = \boldsymbol{\omega_t'} \boldsymbol{R_{t+1}} (\boldsymbol{S_{t+1}} \div \boldsymbol{S_t}) - \boldsymbol{\theta_t'} (\boldsymbol{S_{t+1}} \div \boldsymbol{S_t}) + \boldsymbol{\theta_t'} (\boldsymbol{F_t} \div \boldsymbol{S_t}),$$

where $\div$ represents element-wise division of vectors. Following Campbell, de Medeiros, and Viceira (2010), we log-linearize the hedged return over the local risk-free rate as follows (details in Appendix C):

$$r_{h,t+1} - i_t^1 = \underbrace{\boldsymbol{\omega_t'} (\boldsymbol{r_{t+1}} - \boldsymbol{i_t} + \boldsymbol{x_t})}_{\text{portfolio asset return}} + \underbrace{\boldsymbol{\psi_t'} (\boldsymbol{\Delta s_{t+1}} - i_t^1 \mathbf{1} + \boldsymbol{i_t} - \boldsymbol{x_t})}_{\text{portfolio currency return}} + \frac{1}{2} \Sigma_{h,t+1}. \tag{2}$$

Here and throughout, we use boldface to indicate an $(n + 1) \times 1$ vector where the first element corresponds to home country (currency). The cross-currency basis for the home country (currency), x_t^1, is zero, as $f_t^1 = s_t^1 = 0$.

The first term represents the "portfolio asset return," which is the sum of each portfolio asset's excess return in its local currency. The cross-currency basis x_t adjusts for the effective foreign currency short rate accessible to the investor. The second term captures the "portfolio currency return," which is the excess return from foreign currency exposure. The third term is Jensen's inequality, with $\Sigma_{h,t+1}$ denoting the variance of the log excess return.

4.2 The mean-variance investor's problem

We derive the mean-variance investor's optimal foreign currency exposure, $\boldsymbol{\psi_t}$, conditional on the portfolio asset share $\boldsymbol{\omega_t}$:

$$\max_{\boldsymbol{\psi_t}} \mathbb{E}_t(r_{h,t+1} - i_t^1) - \frac{\gamma}{2}\mathbb{V}(r_{h,t+1} - i_t^1),$$

where γ is the risk aversion coefficient. Biases and frictions, such as home bias, investor mandates, and information frictions, are known to cause portfolio asset allocations to deviate from a global mean-variance benchmark (e.g., French and Poterba 1991). We therefore abstract from asset allocation and focus directly on drivers of optimal currency exposure.

Substituting the hedged return in Equation (2) and solving the optimization problem, we derive the optimal currency exposure as:

$$\begin{aligned}\boldsymbol{\psi}_t^* &= \frac{\boldsymbol{\xi}_t - \boldsymbol{x}_t}{\gamma \mathbb{V}(\boldsymbol{\Delta s}_{t+1} - i_t^1 \mathbf{1} + \boldsymbol{i}_t - \boldsymbol{x}_t)} \\ &\quad - \frac{\mathbb{C}\left[\boldsymbol{\omega}_t'(\boldsymbol{r}_{t+1} - \boldsymbol{i}_t + \boldsymbol{x}_t), (\boldsymbol{\Delta s}_{t+1} - i_t^1 \mathbf{1} + \boldsymbol{i}_t - \boldsymbol{x}_t)\right]}{\mathbb{V}(\boldsymbol{\Delta s}_{t+1} - i_t^1 \mathbf{1} + \boldsymbol{i}_t - \boldsymbol{x}_t)} \\ &= \underbrace{\frac{\boldsymbol{\xi}_t - \boldsymbol{x}_t}{\gamma \mathbb{V}(\boldsymbol{\Delta s}_{t+1} - i_t^1 \mathbf{1} + \boldsymbol{i}_t - \boldsymbol{x}_t)}}_{\text{var-adjusted FX return}} - \underbrace{\boldsymbol{\beta}}_{\text{var-adj cov(FX, portfolio assets)}}, \qquad (3)\end{aligned}$$

where $\boldsymbol{\beta}$ is the regression coefficient of portfolio asset returns on currency excess returns adjusted for CIP deviations:

$$\boldsymbol{\omega}_t'(\boldsymbol{r}_{t+1} - \boldsymbol{i}_t + \boldsymbol{x}_t) = \alpha + \boldsymbol{\beta}'(\boldsymbol{\Delta s}_{t+1} - i_t^1 \mathbf{1} + \boldsymbol{i}_t - \boldsymbol{x}_t) + \boldsymbol{\epsilon}_t.$$

The term $\boldsymbol{\beta}$ captures the effect of portfolio return volatility on the optimal FX exposure, as emphasized in Campbell, de Medeiros, and Viceira (2010) and Viceira and Shen (2023). The optimal foreign currency exposure decreases in the covariance between foreign currency excess returns and the portfolio asset return. If a foreign currency return is highly correlated with the portfolio asset return, adding exposure to that foreign currency amplifies the overall portfolio return's volatility, which a risk-averse mean-variance investor seeks to avoid. Conversely, if a foreign currency return is negatively correlated with the portfolio asset return, currency risk offers a good hedge for the overall portfolio, and the mean-variance investor would take on some exposure to that foreign currency.

In addition to $\boldsymbol{\beta}$, we analyze the effect of currency return on optimal FX exposure, as captured by the first term in Equation (3). The term $\boldsymbol{\xi}_t$ is the expected excess return of investing in foreign currencies, which could be nonzero due to UIP violations. The higher the expected foreign currency excess return, the greater the demand for foreign currency exposure by a mean-variance investor. The term $-\boldsymbol{x_t}$ represents the cost of foreign currency hedging arising from CIP deviations: the more negative $\boldsymbol{x_t}$ is, the higher the cost of foreign currency hedging, and the greater the incentive to leave foreign currency exposure unhedged. The overall effect of UIP and CIP deviations $\boldsymbol{\xi_t} - \boldsymbol{x_t}$ decreases in the degree of investor risk aversion and FX return volatility, as the mean-variance investor balances utility from expected return with disutility from portfolio return variance.

Similar to Liao and Zhang (2025), we focus on cases in which investors find it optimal to have nonnegative currency exposure. This is the case if the covariance between the foreign currency return and the foreign asset return is lower than expected return on currency scaled by investor's risk aversion: $\mathbb{C}\left[\boldsymbol{\omega_t'}(\boldsymbol{r_{t+1}} - \boldsymbol{i_t} + \boldsymbol{x_t}), (\boldsymbol{\Delta s_{t+1}} - i_t^1\mathbf{1} + \boldsymbol{i_t} + \boldsymbol{x_t})\right] < \frac{\boldsymbol{\xi_t} - \boldsymbol{x_t}}{\gamma}$. The following proposition summarizes the key drivers of optimal FX exposure for a mean-variance investor.

Proposition 1. *Fixing asset allocations, ψ_c^*, the optimal foreign currency exposure of a mean-variance investor to currency c,*

1. *increases with the expected excess return of holding foreign currency, ξ_c;*
2. *decreases with the cross-currency basis between the foreign and home currency, x_c;*
3. *decreases with the covariance between foreign currency return and portfolio asset return;*
4. *decreases with foreign currency return volatility.*

Compared to a framework that considers only the effect of covariance or volatility, we emphasize FX returns also as drivers of optimal currency exposure. Our framework moreover shows that the effect FX returns and volatility could vary depending on investors' risk aversion. Taking the mixed partial of ψ^* first with respect to ξ, x, and $\mathbb{V}(\boldsymbol{\Delta s_{t+1}} - i_t^1\mathbf{1} + \boldsymbol{i_t} - \boldsymbol{x_t})$, and then with respect to risk aversion, γ, the resultant signs are in the opposite direction from the single partial. In other words, a higher risk aversion attenuates the effect of expected FX return and volatility on FX exposure, and a lower risk aversion amplifies the effect. We summarize this in the following proposition:

Proposition 2. *All else equal, a lower risk aversion, γ, increases the level and the sensitivity of a mean-variance investor's optimal foreign currency exposure, ψ_c^*, to the expected excess return of holding foreign currency, ξ_c, the cross-currency basis between the foreign and home currency, x_c, and the foreign currency return volatility.*

4.3 Testing mean-variance predictions

We begin by testing the predictions for optimal currency exposure (Proposition 1). As non-U.S. investors' nondomestic investments predominantly consist of USD securities, we simplify the analysis by assuming their portfolios consist of assets denominated in either their local currency or USD.

We first estimate the empirical covariance between FX returns and portfolio asset returns. We construct each investor's portfolio asset return from USD bond, USD equity, local-currency bond, and local-currency equity returns, weighted by the investor's observed, time-varying portfolio allocation. To approximate bond returns, we use 10-year government bond yields; for equities, we use major local stock market indices.[23] Focusing on annualized 1-month holding-period excess returns, and adjusting for the cross-currency basis x_t (as in

[23]For Europe, we use the 10Y German bund to estimate bond returns and STOXX Europe 600 to estimate equity returns.

Equation (2)), we estimate the following:[24]

$$
\begin{aligned}
rx^{\text{bond, adj}}_{t+1} &= 12(p_{9\frac{11}{12}Y,t+1M} - p_{10Y,t}) - i_{1M,t} + x_t, \\
&\approx y_{10Y,t} - i_{1M,t} - 119(\Delta y_{10Y,t+1}) + x_t, \\
rx^{\text{equity, adj}}_{t+1} &= 12(\Delta p_{t+1}) - i_{1M,t} + x_t, \\
rx^{\text{FX, adj}}_{t+1} &= 12(\Delta s_{t+1}) - i_{1M,t} + i^{\$}_{1M,t} - x_t.
\end{aligned}
$$

Our estimation period spans June 2002 to September 2020, inclusive of the GFC and COVID-19.[25] We use month-end nonoverlapping returns, and proxy $i_{1M,t}$ with 1-month IBOR in the respective currency.

In our empirical design, we treat the covariance between FX returns and portfolio asset returns as a salient cross-sectional characteristic that varies across investor types. In the time series, by contrast, the primary source of variation relevant for testing Proposition 1 is changes in exchange rate volatility, which we measure using option-implied FX volatility from 1-month at-the-money contracts. Internet Appendix Table A4 shows that allowing for time variation in the covariance structure does not materially affect investors' currency exposure, suggesting that such variation is not a first-order consideration. Finally, given the persistent violation of UIP, we use interest rate differentials as proxies for expected FX returns.

Before conducting regression analysis, we explore the data visually. Figure 7 presents

[24]We construct bond returns using a constant-maturity benchmark to ensure that the bond component of the portfolio is not affected by time-varying duration in aggregate bond indices. The first line corresponds to the annualized 1-month holding-period excess return on a constant-maturity 10-year bond, following the convention in Campbell, Lo, and MacKinlay (1997). A bond purchased at maturity 10 years and held for 1 month becomes a $9\frac{11}{12}$-year bond at $t + 1$, so the price difference isolates true bond price movements and abstracts from changes in index duration.

[25]This estimation period ends slightly before our sample period concludes in June 2021, as September 2020 is the latest point when we have a complete panel of holdings and hedging data.

cross-currency scatter plots of observed portfolio FX exposure in the post-GFC period against various mean-variance drivers. We construct the currency-level representative investor's portfolio as the weighted average of portfolios held by insurance companies, pension funds, and mutual funds in a particular currency area. Panel A shows the correlation between observed unhedged USD exposure (ψ) and $-\beta$, the negative covariance between currency excess returns and portfolio asset returns (adjusted for FX return volatility). This $-\beta$ has been the main driver of foreign currency exposure in the literature. We find a positive correlation between unhedged USD exposure and $-\beta$, though the correlation of 0.42 is far from perfect, suggesting that return covariance alone does not fully explain observed FX exposures.

Panel B explores the role of expected currency returns. The vertical axis measures the residual portion of unhedged exposure after accounting for covariance, $\psi - (-\beta)$ or $\psi + \beta$. The horizontal axis measures the 3M IBOR differential between the United States and the investor's home country, which is our proxy for UIP violations.[26] Consistent with mean-variance predictions, there is a strong positive correlation of .86. Low-interest-rate countries, such as Japan, Denmark, and Switzerland, show high unhedged USD exposure after accounting for the covariance between portfolio asset returns and USD currency returns. Conversely, high-interest-rate countries like Chile, Australia, Canada, and Norway have low unhedged USD exposure after adjusting for the covariance term.

Panels C and D further illustrate the relationship between covariance-adjusted unhedged exposure ($\psi + \beta$) and 3M CIP deviations between USD and home currency. Taiwan appears as a large outlier for CIP deviations in panel C. Panel D excludes Taiwan and finds a negative correlation of -.55. Overall, in addition to return covariance, UIP and CIP deviations are

[26] As with the portfolio covariance in panel A, UIP deviation in panel B and CIP deviation in panels C and D are divided by FX return variance, per Equation (3).

strongly correlated with observed USD exposure in the cross-section, consistent with mean-variance predictions in Proposition 1.

4.3.1 Cross-country panel regression tests.

We now investigate the mean-variance drivers of optimal FX exposure using panel regressions. Table 5 reports results from the cross-section. The outcome variable is representative investor's observed unhedged USD exposure, stated as a portfolio share. The explanatory variables directly follow from the mean-variance solution in Equation (3).[27] The results confirm the patterns observed in Figure 7. At each point in time, looking across currencies, differences in return covariance, interest rate differentials (a proxy for violations of UIP under a random walk assumption for exchange rate), and CIP deviations are all statistically significant and exhibit signs consistent with Proposition 1. These relationships hold in both the full sample (columns 1 and 2) and the post-GFC sample (columns 3 and 4). The explanatory power of these drivers increased post-GFC, as seen in the rise in "Within Adjusted R^2" (adjusted R^2 excluding fixed effects) from .23 in column 2 to .3 in column 4. More importantly, comparing columns 1 and 3, where return covariance is the sole explanatory variable, to columns 2 and 4, we see that including UIP and CIP deviations meaningfully improves model fit: the Within R^2 rises from .09 to .23 in the full sample, and from .1 to .3 post-GFC.

Mean-variance drivers of FX exposure could also affect investor portfolios over time. Table 6 shows results from the time series. Fixing a currency, higher option-implied FX volatility reduces unhedged USD allocation, consistent with Liao and Zhang (2025).[28] Inter-

[27] As in Equation (3), each explanatory variable is divided by FX return variance. Because return variance is estimated, we conduct inference using confidence intervals block bootstrapped by time, which preserves the panel structure and allows for serial correlation.

[28] Internet Appendix Table A3 reports the summary statistics for regression variables. Internet Appendix

est rate differential (a proxy for UIP deviation) also correlate statistically significantly with FX exposure. This relationship is positive, consistent with Proposition 1, and is observed both in the full-sample (column 2) and in the post-GFC period (column 4). In contrast, the effect of CIP deviations in the time series is not entirely consistent with Proposition 1. In column 4, more positive CIP deviations (i.e., lower hedging costs) are associated with higher unhedged USD exposure, contrary to the model prediction. This inconsistency likely arises because the supply of FX hedges by intermediaries is not perfectly elastic but upward sloping with respect to the cost of hedging. This observation motivates two additional inquiries. First, in the next subsection we examine the relationship between FX exposure and the cross-currency basis at more disaggregated levels. We find that, at the sector level where the residual supply curve is flatter than in the aggregate, the relationship is not statistically distinguishable from zero; at the firm level where the residual supply curve is likely flat, the relationship is negative, consistent with Proposition 1. Second, in Section 5, we analyze the equilibrium price effects of hedging demand in the presence of an upward-sloping supply curve.

Overall, similar to the cross-section, the joint explanatory power of mean-variance drivers increases substantially when UIP and CIP deviations are included. The increase in "Within adjusted R^2" is .11 in the whole sample (column 1 vs. column 2) and .22 in the post-GFC period (column 3 vs. column 4).

Table A4 conducts the time-series analysis, while including as a regressor the 1-year trailing return covariance, reestimated each month. Statistically, realized time variation in covariance is not a salient consideration for investors.

