# Dollar Asset Holding and Hedging Around the Globe[*]

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### Abstract

We analyze a large number of industry- and company-level filings of global institutional investors to provide the first comprehensive estimates of foreign investors' U.S. dollar (USD) security holdings and currency hedging practices. We find that foreign investors increased their holdings of USD securities by six fold over the past two decade, and showed preference for debt over equities. After the financial crisis of 2007-09, foreign investors maintained persistent and high hedge ratios for their USD holdings despite significant and fluctuating deviations from covered-interest rate parity. We estimate that USD hedging volume by insurance, pensions and mutual funds amounts to $2 trillion per annum. We benchmark foreign investors' USD holdings and hedging patterns using a mean-variance framework, and discuss important empirical drivers of USD allocation and hedging, including the role of the yield curve slope, spot exchange rate, and CIP deviations.

*JEL Classifications*: F21, F31, G11, G15, G22, G23
*Keywords*: dollar holdings, FX hedging, CIP deviations, institutional investors, portfolio allocation

# 1 Introduction

The U.S. dollar is the predominant currency in cross-border security holdings, and foreign holdings of dollar-denominated securities have been steadily increasing. According to 2022 data from U.S. Flow of Funds, the category "Rest of the World" accounts for about 30% of U.S. Treasury securities and 25% of U.S. corporate bonds. Yet this "Rest of the World" category belies substantial heterogeneity in the composition of foreign investors. Without knowing the ultimate investors and their overall portfolios, it is challenging to study how foreign investors value U.S. dollar (USD) securities and manage their USD exposure. In this paper, we take a deep dive into a large number of industry- and company-level filings of global institutional investors to provide the first comprehensive estimates of foreign investors' USD security holdings and currency hedging practices. Our analysis sheds light on global investors' preference for dollars and the economic cost of managing dollar exposure.

The best existing reporting for foreign holdings of U.S. securities is the Treasury International Capital (TIC) reporting system, which informs the "Rest of the World" category in the U.S. Flow of Funds. The TIC system routinely surveys a panel of large security custodians, broker-dealers, and important market participants to collect transaction and position data on U.S. securities by foreign investors.[1] Because of its reliance on data reported from security intermediaries, TIC can only distinguish between the official versus private foreign holdings, but not among private foreign security holders. Furthermore, no information on the currency hedging practices is collected.

Another data challenge is, that in addition to the USD securities issued in the United States and captured in the TIC system, non-U.S.-based issuers also account for a significant

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[1]Following the TIC system, we define "foreign-holding" as holdings by non-US residents.

amount of USD securities issued in international markets. Accordingly, we seek to include foreign holdings of USD securities outside the US to arrive at a more complete picture of the global USD asset holdings.

In contrast to centralized reporting systems such as TIC, which focus on aggregated cross-border liabilities of the United States, we take a bottom-up approach to track the rest of the world's USD assets.[2] We focus on data for foreign holdings of USD assets across seven major sectors: the official sector, banks, insurance companies, pension funds, mutual funds, the non-financial sector, and hedge funds. We comb through company filings and industry statistics to generate the first by-sector account of foreign dollar holdings. The combined foreign holdings across the seven major sectors that we cover amount to 75% of foreign holdings of U.S. assets from TIC, and about 60% of total foreign holdings of USD securities.

After describing our data sources and methodology, we provide six stylized facts — three on dollar holdings and three on the hedging of these holdings. On the holding patterns of foreign investors, we find that, first, the size of foreign holdings of USD securities increased sixfold over the past two decades, from $5.5 billion in 2002 to about $33.4 billion in 2021. This is driven not only by larger foreign wealth, but also by ever-higher allocations to USD assets within foreign private investors' portfolios. Second, foreign investors overall show a preference for bonds over equities, holding twice as much bonds as equities. Foreign holdings, in fact, constituted 34% of total value of USD bonds outstanding between 2015 and 2020; compared to 25% of USD equity outstanding over the same period. Third, foreign issuers issue a substantial amount of USD bonds. By the end of 2020, foreigner-issued USD bonds

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[2]IMF's Coordinated Portfolio Investment Survey (CPIS) reports cross-border holdings of assets by country and offers industry breakdown in some instances. However, CPIS data are not ideal for our analysis for at least three reasons. First, CPIS' overall USD holdings are understated, because not all countries reporting to CPIS break out their cross-border portfolio holding by country, and because USD holdings need not be restricted to assets in the U.S. Second, many countries do not break out their U.S. investments by sector of holders. Third, there are no data on allocation or hedging.

made up 16% of the total outstanding. Foreign-issued USD bonds are disproportionately held by other foreigners, whose USD debt portfolios contain 37% of foreign-issued securities by 2020.

Combining data on holdings and currency hedging activities, we are uniquely positioned to study foreign investors' management of their USD exposures. We find that, first, there is a substantial amount of currency hedging, especially post-GFC. The hedge ratios for insurance companies, pension funds, and mutual funds were 42%, 36%, and 22%, respectively, as of 2020 (Table 1). The total hedging demand from these three sectors alone amounted to almost $2 trillion per annum. Investors' hedge ratios were significantly higher post-GFC than pre-GFC. This new hedging regime developed despite elevated and fluctuating deviations from covered interest rate parity (CIP).

In fact, we find that CIP deviations increased the financial cost of currency hedging for most investors, but investors' hedging demand is not deterred by rising hedging costs. CIP deviations have drawn much academic attention because their presence and magnitude indicate that intermediaries' regulatory constraints affect asset prices (Du, Tepper, and Verdelhan (2018), Du, Hébert, and Huber (2022)). Yet it remains an open question what the economic costs of CIP deviations are.[3] CIP deviations could impose direct financial cost to investors seeking FX hedges. CIP deviations could also cause inefficiency if investors' optimal hedging decisions are distorted. Our data illuminate both points. Given that the typical FX hedging strategy involves rolling over short-term FX forwards, we calculate that the cost of hedging due to short-term CIP deviation averaged $3.4 billion per annum between 2017 and 2020 for the insurance and pension industries. Importantly, the cost of hedging due to CIP fluctuates considerably from year to year. For example, this cost was $5.3 billion

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[3]Davila, Graves, and Parlatore (2022) study the social welfare implications of arbitrage violations, including CIP deviations.

in 2017, dipped to \$2.2 billion in 2019, and rose again to \$2.7 billion in 2020. Nevertheless, the hedging behavior of pension funds and insurers was extremely stable in comparison. This suggests that the pension and insurance sectors have relatively inelastic demands for currency hedges.

Finally, we document that hedge ratios exhibit persistent heterogeneity across countries, sectors, and security types. The absence of a dominant hedging strategy that is shared by all investors need not be reflecting suboptimal portfolio allocations. To systematically evaluate investors' USD holdings and hedging practices, we compare empirically observed portfolio choices to the optimal portfolio of a mean-variance investor.

Specifically, we investigate the empirical drivers of USD hedging and holdings patterns by considering a mean-variance optimizing investor's portfolio choice over both USD asset allocation and currency hedging. The investor's problem can be thought of allocating a portfolio over three assets: a long-term local currency bonds, a long-term USD bond without currency hedging, and a long-term USD bond hedged by rolling over 1-month FX forwards. We take the observed post-GFC covariance structure between asset returns as given, and derive comparative statics of USD asset shares and hedge ratios with respect to the difference in the yield curve slopes, the spot exchange rate, and the CIP deviations.

We find that the observed USD allocation patterns are broadly consistent with the model predictions. For USD hedge ratios, the model predicts that hedging activities decline as the cost of hedging increases (i.e. a more negative cross-currency basis). In the data, however, we find that insurers and pensions increase their USD hedge ratios when hedging costs rise. This contrast between investors' actual hedging behavior and the frictionless model's prediction suggests that investors' hedging demand might, in fact, be driving larger CIP deviations.

Our paper contributes to the large literature on dollar safe assets (for example, Caballero,

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Farhi, and Gourinchas (2017); Gourinchas, Rey, and Sauzet (2019); Jiang, Krishnamurthy, and Lustig (2021); Coppola, Krishnamurthy, and Xu (2023)). What contributes to dollar's dominance? Although the USD tends to appreciate and accrue safety premium during crises, the elevated currency hedge ratio documented in our paper suggests that foreign investors are attracted to USD assets for reasons beyond simply getting the USD currency exposure. Indeed, the substantial hedging that foreigners undertake for their USD holdings stands in contrast to U.S. investors' rather modest hedging of their foreign holdings.[4] Our model points to the importance of a steep USD yield curve, which allows for an attractive yield spread from holding long-term USD bonds while rolling over short-term currency hedges, in explaining foreign investors' steady demand for USD fixed income securities on a currency-hedged basis. Such hedged demand corroborates the notion that USD's appeal in part arises from having a deep and liquid U.S. Treasury and corporate bond market, a theoretical point also made in He, Krishnamurthy, and Milbradt (2016).

Our paper is moreover connected to the growing literature that attempts to estimate the impact of asset demand on exchange rates, where foreign asset demand is either assumed to be fully unhedged (Koijen and Yogo (2020)) or fully hedged for bonds but fully unhedged for equities (Camanho, Hau, and Rey (2022)). Recent work by Liao and Zhang (2020) and Bräuer and Hau (2022) present evidence that hedging demand affects exchange rate determination and CIP deviations. Our empirical estimates of currency hedge ratios can help improve the estimates of the FX exposure and hedging demand associated with foreign asset demands. Furthermore, the heterogeneity in asset demand across different sectors across foreign investors can improve estimations of the demand-system based asset pricing models where foreign investors are often treated as a homogeneous group (for example,

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[4]39% of US foreign holding is in mutual funds (Department of Treasury (2021)). Sialm and Zhu (2022) document that hedging in U.S. fixed income mutual funds' foreign holding is 18%.

Koijen, Richmond, and Yogo (2020)).

Finally, our paper augments the broad literature that studies institutional investors' portfolio allocation. Previous works have considered investors' decision to invest abroad or the decision to hedge currency exposure (Campbell and Viceira (2002); Campbell, de Medeiros, and Viceira (2010)). We consider the joint optimization over domestic asset, foreign asset, and foreign exchange hedging. Our hand-collected data uniquely shed light on different types of non-US investors' preferences for USD assets. Our results thus complement existing studies that consider portfolio allocation by public investment funds (e.g., Mitchell, Piggott, and Kumru (2008)), that examine global investors' preferences for sovereign debt (e.g., Fang, Hardy, and Lewis (2022)), and that investigate US investors' currency hedging of non-USD exposures (e.g., Sialm and Zhu (2022)).

Our paper is organized as follows. Section 2 describe our data sources and estimation methodology. Sections 3 and 4 discuss six stylized facts on foreign USD holdings and hedging practices. Section 5 considers a mean-variance optimizing agent's portfolio holdings and hedging, and compares the theoretical optima with empirically observed portfolios. Section 6 concludes.

## 2  Methodology and Data Construction

We now describe our data construction. Using hand-collected industry- and company-level data sets, we first estimate both the aggregate and the country-sector-specific amount of foreign-held USD securities. We then estimate sector-specific hedge ratios and deviations from covered interest-rate parity (CIP) to examine currency hedging practices of foreign investors.

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## 2.1 Estimating Foreign USD Security Holdings

We follow a two-step procedure in estimating foreign holdings of USD securities. First, we determine the total amount of USD bonds and equities held by non-US residents. Second, we estimate holdings of USD securities by seven sectors through a collection of hand-collected company filings, industry reports, and national statistics.

### 2.1.1 Overall Foreign Holdings of USD Securities

To obtain the first systematic estimate of total foreign investors' holdings of USD assets, we start with existing estimates of foreign holdings of U.S. securities and make several adjustments. Conceptually, there are at least two important distinctions between foreign holdings of USD securities and foreign holdings of U.S. securities. First, securities issued by U.S. residents could be denominated in currencies other than USD. Therefore, we must subtract off the non-USD issuance by U.S. residents from foreign investors' U.S. holdings. Second, focusing on U.S. issuers misses the potentially substantial amount of USD securities issued by issuers domiciled outside of the U.S. Therefore, we must add these additional foreign holdings of USD securities by non-U.S. issuers. These adjustments are particularly important for debt securities, as all U.S. equities are denominated in dollars, and equities listed in foreign countries are largely denominated in foreign currencies.

More specifically, our estimation is equal to:

Total Foreign Holding of USD Securities

$=$ Foreign USD Holding of U.S. Issuers $+$ Foreign USD Holding of Non-U.S. Issuers

$=$ (TIC Foreign Holding of U.S. Securities $-$ TIC Foreign Holdings of Non-USD Securities)

$+$ (USD Securities Outstanding Outside the U.S. $-$ U.S. Investors' Cross-border USD Holdings).

We use the annual reporting from the TIC system to inform foreign holdings of U.S. securities, and we use the international debt securities statistics published by the Bank for International Settlements (BIS) to estimate non-US issuance of USD securities. Details of the estimation procedure are in Appendix Section A.1.

### 2.1.2 Sector-Specific USD Security Holdings

We identify seven sectors with large investments in USD securities, and we leverage a large collection of sources to estimate industry-specific portfolio allocations to USD bonds and equities. The sectors we focus on are insurance, pensions, mutual funds, banks, hedge funds, non-financial corporations and households, and the official sector.[5] One potentially significant source that we do not capture is separately managed accounts of institutional investors and high-net-worth individuals.[6]

The sectors that we study and the data sources used for each are summarised in Table 2. We highlight the key aspects of our estimation strategy below, and in Appendix Section

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[5]Because we are interested in understanding foreign-holdings of USD securities, we do not include real estate or infrastructure funds in our analysis.

[6]High-net-worth individuals command a staggering amount of wealth. Forbes estimates that the total amount of wealth owned by non-US billionaires is $8T in 2022. However, much of their wealth is typically tied to the stocks of their own companies.

[A.2](#), we detail the estimation strategy employed for each sector.

**Foreign Insurance Companies' Holdings**

We start with Asia, where the insurance industry is a major holder of investment securities because many insurance products are purchased as retirement savings. This is particularly true for Japan[7] and Taiwan,[8] which we study in depth. For Japan, we hand-collected statutory filings since 2004 from all active insurers and recorded, for each, total assets, investments in USD and all other foreign currencies, and investments in foreign equity and foreign debt. For Taiwan, we located physical copies of the Central Bank of Republic of China's monthly publication on life insurers' total assets and foreign investments. We then hand collected information from the annual reports of the 6 of the largest Taiwanese life insurers to further understand the share of USD in foreign investments and the split between debt and equity.

We leverage the quarterly filings made by all insurers to the European Insurance and Occupational Pensions Authority (EIOPA) to study insurers' portfolio allocations in the EU and the European Economic Area (EEA).[9] We estimate the dollar holding from European insurers as investments in bonds and equities from US issuers. There is considerable issuance of dollar bonds by non-US issuer (see Fact 3 in Section [3]). Our estimate of European insurers' USD bonds holding is therefore likely conservative. Finally, we complement our sample of insurers with monthly statistics from Bank of Israel. We estimate Israeli insurers' USD investments from their total foreign investment portfolios and the typical share of USD in Israeli institutional investors' FX market activities.[10] We then estimate the breakdown

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[7]https://www.mckinsey.com/industries/financial-services/our-insights/the-life-journey-japan/ja-JP

[8]https://www.asiainsurancereview.com/Magazine/ReadMagazineArticle?aid=40056

[9]EIOPA data collection started in 2017. For 2013Q4 to 2017Q4, we use ECB's Securities Holdings Statistics (SHS) to estimate holdings of insurers in the 19 eurozone countries.

[10]Ben Zeev and Nathan (2022) find that 85.9% of Israeli institutional investors' FX swap flow volume is in dollars, and that 87.8% of their FX spot volume is done in dollars. Institutional investors include insurers

between USD equity and bonds using asset allocations in Israeli insurers' overall investment portfolio, also available from Bank of Israel.

**Foreign Pension Funds' Holdings**

We identify countries whose pensions have the largest investment portfolios (OECD (2020)) and study each in detail. The top five non-US countries: the U.K., the Netherlands, Australia, Switzerland, and Japan, can be grouped based on their industry structures. Japan and the Netherlands have highly concentrated pension markets, so we analyze filings from individual pension funds that make up the lion's share of these markets. The pension industries in Australia, Switzerland, and the U.K. is much more fragmented, so we analyze industry-level statistics compiled by industry groups or national authorities.

The Japanese pension fund that we study in detail is the Government Pension Investment Fund (GPIF). GPIF is similar to Social Security in the U.S., and it makes up 72% of Japan's public pensions, or the equivalent of 76% of all private retirement assets in Japan (ICI (2021)). We estimate GPIF's USD allocation by analyzing the benchmarks that managers retained by GPIF are required to target. The pensions industry in the Netherlands is also very concentrated: the two largest pension funds, ABP and PFZW, manage assets equivalent to 1.5 times those of the next 15 biggest combined,[11] or 50% of assets in all Dutch pension funds.[12] We obtain from ABP's and PFZW's annual reports their total assets, USD investments, and the split between USD equities and USD bonds.

For Australia, Switzerland, the U.K., Israel, and 10 mostly Latin American countries, we obtain statistics on pension funds published by the respective national or regional authority.

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and pension funds.

[11]https://www.investmentoffice.com/Pension_Funds/Netherlands/

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

These statistics allow us to track pension funds' total portfolio size and foreign investments. We then complement these statistics with various other datasets to estimate the share of USD investments in pensions' foreign portfolio; see Appendix Section A.2 for details.

**Other Sectors**

We study foreign mutual funds' allocations to USD by using a data set of holdings from open-ended funds and exchange-traded funds (ETF) domiciled in 64 non-US countries. Our security-level data are from Morningstar and are similar to data used in Maggiori, Neiman, and Schreger (2020) and Coppola et al. (2021). We estimate foreign bond holdings by aggregating bond securities denominated as USD, and estimate foreign equity holdings by obtaining each fund's share in U.S. equity investments from the Morningstar Direct platform.

We estimate holdings of USD securities by non-US banks using BIS Locational Banking Statistics (LBS). LBS provides quarterly data on the outstanding claims and liabilities of internationally active banks located in reporting countries. We focus on non-US banks' USD debt holdings.[13] We first estimate the difference between foreign banks' USD holdings and USD loans, and we then apply an adjustment to arrive at an estimate of debt securities holding. Our estimated series has a 0.98 correlation with LBS' confidential series on non-US banks' cross-border holdings of USD debt securities.[14]

We estimate non-US hedge funds' investments in U.S. equities by leveraging 13F reporting requirements, whereby institutional investment managers with at least $100 million in assets under management must disclose their equity holdings quarterly. The 13F filing classifies

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[13]We focus on holdings of debt securities by banks because these — along with loans — make up the preponderance of a typical bank's assets. It is much more capital intensive for banks to hold equity securities.

[14]This time series is confidential and available only to central banks. This information cannot be deduced from United States' reporting to the BIS because the U.S. reports only U.S. banks' loan and deposit positions and does not include debt securities positions.

whether a reporting entity is a hedge fund. We merge with Factset to determine the domicile of the fund.

To estimate foreign non-financial companies and households' USD holdings, we use the IMF's Coordinated Portfolio Investment Survey (CPIS) data. Of the 81 countries reported as having assets in the United States, 56 countries report their investment separately for the non-financial sector. Our estimate is therefore conservative: there could be countries who own assets in the U.S. but choose to not report, there could be investments by the non-financial sector that were not separately reported, and there could be USD investments in non-US countries.

Finally, we estimate the foreign official sector's holding of U.S. securities from TIC. Starting 2007, TIC reports securities held by the official sector in 237 countries separately for debt and equity. For years prior to 2007, we estimate the total as the sum of the official sector's holding of long-term debt and equity, provided by Bertaut and Judson (2014), and of short-term Treasury securities, as released by the Treasury's department. Our assumption is that the official sector — central banks, sovereign wealth funds, and other public financial agencies — do not obtain significant USD assets from non-US entities.

## 2.2 Estimate Foreign Investors' FX Hedging Practices

We next describe our methodology for studying foreign investors' hedging practices for USD FX exposure. We first estimate USD hedging activities by sector and by country, which we combine with our estimated investors' USD exposure to arrive at investor-specific hedge ratios. We next estimate the deviations from covered interest-rate parity in various currencies, which represent additional financial gains or costs to FX hedging.

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### 2.2.1 Hedging activities

Among the major sectors we study for USD security holdings, we focus the analysis of hedging activities on three sectors that employ active hedging strategies: insurances, pensions, and mutual funds.

Hedging in the banking sector and the official sector can be materially influenced by regulations or reserve considerations. On the one hand, any unhedged FX positions on banks' balance sheets are associated with hefty regulatory capital charges. Therefore, we estimate that the foreign banking sector fully hedges their FX risk to the first-order approximation, either through dollar liabilities or FX derivatives.[15] On the other hand, FX hedging by the official sector is likely to be minimal because its dollar holdings form its FX reserves and can be used for FX interventions, managing shortfalls in international financial obligations, and so forth.[16]

In contrast, currency hedging by insurances, pensions, and mutual funds likely reveal preferences for FX risk exposure. Mutual funds are not generally mandated to maintain a certain amount of FX exposure but they choose hedging strategies to attract investors with specific degrees of FX risk tolerance. Pensions and insurances can face foreign investment limits, above which further investments must be hedged back to domestic currencies. In Table 3, we summarize the foreign investment limits on pensions and insurances whose hedging strategies we study. At a glance, these limits seem generous and unlikely to be dictating pensions' and insurers' hedging decision; we discuss the implication of these limits on hedging in more detail in Section 4.

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[15]From the BIS LBS data, we estimate that 50% of banks' FX exposure is hedged through derivatives and the other 50% is hedged — or funded — with USD liabilities, including deposits and capital market borrowing.

[16]Conversations with the Government Pension Fund of Norway confirms that one of the largest sovereign wealth funds conducts no currency hedging.

## Foreign Insurance Companies' Hedging

We estimate Japanese insurers' hedging practice directly from company-level filings on FX derivatives positions, available at the seminual frequency Specifically, because we are interested in the management of long dollar positions, we estimate the total USD hedge as the sum of net forward USD sales positions and USD swaps.[17] The net forward position is the difference in notional between USD forward sold and USD forward bought. We exclude small positions in FX options.

We obtain hedging activities for Taiwanese and Israeli insurers from their respective central banks' monthly publications. The Central Bank of Republic of China's *Financial Statistics Monthly* reports the aggregate FX hedging undertaken by life insurers. Similarly, Bank of Israel's *Institutional Investors' Foreign Exchange Exposure* shows insurers' portfolio FX exposure before and after hedging. Through the Solvency II filings, European insurers disclosure their derivatives usage and FX risk exposures. Currently, we estimate hedging activities of European insurers using the insurance industry average hedge ratio.[18]

## Foreign Pension Funds' Hedging

We start with Japan's GPIF. Because GPIF invests its assets to target benchmarks, we estimate GPIF's hedging activities from its investments in benchmark-tracking USD assets that are explicitly hedged. To illustrate, investments in "FTSE US Government Bond Index (JPY hedged/JPY basis)" are considered hedged, whereas investments in "FTSE US Government Bond Index (no hedge/JPY basis)" are considered not hedged.

In the Netherlands, the two pension funds we analyze are ABP and PFZW. Both funds

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[17]This contrasts with the Japanese insurers' hedging activities reported by Liao and Zhang (2020), where the authors consider hedging of all foreign investments irrespective of currency.

[18]We will use the EIOPA Solvency II's hedge ratios after receiving data clearance.

disclose in their annual report their overall USD exposure and their net USD exposure after FX derivatives are factored in. We estimate their hedging activity as the difference between gross and net USD exposure. We make our estimates separately for bonds and for equities.

In Australia, we rely on the Australian Prudential Regulation Authority (APRA)'s *Quarterly Superannuation Performance*. This quarterly publication reports the aggregated amount of FX hedging done by regulated pension funds, separately for bonds and for equities.

The Swiss Federal Statistical Office's publication on pensions does not contain hedging activities. We use the industry aggregate hedge ratio from Swiss Pension Fund Study 2021 (Swisscanto Pensions (2021)) to estimate hedging activities. Hedging activities of Israeli pension funds are estimated in a manner that is similar to that for Israeli insurers. Finally, we estimate hedging activities of insurers in the UK and in the 10 mostly Latin American countries from the pensions industry's average hedge ratio.[19]

**Foreign Mutual Funds' Hedging**

We assess the hedging strategy of mutual funds at the share class level. Specifically, each share-class of a mutual fund in Morningstar reports its hedging status as completely hedged, partially hedged, or not hedged. In addition to relying on the self-reported currency hedging status, we also identify additional hedged share classes if their tracking benchmarks are currency-hedged, for example, "U.S. Corporate Bond EUR Hedged". We sum the AUM of all share-classes that are either completely hedged or partially hedged. Partially hedged is not common in the data. However, we are aware of the data limitation as we do not observe the exact hedge ratio of mutual fund investments.

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[19]The average is taken over the hedge ratio of Dutch pensions, Australian pensions, Swiss pensions, and Israeli pensions. We exclude GPIF from this calculation because GPIF did not engage in hedging until very recently and GPIF's rapidly increasing hedge ratio suggests that the historical absence of hedging was not necessarily a reflection of deliberate FX management.

### 2.2.2 Deviations from covered interest-rate parity

We measure the degree of deviations from covered interest-rate parity (CIP) using cross-currency basis, henceforth, CIP basis. Following convention (e.g., Du, Tepper, and Verdelhan (2018)), we define $X_{t,\tau}^{c,\$}$, the $\tau$-month tenor CIP basis of foreign currency $c$ vis-à-vis the USD as

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

and the log version as $x_{t,\tau}^{c,\$} = \ln\left(1 + X_{t,\tau}^{c,\$}\right)$. We use $R_{t,\tau}^{c}$ to denote the annualized spot gross $\tau$-month interest rate in foreign currency $c$ available at time $t$, and $R_{t,\tau}^{\$}$ for the corresponding interest rate in USD. We express exchange rates in units of foreign currency per USD. That is, an increase in the spot exchange rate at time $t$, $S_t$, is a depreciation of the foreign currency and an appreciation of the USD. The $\tau$-month forward exchange rate at time $t$ is $F_{t,\tau}$.

The classic CIP condition is that $x_{t,\tau}^{c,\$} = X_{t,\tau}^{c,\$} = 0$, which occurs when the forward exchange rate is priced based on the interest rate differential. If the cross-currency basis $x_{t,\tau}^{c,\$}$ is negative (positive), then the forward exchange rate is priced too low (high) relative to the prevailing interest rates. For foreign investors to hedge their USD exposure, they need to buy forward exchange rates that convert USD back to foreign currency. Lower (higher) forward exchange rates thus translate to more (less) expensive hedging.

We measure $R$ using IBOR in different countries, and focus on the one-month and three-month tenor because the prevailing hedging practice is to continuously roll over short-term hedges. We obtain daily data on IBOR and spot and forward FX rates from Bloomberg using London closing rates.

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## 2.3 Other data

We include several other data series to contextualize the foreign USD holding data we constructed. From BIS, we obtain the Triennial Central Bank Survey on Foreign Exchange and Derivatives Market Activities from 2001 through 2022. From the World Bank, we obtain public stock market capitalizations. From Preqin, we obtain the total assets under management (AUM) by U.S. private equity funds. From SIFMA, we obtain the amount of outstanding debt securities in the U.S., which is compiled from data from Bloomberg, the Federal Reserve, US Agencies, and the US Treasury.

Finally, from Bloomberg we obtain historical yields on the generic ten-year government bond yield in the U.S., Japan, Australia, Taiwan, and Israel. We use these data and the FX market data from Bloomberg to study the historical correlations between bond yields and currency returns.

# 3  Stylized Facts on Foreign USD Holdings

In this section, we present six stylized facts on foreign investors' aggregate dollar holdings and currency hedging patterns.

**Holdings Fact 1: Foreign investors show increasing preference for USD securities.**

Foreign holdings of USD securities reached $33.4B by the middle of 2021; see Figure 1. Our estimate is higher than the comparable estimate from TIC because we include the substantial USD debt issued by non-US residents. Our estimate is also nearly double the comparable estimates from CPIS, which relies on reporting countries to break out their cross-border holdings either by country or by currency.