4.3.2 Cross-sectoral comparisons.

Cross-sectoral comparisons can further help us identify the drivers of foreign investors' hedging behavior and currency risk management decisions. A key distinction that sets mutual funds apart from insurance companies and pension funds is that mutual funds do not have fixed, contractual liabilities, as investors can redeem mutual fund shares at the prevailing net asset value (NAV). In other words, currency risk is fully passed through to mutual fund investors. In contrast, insurance companies and defined-benefit pensions often have fixed liabilities in local currency, and may also face solvency capital regulations that penalize foreign currency exposure. As a result, mutual funds are likely to be less risk averse with respect to currency mismatches between assets and liabilities, In the context of the model, higher risk aversion corresponds to lower USD exposure, translating into a higher hedge ratio for a given U.S. asset allocation and lower sensitivity to mean variance drivers, as discussed in Proposition 2.

In Table 7, we compare hedge ratios across mutual funds, insurance companies, and pension funds. Mutual funds are the omitted category across all regression specifications. Column 1 shows that insurance companies hedge significantly more than pension funds, who in turn hedge more than mutual funds. This pattern remains robust when controlling for the share of bonds in the portfolio (column 2). It also appears in both the time-series (column 3) and cross-sectional (column 4) dimensions. After controlling for both currency and time fixed effects, as well as the bond share, column 5 shows that mutual funds' hedge ratios are, on average, 30 percentage points lower than those of insurance companies and 17 percentage points lower than those of pension funds.

Next, we examine the interactions between mean-variance drivers and sector indicators: within a given currency area, does time-series variation in FX volatility, UIP violations, and CIP deviations affect unhedged USD exposure differently across investor sectors? As highlighted in Proposition 2, the mean-variance framework predicts that higher risk aversion attenuates the effects of expected return and volatility on the currency exposure. We summarize the results of our cross-sector comparisons in Table 8. Across all specifications, we control for sector fixed effects to address persistent difference, such as bond versus equity portfolio shares. We also include currency fixed effects and allow the mean-variance drivers to have currency-specific effects so as to remove heterogeneity across currency areas.

Column 1 of Table 8 shows that higher volatility reduces unhedged USD allocations by mutual funds, the omitted category, in line with Proposition 1. We do not find statistically significant difference in how insurance and pensions react to volatility. In contrast, sectoral responses to the expected FX returns, proxied by interest rate differentials in column 2, differ meaningfully across investor types. The effect is positive for mutual funds and significantly less so for pensions and insurance. This suggests that expected FX returns play an important role in shaping currency exposure, but the impact is dampened for pension and insurance investors due to their higher risk aversion, consistent with Proposition 2. Finally, the relationship between CIP deviations and unhedged exposure is not statistically different from zero, whether examined on its own (column 3) or jointly with other mean–variance drivers (column 4). This stands in contrast to the currency-area results in Table 6, where CIP deviations are positively associated with unhedged exposure. The attenuation of this positive relationship at the sector level likely reflects that the residual supply curve facing sectors within a currency area is much flatter than the aggregate supply curve accommodating the total hedging demand in that currency. Appendix Table A5 further examines the relationship at the firm level using data on Japanese insurers. The residual supply curve faced by an individual firm is plausibly close to perfectly elastic; consistent with Proposition

1, we find a strongly negative relationship at this most disaggregated level.

In summary, mutual funds, with flexible NAV-based liabilities, exhibit lower hedge ratios and greater responsiveness of unhedged USD exposure to expected FX returns, consistent with lower risk aversion. In contrast, insurance companies and pension funds, facing fixed local-currency obligations and regulatory capital requirements, hedge more extensively and are less sensitive to return-based incentives. These patterns align with the predictions of the mean-variance framework and highlight how risk preferences and institutional features jointly determine currency exposure decisions across investor types.

5 Intermediary's Supply of FX Hedging and Equilibrium Hedging Cost

To hedge their USD exposure, investors enter into FX forward or FX swap contracts with a financial intermediary. In the previous section, we considered the partial equilibrium case where investors take the hedging cost as given. In this section, we consider the equilibrium hedging cost when investors' hedging demand is met by intermediaries with constrained balance sheet capacity.

5.1 The intermediary's problem

We model the supply of FX hedges by a representative, competitive, and risk-neutral intermediary. As discussed in Fact 4 of Section 3, financial intermediaries supply FX hedges by sourcing USD funding in the cash market, which expands its balance sheet. This expansion has become costly post-GFC, as the non-risk-weighted leverage ratio under Basel III assesses capital charges based on the total size of a bank's balance sheet; see Appendix B for a detailed discussion of how FX derivatives interact with bank regulations. Thus, the intermediary requires compensation to provide FX hedges.

We assume that the competitive intermediary takes prices as given and faces a total leverage constraint. In the short term, the size of the intermediary's balance sheet, comprising H, the net notional amount of FX derivatives, and I, the amount of other investments, must not exceed a fixed total size W.[29] Furthermore, we assume that the intermediary operates with a segmented balance sheet across currency areas c:

$$
\begin{aligned}
H_c \cdot \text{sign}(H_c) + I_c &= W_c, \\
H_c &= \sum_{i \in c} (\boldsymbol{\omega_i'} - \boldsymbol{\psi_i'}) A_i \mathbf{1}, \\
\sum_c W_c &= W.
\end{aligned}
$$

Here, A_i is the portfolio size of investor i (in currency area c), $\boldsymbol{\omega_i}$ is the vector of portfolio asset weights, and $\boldsymbol{\psi_i}$ is the vector of investor's foreign currency (USD) exposures, both in portfolio shares. Hence, $(\boldsymbol{\omega_i'} - \boldsymbol{\psi_i'}) A_i \mathbf{1}$ is the amount of FX hedging sought by investor i. If the aggregate FX hedging demand in a currency area is not zero, then the intermediary clears the market by providing $H_c \neq 0$.[30]

In the data, comovement in CIP deviations across currencies is far from perfect. The first principal component of the 3-month basis in our sample explains only 46% of the total variation, and the bilateral correlation between the bases of advanced-economy currencies, such as the euro and yen, is only 51%. Such divergence implies a departure from a fric-

[29] The intermediary's balance sheet size is fixed in the short term by capital market frictions that prevent it from quickly and cheaply raising outside equity.

[30] The investors here include all customers of the intermediary, including both the institutional investors we study and model, and other customers with FX hedging needs that may offset or amplify institutional demand.

tionless environment with a single representative intermediary facing a unified balance sheet constraint across currencies, in which the basis would be equalized across currencies in both levels and changes. Our assumption of a segmented intermediary balance sheet reflects this feature and can capture frictions within large banking organizations that prevent investment opportunities from being equalized at the margin (Siriwardane, Sundaram, and Wallen 2025). For instance, trading desks in different countries may be allocated different balance sheet capacities, depending on market size or investment opportunities, and these allocations may not adjust flexibly.

Taking as given the compensation for supplying FX hedges ($-x_c$), the intermediary chooses its supply of FX hedges to maximize risk-adjusted total return subject to the balance sheet constraint:

$$\max_{H_c} -x_c H_c + f(I_c),$$
$$\text{s.t. } H_c \cdot \text{sign}(H_c) + I_c = W_c.$$

Here, $f(I)$ denotes the risk-adjusted expected excess return on the intermediary's other investments.[31] At the optimum, the intermediary chooses H_c such that $-x \cdot \text{sign}(H^*) = f'(I^*)$. This x corresponds to the cross-currency basis in practice and has the opposite sign as H, the net FX derivative position demanded by investors.[32] Note that this optimization arises because post-GFC regulations constrain banks' balance sheet size. Without such regulations, the intermediary would not require compensation for balance sheet expansion

[31] For simplicity, we abstract from other regulatory constraints such as risk-weighted capital requirement, by interpreting $f(I)$ as net of all other constraints.

[32] For instance, when non-U.S. investors demand to sell USD forward to hedge, the net derivative position demanded, H_c is positive. Because the intermediary takes the opposite position, it requires $x_c < 0$ as compensation.

and $x = 0$, in which case FX derivatives would be priced by CIP and the supply of H would be perfectly elastic.

Following Ivashina, Scharfstein, and Stein (2015), we adopt the functional form $f(I) = \delta \log(I) - I$, which reflects diminishing marginal returns and limited profitable investment opportunities. This results in:

$$-x_c = \frac{\delta \cdot \text{sign}(H_c^*)}{W_c - H_c^* \cdot \text{sign}(H_c^*)} - \text{sign}(H_c^*).$$

Because x represents compensation for using the balance sheet, it must be zero when there is no net hedging demand. This implies $\delta = W$. Thus, we have:

$$-x_c = \frac{H_c^*}{W_c - H_c^* \cdot \text{sign}(H^*)_c} = \frac{H_c^*}{I_c^*}. \tag{4}$$

From Equation (4), we see that the cross-currency basis must become more negative to induce the intermediary to supply more FX hedges in a currency. Moreover, this expression highlights that what matters to the intermediary is not the absolute volume of hedging, but how much hedging is supplied relative to the intermediary's balance sheet capacity in that currency area. Given a fixed balance sheet, supplying FX hedges comes at the cost of reducing other investments. This trade-off underpins the intermediary's optimization that leads to the supply of FX hedging increasing in the cost of hedging.

Proposition 3. *Cross-currency basis is not uniform in the cross-section. The more FX derivatives the intermediary supplies relative to its balance sheet allocated to a currency area, the larger the cross-currency basis is in absolute terms.*

Comparing Propositions 1 and 3, we can distinguish demand-side and supply-side implications. From the individual investor's perspective, an increase in the hedging cost (that is, a more negative CIP basis) reduces the demand for hedging, reflecting a movement along the individual demand curve.[33] In contrast, a currency area with stronger aggregate demand experiences an outward shift in the demand curve. Because the supply curve for currency hedging is upward sloping, due to balance sheet constraints faced by financial intermediaries, the equilibrium basis must be more negative when hedging demand increases.

5.2 Testing asset pricing implications of hedging

The intermediary's problem highlights that in the presence of constrained and segmented balance sheets, aggregate hedging demand affects both the distribution and magnitude of CIP deviations across currencies. We now empirically assess these predictions by first examining the cross-sectional relationship between aggregate hedging and cross-currency basis.

5.2.1 Hedging demand and CIP deviations in the cross-section.

To test Proposition 3, we make two assumptions. First, because institutional investors' liabilities are mostly domestic, the USD FX hedges they demand should convert USD back into their local currency, not into other currencies. Therefore, we assume that the bank-supplied USD FX hedges in a particular currency are proportional to the total amount of hedges demanded by institutional investors in that currency area. Our approach differs from using the on-balance-sheet USD mismatch of banks headquartered in a currency area to approximate USD-hedge supply in that currency (e.g., Borio et al. 2016; Borio et al. 2018). This alternative approach assumes that the net supply of FX hedges in a currency comes only from banks headquartered in that area. In contrast, we do not take a stance on which

[33] In Appendix D, we solve the full model and show that Propositions 1 and 2 continue to hold in equilibrium when the hedging supply curve is upward sloping.

bank meets the FX hedging demand in a particular currency, recognizing that many banks operate deposit-taking branches outside their home jurisdictions.

Second, we assume that the intermediary segments its balance sheet in proportion to GDP, as GDP is often correlated with the depth of financial markets and the availability of investment opportunities. We collect trading asset data by geography for two large global banks, Citi and JP Morgan, and confirm in Appendix Table A6 that banks' trading asset allocations are strongly correlated with GDP across countries.

Figure 8 demonstrates a striking linear relationship between the time-series average of the 3M cross-currency basis and the GDP-normalized total hedging volume of insurance companies, pension funds, and mutual funds in each currency area. Currency areas with higher normalized hedging volume exhibit more negative CIP deviations. In the cross-section, this relationship has an R^2 of .73. Importantly, it holds across both advanced and emerging economies.

This cross-sectional result is robust along several dimensions. First, the finding is not driven by the choice of normalization. Another proxy for how banks segment their balance sheets across currencies is FX turnover. In Appendix Figure A4, we measure FX turnover using currency-specific trading volume from the BIS Triennial Survey. We show that the cross-sectional relationship between CIP deviations and hedging volume when normalized by FX turnover instead of GDP is, if anything, stronger.

Second, our use of foreign institutional investors' hedging as a proxy for the currency-specific hedging services provided by banks is empirically defensible. In Appendix Figure A5, we show that when bank-provided hedging is approximated using on-balance-sheet USD funding gaps, the cross-sectional relationship between hedging and the cross-currency basis is nearly zero.

One limitation of our measure is that it does not capture hedging by all investors. In particular, U.S. investors also hedge their foreign currency exposures abroad (Sialm and Zhu 2024), which in effect reduces the aggregate demand for USD hedges from foreign investors. However, as shown in Appendix Figure A6, including U.S. investor hedging reduces the overall volume but does not alter the cross-sectional ranking of foreign hedging demand.

5.2.2 GIV and hedging in the time series.

Having established that intermediaries' supply of FX hedges is upward sloping, we next aim to identify the effect of hedging demand on hedging costs by isolating exogenous variation in the hedging demand. We appeal to granular instrumental variables and focus on Japanese insurers for several reasons. First, these insurers engage in considerably more hedging than other entities in Japan, such as pension funds and mutual funds, making their aggregate hedging plausibly large enough to move market prices. Second, Japanese insurers have substantial foreign investments in both USD and EUR, enabling two sets of tests to ensure that findings are not driven by idiosyncrasies in a single currency. Finally, we are able to gather firm-level panel data on all insurers in Japan, which allows for a granular instrumental variable (GIV) approach to establish causality.

We construct an instrument for total FX hedging by Japanese insurers following the approach of Gabaix and Koijen (2024). In essence, we argue that idiosyncratic shocks to the large insurers affect CIP deviations only through their effect on the sector-wide hedging volume. We extract these idiosyncratic shocks in two steps, treating USD and EUR hedging separately throughout. First, in columns 1 and 2 of Table 9, we regress firms' hedging volumes on time fixed effects to remove any common shocks across insurers. Next, in Columns 3 and 4, we regress the residuals from columns 1 and 2 on key variables that could systematically affect a firm's hedging behavior.

To isolate firm-specific variation, we control for both regulatory and portfolio factors. Two regulatory measures plausibly influence an insurer's risk tolerance. The first such measure is the "Reserve for Price Fluctuation," a statutory reserve that Japanese insurers are required to accumulate to absorb losses on risky investments, such as equities and foreign securities. A larger reserve implies greater capacity to withstand temporary valuation changes and, likely, lower risk aversion. Crucially, the accumulation of the reserve depends on the insurer's overall profit, which is affected by sales, redemption, and many other factors, so it is not mechanically linked to insurers' unhedged USD exposure.

The second measure is the "Solvency Margin Ratio," which reflects an insurer's capital buffer relative to total risk. A higher ratio typically implies better risk tolerance and lower effective risk aversion. The ratio itself is shaped by net assets, earnings, various reserves, and multiple risk exposures. In Appendix Table A5, we confirm that both regulatory measures interact with expected FX returns in ways that systematically affect firms' currency exposures. We moreover include the share of portfolio invested in bonds ("Portfolio Share in Bonds"), as investors tend to hedge bonds more than equities; see also Fact 3 in Section 3. We interpret the residuals from columns 3 and 4 as firm-level idiosyncratic shocks to FX hedging over time.

Finally, we weight each firm's idiosyncratic shock by its market share, measured as the proportion of the sector's total foreign portfolio it holds. This yields a granular instrument for the time series of aggregate USD and EUR hedging by Japanese insurers.

Our GIV proves to be a relevant instrument for sector-wide USD and EUR hedging. In columns 5 and 6, the first-stage F-statistics exceed the rule-of-thumb threshold of 10, alleviating concerns about weak instrument. Using this GIV, we estimate that a \$1 billion increase in USD-JPY hedging supplied by intermediaries widens the 3M cross-currency basis to widen by 0.3 bps (column 7), while a €1 billion increase in EUR-JPY hedging widens the basis by 0.5 bps (column 8). For both USD and EUR, increased JPY hedging demand causally widens the respective cross-currency basis.

We caution that the GIV strategy would be invalid if the residual "idiosyncratic" shocks still contained forces that jointly affect hedging quantities and prices. For example, a supply shock that survives the time fixed effects could simultaneously move price and quantity but would not help identify how price responds to changes in demand. For this reason, it is useful to consider the likely direction of bias. In the OLS specification, the coefficient would be positive if the predominant residual shocks reflect supply rather than demand, as investors tend to hedge more when the cross-currency basis is more positive and the cost of hedging is lower. By contrast, our IV estimate is statistically significantly negative. This pattern suggests that, while the instrument is not perfect, it does mitigate at least some of the confounding variation that biases the OLS estimate.

6 Conclusion

In this study, we collect and analyze a vast array of sector statistics and company filings to examine foreign investors' USD-denominated security holdings and hedging strategies. Our findings reveal a sixfold increase in foreign investors' USD holdings, largely driven by growing portfolio allocations to USD assets. We also demonstrate that, in the post-GFC period, investors hedge a significant portion of their USD exposure despite large CIP deviations, incurring substantial financial costs. We further uncover significant cross-currency and cross-sector heterogeneity in the hedging practices of foreign institutional investors, and we highlight the important role of global banks in providing USD FX hedges in aggregate.

Employing a mean-variance framework, we derive the relationship between optimal currency exposure and its key drivers: the volatility of USD FX returns, the covariance between USD FX and U.S. asset returns, and, importantly, the FX returns driven by deviations from UIP and CIP. Our results underscore the empirical importance of expected FX returns in shaping investors' FX management. Finally, we document a strong relationship between the cross-section of hedging demand and the cross-currency basis, highlighting the role of constrained financial intermediaries in currency hedging markets.

Our findings provide the first comprehensive empirical investigation into foreign investors' USD asset holdings and hedging practices. The rising hedge ratios among foreign investors emphasize the distinction between demand for U.S. assets and demand for the U.S. dollar itself. This shift in perspective opens new avenues for research on the drivers of international investment flows and the strategic management of currency risk. While our empirical results rely on a recent historical sample, looking ahead, the uncertain trajectory of global demand for USD assets amid tariff wars, geopolitical tensions, and shifts in macroeconomic and fiscal policies makes our analysis especially timely and relevant.

Code and Data Availability: The replication code and data are available in the Harvard Dataverse at https://doi.org/10.7910/DVN/4EQSFK.

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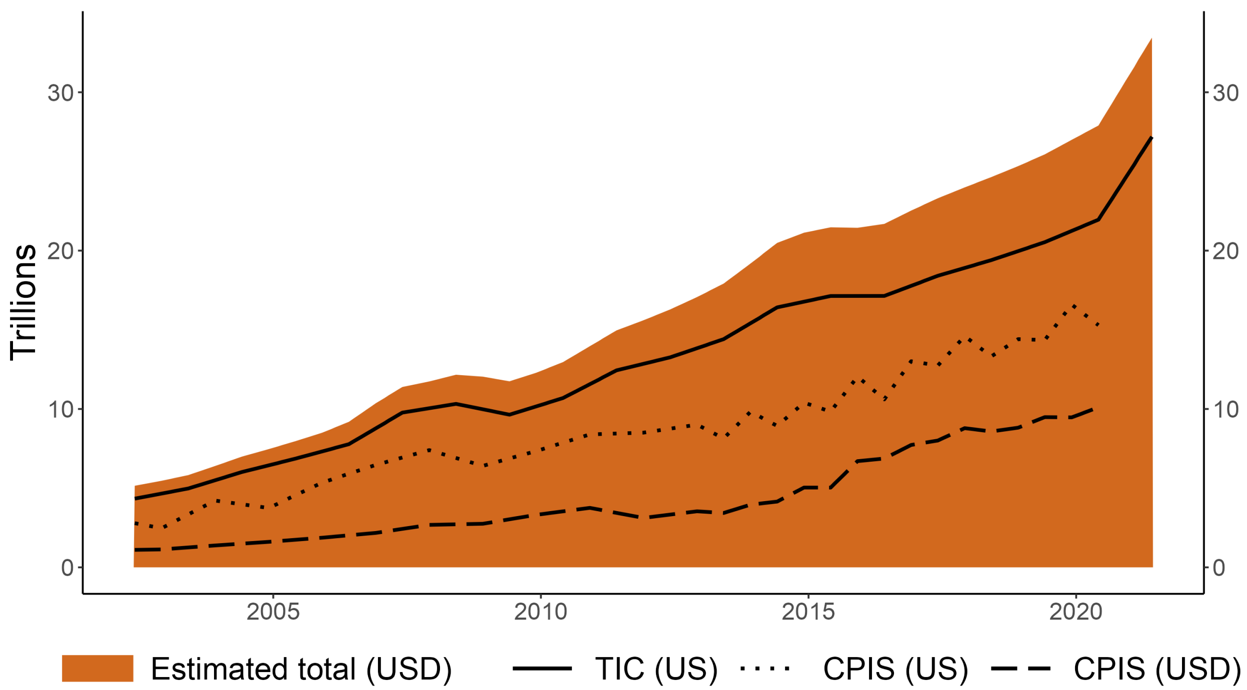
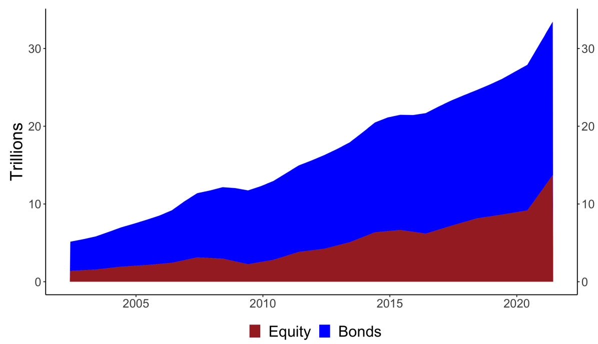
Figures and Tables

Figure 1: **Foreign holdings of U.S. or USD securities**

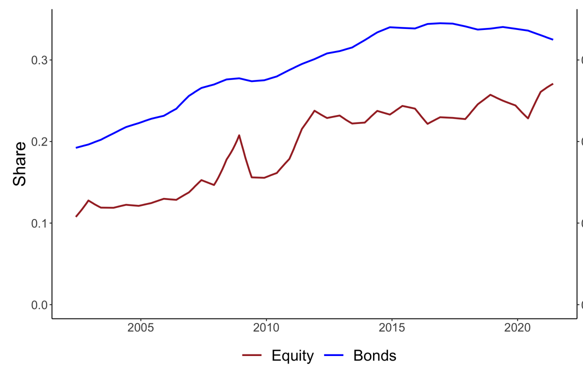


This figure plots different estimates of foreign holdings of US or USD securities. Orange shading represents our estimate of total USD holdings, which builds on the TIC estimate but adjusts for foreign-issued USD securities and U.S.-issued non-USD securities. The solid line represents the TIC estimate of foreign holdings of securities issued by U.S. residents. The dotted line represents the CPIS estimate of foreign holdings of securities issued by U.S. residents. The dashed line represents the CPIS estimate of foreign holdings of USD securities. The sample period is June 2002 to June 2021.

Figure 2: **Foreign USD holdings by security type**



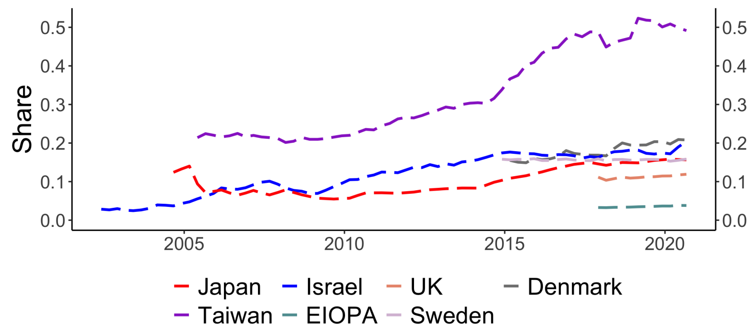
(a) **Volume**



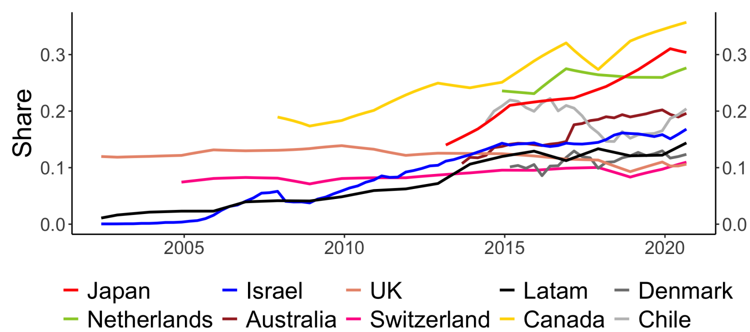
(b) **Share of total outstanding**

This figure plots estimated foreign-held USD securities by type. Panel A is volume of securities. Panel B is the share of total USD bonds and USD equity held by foreign investors. Total USD bond holdings are estimated as outstanding U.S. fixed income securities adjusted for foreign-issued USD bonds. Total USD equity is estimated as the sum of U.S. public market capitalization and AUM of U.S. private equity funds. The sample period is June 2002 to June 2021.

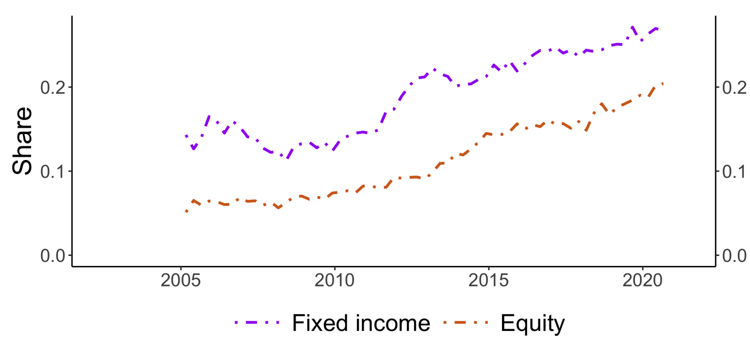
Figure 3: **Portfolio allocation to USD securities across sectors**



(a) **Insurance companies**



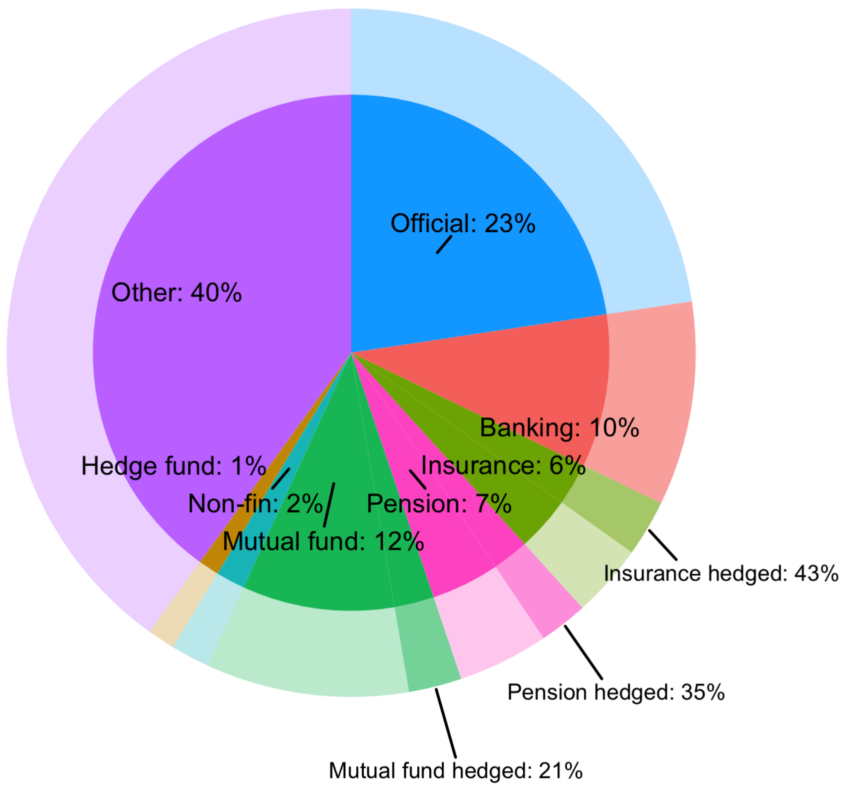
(b) **Pension funds**



(c) **Mutual funds**

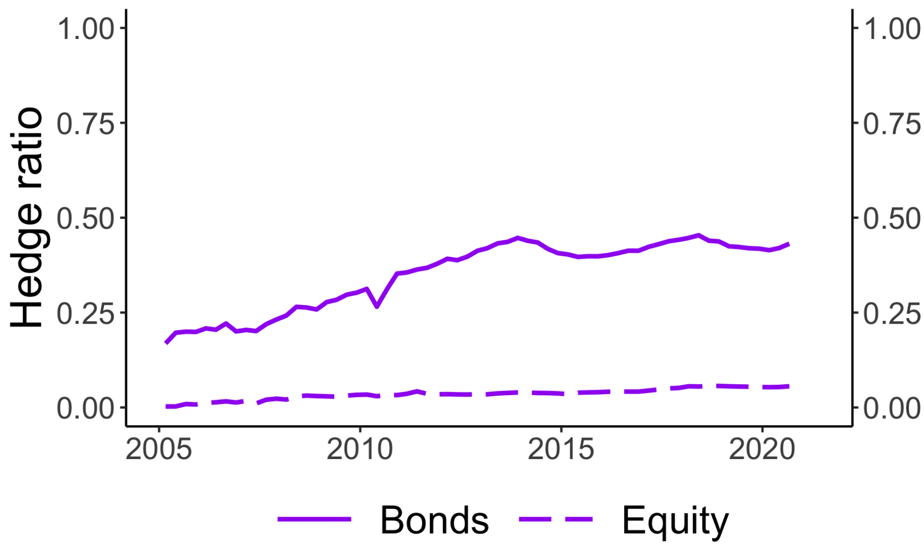
This figure plots foreign investors' portfolio allocation to USD securities. Allocation is estimated as the ratio of USD securities to total assets. See Table 1 for sample period coverage of different series. Each country is plotted in the same color across different panels. See Section 2.1.2 and Appendix A.1 for estimation methodologies.

Figure 4: **Foreign holdings of USD securities by sector and hedging status, June 2020**

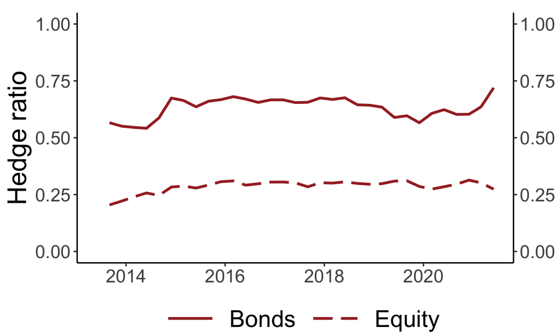


This figure illustrates foreign investors' USD holdings and hedging, by sector, as of June 2020. Each slice of the inner pie corresponds to sector holdings as a percentage of the total amount of USD securities held by foreign investors. Shading on the outer ring corresponds to hedging status, with darker shades indicating the percentage hedged, and lighter shades indicating the complement.