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We estimate that foreign holdings of USD securities grew sixfold since the start of our analysis period in 2002 ($5.5B). This dramatic increase happened over a period where world GDP (ex-US) expanded less than three times. Indeed, the rapid increase in the amount of USD held by foreigners is only in part driven by foreigners' becoming wealthier; the increase also reflects foreigners' growing preference for dollar assets.

Figure 1: **Foreign holding of USD securities**
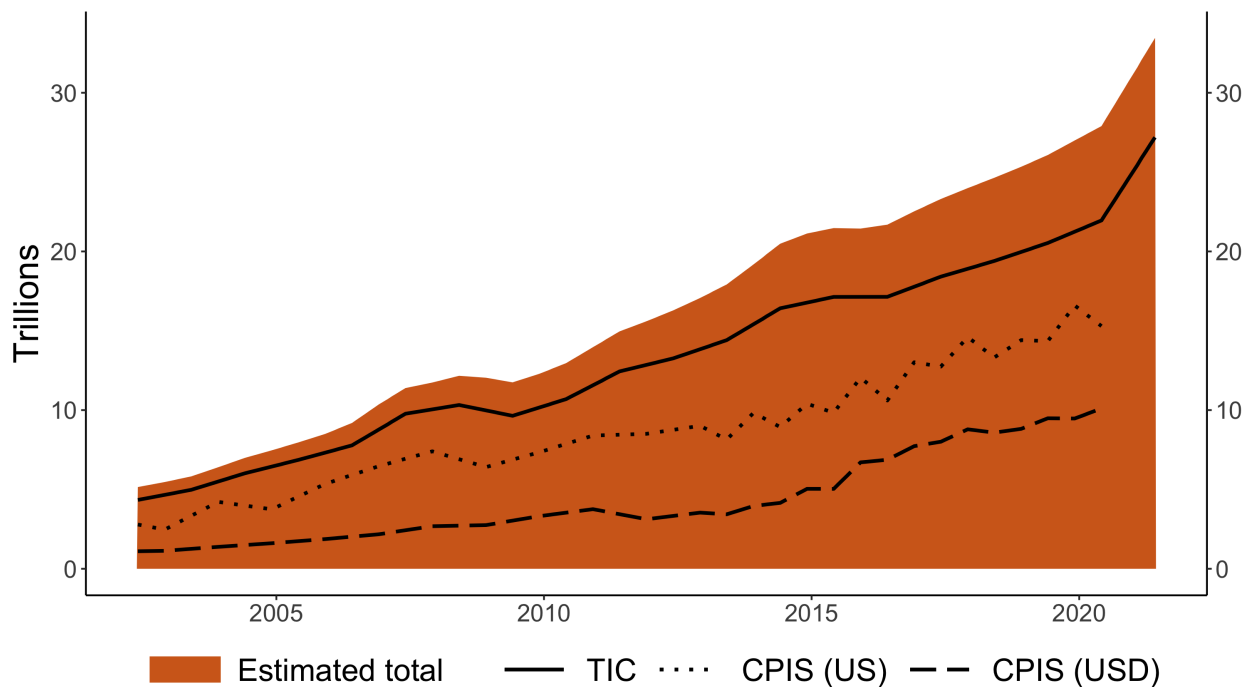


*Notes*: This figure plots different estimates of foreign holding of USD securities. Plotted in brown is our estimate, which builds on the TIC estimate but adjusts for foreign-issued USD securities and US-issued non-USD securities. The solid line is the TIC estimate of foreign holding of securities issued by US-residents. The dotted line is the CPIS estimate of foreign holding of securities issued by US-residents. The dashed line is the CPIS estimate of foreign holding of USD securities. The sample period is June 2002 to June 2021.

In Figure 2, we analyze the portfolio allocation to USD securities in three industries over time, defined as portfolio allocation as the ratio of USD bonds and equities to total

asset.[20] Panel (a) explores this allocation in the insurance sector. Allocation of total assets to USD securities by insurers in Japan, Taiwan, and Israel all show a marked increase after the Financial Crisis of 2007-09. Insurers in Taiwan, in particular, are allocating close to 50% of their portfolio to USD securities in recent years. The allocation to USD by insurers in the UK and EU regions (under the supervisory authority of EIOPA) have been stable, albeit at much lower levels: 12% in UK by the end of 2020, and just 4% in all EU by June 2021. The lower allocation to USD reflects EU insurers' preference for euro-denominated assets. Indeed, the share of USD within all foreign investments is about 20% for EU insurers. But EU insurers' total foreign investment is also modest. Insurers in the 19 Eurozone countries,[21] in particular, have only about 17% of their portfolios in assets from countries outside of the Eurozone.

Panel (b) shows portfolio allocation to USD debt and equities by pension funds. Almost all pension funds in the data show a marked increase in their share of USD assets.[22] By 2021, with the exception of Switzerland and the U.K., all other countries and regions in the data allocated between 20%-30% of their total assets to USD securities. Notably, the share of USD securities in Dutch pensions was around 30%. This stands in contrast to insurers in the Eurozone, who strongly favored euro-denominated assets.

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[20]In particular, our definition of allocation to USD securities does not include investments in real estate and infrastructure. Anecdotally, the share of USD real estate and infrastructure has also been rising, leading to an even higher overall portfolio exposure to USD assets.
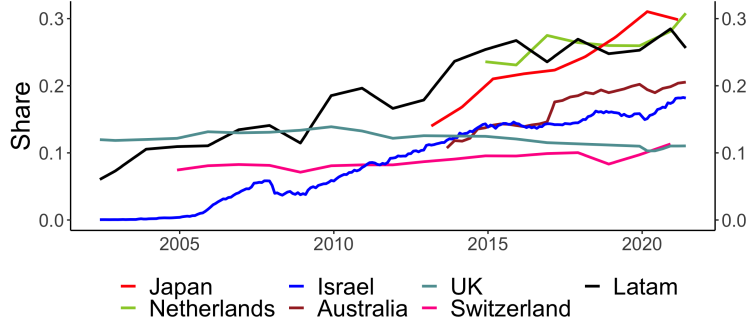
[21]Croatia adopted the euro on January 1, 2023. Because our data ends in June 2021, Croatia is not considered a Eurozone country.

[22]The only exception is the U.K., which shows a mild decrease in allocation post the Financial Crisis of 2007-09.
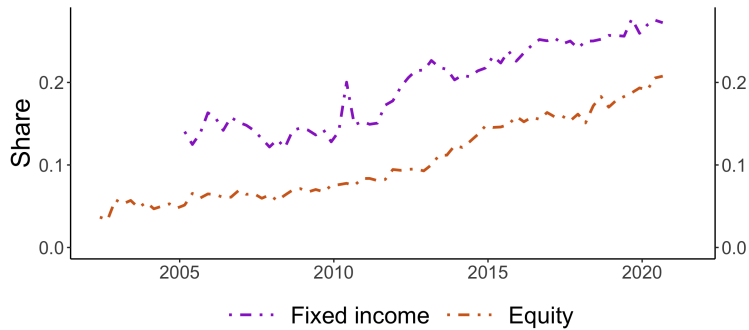
Figure 2: **Portfolio allocation to USD across industries**
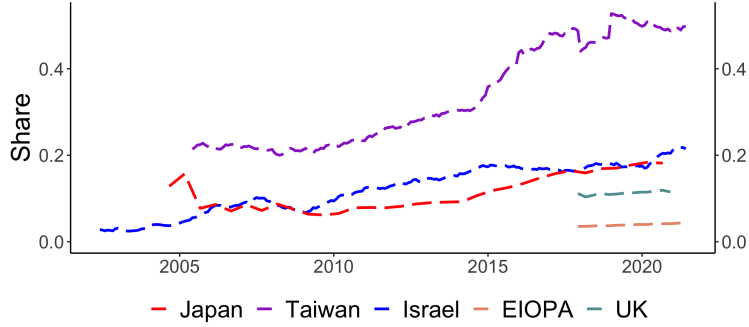


(a) **Insurance**



(b) **Pensions**



(c) **Mutual funds**

*Notes*: This figure plots foreign investors' portfolio allocation to USD asset. Allocation is estimated as the ratio of USD securities to total assets. See Table 2 for sample period coverage of different series. This figure is best viewed in color. Each country is plotted in the same color across different panels.

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Non-US mutual funds' allocations to USD appears in panel (c). Similar to the broad trends for insurance and pensions, the foreign mutual funds industry also steadily increased their allocation of their AUMs to USD. For equity mutual funds, USD allocation rose from 6% in September 2007, on the eve of the financial crisis, to 21% in September 2020. For fixed income mutual funds, USD allocations rose from 13% just before the financial crisis in 2007, to 27% in September 2020.

**Holdings Fact 2: Foreigners prefer holding USD bonds over equities.**

As illustrated in Figure 3, foreigners consistently hold more USD bonds than USD equities. The ratio of foreign-held bonds to equities was 2.7 in 2002, and foreign holdings of both bonds and equities increased over time. Yet the ratio of foreign-held bonds to equities still stood at around 2 in June 2020, before the run-up in equity market valuation in the second half of 2020. Since 2020, the bond-to-equity ratio has slipped down to 1.5, because the dramatic post-COVID bull market disproportionately increased equity valuations.

In Figure 4, we compare the two types of foreign-held USD securities to the respective total amount outstanding. We estimate total outstanding USD debt as the sum of outstanding US fixed income securities and USD cross-border debt issued by non-US residents. For equities, we estimate the total amount outstanding to be the sum of the market cap of U.S. listed stocks and AUM of U.S. private equity funds. Two trends emerge. First, foreign holdings make up an increasingly large share of the total amount outstanding, both in equity and in debt. Second, foreigners have consistently held a larger share of available USD bonds compared to US equities.

Figure 3: **Foreign USD holding by security type**
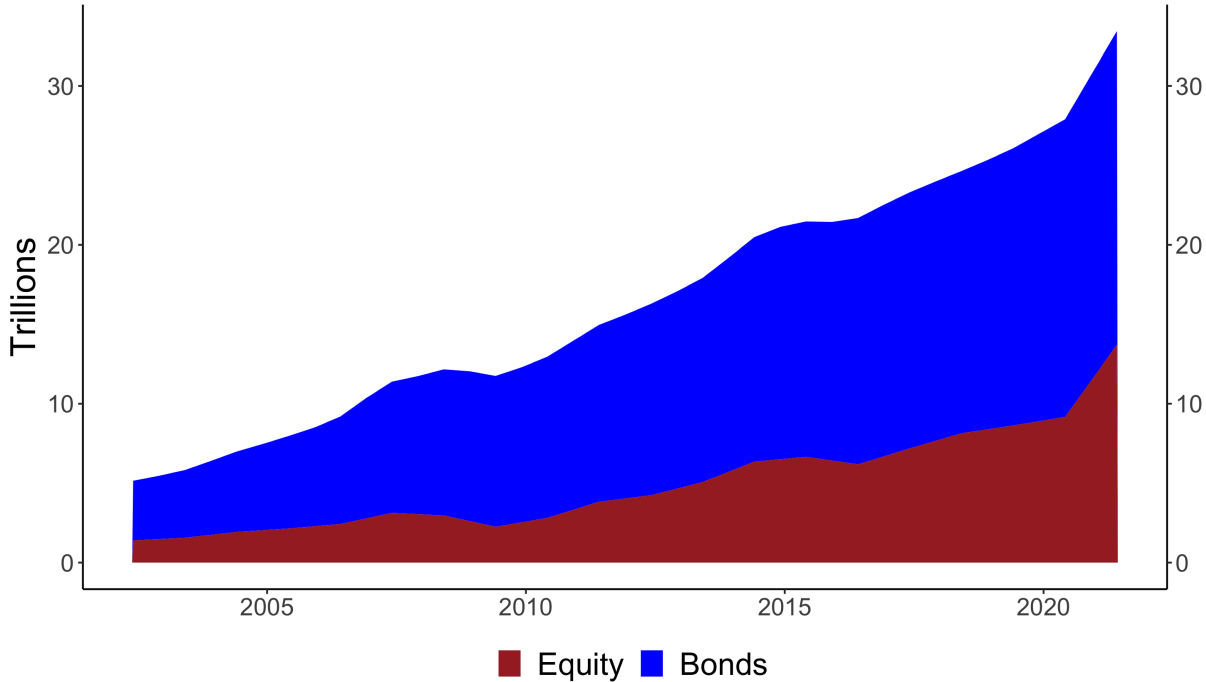


*Notes*: This figure plots estimated foreign-held USD securities by type. The sample period is June 2002 to June 2021.