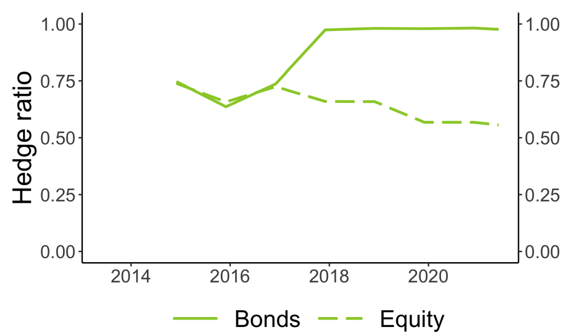
Figure 5: **USD hedging in bonds versus equities**



(a) **Mutual funds**



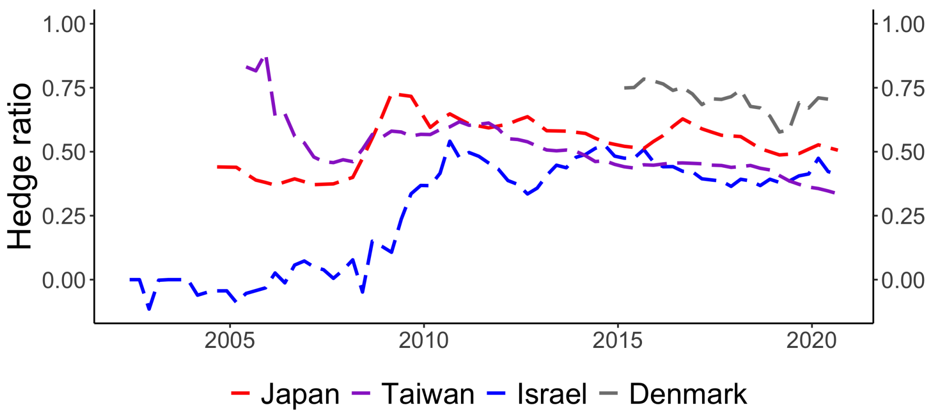
(b) **Australian pensions**



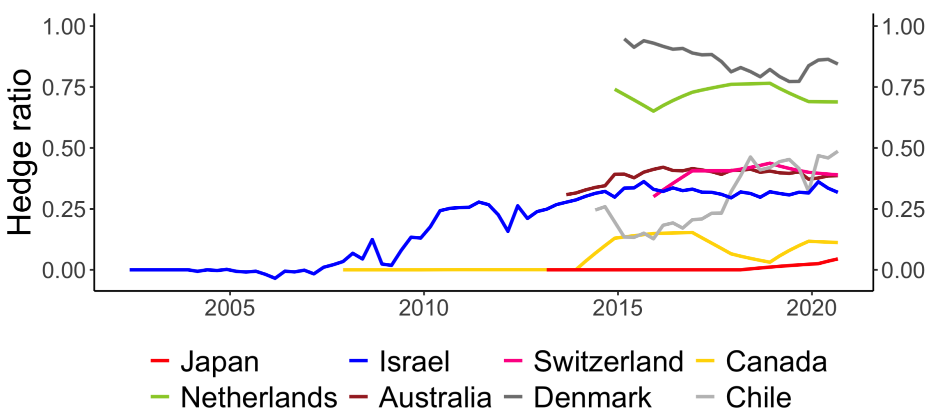
(c) **Dutch pensions**

This figure plots hedge ratios for USD bonds versus equities in mutual funds, Australian pensions, and Dutch pensions. See Section 2.1.2 and Appendix A.1 for estimation methodologies.

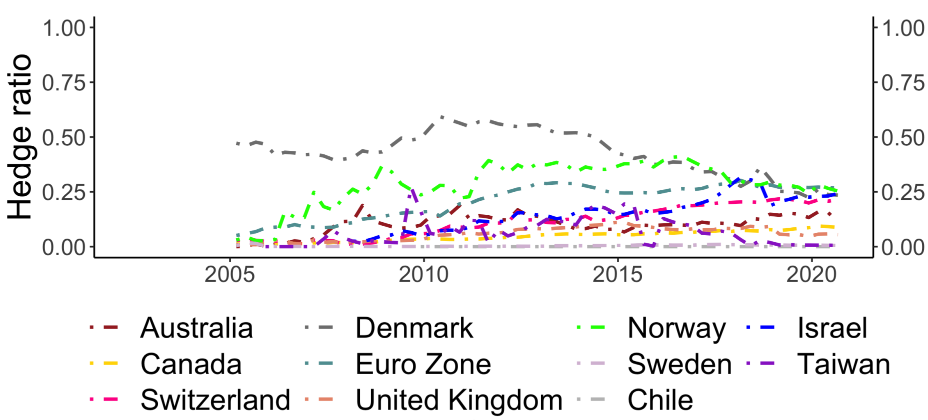
Figure 6: **USD hedging across sectors**



(a) **Insurance companies**



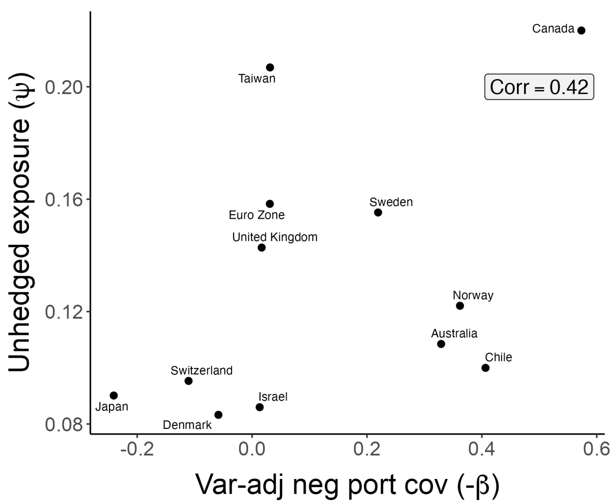
(b) **Pension funds**



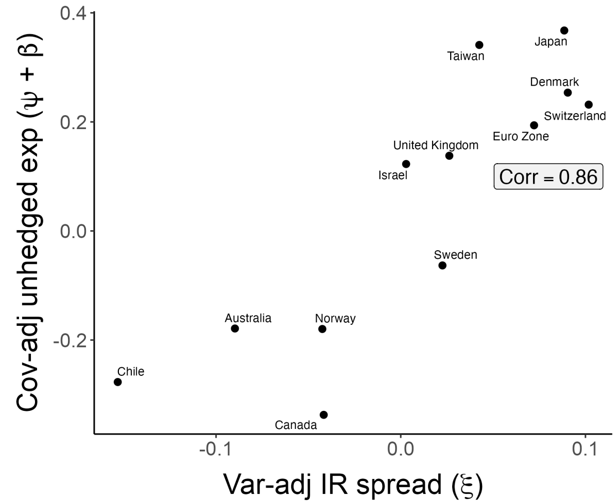
(c) **Mutual funds**

This figure plots the USD hedge ratio of different countries in the insurance companies, pension funds, and mutual fund sectors. Each country is plotted in the same color across different panels. See Section 2.1.2 and Appendix A.1 for estimation methodologies.

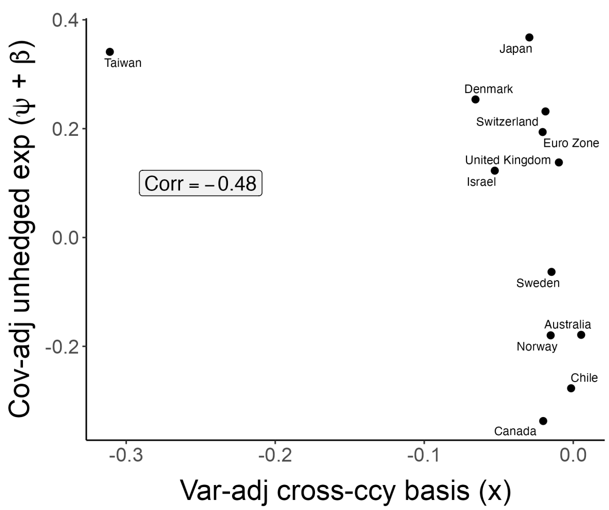
Figure 7: **Mean-variance drivers of USD exposure**



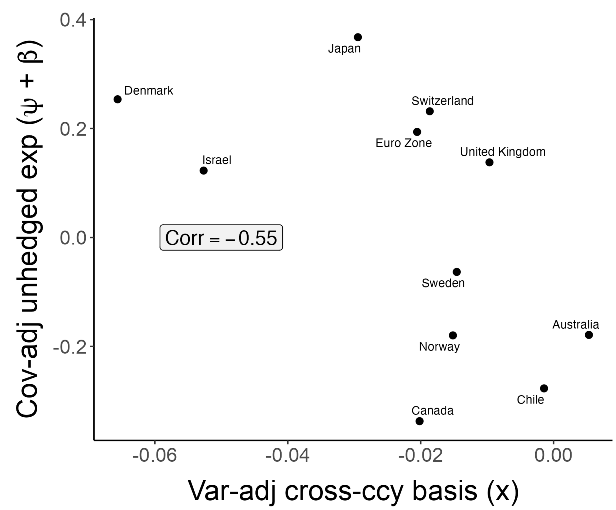
(a) **Return covariance** (β)



(b) **UIP deviation** (ξ)



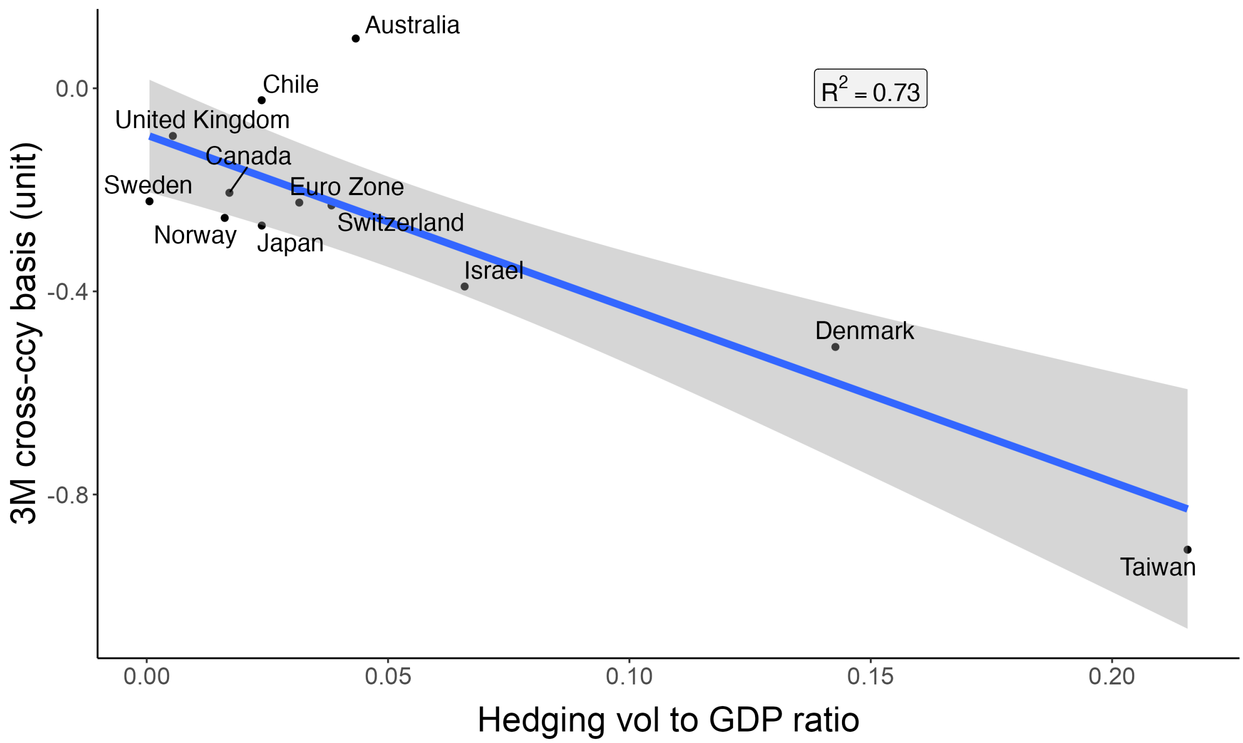
(c) **CIP deviation** (x)



(d) **CIP dev.** (x) **no TWD**

This figure plots the unhedged USD exposure, measured as shares of the portfolio, against three mean-variance drivers of the optimal FX exposure. Each observation reflects the post-GFC time-series average. The portfolio for a currency area is constructed as the weighted-average portfolio of insurance companies, pension funds, and mutual funds in that currency area. "Var-adj neg port cov" is the negative covariance between FX return and portfolio asset return, divided by the variance of FX return. "Var-adj IR spread" is the U.S.-local 3M IBOR spread, divided by the variance of FX return. "Var-adj cross-ccy basis" is the U.S.-local 3M IBOR cross-currency basis, divided by the variance of FX return. Estimation period is September 2010 through September 2020.

Figure 8: **Cross-section of hedging and cross-currency basis**



This figure plots each currency's time-series average of 3M IBOR cross-currency basis against their time-series average of hedging volume to GDP ratio. Hedging volume is the estimated from USD FX hedging of insurance companies, pension funds, and mutual funds. Sample period is July 2010 to September 2020.

Table 1: **Summary of coverage and sources**

Sector	Region / Country	Firm filings	Sector or national statistics providers	Start	End	Hedging info start
Insurance	Asia: Japan	11		2004	2020	2004
	Asia: Taiwan	6	Central Bank of the Republic of China	2005	2021	2005
	Europe: Denmark		Danmarks Nationalbank	2015	2021	2015
	Europe: Sweden		Sveriges Riksbank	2014	2021	2019
	Europe: U.K.		EIOPA	2017	2020	2017
	Europe: 19 Euro countries		EIOPA SHS	2017 2013	2021 2017	– –
	Europe: 9 other EU countries		EIOPA	2017	2021	–
	ROW: Israel		Bank of Israel	2002	2021	2002
Pensions	Asia: Japan	1		2013	2021	2013
	Asia: Australia		APRA, Australian Bureau of Statistics	2004	2021	2013
	Europe: Netherlands	2		2014	2021	2014
	Europe: Denmark		Danmarks Nationalbank	2015	2021	2015
	Europe: Sweden		Sveriges Riksbank	2014	2021	2019
	Europe: Switzerland		Federal Statistical Office	2004	2020	2015
	Europe: U.K.		Office for National Statistics	2002	2021	–
	NA: Canada	2		2007	2021	2010
	ROW: Israel		Bank of Israel	2002	2021	2002
	ROW: Chile		Superintendencia de Pensiones	2014	2023	2014
	ROW: 9 Latam countries		FIAP	2002	2021	–
Mutual funds	64 countries		Morningstar	2002	2021	2002
Banking	48 countries		BIS Locational Banking Statistics	2002	2021	–
Hedge funds	53 countries		13F, FactSet	2002	2021	–
Nonfinancial	56 countries		CPIS	2002	2020	–
Official sector	237 countries and jurisdictions		TIC	2002	2021	–

This table reports the data sources used to construct sector-specific USD holdings and hedging. "Company filings" records the number of companies from whom filings are obtained. Within "Sector or national statistics providers", EIOPA is the European Insurance and Occupational Pensions Authority, APRA is the Australian Prudential Regulation Authority, and FIAP is Federación Internacional de Administradoras de Fondos de Pensiones. "Start" and "End" refer to the first and the last years of availability for each source. "Hedging info start" is the start year of hedging information.

Table 2: **USD asset allocations in the time series**

	Share: USD in overall		Share: USD in foreign	
	(1)	(2)	(3)	(4)
Indicator: Crisis	0.69**		2.8*	
	(0.31)		(1.4)	
Indicator: Postcrisis	7.7***		6.6***	
	(0.85)		(1.1)	
Counter by quarter		0.23***		0.18***
		(0.01)		(0.02)
Currency X Sector	Yes	Yes	Yes	Yes
Observations	1,449	1,449	1,082	1,082
R^2	.78	.84	.69	.70
Within adjusted R^2	.34	.53	.03	.06

This table examines time-series patterns in portfolio allocation to USD securities. *Share: USD in overall* is the share of USD securities in investors' overall portfolio, stated in percentage points. *Share: USD in foreign* is the share of USD securities in investors' foreign portfolio, stated in percentage points. Foreign portfolio comprises all nonlocal investments. *Counter by quarter* is a counter that increases linearly for each passing quarter. Estimation period is June 2002 through September 2020, and observations are sector-currency-quarter, where the sectors include insurance companies, pension funds, and mutual funds. Standard errors are calculated using Driscoll and Kraay (1998). *$p < .1$; **$p < .05$; ***$p < .01$.

Table 3: **USD hedging and currency exposure in the time series**

	USD hedge ratio		USD ccy exposure	
	(1)	(2)	(3)	(4)
Indicator: Crisis	5.2***	7.9***	1.2**	0.72**
	(1.6)	(2.3)	(0.51)	(0.28)
Indicator: Postcrisis	15.7***	14.7***	5.8***	6.7***
	(1.5)	(1.7)	(0.78)	(0.94)
Currency X Sector	No	Yes	No	Yes
Observations	1,209	1,209	1,209	1,209
R^2	.07	.86	.10	.68
Within adjusted R^2		.23		.28

This table examines time-series patterns in hedging. *USD hedge ratio* is the ratio of the amount of USD securities with currency exposure hedged to the amount of all USD security holdings. *USD ccy exposure* is the share of the portfolio invested in USD securities and not hedged. Estimation period is June 2002 through September 2020, and observations are sector-currency-quarter, where the sectors include insurance companies, pension funds, and mutual funds. Standard errors are calculated using Driscoll and Kraay (1998). *$p < .1$; **$p < .05$; ***$p < .01$.

Table 4: **Foreign holdings and hedging of USD securities, December 2019**

Currency area	Active sectors holdings	Active sectors hedging	Hedge ratio (%)	Bank hedging	Total hedging
Australia	368	114	31	-183	-69
Canada	670	65	10	143	208
Chile	38	11	30	-5	6
Denmark	157	90	57	-20	69
Euro zone	2,734	911	33	-147	764
Israel	97	35	36	–	35
Japan	724	172	24	305	477
Norway	35	9	24	-19	-10
Sweden	217	85	39	32	117
Switzerland	197	60	30	31	90
Taiwan	539	178	33	-60	119
United Kingdom	979	241	25	-166	75
United States	–	–	–	-244	-244
Total	6,755	1,971	29	-333	1,638

This table reports foreign holdings and hedging of USD securities by country as of December 2019. *Active sectors holdings* and *Active sectors hedging* are our estimates of holdings and hedging of USD securities by insurance companies, pension funds, and mutual funds. *USD hedge ratio* is the share of *Active sectors holdings* that is FX hedged. *Bank hedging* is the implied hedging demand (supply, if negative) by banks headquartered in Canada, Switzerland, eurozone, the United Kingdom, and the United States, and by banks located in each of the other currency areas. *Total hedging* is the sum of *Active sectors hedging* and *Bank hedging*.

Table 5: **Mean-variance drivers of USD exposure in the cross-section**

	Unhedged USD allocation			
	Sample		Post-GFC	
	(1)	(2)	(3)	(4)
Var-adj neg port covariance ($-\beta$)	0.06***	0.09***	0.07***	0.13***
	[0.04, 0.08]	[0.07, 0.11]	[0.04, 0.10]	[0.08, 0.16]
Var-adj US-local 3M IBOR spread (ξ)		0.07***		0.17***
		[0.03, 0.09]		[0.06, 0.22]
Var-adj cross-ccy basis (x)		-0.19***		-0.22***
		[-0.26, -0.12]		[-0.31, -0.13]
Time FE	Yes	Yes	Yes	Yes
Observations	740	649	492	492
R^2	.39	.46	.29	.45
Within adjusted R^2	.09	.23	.10	.30

This table examines the mean-variance drivers of the optimal FX exposure in the cross-section. Observations are by currency and quarter. *Var-adj neg port cov* is the negative covariance between FX return and portfolio asset return, divided by the variance of FX return. *Var-adj IR spread* is the U.S. local 3M IBOR spread, divided by the variance of FX return. *Var-adj cross-ccy basis* is the U.S. local 3M IBOR cross-currency basis, divided by the variance of FX return. Estimation period is July 2002 through September 2020 for the whole sample and July 2010 through September 2020 for post-GFC. The 95% confidence intervals are calculated using block bootstrap by time to preserve the panel structure and allow for serial correlation. ***$p < .01$.

Table 6: **Mean-variance drivers of USD exposure in the time series**

	Unhedged USD allocation			
	Sample		Post-GFC	
	(1)	(2)	(3)	(4)
Option-implied FX vol	-0.003***	-0.003***	-0.004**	0.0010
	(0.0010)	(0.0007)	(0.002)	(0.001)
US-local 3M IBOR spread		0.006**		0.01***
		(0.002)		(0.002)
3M cross-ccy basis		0.01		0.04***
		(0.01)		(0.01)
Currency FE	Yes	Yes	Yes	Yes
Observations	749	649	492	492
R^2	.47	.54	.60	.70
Within adjusted R^2	.05	.14	.04	.26

This table examines the mean-variance drivers of the optimal FX exposure in the time series. Observations are by currency and quarter. *Option-implied FX vol* is from 3M at-the-money options. *US-local 3M IBOR spread* is calculated as US 3M IBOR less local 3M IBOR. *3M cross-ccy basis* is calculated using IBOR in the log version of Equation (2.2). Estimation period is July 2002 through September 2020 for the whole sample and July 2010 through September 2020 for post-GFC. Standard errors are calculated using Driscoll and Kraay (1998). *$p < .1$; **$p < .05$; ***$p < .01$.

Table 7: **USD hedging across sectors**

	USD hedge ratio				
	(1)	(2)	(3)	(4)	(5)
Insurance	0.31***	0.28***	0.29***	0.28***	0.30***
	(0.02)	(0.03)	(0.01)	(0.02)	(0.01)
Pensions	0.14***	0.14***	0.19***	0.12***	0.17***
	(0.03)	(0.03)	(0.01)	(0.03)	(0.02)
Portfolio share in bonds		0.07*	0.24***	0.12***	0.27***
		(0.04)	(0.03)	(0.03)	(0.03)
Currency FE	No	No	Yes	No	Yes
Time FE	No	No	No	Yes	Yes
Observations	1,209	1,209	1,209	1,209	1,209
R^2	.27	.28	.67	.40	.74
Within adjusted R^2			.43	.33	.49

This table compares hedging behaviors across sectors. *USD hedge ratio* is the ratio of the amount of USD securities with currency exposure hedged to the amount of all USD security holdings. Estimation period is June 2002 through September 2020, and observations are sector-currency-quarter, where the sectors include insurance companies, pension funds, and mutual funds. Mutual funds are the omitted sector. Standard errors are calculated using Driscoll and Kraay (1998). $^{*}p < .1$; $^{**}p < .05$; $^{***}p < .01$.

Table 8: **Cross-sector comparison of MV drivers**

	Unhedged USD allocation			
	(1)	(2)	(3)	(4)
Option-implied FX vol	-0.004**			-0.003*
	(0.002)			(0.001)
Option-implied FX vol × Insurance	-0.004			-0.006*
	(0.003)			(0.004)
Option-implied FX vol × Pensions	0.003			-0.001
	(0.002)			(0.002)
US-local 3M IBOR spread		0.01**		0.01***
		(0.004)		(0.004)
US-local 3M IBOR spread × Insurance		-0.02***		-0.02***
		(0.004)		(0.005)
US-local 3M IBOR spread × Pensions		-0.01***		-0.02***
		(0.003)		(0.003)
3M cross-ccy basis			0.01	-0.01
			(0.01)	(0.01)
3M cross-ccy basis × Insurance			-0.05***	-0.02
			(0.01)	(0.02)
3M cross-ccy basis × Pensions			-0.0001	-0.01
			(0.01)	(0.01)
Sector FE	Yes	Yes	Yes	Yes
Currency FE	Yes	Yes	Yes	Yes
Ccy-specific sensitivity to FX vol	Yes	No	No	Yes
Ccy-specific sensitivity to IBOR spread	No	Yes	No	Yes
Ccy-specific sensitivity to cross-ccy basis	No	No	Yes	Yes
Observations	1,209	1,206	1,084	1,084
R^2	.36	.38	.37	.45

This table examines the cross-sector response to time-series variation in mean-variance drivers of the optimal FX exposure across sectors. Observations are by currency-sector-quarter, where sectors included are insurance companies, pension funds, and mutual funds. *Option-implied FX vol* is from 3M at-the-money options. *US-local 3M IBOR spread* is calculated as US 3M IBOR less local 3M IBOR. *3M cross-ccy basis* is calculated using IBOR in the log version of Equation (2.2). Estimation period is July 2002 through September 2020. Standard errors are calculated using Driscoll and Kraay (1998). $^*p < .1$; $^{**}p < .05$; $^{***}p < .01$.

Table 9: **Hedging's effect on cross-currency basis**

	Firm hedging		Firm residual Idio. shock		Total hedging 1st stage		3M cross-ccy basis IV	
	USD (1)	EUR (2)	USD (3)	EUR (4)	USD (5)	EUR (6)	USD (7)	EUR (8)
Reserve for fluctuation			188.5***	67.9*				
			(61.8)	(36.6)				
Solvency margin ratio			-1.0***	-0.45***				
			(0.13)	(0.08)				
Portfolio share in bonds			-29.8***	-6.7*				
			(6.0)	(3.6)				
GIV					9.7***	7.8***		
					(2.6)	(1.5)		
Total hedging							-0.003***	-0.005**
							(0.0009)	(0.002)
Time FE	Yes	Yes	No	No	No	No	No	No
F-stat:					13.8	26.5		
Observations	333	322	248	241	28	28	28	28
R^2	.14	.09	.25	.14	.35	.50	.29	.14

This table examines the effect of hedging on cross-currency basis using granular instrumental variables (GIV). The GIV is constructed from Japanese insurers' firm-level USD hedging, residualized after taking out time FE and the effect of *Reserve for fluctuation*, *Solvency margin ratio*, and *Portfolio share in bonds*, and weighted by each firm's total foreign investment. This GIV is used to instrument total hedging done by Japanese insurers, measured in $ billions. *3M cross-ccy basis* is calculated using IBOR in the log version of Equation (2.2). Estimation period is July 2002 through September 2020. *$p<.1$; **$p<.05$; ***$p<.01$.

Appendix

A Details of Data Construction

A.1 Overall Foreign Holdings of USD Securities

We first estimate foreign holdings of USD securities issued by U.S. entities. We obtain data on "TIC Foreign Holding of U.S. Securities" directly from the TIC system, specifically from annual reports on *Foreign Residents' Portfolio Holdings of U.S. Securities*, beginning in June 2002 and ending in June 2021. These reports detail non-U.S. residents' holdings of securities issued by U.S. entities, separately reported for equities and bonds. Because U.S. residents may issue non-USD-denominated securities, we estimate "TIC Foreign Holdings of Non-USD Securities" using TIC's reporting on non-USD debt held by foreign investors.

Next, we estimate foreign holdings of USD securities issued by non-U.S. residents. To do so, we first calculate "USD Securities Outstanding Outside the United States" from the international debt securities statistics published by the Bank for International Settlements (BIS). We then subtract the amount of foreign-issued USD assets held by U.S. residents, referred to as "U.S. Investors' Cross-border USD Holdings." TIC's *U.S. Residents' Portfolio Holdings of Foreign Securities* provides the currency breakdown of U.S. residents' foreign holdings by country, with annual data starting in 2007. From this, we find that U.S. residents primarily hold USD-denominated debt abroad, with country-level averages fluctuating between 72% and 79%. For the period from 2002 to 2007, we estimate the share of U.S.-held foreign-issued USD debt as the average between 2007 and 2021.

A.2 Sector-specific USD Securities Holdings and Hedging

A.2.1 Foreign insurance companies' holdings and hedging

In Japan, we hand-collect quarterly filings since 2004 from all 25 active domestic companies and 12 foreign-controlled companies. The largest 11 Japanese insurance companies break out their portfolio holdings by currency. For these companies, we record total assets, investments in USD and other foreign currencies, and investments in foreign equity and foreign debt. We use the equity-to-debt split in foreign investments to infer Japanese insurers' risk-return preferences, and we estimate the amount of USD equity and debt by multiply the share of USD in their foreign investment portfolios with total foreign equity or total foreign debt. Japanese insurers' hedging practices are estimated directly from company-level filings on FX derivatives positions, available semiannually. Because we are interested in managing long USD positions, we estimate the total USD hedge as the sum of net forward USD sales positions and USD swaps.[34] The net forward position is calculated as the notional differ-

[34] This contrasts with Liao and Zhang (2025), who estimate USD hedging based on all FX derivatives and total foreign investments.

ence between USD forward sold and USD forward bought, excluding small positions in FX options.

In Taiwan, the Central Bank of the Republic of China publishes the *Financial Statistics Monthly*, which details life insurers' total assets and foreign investments. We locate physical copies of these reports dating back to 2005 to form a monthly series of aggregate investments. To further understand the share of USD in foreign investments and the debt-to-equity split, we hand-collect detailed information from the annual reports of six of the largest Taiwanese life insurers. The Central Bank's monthly reports also provide information on the aggregate FX hedging undertaken by life insurers in the footnotes to Appendix Table 8.

We leverage quarterly filings made by all insurers to the European Insurance and Occupational Pensions Authority (EIOPA) to study portfolio allocations in the European Economic Area (EEA). The sample includes 31 countries, covering 19 in the eurozone, 11 others in the EEA, and the United Kingdom. We estimate European insurers' USD holdings as investments in bonds and equities issued by U.S. entities. Our estimates of European insurers' USD bond holdings may be conservative due to USD bonds issued by non-U.S. residents. EIOPA data collection started in 2017. For the period between 3Q2013 and 4Q2017, we use ECB's Securities Holdings Statistics (SHS) to estimate holdings by insurers in the 19 eurozone countries. As with EIOPA data, our estimates from SHS are conservatively based on investments in U.S. issuers' securities. SHS includes reporting from both insurers and pensions; we subtract pensions' holdings from our SHS estimates to focus on insurers' holdings in the eurozone (e.g., the Netherlands).

In Denmark, instead of EIOPA, we use the monthly reporting by Danmarks Nationalbank, which tracks Danish insurers' investments by currency and security type. These reports also outline total FX exposure and hedging by currency. For Swedish insurers, we use the Sveriges Riksbank's semiannual Financial Stability Report, which provides historical quarterly investment data for insurance companies. Life insurers have the longest series, from 2014 through 2022, while nonlife and unit-linked insurance products have data through 2019. Using the ratio of life to nonlife insurers before 2019, we impute the size of nonlife insurers after 2019. We use the debt-to-equity split in the overall portfolio to infer the security type split of the foreign portfolio. Hedging information for Swedish life insurers is available starting in 2019.

For Israel, we use data from the Bank of Israel's *Institutional Investors' Exposure to Foreign Exchange*, which provides monthly statistics from 2002 onward, covering foreign investments made by Israeli insurers and pension funds. We estimate Israeli insurers' USD investments based on their total foreign investment portfolios and the typical share of USD in Israeli institutional investors' FX market activities.[35] We estimate the breakdown between USD equity and bonds using asset allocations in Israeli insurers' overall portfolios, which are

[35] Ben Zeev and Nathan (2024) find that 85.9% of Israeli institutional investors' FX swap flow volume and 87.8% of FX spot volume is in dollars. Institutional investors include insurers and pension funds.

available from the Bank of Israel's *Assets Portfolio of the Institutional Investors by Securities*. The *Institutional Investors' Foreign Exchange Exposure* publication shows insurers' portfolio FX exposure before and after hedging. We use these data to estimate Israeli insurers' hedge ratios.

A.2.2 Foreign Pension Funds' Holdings and Hedging

We study the Japanese Government Pension Investment Fund (GPIF), which manages 72% of Japan's public pensions and whose size is equivalent of 76% of private retirement assets (ICI (2021)). GPIF is almost exclusively invested through external managers targeting specific benchmarks. For instance, in the fiscal year ending March 2021, GPIF invested in Fund VI, managed by BlackRock Japan Co., to track the FTSE U.S. Government Bond Index (USGOV). We analyze GPIF's investments manager by manager and estimate GPIF's USD investments based on allocations to U.S. bond or equity benchmarks. Similarly, we estimate GPIF's FX hedging activities by tracking allocations to hedged benchmarks, such as "FTSE US Government Bond Index (JPY hedged/JPY basis)," versus nonhedged benchmarks, such as "FTSE US Government Bond Index (no hedge/JPY basis)."