Figure 4: **Foreign-held USD debt and equity as share of total outstanding**
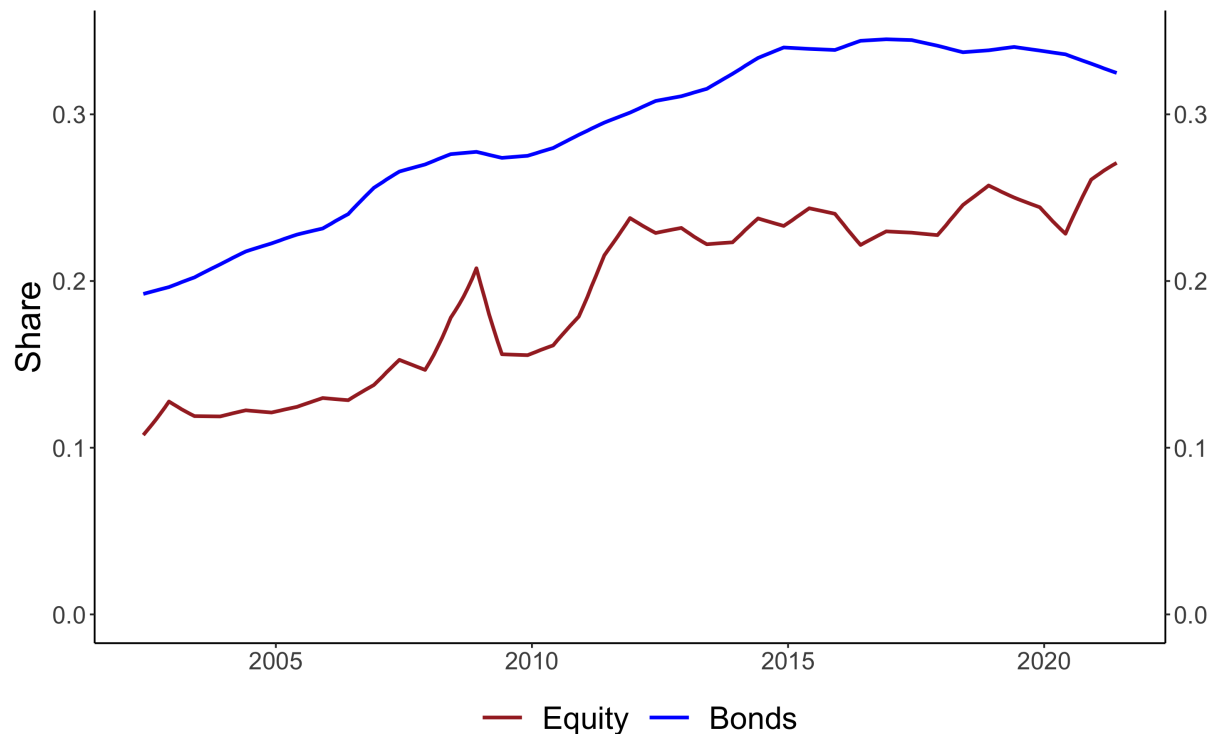


*Notes*: This figure plots the share of total USD bonds and USD equity held by foreign investors. Total USD bond holdings are estimated as outstanding US fixed income securities adjusted for foreign-issued USD bonds. Total USD equity is estimated as the sum of US public market capitalization and AUM of US private equity funds. Sample period is June 2002 to June 2021.

The preference for bonds over equities is particularly salient in the insurance, banking, and official sectors. We summarize the patterns of industry-specific USD holdings and share of debt in Table 1. Insurance companies hold 78% of their USD securities in bonds; in contrast, pension funds hold less than half of their USD securities in debt. This difference may be due to the more stringent regulatory requirements that insurers face, e.g., high capital charges of holding risky equities, which tilt insurers' portfolios to debt securities. The official sector also holds most of its USD in debt securities, reflecting conservative risk

management practices of FX reserve managers. Finally, the share of bonds is extreme in banking and hedge funds in our dataset — 100% and 0%, respectively — because our data is limited to banks' debt securities and hedge funds' equity investments. However, because of banks' funding structure, we believe that the preponderance of banks' asset holdings is indeed in debt.

Overall, Table 1 shows that significant demand for USD debt comes from the official sector, banking, and insurance.

**Holdings Fact 3: A large fraction of foreign investors' holdings of USD bonds is issued by non-U.S. issuers.**

In addition to U.S. issuers, foreign issuers also actively issue bonds denominated in USD. These foreign-issued USD bonds are disproportionately held by foreign investors.

In Figure 5, we examine the importance of foreign-issued USD debt securities. First, we consider non-US issued bonds as a share of total outstanding USD bonds. The dashed line indicates that this share doubled from 8.5% in 2002, to 17% in 2021. Second, we consider foreign-issued USD bonds as a share of foreign-held bonds. If foreign-issued USD bonds are equally appealing to U.S. investors and to foreign investors, then we would expect foreign investors to hold foreign-issued USD bonds in the same proportion as the share of foreign-issued in total outstanding USD bonds. Yet we find that the share of foreign-issued USD bonds in foreign portfolios, indicated by the solid line, is consistently about 20 percentage points higher than the share of foreign-issued USD bonds in the total available. These two trends together suggest that increasing foreign issuance goes hand-in-hand with increasing demand from foreign investors for USD bonds.

Figure 5: **Importance of USD debt issued outside of U.S.**
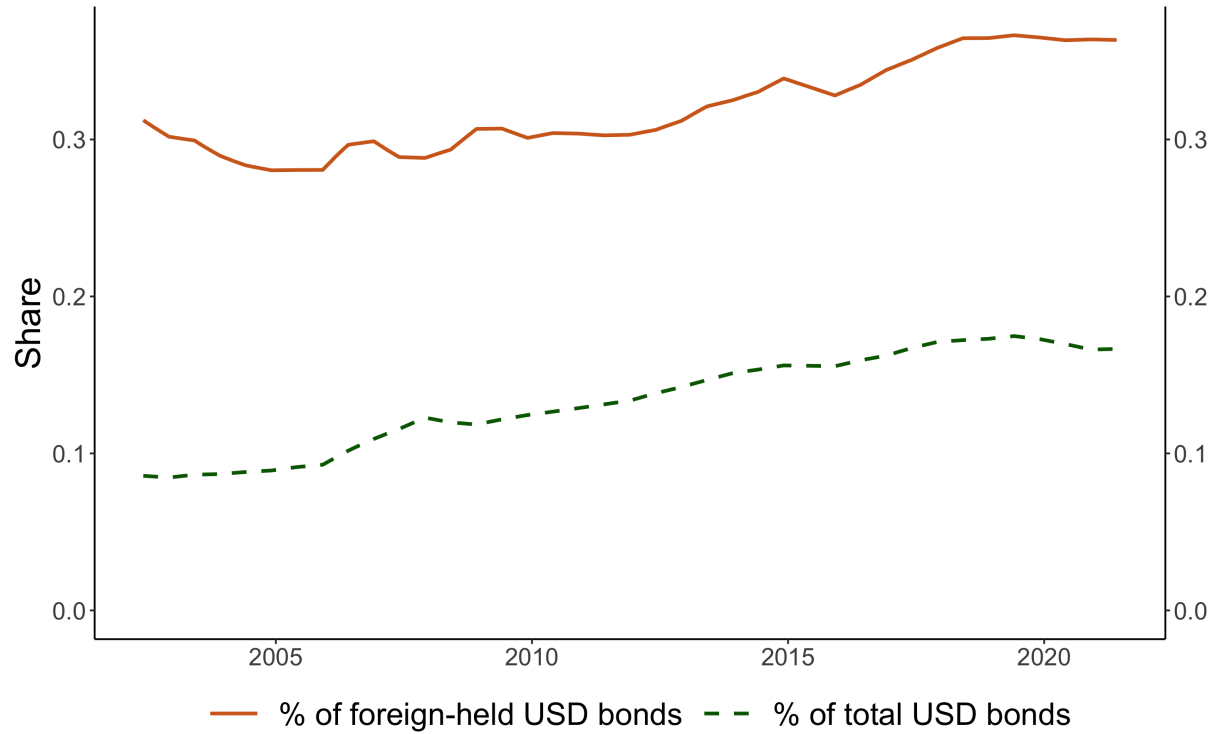
## 4    Stylized Facts on Foreign USD Hedging

Next we turn to three facts on foreign investors' dollar hedging. Throughout, we focus on hedge ratios to learn about investors' preference in FX management.

**Hedging Fact 1: There is a substantial amount of hedging in actively-managed industries, especially post-GFC.**

As of June 2020, we estimate that the hedge ratio for insurance, pensions, and mutual funds was 42%, 36%, and 22%, respectively. Collectively, hedging demand from these three sectors was almost $2 trillion. Figure 6 illustrates this snapshot of hedging practices. Our hand-collected, industry-level data account for over 60% of all foreign-held USD debt and equity, suggesting that our results are unlikely driven by small sample bias. We estimate the hedge ratio for each sector as outlined in Section 2.2; in particular, sector-specific hedge ratios are estimated as the mean hedge ratio in sample countries.

Across sectors, a new regime of hedging practices emerged following the Financial Crisis of 2007-09 (Crisis). In Figure 7, we plot the time series variation in hedge ratios for insurance, pensions, and mutual funds. Compared to pre-Crisis, the new regime of hedging practices differs along two dimensions. First, hedge ratios since 2015 have been very stable. Second, hedge ratios post-2015 stabilized at levels much higher than pre-Crisis, particularly for pensions and mutual funds, two industries which previously hedged at low absolute levels. Even for insurance, which had substantial hedging before the Crisis, the hedge ratio post-Crisis is higher on average.

Figure 6: **Foreign holding of USD by industry and hedging status, June 2020**
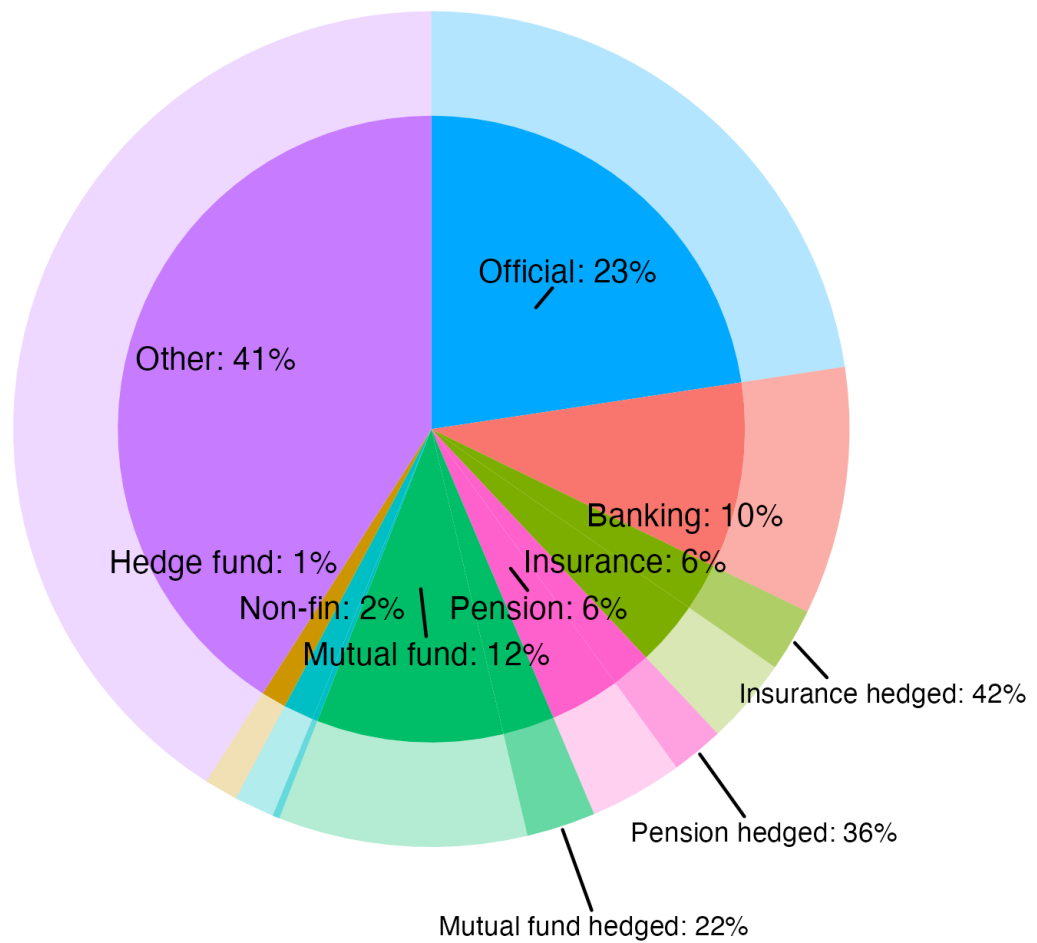


*Notes*: This figure illustrates foreign investors' USD holding and hedging, by industry, as of June 2020. Each slice of the inner pie corresponds to industry holding as a percentage of the total amount of USD securities held by foreign investors. Different shading on the outer ring corresponds to hedging status, with a darker shade indicating the percentage hedged and the lighter shade indicating the complement.

Figure 7: **USD hedging by industry**
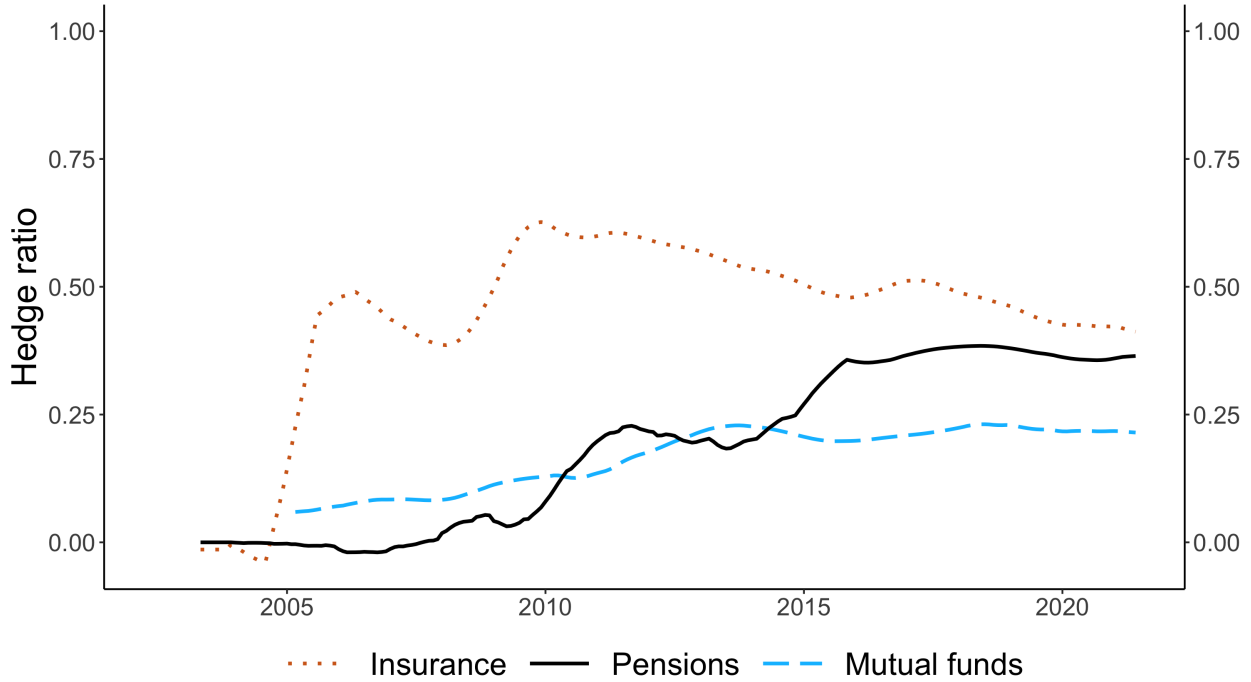
The increased hedging post-GFC is unlikely driven by regulations. Although mutual funds do not face regulations curtailing their FX exposure, pensions and insurers could be subjected to foreign investment limits. If a pension or an insurer is at its foreign investment limit, any additional investments abroad must be hedged back to domestic currency. In Table 3, we summarize the foreign investment limits for pensions and insurers whose hedging activities we study. Most countries in our sample do not impose investment limits on dollar securities. Examining the two that do, Taiwanese insurance and Swiss pensions, we note

that their limits are above their portfolio allocation to dollars (Figure 2),[23] suggesting that the observed hedging is not mechanically driven by regulations.

This new regime of hedging suggests that the demand for FX derivatives grew stronger over time, which is corroborated by data on FX derivative trading. In Figure 8, we plot the daily average turnover in FX markets using the BIS Triennial Central Bank Surveys. We are interested in trends in forward and FX swap transactions that have USD as one of the two transacting currencies. Forwards and FX swaps are the two most commonly traded FX derivatives and are the predominant tools used for hedging FX exposure.

As illustrated in Panel (a), transactions in these derivatives have been steadily increasing between 2001 and 2022. In particular, the increase in forward and FX swap transactions outpaced the increase in spot transactions. If the volume of spot transactions reflects the intensity of global trades and activities, then the pattern suggests that there has been an increase in hedging per unit of activity.

In Panel (b), we focus on transactions where one party is an institutional investor. Transactions by institutional investors most closely relate to hedging activities from insurance, pensions, and mutual funds.[24] Although the time series of institutional investor starts in 2014, the pattern is still suggestive that trading in FX derivatives typically used in hedging has been increasing and outpacing the concurrent increase in spot transactions.

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[23]Foreign investment limits apply also to non-dollar foreign investments. Taiwanese insurers' total foreign exposure is below the statutory limit of 65%. Swiss pensions' total foreign security exposure has been slightly above the limit of 30% since 2012, fluctuating between 30% and 35%.

[24]BIS uses the label "institutional investors" to mean "such as mutual funds, pension funds, insurance and reinsurance companies and endowments. Primary motives for market participation are to trade FX instruments eg for hedging, investing and risk management purposes. A common label for this counterparty category is 'real money investors'." BIS (2022)

Figure 8: **FX daily turnover against USD**
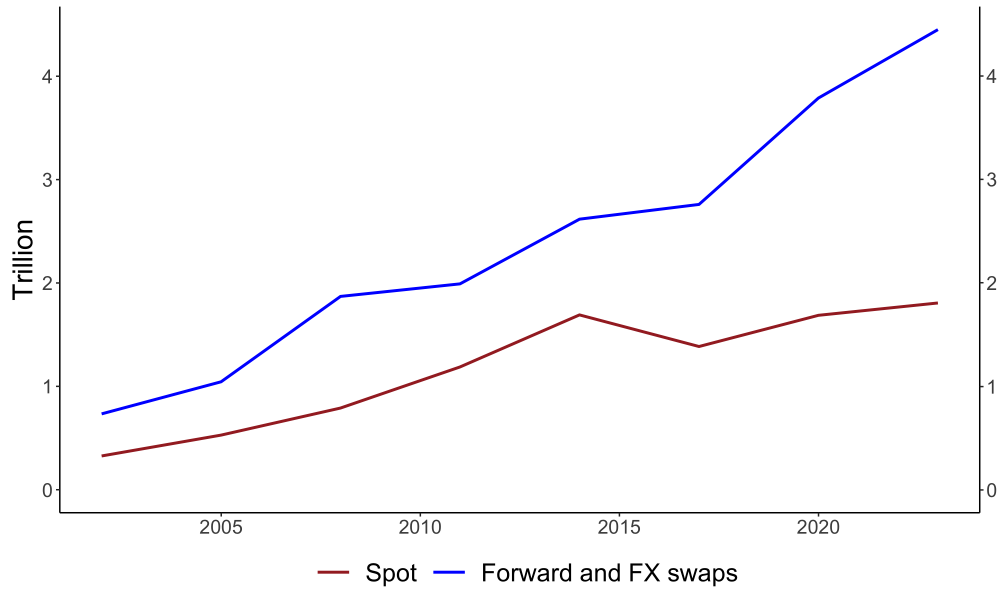


(a) **All volumes**
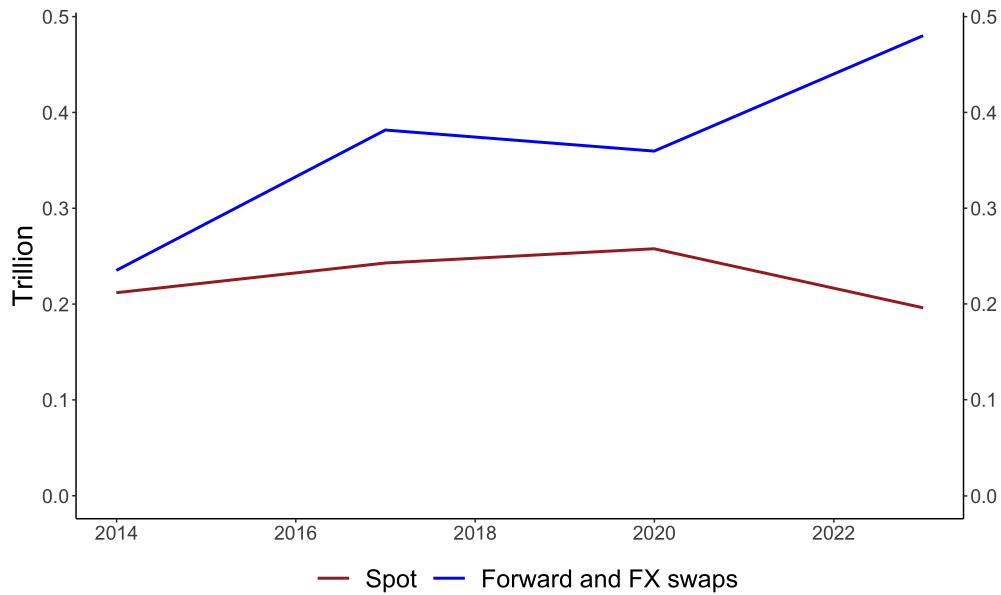


(b) **Institutional investors**

*Notes*: This figure plots the global daily volume of foreign exchange spot vs. 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. The survey is conducted triennially from 2001 to 2022 by BIS.

**Hedging Fact 2: Investors' hedging demand not deterred by rising hedging costs**

The covered interest-rate parity (CIP) condition governs the pricing of forward in a risk-neutral no-arbitrage world. CIP held before the Financial Crisis of 2007-09. Since then, deviations from CIP have been large and fluctuating. We leverage the detailed country-sector-level data that we constructed for the insurance and the pensions industries to calculate the financial costs of hedging associated with CIP deviations, and examine if this cost affects investors' hedging decision.

We estimate the financial cost of CIP deviations by combining hand-collected hedging activities with calculated CIP basis in different currencies. In Figure 9, we present the average annual cost of hedging for different countries and regions in the insurance and pensions industries. Different jurisdictions have different reporting frequencies; for each observation, we apply the average annualized 1-month (1M) CIP basis in the preceding period and then average all observations in a year to arrive at the annual cost of hedging due to 1M CIP deviations. To illustrate: we observe Taiwanese insurers' hedging activities monthly. At the end of each month, we apply the monthly average 1M USD-TWD CIP basis (annualized) to the reported hedging amount to arrive at the annual cost from CIP deviations — should the hedging amount and CIP basis both stay constant. We then average the annual costs assessed at each month-end of the year to arrive at the true average annual cost. The use of 1M CIP basis in this cost calculations assumes that investors use 1M forwards to hedge and continuously roll over short-term hedges, consistent with industry practices.

CIP deviations cause significant hedging costs. As Panel (a) illustrates, the additional hedging cost due to CIP deviations is in the billions for the insurance industry. Although the magnitude of this cost is less for pensions, Panel (b), it is still substantial. Take the Dutch pensions as an example: CIP-induced hedging costs rose to $0.6 billion in 2016, which is 1%

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of the total portfolio return earned by Dutch pensions that year. Overall, the total hedging cost due to CIP deviations amounted to $2.7 billion in 2020.

We note that we are applying the CIP deviations implied by Bloomberg quotes to the insurers and pensions. In practice, market power of dealers can make clients pay more than the inter-dealer spreads in the FX derivatives market (Hau, Hoffmann, Langfield, and Timmer (2021)). Therefore, our estimates may underestimate the actual cost of financial hedging.

Importantly, CIP-induced hedging costs show significant fluctuations over time, in stark contrast to the stable hedge ratios in Figures 7 and 11. In fact, hedging decisions seem to be minimally affected by rising CIP-induced hedging costs. From Panel (a) of Figure 9, we see that Taiwanese insurers incur huge costs by hedging. Yet as Panel (a) of Figure 10 illustrates, the amount that Taiwanese insurers hedge exhibits little negative correlation with the swinging hedging cost, and instead it shows a steady upward trend. Due to the steady hedging volume, the incurred hedging cost has a 0.63 correlation with the 1M USD-TWD CIP basis, see Panel (b). The co-movement between hedging costs and hedging volume suggests that the increasing hedging demand plays a role in driving up CIP deviations in countries with large USD-hedged institutional investors. We more systematically analyze the correlation between hedging and CIP deviations in Section 5.

Figure 9: **Cost of hedging due to 1M CIP deviations**
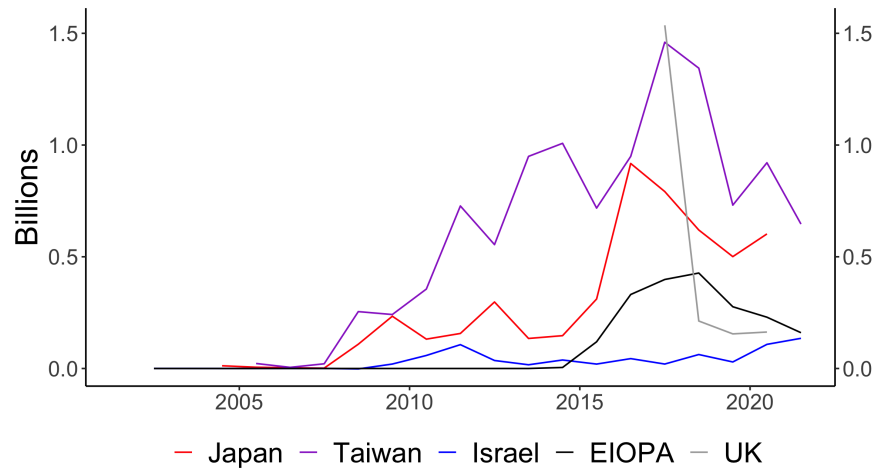


(a) **Insurance**
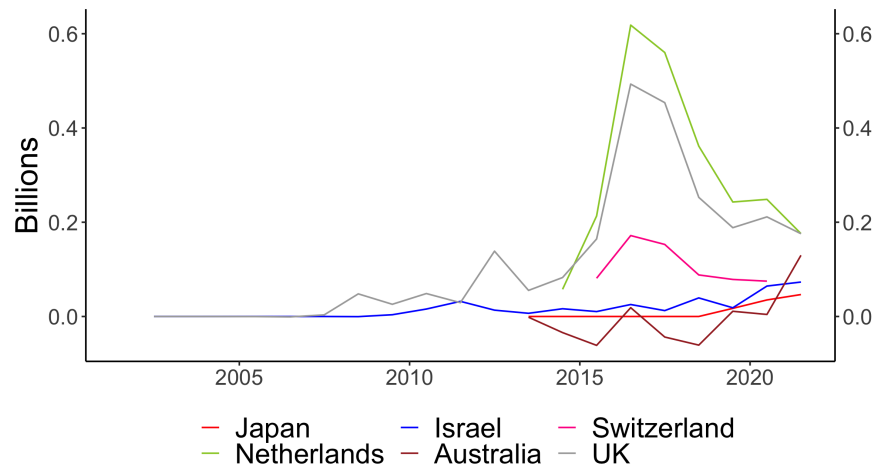


(b) **Pension**

*Notes*: This figure plots the annualized CIP-induced cost institutions incur to execute their USD hedge. The cost is estimated by assuming that the currency hedges are done by rolling over 1-month FX forward or swaps. CIP deviations are calculated using IBOR in respective currencies. This figure is best viewed in color. Each country is plotted in the same color across different panels.