The pension industry in the Netherlands is highly concentrated, with the two largest funds, ABP and PFZW, managing assets equivalent to 1.5 times those of the next 15 largest funds combined.[36] Together, the two funds have 50% of total assets across all Dutch pension funds.[37] From ABP's and PFZW's annual reports, we gather data on total assets, USD investments, and the split between USD equities and USD bonds. Both funds disclose their unhedged (or net) USD exposure after factoring in FX derivatives. We estimate their hedging activity as the difference between total and unhedged USD exposure, separately for bonds and equities.

Canada's two largest pension funds, the Canada Pension Plan Investment Board (CPP) and Caisse de dépôt et placement du Québec (CDPQ), account for 45% of the assets under management (AUM) of the top eight public pension funds in Canada, which together represent two-thirds of the country's total pension assets.[38] For CPP, we collect data from its annual reports on total assets, U.S. investments, and portfolio allocations. Since 2015, CPP has ceased investing in foreign bonds, so its U.S. exposure is entirely through equity. We also analyze CPP's discussions of hedging strategy. CPP conducted no currency hedging between 2004 and 2007, and after 2015. Between 2008 and 2014, it hedged only bond investments. For CDPQ, we collect data from its annual reports on total assets, foreign portfolios, and the split between debt and equity, along with USD exposure. In recent years, CDPQ has stopped reporting USD exposure, instead reporting only its U.S. exposure, which we use as a conservative estimate of USD exposure. Since 2013, CDPQ has reported its unhedged

[36] `https://www.investmentoffice.com/Pension_Funds/Netherlands/`

[37] `https://www.pensioenfederatie.nl/website/the-dutch-pension-system-highlights-and-characteristics`

[38] `https://www.bankofcanada.ca/wp-content/uploads/2016/06/fsr-june2016-bedard-page.pdf`

(or net) USD exposure. We estimate CDPQ's hedging as the difference between total USD exposure and unhedged USD exposure.

To be conservative, we do not extrapolate holdings and hedging of the pensions we study in Japan, Canada, and Australia to the entire pension sectors in these countries.

In Australia, the Australian Prudential Regulation Authority (APRA) publishes the *Quarterly Superannuation Performance*, which provides data on all regulated pensions (those with more than four members) dating back to 2004. These reports include detailed information on total assets, foreign investments, and FX hedging activities. Foreign investments and hedging are reported separately for equities and bonds. To estimate USD bond and equity holdings, we supplement APRA statistics with data from the Australian Bureau of Statistics' (ABS) *Foreign Currency Exposure, Australia*, a triennial survey of Australian enterprises with foreign currency exposure. From this, we analyze nonbank financial institutions' (including pension funds, insurance companies, and other financial intermediaries) currency holdings in foreign equity and bond portfolios, which we use to estimate pensions' USD exposure.

The Swiss Federal Statistical Office provides annual data similar to APRA's, detailing pension funds' foreign investments, though without a currency breakdown. To address this gap, we use Credit Suisse's Swiss Pension Fund Index 2020, which estimates the currency allocation of Swiss pension funds' investment portfolios between 2018 and 2020. Like APRA, the Swiss data does not differentiate between domestic and foreign private equity investments, so we conservatively exclude private equity from our estimates of USD equity holdings. We estimate hedging activities for Swiss pensions using the industry-wide hedge ratio from the Swiss Pension Fund Study 2021 (Swisscanto Pensions (2021)).

For U.K. pension funds, we rely on data from the Office for National Statistics (ONS). Since 2019Q4, the ONS has released quarterly reports on U.K. pension funds' overseas assets, broken down by country and security type. We conservatively estimate U.K. pension funds' USD bond and equity holdings as those issued by U.S. entities. Before 2019, the ONS released annual statistics on foreign bond and equity investments by pension funds; we use the post-2019 average share to impute the share of USD in earlier years' foreign equity and foreign bond portfolios.

Chile's Superintendencia de Pensiones publishes quarterly reports on the country's pension sector beginning in 2014. These reports provide detailed information, including total assets, foreign investments, and net FX exposure after hedging, broken down by currency and by bond versus equity holdings.

Finally, we analyze pension funds in Denmark, Sweden, Israel, and nine other Latin American countries. Data for Danish, Swedish, and Israeli pension funds come from the same sources as insurers in these countries, as previously described. For the nine Latin American countries, we use data from Federación Internacional de Administradoras de Fondos de Pensiones (FIAP), which has published annual series on pension funds' foreign investments in Argentina, Bolivia, Colombia, Costa Rica, El Salvador, Mexico, Peru, the Dominican

Republic, and Uruguay.[39]

A.2.3 Foreign mutual funds' holdings and hedging

We analyze foreign mutual funds' allocations to USD using a data set of holdings from open-ended funds and exchange-traded funds (ETFs) domiciled in 64 non-U.S. countries. This data set includes security-level holdings from Morningstar for bond funds, mixed bond-equity funds (referred to as "allocation funds" by Morningstar), and equity funds, similar to the data used by Maggiori, Neiman, and Schreger (2020) and Coppola et al. (2021). We estimate foreign bond holdings by aggregating bond securities denominated in USD, excluding bank loans, alternative investments, and all derivatives (including bond futures and CDS). We estimate foreign equity holdings by obtaining each fund's share of U.S. equity investments from the Morningstar Direct platform.

We assess mutual funds' hedging strategies at the share-class level. Each Morningstar share class reports its hedging status as fully hedged, partially hedged, or unhedged. In addition to the self-reported hedging status, we identify additional hedged share classes by their currency-hedged benchmarks (e.g., "U.S. Corporate Bond EUR Hedged"). We aggregate the assets under management (AUM) of all share classes that are fully or partially hedged. While partially hedged share classes are rare, we acknowledge that we do not observe the exact hedge ratios for mutual fund investments.

A.2.4 Holdings of foreign banks, hedge funds, Nonfinancials, and the official sector

Foreign banks' holdings

We estimate the holdings of USD securities by non-U.S. banks using the BIS Locational Banking Statistics (LBS), which provide quarterly data on the outstanding claims and liabilities of internationally active banks in reporting countries. Our focus is on banks' holdings of debt securities, as it is more capital-intensive for banks to hold equity securities. However, non-U.S. banks' cross-border holdings of USD debt securities are a confidential time series, available only to central banks.[40] To estimate USD debt securities holdings, we apply an adjustment factor to the difference between foreign banks' USD holdings and USD loans, yielding an estimate of debt securities holdings. Our estimated series has a 0.98 correlation with LBS' confidential series.

[39] FIAP also reports sparse data from Russia, Poland, Romania, and Kazakhstan, though these reports stopped after 2013. For Chile, we use information directly from the Superintendencia de Pensiones instead of FIAP's aggregate data.

[40] This information cannot be deduced from United States reporting to the BIS, as the U.S. reports only U.S. banks' loan and deposit positions, excluding debt securities.

Foreign hedge funds' holdings

We estimate non-U.S. hedge funds' investments in U.S. equities by utilizing 13F reporting requirements, whereby institutional investment managers with at least $100 million in assets under management must disclose their equity holdings quarterly. The 13F filings specify whether the reporting entity is a hedge fund. We merge these data with FactSet to determine each fund's domicile.

Foreign nonfinancial sector's holdings

We estimate the USD holdings of foreign nonfinancial companies and households using data from the IMF's Coordinated Portfolio Investment Survey (CPIS), which reports bilateral investment portfolios. In some cases, CPIS data are broken out by currency and sector. Since few countries report cross-border investments by currency, our estimates are based on investments in the United States by the nonfinancial sector in reporting countries. Of the 81 countries reporting U.S. asset holdings, 56 report investments separately for the nonfinancial sector. Our estimates are therefore conservative: some countries may own U.S. assets but choose not to report, and some investments by the nonfinancial sector may not be reported separately.

Foreign official sector's holdings

We estimate the foreign official sector's holdings of U.S. securities using TIC data. Since 2007, TIC has reported official sector holdings in 237 countries and jurisdictions, broken down by debt and equity. For years before 2007, we estimate the total as the sum of the official sector's holdings of long-term debt and equity, as reported by Bertaut and Judson (2014), and short-term Treasury securities, as released by the Treasury Department. We assume the official sector—central banks, sovereign wealth funds, and other public financial agencies—does not acquire significant USD assets from non-U.S. entities.

B Bank Regulations and FX Derivatives

Under the Basel III framework, bank capital regulation is governed by two distinct constraints: risk-weighted capital requirements and non-risk-weighted leverage ratio requirements. FX derivatives can, in principle, affect both. In practice, however, because the risk-weighted capital treatment of unhedged FX exposure is highly punitive, large global banks have strong incentives to maintain negligible net FX positions. As a result, the key regulatory friction facing banks' FX derivatives positions is the non-risk-weighted leverage ratio.

In what follows, we briefly review how FX derivatives enter risk-weighted assets (RWA) and present evidence that banks minimize FX derivatives' contribution to RWA. We then show that FX derivatives do contribute to the non-risk-weighted leverage ratio, which forms the friction that we model.

Risk-weighted capital requirements mandate that banks hold capital against total RWA, which include credit risk, counterparty credit risk, and market risk. FX derivatives affect RWA through two channels. First, they contribute to counterparty credit risk, which is measured by the replacement cost (i.e., mark-to-market value) of derivative positions, adjusted for legally enforceable netting and reduced by the use of variation and initial margin. Because FX swaps and forwards typically have very small market values relative to notional amounts, and because these contracts are commonly margined, their contribution to counterparty credit risk RWA is quantitatively limited. Second, and more meaningfully, FX derivatives can contribute to market risk RWA, which captures the risk of adverse movements in market prices. Under Basel III, market risk is calibrated using Value-at-Risk (VaR)–based measures applied to banks' trading portfolios. Importantly, unhedged FX positions are heavily penalized under these frameworks, implying a large market risk capital charge. Furthermore, the capital requirement for foreign exchange risk applies to the bank's entire business, including positions in the banking and trading book. Therefore, supplying FX derivatives without offsetting spot positions is generally unattractive for large global banks.

Consistent with this institutional background, banks hedge nearly all of the FX risks inherent in their FX derivatives positions such that market risk accounts for only a small share of total RWA at large U.S. banks, and FX risk is a particularly minor component within market risk. Appendix Table A2 reports Tier 1 capital ratios and Supplementary Leverage Ratios for JPMorgan Chase, Citigroup, and Bank of America, along with a decomposition of market risk RWA. For all three institutions, market risk accounts for only about 4–5% of total RWA. Moreover, FX risk represents a small fraction of overall market risk: the 10-day, 99th percentile FX VaR accounts for between 4.3% and 13% of total market risk VaR. For example, JPMorgan Chase's FX VaR in 2025Q3 is $48 million, which is negligible relative to its total assets of approximately $4.5 trillion and its Tier 1 capital of $306 billion.

A simple back-of-the-envelope calculation further illustrates how limited net FX exposure is for large banks. The 10-day, 99th percentile VaR of the U.S. dollar index (e.g., Bloomberg DXY) is approximately 8%, implying that a $48 million FX VaR corresponds to roughly $600 million of unhedged foreign currency exposure. Even under the conservative assumption that 5% of JPMorgan Chase's total assets (about $225 billion) are denominated in foreign currency, this implies that the bank hedges more than 99.7% of its FX exposure. These calculations suggest that for most currencies and most of the time, global banks operate close to the being perfectly hedged, in which FX derivative positions are tightly hedged and FX market risk is minimal.

Banks' need to hedge FX risk further amplifies the impact of FX derivatives on the non-risk-weighted leverage ratio. When global banks provide net dollar hedges via FX swaps or forwards, they typically hedge the resultant FX exposure by borrowing dollars in the dollar cash market. This dollar borrowing appears on balance sheet and increases total exposures measured under the non-risk-weighted leverage ratio, making it the primary regulatory friction associated with supplying dollar hedges. This mechanism has been emphasized in a large literature on CIP deviations, including Du, Tepper, and Verdelhan (2018), Cenedese, Della Corte, and Wang (2021), Du and Schreger (2022), Du, Hébert, and Huber (2022), and Moskowitz et al. (Forthcoming). Du, Strasser, and Verdelhan (2025) show that euro area banks' on–balance-sheet dollar repo borrowing closely tracks their net dollar lending in FX swaps. Taken together, this evidence reinforces the view that the balance-sheet cost of funding FX swap positions is central to understanding persistent CIP deviations.

C Additional Derivations

In this section, we show derivations of the log-linearized version of the hedged portfolio return. The hedged portfolio return is given by

$$\begin{aligned} R_{h,t+1} &= \boldsymbol{\omega}_t' \boldsymbol{R}_{t+1} \boldsymbol{\cdot} (\boldsymbol{S}_{t+1} \div \boldsymbol{S}_t) - \boldsymbol{\theta}_t' (\boldsymbol{S}_{t+1} \div \boldsymbol{S}_t) + \boldsymbol{\theta}_t' (\boldsymbol{F}_t \div \boldsymbol{S}_t) \\ &= \boldsymbol{\omega}_t' \boldsymbol{R}_{t+1} (\boldsymbol{S}_{t+1} \div \boldsymbol{S}_t) - \boldsymbol{\theta}_t' (\boldsymbol{S}_{t+1} \div \boldsymbol{S}_t) + \boldsymbol{\theta}_t' [(1 + i_t^1 \mathbf{1}) * (1 + \boldsymbol{X}_t) \div (1 + \boldsymbol{i}_t)] \\ &= \boldsymbol{\omega}_t' \boldsymbol{R}_{t+1} (\boldsymbol{S}_{t+1} \div \boldsymbol{S}_t) - (\boldsymbol{\omega}_t' - \boldsymbol{\psi}_t') (\boldsymbol{S}_{t+1} \div \boldsymbol{S}_t) + (\boldsymbol{\omega}_t' - \boldsymbol{\psi}_t') [(1 + i_t^1 \mathbf{1}) * (1 + \boldsymbol{X}_t) \div (1 + \boldsymbol{i}_t)] \\ &= \boldsymbol{\omega}_t' \boldsymbol{R}_{t+1} (\boldsymbol{S}_{t+1} \div \boldsymbol{S}_t) - \boldsymbol{\omega}_t' [(\boldsymbol{S}_{t+1} \div \boldsymbol{S}_t) - (1 + i_t^1 \mathbf{1}) * (1 + \boldsymbol{X}_t) \div (1 + \boldsymbol{i}_t)] \\ &\quad + \boldsymbol{\psi}_t' [(\boldsymbol{S}_{t+1} \div \boldsymbol{S}_t) - (1 + i_t^1 \mathbf{1}) * (1 + \boldsymbol{X}_t) \div (1 + \boldsymbol{i}_t)] \end{aligned}$$

We now want to log-linearize the hedged portfolio return:

$$\begin{aligned} r_{h,t+1} &= \boldsymbol{\omega}_t' (\boldsymbol{r}_{t+1} + \boldsymbol{\Delta s}_{t+1}) - \boldsymbol{\omega}_t' (\boldsymbol{\Delta s}_{t+1} - i_t^1 \mathbf{1} - \boldsymbol{x}_t + \boldsymbol{i}_t) + \boldsymbol{\psi}_t' (\boldsymbol{\Delta s}_{t+1} - i_t^1 \mathbf{1} - \boldsymbol{x}_t + \boldsymbol{i}_t) + \frac{1}{2} \Sigma_{h,t+1} \\ &= \boldsymbol{\omega}_t' (\boldsymbol{r}_{t+1} - \boldsymbol{i}_t + \boldsymbol{x}_t + i_t^1 \mathbf{1}) + \boldsymbol{\psi}_t' (\boldsymbol{\Delta s}_{t+1} - i_t^1 \mathbf{1} - \boldsymbol{x}_t + \boldsymbol{i}_t) + \frac{1}{2} \Sigma_{h,t+1} \end{aligned}$$

Since $\boldsymbol{\omega}_t' i_t^1 \mathbf{1} = i_t^1$, the hedged excess return is given by

$$r_{h,t+1} - i_t^1 = \boldsymbol{\omega}_t' (\boldsymbol{r}_{t+1} - \boldsymbol{i}_t{}^1 + \boldsymbol{x}_t) + \boldsymbol{\psi}_t' (\boldsymbol{\Delta s}_{t+1} - i_t^1 \mathbf{1} + \boldsymbol{i}_t - \boldsymbol{x}_t) + \frac{1}{2} \Sigma_{h,t+1}.$$

D Optimal Mean-Variance Exposure under Intermediary Constraints

In this section, we solve for optimal currency exposure in the presence of intermediary constraints. For simplicity, we consider the case where the USD is the only foreign currency for the non-U.S. investor. Equation (3) implies that the optimal USD exposure of the investor becomes

$$\psi = \frac{\xi - x}{\gamma \sigma^2} - \beta.$$

Given the portfolio allocation to the USD assets ω, the investor's demand for FX hedging, measured as a share of total portfolio is given by

$$\theta^D(x) = \omega - \frac{\xi - x}{\gamma\sigma^2} + \beta. \tag{A1}$$

The hedging demand curve is downward sloping with respect to the cost of hedging $(-x)$.