Figure 10: **Taiwanese insurers' hedging**
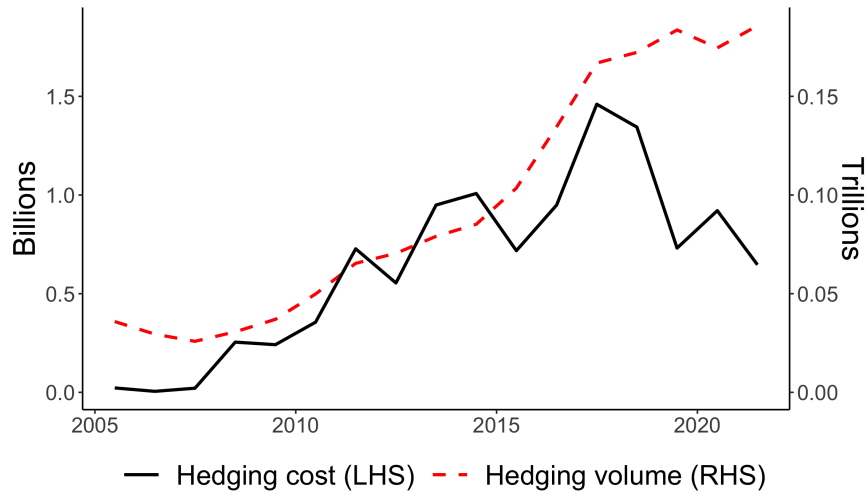
(a) **Hedging cost vs. hedging amount**
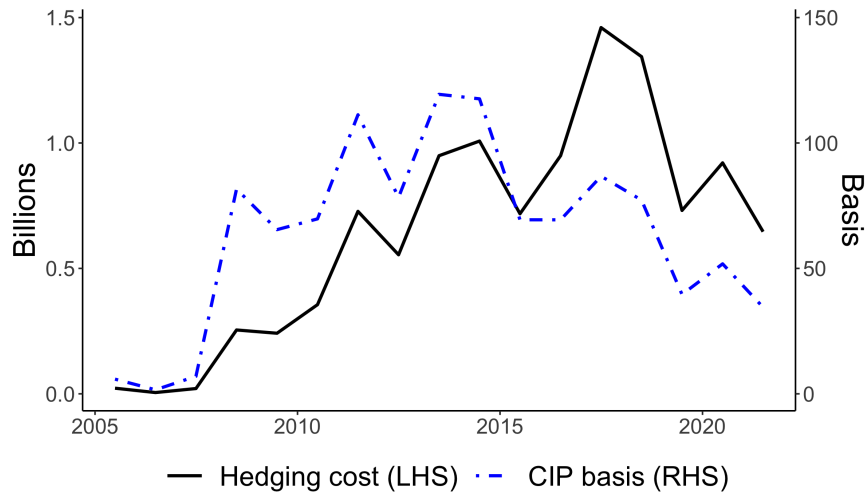
(b) **Hedging cost vs. CIP basis**

*Notes*: This figure plots Taiwanese insurers' CIP-induced hedging cost against their hedging volume and CIP basis. Hedging cost is annualized and is estimated by assuming that the currency hedges are done by rolling over 1-month FX forward or swaps. CIP basis is calculated using TAIBOR.

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**Hedging Fact 3: Hedging behaviors show persistence and heterogeneity across sectors, geographies, and security types**

While most countries and sectors have been increasing their hedge ratio, there is considerable heterogeneity in the levels of the observed hedge ratios.

Figure 11 illustrates hedge ratios across different countries for insurance, pensions, and mutual funds. Panel (a) plots the hedge ratio of insurers in Japan, Taiwan, and Israel. The hedge ratios in these three countries differed wildly prior to the Financial Crisis of 2007-09. Since that time, the hedge ratios have converged, yet there is still dispersion. By the end of 2020, Japanese insurers were hedging at 51%, while Taiwanese insurers were hedging at 34%. Of note is the steady decline in Taiwanese insurers' hedge ratio, which contrasts with all the other series in our data. The declining hedge ratio is likely in response to the enormous volume of USD in Taiwanese insurers' portfolios. As shown in Panel (a) of Figure 2, Taiwanese insurers' portfolio allocations to USD rose from 20% pre-Crisis, to 50% in recent years. Indeed, the dollar amount hedged by Taiwanese insurers never ceased to increase over our sample period.

Heterogeneity in hedge ratios is quite evident in the cross-country comparison for pensions, illustrated in Panel (b). While Israel, Australia, and Switzerland stabilized their respective hedge ratios at between 30% and 40%, the Netherlands hedged close to 70% of its pension portfolio while Japan hedged just 6% by 2021. Hedging heterogeneity is also present within mutual funds. In Panel (c), we present the hedge ratio of the 64 countries in our mutual fund sample by security type, to highlight the differences. Compared to equity mutual funds, which hedge about 5% of their US exposure, fixed income mutual funds hedge 44% of their USD exposure.[25]

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[25]We calculate hedged fixed income AUM based on share-class-level indicators. These indicators are

The fact that the FX hedge ratio is higher for bonds than for equities persists beyond mutual funds, consistent with the theoretical prediction in Campbell, Serfaty-De Medeiros, and Viceira (2010). We explore the difference in equity vs. bond hedge ratios in Figure 12. Here, we plot bond and equity hedge ratios for mutual funds, Japanese pensions, Dutch pensions, and Australian pensions. On the one hand, it is universally true that bonds are hedged at higher ratios than equities. On the other hand, some investors hedge even bonds at very modest levels (e.g., Japanese pensions), and some investors hedge even equities at rather elevated levels (e.g., Dutch pensions).

"completely hedged", "partially hedged", and "not hedged". Conservatively assuming that "partially hedged" are nominal and hedge basically nothing, the hedge ratio for fixed income mutual fund would still be 35%, much higher than equity mutual funds.

Figure 11: **USD hedging across industries**
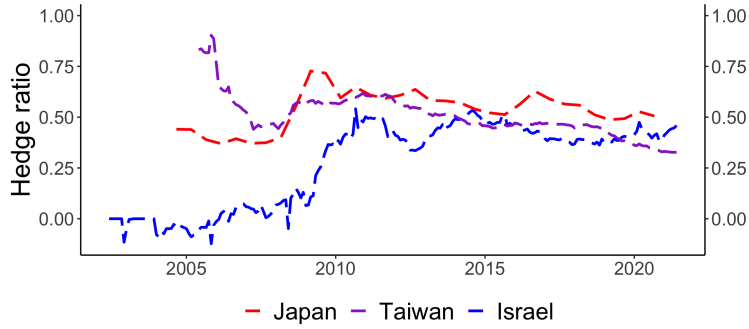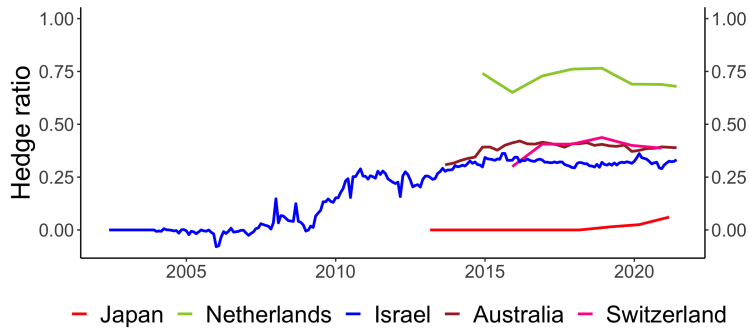
(a) **Insurance**
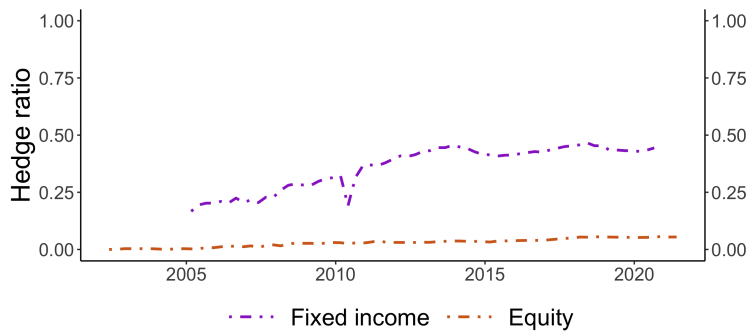
(b) **Pension**

(c) **Mutual funds**

*Notes*: This figure plots the hedge ratio of different countries in the insurance, pension, and mutual fund industry. This figure is best viewed in color. Each country is plotted in the same color across different panels.

Figure 12: **USD hedging by security type**



(a) **Mutual funds**

(b) **Australian pensions**

(c) **Dutch pensions**

(d) **Japanese pensions**
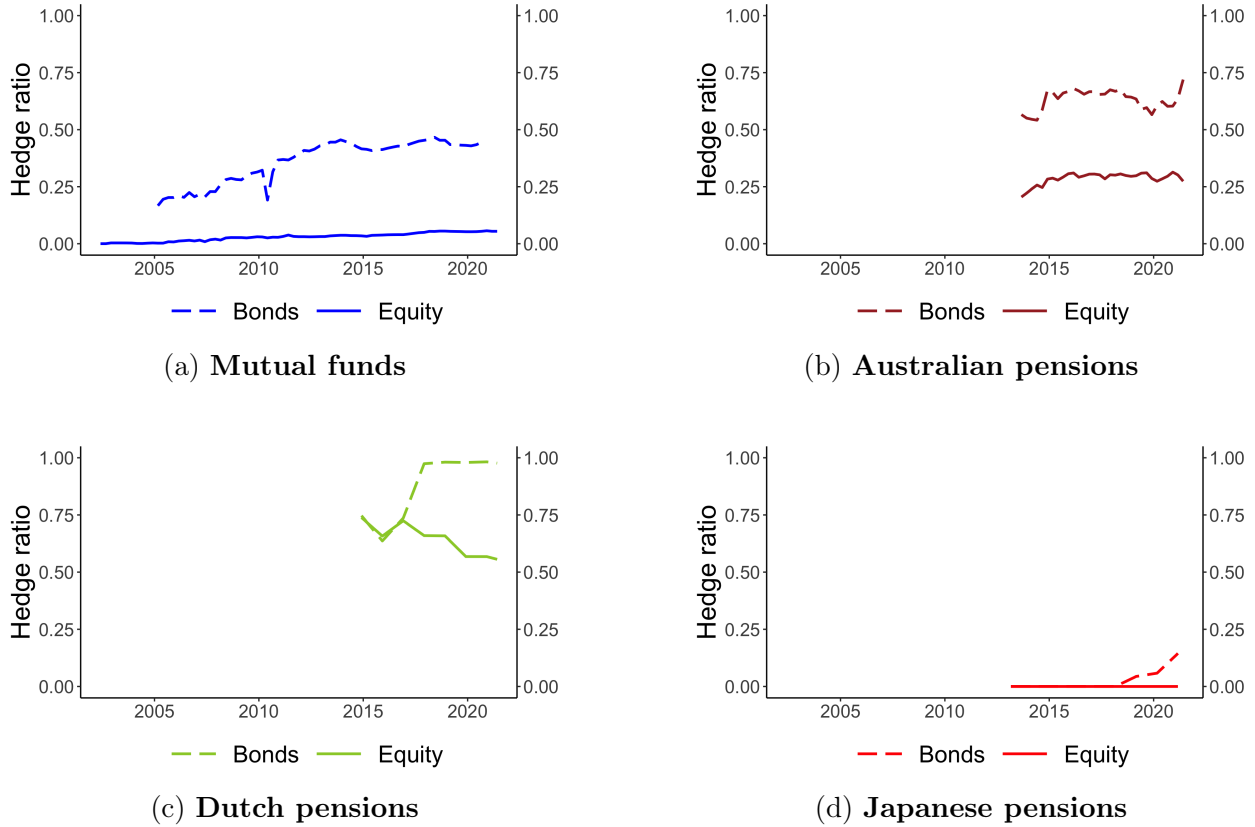
*Notes*: This figure plots hedge ratios for USD bonds vs. for USD equity in mutual funds, Australian pensions, Dutch pensions, and Japanese pensions. See Section 2.2 for the estimation methodology of hedge ratios. See Table 2 for sample period coverage of different series.

Examining the hedge ratios across countries, sectors, and security types, it appears that the leading pattern is the stability in hedge ratios post-2015. In contrast, little can be said of a dominant hedging strategy shared by all foreign investors.

# 5  Optimal Portfolio in Theory and in Practice

Foreign investors invest heavily in dollar-denominated securities and they hedge a substantial amount of their USD FX exposure. At the same time, there is considerable heterogeneity in how investors allocate and hedge USD. In this section, we evaluate investors' empirical portfolio choices against a mean-variance optimizing agent's optimal portfolio.

## 5.1  Optimal portfolio allocation

We study a mean-variance investor allocating his portfolio between domestic bonds and US bonds. The foreign investor chooses the share of his portfolio invested in the US bonds, and decides whether to take the currency risk associated with the USD bonds.

### 5.1.1  Return Definitions

We denote the log excess return on the local currency bond in the foreign country as

$$rx_{t+1}^b = r_{t+1}^b - rf_t,$$

where $r_{t+1}^b$ is the log return on the local currency bond between $t$ and $t+1$ and $rf$ is the local currency risk free rate. Similarly, we denote the log USD excess return on the USD bond as

$$rx_{t+1}^{\$b} = r_{t+1}^{\$b} - rf_t^\$,$$

where $r_{t+1}^{\$b}$ is the log USD return on the USD bond between $t$ and $t+1$ and $rf_t^\$$ is the USD risk free rate.

The foreign investor cannot directly earn $rx_{t+1}^{\$b}$ directly, the local currency return on

holding the USD bond depends on the currency hedging strategy. If the foreign investor does not hedge the currency risk, the unhedged excess returns of investing in the USD bond is given by

$$
\begin{aligned}
rx_{t+1}^{\$b,NH} &= r_{t+1}^{\$b} + \Delta s_{t+1} - rf_t \\
&= rx_{t+1}^{\$b} + (rf_t^{\$} + \Delta s_{t+1} - rf_t) \\
&\equiv rx_{t+1}^{\$b} + rx_{t+1}^{FX},
\end{aligned}
$$

which is equal to the sum of the log excess returns on the USD bond and the currency returns of going long the USD risk-free rate, and shorting the local currency risk-free rate.

If instead, the local investor decides to hedge the currency risk of the USD bond, and then the hedged return over the local currency risk free rate becomes

$$
\begin{aligned}
rx_{t+1}^{\$b,H} &= r_{t+1}^{\$b} + (f_t - s_t) - rf_t \\
&= rx_{t+1}^{\$b} + [rf_t^{\$} + (f_t - s_t) - rf_t] \\
&= rx_{t+1}^{\$b} + x_t.
\end{aligned}
$$

Therefore, the hedged return for the foreign investor is equal to the sum of the log USD excess return and the cross-currency basis. A negative cross-currency basis reduces hedged returns for foreign investors in USD bonds.

### 5.1.2  Portfolio Optimization

We solve a standard mean-variance for the foreign investor with CARA utility with the risk aversion parameter $\gamma$. We let $w_{US}$ denote the portfolio share in total USD bonds, and $w_{NH}$

denote the portfolio share in unhedged USD bonds; we therefore have the portfolio share in the hedged USD bonds given by $w_{US} - w_{NH}$.

The investor chooses $w_{US}$ and $w_{NH}$ to maximize his utility:

$$\max_{w_{US}, w_{NH}} \mathbb{E} r x_{t+1}^P - \frac{\gamma}{2} \mathbb{V}(r x_{t+1}^p),$$

where $r x_{t+1}^P$ is the log excess return of the entire portfolio given by:

$$
\begin{aligned}
r x_{t+1}^P &= (1 - w_{US}) r x_{t+1}^b + w_{NH}(r x_{t+1}^{\$b} + r x_{t+1}^{FX}) + (w_{US} - w_{NH})(r x_{t+1}^{\$b} + x_t) \\
&= (1 - w_{US}) r x_{t+1}^b + w_{US} r x_{t+1}^{\$b} + w_{NH} r x_{t+1}^{FX} + (w_{US} - w_{NH}) x_t.
\end{aligned}
$$

The expected return and the variance of the portfolio are:

$$
\begin{aligned}
\mathbb{E}[r x_{t+1}^P] &= (1 - w_{US}) \mathbb{E}[r x_{t+1}^b] + w_{US} \mathbb{E}[r x_{t+1}^{\$b}] + w_{NH} \mathbb{E}[r x_{t+1}^{FX}] + (w_{US} - w_{NH}) x_t, \\
&\equiv (1 - w_{US}) \overline{rx}^b + w_{US} \overline{rx}^{\$b} + w_{NH} \overline{rx}^{FX} + (w_{US} - w_{NH}) x, \\
\mathbb{V}(r x^p) &= (1 - w_{US})^2 \sigma_b^2 + w_{US}^2 \sigma_{\$b}^2 + w_{NH}^2 \sigma_{FX}^2 \\
&\quad + 2 w_{US}(1 - w_{US}) \sigma_{b,\$b} + 2 w_{US} w_{NH} \sigma_{\$b,FX} + 2(1 - w_{US}) w_{NH} \sigma_{b,FX},
\end{aligned}
$$

where $\bar{x}$ is the expected return on $x_{t+1}$, $\sigma_{A,B}$ is the covariance between asset A's return and asset B's return, and $\sigma_C^2$ is the variance of asset C's return. By extension, $\sigma_{b-\$b}^2$ is the variance of the difference between $rx_b$ and $rx_{\$b}$. Note that while the portfolio's expected return depends linearly on CIP basis, $x$, its variance does not. CIP basis is determined at time $t$ and therefore does not contribute to the conditional variance.

Solving the investor's first-order conditions, we derive his optimal portfolio allocations:

$$w_{US}^* = \frac{(\sigma_{\$b,FX} - \sigma_{b,FX})(\overline{rx}^{FX} - x - \gamma\sigma_{b,FX}) + \sigma_{FX}^2(\overline{rx}^b - \overline{rx}^{\$b} - x + \gamma\sigma_{b,\$b} - \gamma\sigma_b^2)}{\gamma(\sigma_{b,FX} - \sigma_{\$b,FX})^2 - \gamma\sigma_{FX}^2\sigma_{b-\$b}^2},$$

$$w_{NH}^* = \frac{\gamma\sigma_{b,FX}(\sigma_{\$b}^2 - \sigma_{b,\$b}) + \gamma\sigma_{\$b,FX}(\sigma_b^2 - \sigma_{b,\$b}) + (\sigma_{b,FX} - \sigma_{\$b,FX})(\overline{rx}^b - \overline{rx}^{\$b} - x) - (\overline{rx}^{FX} - x)\sigma_{b-\$b}^2}{\gamma(\sigma_{b,FX} - \sigma_{\$b,FX})^2 - \gamma\sigma_{FX}^2\sigma_{b-\$b}^2}$$

### 5.1.3 Comparative Statistics

The optimal portfolio allocation depends on the excess return of assets, the covariance between asset returns, and the investor's risk aversion. To see how the optimal portfolio allocation is affected by asset returns, we examine the partials of optimal portfolio weights with respect to the expected excess return differential between USD and local bonds, $(\overline{rx}^{\$b} - \overline{rx}^b)$, expected currency return $(\overline{rx}^{FX})$, and CIP basis $(x)$.

We first derive the comparative statics for optimal USD bond share:

$$\frac{\partial w_{US}^*}{\partial \overline{rx}^{\$b} - \overline{rx}^b} = \frac{-\sigma_{FX}^2}{\gamma(\sigma_{b,FX} - \sigma_{\$b,FX})^2 - \gamma\sigma_{FX}^2\sigma_{b-\$b}^2}$$

$$\frac{\partial w_{US}^*}{\partial \overline{rx}^{FX}} = \frac{\sigma_{\$b,FX} - \sigma_{b,FX}}{\gamma(\sigma_{b,FX} - \sigma_{\$b,FX})^2 - \gamma\sigma_{FX}^2\sigma_{b-\$b}^2}$$

$$\frac{\partial w_{US}^*}{\partial x} = \frac{\sigma_{b,FX} - \sigma_{\$b,FX} - \sigma_{FX}^2}{\gamma(\sigma_{b,FX} - \sigma_{\$b,FX})^2 - \gamma\sigma_{FX}^2\sigma_{b-\$b}^2}$$

Similarly, we can derive the comparative statics for optimal unhedged USD bond share:

$$\frac{\partial w_{NH}^*}{\partial \overline{rx}^{\$b} - \overline{rx}^b} = \frac{\sigma_{\$b,FX} - \sigma_{b,FX}}{\gamma(\sigma_{b,FX} - \sigma_{\$b,FX})^2 - \gamma\sigma_{FX}^2\sigma_{b-\$b}^2}$$

$$\frac{\partial w_{NH}^*}{\partial \overline{rx}^{FX}} = \frac{-\sigma_{b-\$b}^2}{\gamma(\sigma_{b,FX} - \sigma_{\$b,FX})^2 - \gamma\sigma_{FX}^2\sigma_{b-\$b}^2}$$

$$\frac{\partial w_{NH}^*}{\partial x} = \frac{\sigma_{b-\$b}^2 + \sigma_{\$b,FX} - \sigma_{b,FX}}{\gamma(\sigma_{b,FX} - \sigma_{\$b,FX})^2 - \gamma\sigma_{FX}^2\sigma_{b-\$b}^2}$$

In general, the investor's optimal portfolio allocation depends on the covariance structure between the three asset returns. It is therefore an empirical question what the optimal portfolio responses are for investors in different countries.

Assuming a stationary covariance structure between returns, we empirically estimate the covariance between $rx^{\$b}$ and $rx^b, rx^{FX}$ in Japanese yen (JPY), Australian dollar (AUD), Taiwanese dollar (TWD), and Israeli sheikl (ILS). We focus on annualized one-month (1M) holding period excess returns for US ten-year (10Y) government bonds, domestic 10Y government bonds, and spot FX gains. Specifically,

$$rx_{t+1}^b = 12(p_{9\frac{11}{12}Y,t+1M} - p_{10Y,t}) - r_{1M}$$

$$\approx y_{10Y,t} - r_{1M,t} - 119(\Delta y_{10Y,t+1})$$

$$rx_{t+1}^{FX} = (rf_t^{\$} - rf_t) + \Delta 12 s_{t+1}$$

Our estimation period is the post-Crisis decade from 2010 July to 2022 August. We use month-end non-overlapping returns and we proxy both $r_{1M}$ and $rf_t$ with 1M IBOR in the

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appropriate currency. Because we take the perspective of a domestic investor, exchange rates are stated as USD per CCY, where a positive $\Delta s_{t+1}$ corresponds to the domestic currency strengthening.

Our estimates point to optimal portfolio responses as laid out in Table 4. The denominator in the comparative statics is all negative; hence, $\frac{\partial w^*_{US}}{\partial \overline{rx}^{\$b} - \overline{rx}^b}$ and $\frac{\partial w^*_{NH}}{\partial \overline{rx}^{FX}}$ have unambiguously positive signs across currencies. These predictions are intuitive: if there is higher expected excess return in the US, then investors would allocate more of their portfolios to the US. Similarly, if the expected return on going long USD is high, then investors would want to have more of their portfolios unhedged.

The optimal response in other cases depends on the relative covariance between currency and domestic vs. US bond returns. For example, the sign of $\frac{\partial w^*_{NH}}{\partial rx^{\$b} - rx^b}$ depends on whether currency return covaries more positively with domestic bonds or US bonds. Evidently, for JPY and AUD, currency returns are less positively correlated with US bond returns, making currency exposure a natural hedge to US bond investment. Therefore, $\frac{\partial w^*_{NH}}{\partial \overline{rx}^{\$b} - \overline{rx}^b} > 0$. Conversely, when US bond return goes up, Taiwanese and Israeli investors would want to hedge more because their respective currency returns positively covary with US bond returns, or $\frac{\partial w^*_{NH}}{\partial \overline{rx}^{\$b} - \overline{rx}^b} < 0$.

Finally, we note that $\frac{\partial w^*_{NH}}{\partial x}$ is uniformly negative. This result is intuitive: if hedging costs more in the form of a more negative CIP basis, then all else equal, an investor would leave more of his portfolio exposed to currency risk. Because $\frac{\partial w^*_{NH}}{\partial x} = \frac{\partial w^*_{NH}}{\partial rx^{\$b} - rx^b} - \frac{\partial w^*_{NH}}{\partial rx_{FX}}$, $\frac{\partial w^*_{NH}}{\partial x} < 0$ also reflects that in hedging decisions, the volatility of currency return dominates whether a currency serves as a natural hedge.

## 5.2 Empirical portfolio allocation

We now compare institutional investors' empirically observed portfolios to the mean-variance investor's optimal portfolio. We focus on five groups of institutional investors: Japanese insurers, Australian pensions, Taiwanese insurers, Israeli insurers, and Israeli pensions. We have portfolio snapshots of these investors at comparatively higher frequencies, which gives us more observations and analytical power.

There are several challenges in taking the model predictions to data. First, we need a proxy of investors' expected returns. We assume that $\overline{rx} = y_{10Y,t} - rf_t$, or that the expected return on holding bonds is equal to the spread between 10Y government bond yield and the risk-free rate, the latter of which we proxy with 1M IBOR. We moreover assume that $\overline{rx}^{FX} = f(s_t), f'(s_t) > 0$, or that the expected return on currencies is an increasing function of the current spot rate due to momentum. Second, because the model predictions are based on a covariance structure estimated using US and domestic government bond yields, we are implicitly assuming that the return profile of government bonds sufficiently captures that of the much broader investment universe available to the investor. In particular, investors are observed to invest in both equity and debt, though investors in our sample, especially the three insurers, maintain high ratios of debt investment (Table 1). Finally, there is a strong secular trend in increased USD allocation. We therefore consider the relationship between changes in USD allocation and changes in various returns.

Table 5 summarizes the comparison between the theoretic prediction and the empirical portfolio for the overall allocation to USD securities. Red indicates that the empirical observation coheres with the theoretical prediction. Asterisks denote the statistical significance of the estimates. In general, investors behave in line with the model prediction. The predictive power is particularly strong for spot exchange rate, suggesting that currency return is

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salient in the decision to invest abroad. The yield slope of USD bonds is sometimes helpful in explaining investors' portfolio allocations. However, the sign for JPY and TWD are statistically significantly estimated to be contrary to the theoretical predictions. This is because the US yield spread materially narrowed since the first post-Crisis interest rate increase in December 2015. Yet allocation by Japanese and Taiwanese insurers to USD has not abated.

Table 6 summarizes a similar comparison for allocations to non-hedged USD securities. Investors conform much less to theoretical predictions when it comes to managing currency exposure. The most striking result is the relationship between CIP basis and FX exposure. The theory predicts that when 1M basis is more negative, it is more costly to hedge and investors would the optimally leave more of the portfolio unhedged. In reality, investors' empirical portfolios behave in the exact opposite direction. This is consistent with the stylized fact documented in Section 4, where investors' hedging decisions do not seem to be negatively affected by CIP deviations (Hedging Fact 2). One potential reason for this conspicuous divergence is that shocks to investors' hedging demand are more powerful than shocks to supply of FX forwards, leading to concurrent increase in price and quantity. This suggests that investors' hedging demand could be what *leads* to CIP deviations.

## 6  Conclusion

We collect an immense array of industry statistics and company filings to study foreign investors' holding and hedging of USD securities. We first document a sixfold increase in foreign investors' USD holding. This increase is driven by investors' increasing portfolio allocation to USD securities. Second, we describe foreign investors' preference for USD bonds over equities, driven predominantly by insurance companies, banks, and the official sector. Third, we find that USD bonds issued by non-U.S. issuers account for a disproportionately

high share of foreign investors' portfolios. Finally, we investigate foreign investors' FX management, as our unique dataset allows us to examine hedging activity relative to investors' overall USD exposure. We find that hedge ratios are in general high post-GFC despite widening CIP deviations. At the same time, we show heterogeneity in hedge ratios across security type, industry, and country. We estimate that the annual volume of hedging done by insurance companies, pension funds, and mutual funds amount to $2 trillion, and that between 2017 and 2020, CIP-induced financial costs to hedging was $3.4 billion per annum for insurance companies and pension funds.

We empirically test whether investors' portfolio allocations are consistent with a mean-variance investor's optimal portfolio. We find that investors' allocation to USD securities is largely in-line with theoretical predictions but that investors' hedging decisions show distinct deviations. In particular, investors hedge more when CIP deviations are large, suggesting that institutional investors' demand is more a cause than an effect of CIP deviations.

Our results represent the first comprehensive and empirical investigation into foreign investors' behavior toward USD securities. As the dollar is the preeminent currency in global finance and trade, it is important to understand global investors' preferences for dollar and the economic cost of managing dollar exposure. We view this paper as complementing the large body of theoretical work on this topic, and paving the way for continued work to more closely integrate theory and empirics.