The supply of FX hedging b the intermediary is given by Equation (4).

$$-x_c = \frac{H_c}{W_c - H_c \operatorname{sign}(H_c)} = \frac{\theta_c^S}{W_c - \theta_c^S \cdot \operatorname{sign}(\theta_c^S)},$$

where $\theta_c^S \equiv H_c$ is defined as the USD hedging supplied by the intermediary in currency area c. For simplicity, we focus on the case where $H > 0, \theta^S > 0$, we thus omit $\operatorname{sign}(H), \operatorname{sign}(\theta^S)$. We also omit the currency index c for ease of exposition. Therefore, we can write the supply curve for FX hedges as a function of the hedging cost,

$$\theta^S(x) = -\frac{xW}{1 - x}. \tag{A2}$$

The hedging supply is increasing in the cost of hedging $-x$.

In equilibrium, hedging demand equals hedging supply $\theta^D(x) = \theta^S(x)$

$$\omega - \frac{\xi - x}{\gamma\sigma^2} + \beta = -\frac{xW}{1 - x}. \tag{A3}$$

Once we solve for the equilibrium hedge θ^* and the equilibrium basis x^*, the optimal currency exposure becomes $\psi^* = \omega - \theta^*$. Then we can derive the following comparative statics. We first confirm the results from Proposition 1 for the general equilibrium case.

With respect to ξ:

$$\frac{d\psi^*}{d\xi} = \frac{W}{W\gamma\sigma^2 + (1 - x)^2} > 0 \tag{A4}$$

Higher expected FX returns reduce the incentive to hedge, and therefore, the optimal USD exposure increases with respect to ξ.

With respect to σ^2:

$$\frac{d\psi^*}{d\sigma^2} = -\frac{W(\xi - x)}{\sigma^2(W\gamma\sigma^2 + (1 - x)^2)} \tag{A5}$$

As long as $\xi - x > 0$, we have $\frac{d\psi^*}{d\sigma^2} < 0$. An increase in volatility reduces unhedged exposure, as mean-variance investors prefer to hedge more.

To derive Proposition 2, we now derive the cross partial of these comparative statistics above with respect to the risk aversion parameter γ.

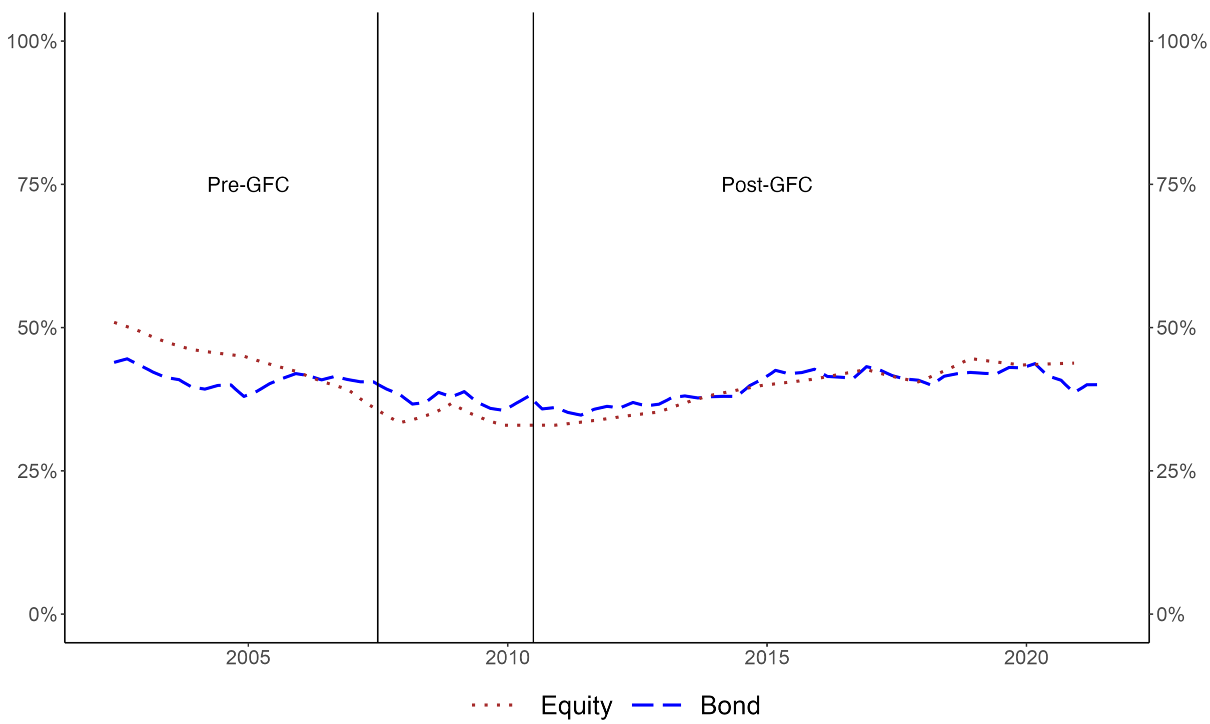
$$\frac{\partial^2 \psi^*}{\partial \xi \, \partial \gamma} = -\frac{W^2 \sigma^2}{\left(W\gamma\sigma^2 + (1-x)^2\right)^2} < 0$$

$$\frac{\partial^2 \psi^*}{\partial \sigma^2 \, \partial \gamma} = \frac{W^2(\xi - x)}{\left(W\gamma\sigma^2 + (1-x)^2\right)^2} > 0$$

Therefore, as stated in Proposition 2, a higher risk aversion dampens the sensitivity of currency exposure with respect to expected foreign currency returns and volatility.

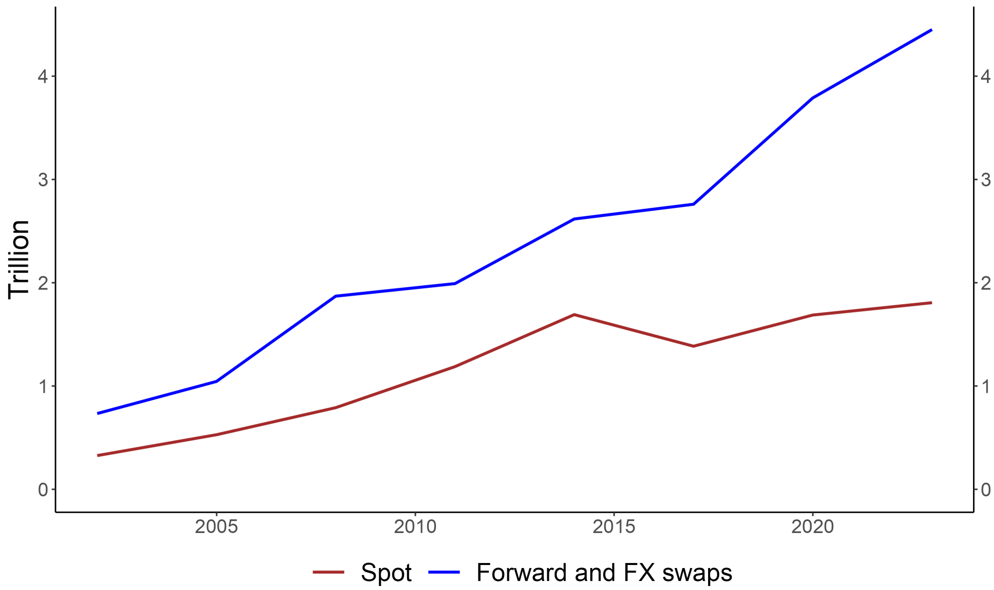
E Additional Figures and Tables

Figure A1: **Share of USD bonds and equities in global markets**

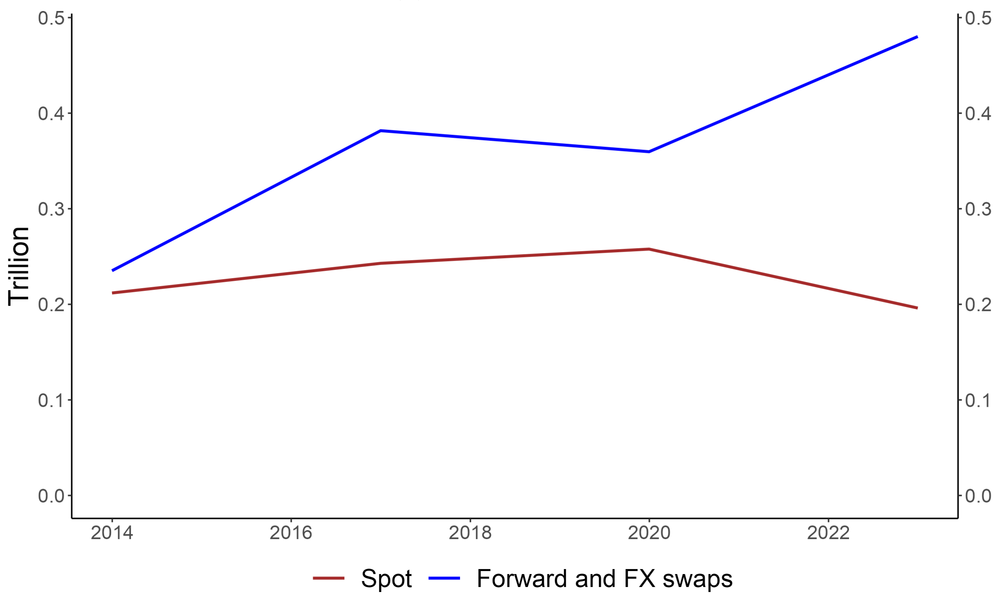


This figure plots the share of USD bonds and equities in their respective global markets. Global bond market size is calculated from BIS' debt securities statistics, inclusive of all issue markets. Global equity market is the sum of global public market cap and global private equity AUM. Global public market cap is compiled by World Bank in conjunction with World Federation of Exchanges. Global private equity AUM is sourced from Preqin.

Figure A2: **FX daily turnover against USD**



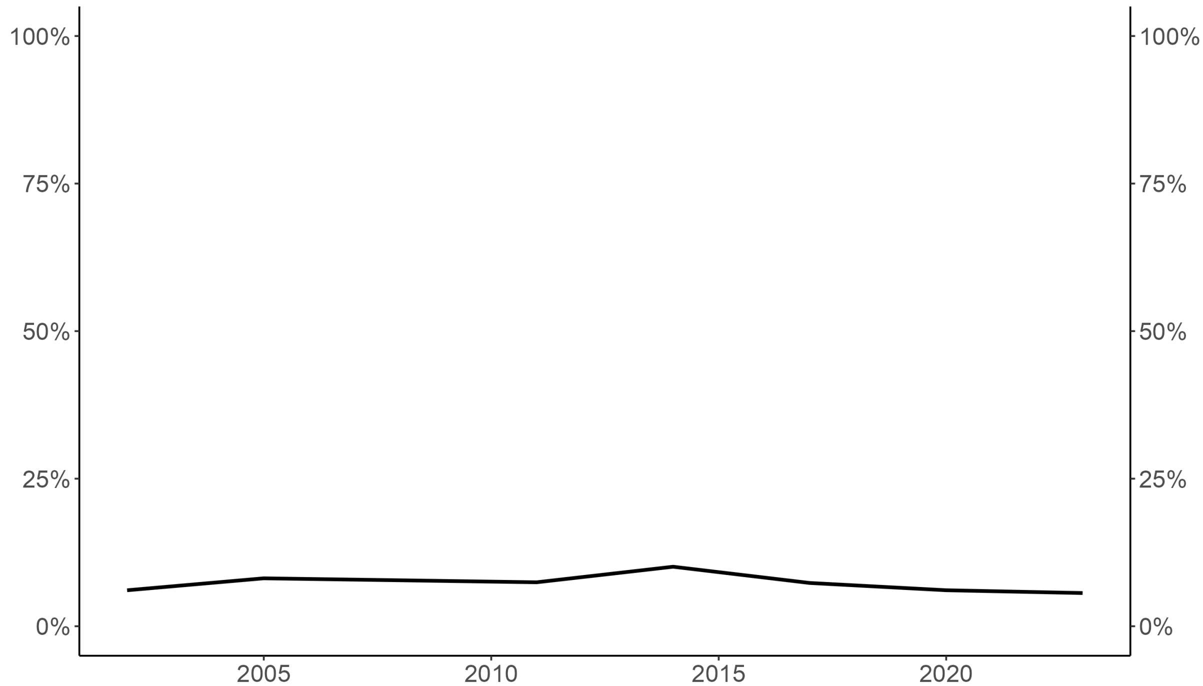
(a) **All volumes**



(b) **Institutional investors**

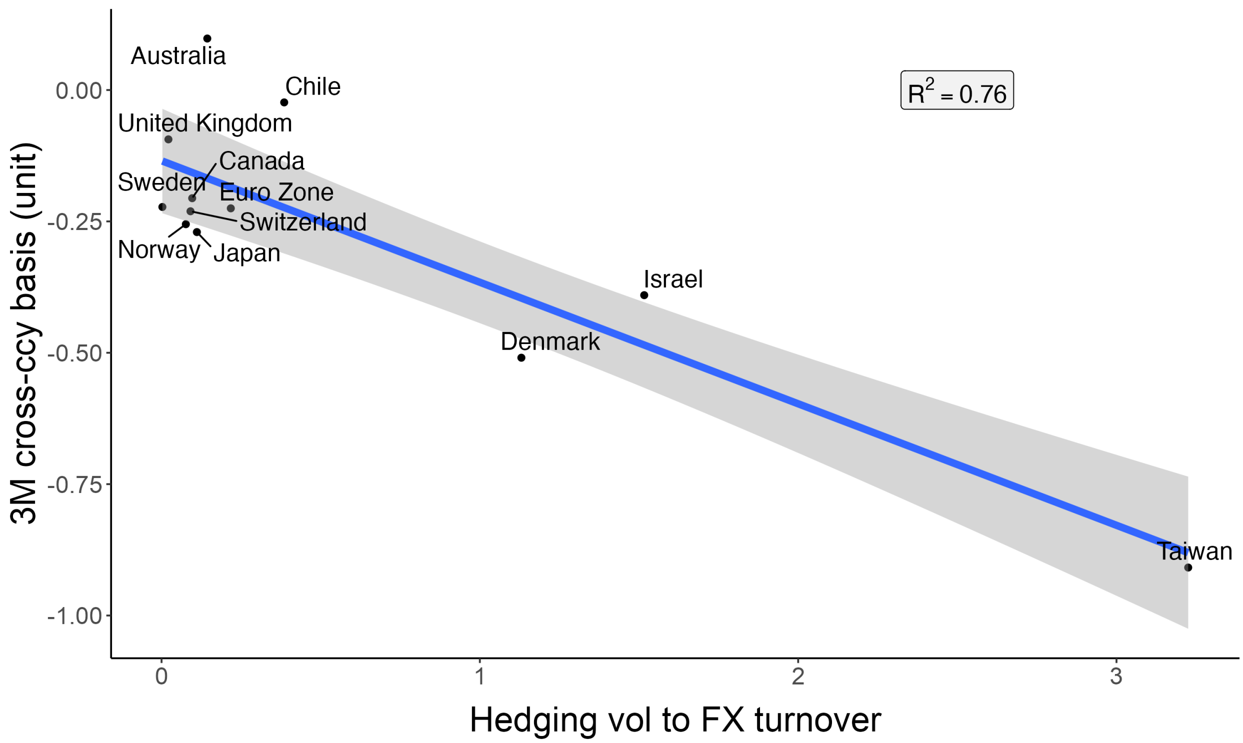
This figure plots the global daily volume of foreign exchange spot versus forward and FX swaps transactions involving USD. Panel A shows the total market volume, and panel B shows the volume from transactions involving institutional investors. Daily volume is calculated as the average of all trading days in April of the survey year. BIS conducted this survey triennially from 2001 to 2022.

Figure A3: **Share of nonforward, nonswap FX derivatives**



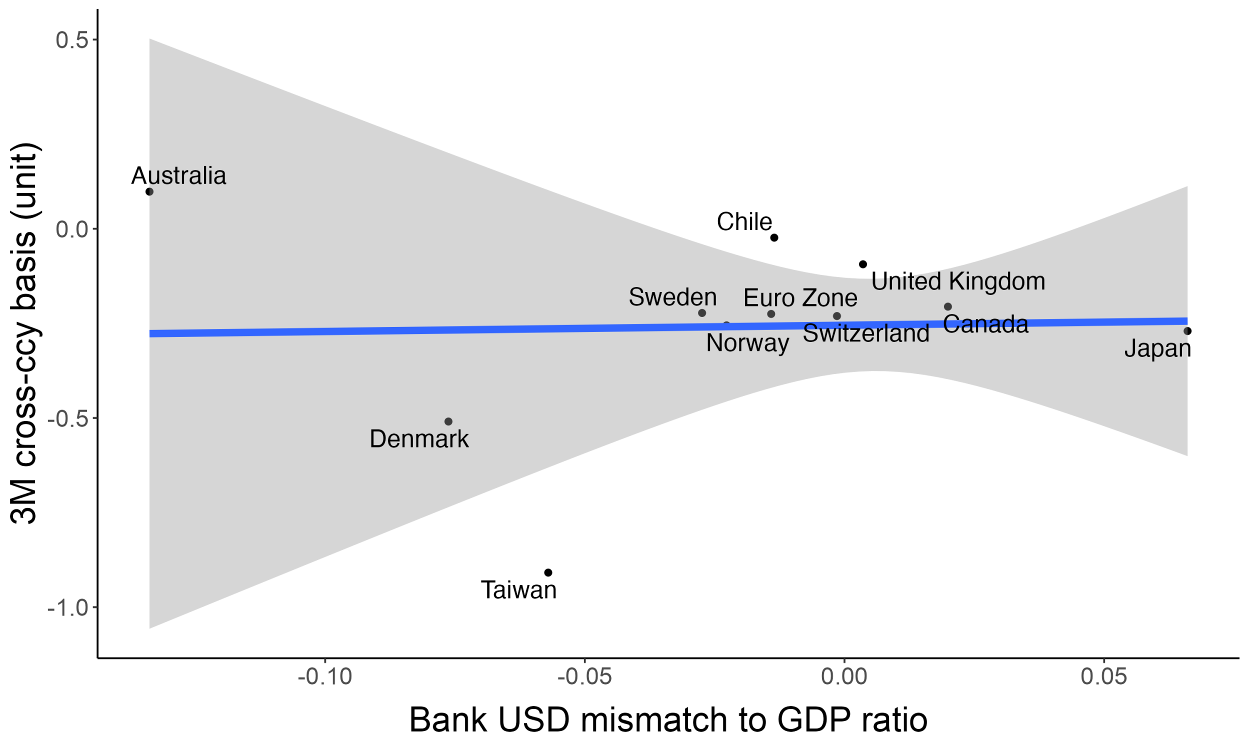
This figure plots the share of nonforward and nonswap derivatives in all FX derivatives. FX derivatives include in FX forward, FX swaps, FX options, FX futures, and other instruments. Daily volume is calculated as the average of all trading days in April of the survey year. BIS conducted this survey triennially from 2001 to 2022.

Figure A4: **Cross-section of hedging and cross-currency basis: Alternative normalization**



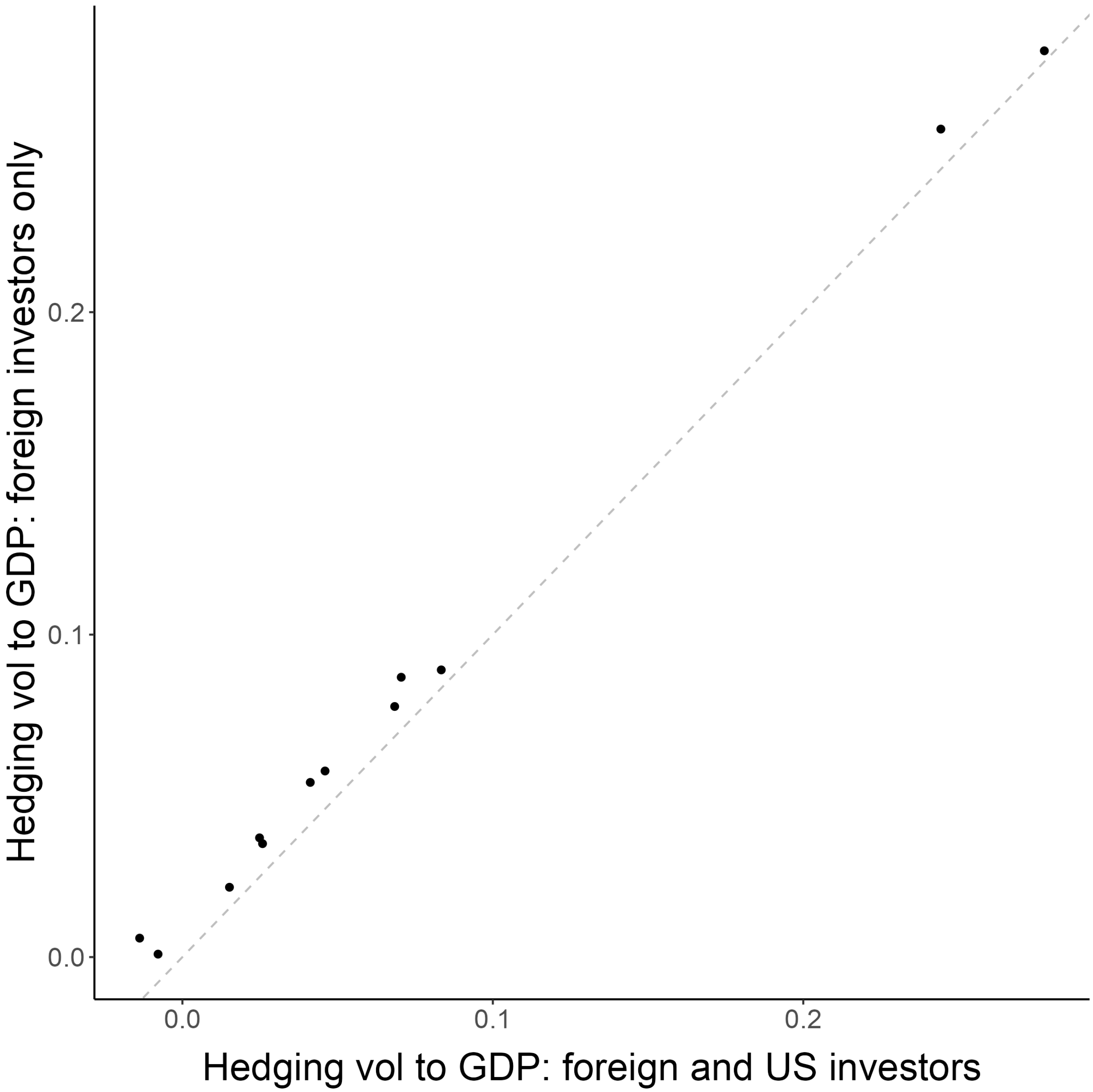
This figure plots each currency's time-series average of 3M IBOR cross-currency basis against their time-series average of hedging volume to FX turnover ratio. Hedging volume is the estimated from USD FX hedging of insurance, pensions, and mutual funds. FX turnover is the total FX trading in a currency as assessed by the BIS Triennial Survey. Sample period is July 2010 to September 2020.

Figure A5: **Cross-section of bank USD mismatch and cross-currency basis**



This figure plots each currency's time-series average of 3M IBOR cross-currency basis against the time-series average of on-balance sheet USD mismatch in banks with headquarter in the corresponding currency area, normalized by GDP. Sample period is July 2010 to September 2020.

Figure A6: **Comparison of GDP-normalized hedging volume**



This figure plots two measures of GDP-normalized hedging volume for each currency area. Along the x-axis measures hedging as the sum of foreign investors' USD hedges and U.S. investors' hedges of non-USD currencies. Along the y-axis measures hedging as only foreign investors. All values reflect time-series average between September 2019 and September 2020.

Table A1: **Summary of investment limits**

Industry	Region / Country	Limit on foreign investment (excluding real estate)
Insurance	Asia: Japan	None post-2012, 30% pre-2012
	Asia: Taiwan	65%
	Europe: Denmark	EIOPA risk weights
	Europe: Sweden	EIOPA risk weights
	ROW: Israel	None for countries rated A and above
Pensions	Asia: Japan	None
	Asia: Australia	None
	NA: Canada	None
	Europe: Denmark	None
	Europe: Netherlands	None
	Europe: Switzerland	30%
	ROW: Israel	None for OECD or countries rated at least BBB-
	ROW: Chile	80%

This table summarizes foreign investments limits on pensions and insurances in countries from which we obtain hedging information. Investment limits for pensions are obtained from OECD's Annual Survey of Investment Regulation of Pension Funds and Other Pension Providers (2021). Investment limits for insurances are extracted from laws and regulations governing insurers in Taiwan and Japan and from OECD's Review of the Insurance System (2011, Israel).

Table A2: Capital, leverage, and market risk measures (2025)

(millions USD)	JPM 2025Q3	Citi 2025Q2	BoA 2025Q3
Panel A: Capital and leverage			
Tier 1 capital	306,599	176,619	228,829
Total risk-weighted Assets (RWA)	1,932,404	1,335,913	1,546,142
Tier 1 capital ratio	15.9%	13.2%	14.8%
Total average assets	4,519,945	2,608,993	3,356,512
Total leverage exposure	5,272,950	3,195,323	3,976,630
Supplementary leverage ratio	5.8%	5.53%	5.8%
Panel B: Market risk and regulatory VaR			
Market risk RWA	106,760	61,492	76,367
Share of market risk RWA in total RWA	5.5%	4.6%	4.9%
10-Day regulatory VaR (99% VaR)			
Interest rate	146	216	157
Credit	112	264	135
FX	48	29	62
Equity	128	48	79
Commodity	196	121	28
Total VaR (without diversification)	630	678	461
Share of FX VaR in total	7.6%	4.3%	13%

Notes: Tier 1 capital ratio is defined as the *Tier 1 capital* divided by *Total risk-weighted assets (RWA)*. The *Supplementary leverage ratio (SLR)* is defined as *Tier 1 capital* divided by *Total leverage exposure. Regulatory value-at-risk (VaR)* is reported at the 99% confidence level over a 10-day horizon and shown without diversification benefits across risk classes.

Table A3: Summary statistics for key regression variables

	Unhedged USD share		Option-implied FX vol		US-local 3M IBOR spread		3M cross-ccy basis	
Currency area	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Australia	0.09	0.04	11.01	4.07	-2.16	1.69	0.08	0.11
Canada	0.20	0.04	8.76	3.06	-0.30	0.76	-0.16	0.13
Switzerland	0.09	0.02	9.54	2.73	1.38	1.18	-0.22	0.17
Chile	0.09	0.05	11.33	3.65	-2.15	1.88	-0.25	0.75
Denmark	0.09	0.02	9.45	3.06	0.20	1.49	-0.55	0.30
Euro zone	0.13	0.04	9.31	2.98	0.41	1.34	-0.24	0.22
United Kingdom	0.11	0.05	9.05	2.88	-0.51	1.32	-0.14	0.19
Israel	0.07	0.03	7.61	2.58	-0.89	2.35	-0.35	0.47
Japan	0.07	0.04	9.76	2.90	1.49	1.50	-0.24	0.16
Norway	0.10	0.04	11.48	3.53	-0.61	1.56	-0.27	0.21
Sweden	0.14	0.03	11.17	3.46	0.13	1.71	-0.24	0.17
Taiwan	0.17	0.09	5.07	1.58	0.64	1.39	-0.80	0.41

This table provides summary statistics of the independent and dependent variables in Tables 5 and 6, by currency area.

Table A4: Mean-variance drivers in the time series, controlling for time-varying covariance

	Unhedged USD allocation			
	Sample		Post-GFC	
	(1)	(2)	(3)	(4)
Option-implied FX vol	-0.003***	-0.003***	-0.003**	0.0007
	(0.001)	(0.0008)	(0.001)	(0.001)
US-local 3M IBOR spread		0.009***		0.01***
		(0.002)		(0.002)
3M cross-ccy basis		-0.009		0.03**
		(0.01)		(0.01)
Rolling port cov	0.03	0.04	0.12	0.04
	(0.04)	(0.03)	(0.07)	(0.05)
Currency FE	Yes	Yes	Yes	Yes
Observations	682	605	465	465
R^2	.50	.58	.64	.70
Within adjusted R^2	.07	.17	.07	.24

Table A5: **Cross-firm comparison of MV drivers**

	Unhedged USD allocation				
Interaction:	None	Reserve for fluctuation		Solvency margin ratio	
	(1)	(2)	(3)	(4)	(5)
Option-implied FX vol	-0.004***				
	(0.001)				
US-JP 3M IBOR spread	0.005*				
	(0.003)				
3M cross-ccy basis	-0.04***				
	(0.01)				
Option-implied FX vol × Top half		-0.002**		-0.0008	
		(0.0007)		(0.0009)	
US-JP 3M IBOR spread × Top half		0.003*		0.0001	
		(0.001)		(0.002)	
3M cross-ccy basis × Top half		-0.06***		-0.02*	
		(0.01)		(0.01)	
Option-implied FX vol × Level			-0.02		-0.003
			(0.06)		(0.009)
US-JP 3M IBOR spread × Level			0.23		0.03**
			(0.16)		(0.02)
3M cross-ccy basis × Level			-2.5**		0.002
			(0.97)		(0.10)
Main effects	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	No	No	No	No
Date FE	No	Yes	Yes	Yes	Yes
Observations	285	240	240	264	264
R^2	.51	.34	.36	.26	.27

This table examines the cross-firm response to time-series variation in mean-variance drivers of the optimal FX exposure. Observations are by firm-time, where firms are all Japanese insurers and reportings are available every 6 months. *Option-implied FX vol* is from 3M at-the-money options. *US-local 3M IBOR spread* is calculated as U.S. 3M IBOR less local 3M IBOR. *3M cross-ccy basis* is calculated using IBOR in the log version of Equation (2.2). Estimation period is March 2004 through September 2020. Standard errors are calculated using Driscoll and Kraay (1998). *$p < .1$; **$p < .05$; ***$p < .01$.

Table A6: **Correlation between GDP and banks' cross-country trading assets**

	Trading Assets			
	(1)	(2)	(3)	(4)
	Citi All	Citi Ex China	JPM All	JPM Ex China
GDP	0.073***	0.764***	0.419**	1.29***
	(0.013)	(0.110)	(0.091)	(0.230)
Year	Yes	Yes	Yes	Yes
Observations	120	115	100	95
R^2	.03	.27	.20	.28

This table reports the correlation between GDP and Citi's and JPM's (JP Morgan's) trading assets in reported geographies. Trading assets are measured in billions of USD and GDP is measured in trillions of USD. Sample period is 2018 to 2022, and measurement frequency is annual. Standard errors are calculated using Driscoll and Kraay (1998). $^{*}p<.1$; $^{**}p<.05$; $^{***}p<.01$.