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# Tables

Table 1: **Foreign holdings and hedging of USD securities, June 2020**

| Industry | USD holding ($T) | Share of bonds | Hedging ratio | 1M CIP cost ($B) |
|---|---|---|---|---|
| Insurance | 1.6 | 78% | 0.42 | 2.0 |
| Pensions | 1.6 | 39% | 0.36 | 0.6 |
| Mutual funds | 3.4 | 43% | 0.22 | – |
| Banking | 2.7 | 100% | 1.00* | – |
| Hedge funds | 0.4 | 0% | – | – |
| Non-financial | 0.9 | 58% | – | – |
| Official | 6.3 | 80% | 0.00* | – |
| Other | 11.0 | 64% | – | – |
| Total | 27.8 | 67% | 0.17 | 2.7 |

*Notes*: This table reports estimated foreign investors' holding and hedging of USD securities as of June 2020. USD securities include as bonds and equity. Share of equity is therefore 1 less the estimate "Share of bonds". "Hedging ratio" is the fraction of USD securities not exposed to foreign exchange fluctuations. For all but Banking, hedging is achieved through FX derivatives. Banks are regulated to have zero FX exposure: about 50% of its hedging is achieved through derivatives, and the other 50% is hedged, or funded, with USD deposits. The Official sector is assumed to have a hedging ratio of 0. "1M CIP cost" is the annualized, CIP-induced cost of implementing hedging by rolling over 1M forwards.

Table 2: **Summary of coverage and sources**

| Industry | Region / Country | Company filings | Industry 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: Euro 19 countries | | EIOPA | 2017 | 2021 | – |
| | | | SHS | 2013 | 2017 | – |
| | Europe: 11 other EU countries | | EIOPA | 2017 | 2021 | – |
| | Europe: UK | | EIOPA | 2017 | 2020 | – |
| | 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: Switzerland | | Federal Statistical Office | 2004 | 2020 | 2015 |
| | Europe: UK | | Office for National Statistics | 2002 | 2021 | – |
| | ROW: Israel | | Bank of Israel | 2002 | 2021 | 2002 |
| | ROW: 14 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 | – |
| Non-financial | 56 countries | | CPIS | 2002 | 2020 | – |
| Official sector | 237 countries | | TIC | 2002 | 2021 | – |

*Notes*: This table reports the data sources used to construct industry-specific USD holding and hedging. "Company filings" records the number of companies from whom filings are obtained. Within "Industry 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 year of availability for each source. "Hedging info start" is the start year of hedging information.

Table 3: **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% |
| | ROW: Israel | None for countries rated A and above |
| Pensions | Asia: Japan | None |
| | Asia: Australia | None |
| | Europe: Netherlands | None |
| | Europe: Switzerland | 30% |
| | ROW: Israel | None for OECD or countries rated at least BBB- |

*Notes*: 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 4: **Model-implied optimal comparative statics**

| Currency | Share of USD ($w_{US}$) | | | Share of Not-hedged USD ($w_{NH}$) | | |
|---|---|---|---|---|---|---|
| | $rx^{\$b}-rx^b$ | $rx^{FX}$ | x | $rx^{\$b}-rx^b$ | $rx^{FX}$ | x |
| JPY | + | + | - | + | + | - |
| AUD | + | + | + | + | + | - |
| TWD | + | - | + | - | + | - |
| ILS | + | - | + | - | + | - |

*Notes*: This table reports comparative statics of the mean-variance agent's optimal portfolio.

## Table 5: **Empirical determinants of *change* in USD allocation**

| Currency | Industry | USD yield slope | CCY yield slope | USD-CCY spread in yield slope | CCY spot | CCY 1M basis | CCY 10Y basis |
|---|---|---|---|---|---|---|---|
| JPY | insurance | -** | -** | -* | + | - | + |
| AUD | pension | + | + | - | +** | + | +** |
| TWD | insurance | -* | - | -* | -*** | + | + |
| ILS | insurance | +*** | +* | + | -* | + | -** |
| ILS | pension | +*** | +** | + | -*** | + | - |

*Notes*: This table reports the empirical relationship between changes in USD allocation and various returns. The returns are calculated as period averages, where the period is the investor's reporting frequency. Red denotes that the sign is consistent with the model prediction in Table 4. Standard errors are calculated using Newey-West. *, **, *** denotes significance at the 10%, 5%, and 1% level, respectively.

## Table 6: **Empirical determinants of *change* in *non-hedged* USD allocation**

| Currency | Industry | USD yield slope | CCY yield slope | USD-CCY spread in yield slope | CCY spot | CCY 1M basis | CCY 10Y basis |
|---|---|---|---|---|---|---|---|
| JPY | insurance | + | + | - | - | +** | +*** |
| AUD | pension | + | + | - | +*** | + | +** |
| TWD | insurance | -* | - | -* | -*** | + | + |
| ILS | insurance | + | + | - | + | +*** | -** |
| ILS | pension | +*** | +* | + | - | +*** | - |

*Notes*: This table reports the empirical relationship between changes in non-hedged USD allocation and various returns. The returns are calculated as period averages, where the period is the investor's reporting frequency. Red denotes that the sign is consistent with the model prediction in Table 4. Standard errors are calculated using Newey-West. *, **, *** denotes significance at the 10%, 5%, and 1% level, respectively.

# A   Details of data construction

## A.1   Overall foreign holdings of USD securities

We first tackle foreign-held USD securities by U.S. issuers. We obtain "TIC Foreign Holding of U.S. Securities" directly from the TIC system. In particular, we access the annual reports on *Foreign Residents' Portfolio Holdings of U.S. Securities* from June 2002 through June 2021. These reports show non-U.S. residents' holdings of securities issued by U.S. residents, separately reported for equities and bonds. U.S. residents need not issue only USD securities. To estimate "TIC Foreign Holdings of Non-USD Securities", we use TIC's reporting of non-USD debt held by foreign investors.

We next tackle foreign-held USD securities issued by non-US residents. To do so, we first estimate "USD Securities Outstanding Outside the U.S." from the international debt securities statistics published by the Bank for International Settlements (BIS). We then net out the amount of foreign-issued dollar-asset held by U.S. residents, or "U.S. Investors' Cross-border USD Holdings." In its *U.S. Residents' Portfolio Holdings of Foreign Securities*, TIC reports the currency breakdown of US residents' foreign holdings by country annually starting in 2007. Using this statistic, we find that US residents primarily hold USD debt abroad: the by-country mean fluctuates between 72% and 79%. For the period of 2002 to 2007, we estimate the share of US-held foreign-issued USD debt as the mean between 2007 and 2021.

## A.2   Sector-specific USD security holdings

### Foreign Insurance Companies' Holdings

For Japan, we hand-collected quarterly filings since 2004 from all of the 25 active domestic companies and 12 foreign-controlled companies. The largest 11 of these Japanese insurance companies break out their portfolio holdings by currency. For each of these, we record total assets, investments in USD and all other foreign currencies, and investments in foreign equity and foreign debt. We take the split of equity vs. debt in foreign investments as informative of Japanese insurers' risk-return preference, and we estimate the amount of USD equity and debt as proportional to the the share of USD in the foreign investment portfolios.

In Taiwan, the Central Bank of Republic of China publishes *Financial Statistics Monthly*, which details life insurers' total assets and foreign investments. We locate physical copies of these publications going back to 2005 to form a monthly series of aggregate investment. To further understand the share of USD in foreign investments and the split between debt and equity, we hand collect detailed information from the annual reports of the 6 of the largest Taiwanese life insurers.

We leverage the quarterly filings made by all insurers to the European Insurance and Occupational Pensions Authority (EIOPA) to study insurers' portfolio allocations in the EU

and the European Economic Area (EEA). Thirty-one countries are in the sample, including 19 in the eurozone (as of 2022), 11 others in the European Economic Area, and the U.K. We estimate the dollar holding from European insurers as investments in bonds and equities from US issuers. There is considerable issuance of dollar bonds by non-US issuer (see Holdings Fact 3 in Section 3). Our estimate of European insurers' USD bonds holding is therefore likely conservative. EIOPA data collection started in 2017. For 2013Q4 to 2017Q4, we use ECB's Securities Holdings Statistics (SHS) to estimate holdings of insurers in the 19 eurozone countries. Estimates using the SHS data are also conservatively based on investments in securities from US issuers. SHS contains reporting by both insurers and pensions; we subtract from our SHS estimates what we estimate as holdings by pensions in the eurozone (i.e., the Netherlands).

Finally, we complement our sample of insurers with information from Bank of Israel's *Institutional Investors' Exposure to Foreign Exchange*. The monthly statistics start in 2002, covering foreign investments of Israeli insurers and pension funds. We estimate Israeli insurers' USD investments from their total foreign investment portfolios and the typical share of USD in Israeli institutional investors' FX market activities.[26] We then estimate the breakdown between USD equity and bonds using asset allocations in Israeli insurers' overall investment portfolio, which are available in Bank of Israel's *Assets Portfolio of the Institutional Investors by Securities*.

**Foreign Pension Funds' Holdings**

The Japanese pension fund that we study in detail is the Government Pension Investment Fund (GPIF). GPIF is similar to Social Security in the U.S., and it makes up 72% of Japan's public pensions, or the equivalent of 76% of all private retirement assets in Japan (ICI (2021)). GPIF is almost exclusively invested through external managers to target specific benchmarks. For example, 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 investment manager-by-manager and estimate GPIF's USD investments as the amount of its portfolio allocated to track U.S. bonds or equity benchmarks.

The pensions industry in the Netherlands is also very concentrated: the two largest pension funds, ABP and PFZW, manage assets equivalent to 1.5 times those of the next 15 biggest combined,[27] covering 50% of assets in all Dutch pension funds.[28]. We obtain from ABP's and PFZW's annual reports their total assets, USD investments, and the split between USD equities and USD bonds.

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[26]Ben Zeev and Nathan (2022) find that 85.9% of Israeli institutional investors' FX swap flow volume is in dollars, and that 87.8% of their FX spot volume is done in dollars. Institutional investors include insurers and pension funds.

[27]https://www.investmentoffice.com/Pension_Funds/Netherlands/

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

In Australia, the Australian Prudential Regulation Authority (APRA) publishes *Quarterly Superannuation Performance*, which provides statistics on all regulated pensions (any entity with more than four members). These statistics go back to 2004 and contain detailed information on total asset and foreign investments, including the breakdown between foreign equities and foreign bonds. To estimate the amount of USD bond and equity holdings, we complement the APRA statistics with the Australian Bureau of Statistics' (ABS) *Foreign Currency Exposure, Australia*. This ABS publication presents the results from a triennial survey of Australian resident enterprises with exposure to foreign currencies. In particular, we analyze the currency holding of non-bank financial institutions, which include pension funds, insurance companies, and other financial intermediaries. We take the shares of USD in non-bank financial institutions' foreign equity portfolios and foreign bond portfolios as representative of pension funds' exposure.

The Swiss Federal Statistical Office provides an annual publication akin to the APRA statistics. Similar to APRA, the Swiss publication reports pension funds' foreign investments but does not break down investments by currency. We supplement our analysis with Credit Suisse' Swiss Pension Fund Index 2020, which estimates the currency allocation of Swiss pension funds' investment portfolio between 2018 and 2020. Also similar to APRA, the Swiss publication does not distinguish domenstic vs. foreign private equity investments. To be conservative, we exclude private equity in our estimate of USD equity holdings by both the Australian and the Swiss pensions.

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

Finally, we also consider pension funds in Israel and 10 mostly Latin American countries. The data for Israeli pensions are from the same sources as those for Israeli insurers, described above. Our data on Latin American countries come from Federación Internacional de Administradoras de Fondos de Pensiones (FIAP). FIAP releases annual series starting 2002 on foreign investments by pensions in Bolivia, Colombia, Costa Rica, Chile, El Salvador, Mexico, Peru, Dominican Republic, Uruguay, and Kazakhstan.[29]

**Foreign Mutual Funds' Holdings**

We study foreign mutual funds' allocations to USD by using a data set of holdings from open-ended funds and exchange-traded funds (ETF) domiciled in 64 non-US countries. We

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[29]FIAP also has sparse reporting from Russian Fedration, Poland, and Romania; however, these reports stopped after 2013.

have security-level holding data from Morningstar for all bond funds, mixed bond and equity funds (referred to as "allocation funds" by Morningstar), and equity funds, similar data used in Maggiori, Neiman, and Schreger (2020) and Coppola et al. (2021). We estimate foreign bond holdings by aggregating bond securities denominated as USD; we exclude bank loans, alternatives, investments in funds, and all derivatives including bond futures and CDS. We estimate foreign equity holdings by obtaining each fund's share in U.S. equity investments from the Morningstar Direct platform.

### Foreign Banks' Holdings

We estimate holdings of USD securities by non-US banks using BIS Locational Banking Statistics (LBS). LBS provides quarterly data on the outstanding claims and liabilities of internationally active banks located in reporting countries. However, non-US banks' cross-border holdings of USD debt securities are a confidential time series only available to central banks.[30] We therefore apply an adjustment factor to the difference between foreign banks' USD holdings and USD loans, to arrive at an estimate of debt securities holding. Our estimated series has a 0.98 correlation with LBS' confidential series.[31]

### Foreign Hedge Funds' Holdings

We estimate non-US hedge funds' investments in U.S. equities by leveraging 13F reporting requirements, whereby institutional investment managers with at least $100 million in assets under management must disclose their equity holdings quarterly. The 13F filing classifies whether a reporting entity is a hedge fund. We merge with Factset to determine the domicile of the fund.

### Foreign Non-Financial Sector's Holdings

We consider two types of entities in the non-financial sector: foreign non-financial companies and households, and overseas subsidiaries of U.S. companies. To estimate foreign non-financial companies and households' USD holdings, we use the IMF's Coordinated Portfolio Investment Survey (CPIS) data. CPIS reports bilateral investment portfolios that are sometimes broken out by currency and by sector. Yet because very few countries report cross-border investment by currency, our estimates are based on investments in the United States by the non-financial sector from a non-U.S. country reporting to the CPIS. Of the 81 countries reported as having assets in the United States, 56 countries report their investment separately for the non-financial sector. Our estimate is therefore a conservative

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[30]This information cannot be deduced from United States' reporting to the BIS because the U.S. reports only U.S. banks' loan and deposit positions and does not include debt securities positions.

[31]We focus on holdings of debt securities by banks because these — along with loans — make up the preponderance of a typical bank's assets. It is much more capital intensive for banks to hold equity securities.

estimate on many dimensions: there could be countries who own assets in the U.S. but choose to not report, there could be investments by the non-financial sector that were not separately reported, and there could be USD investments in non-US countries.

We next estimate dollar security holdings by U.S. non-financial companies' foreign subsidiaries. Because security holdings do not form the core of non-financial companies' business, these holdings tend to come from excess cash from firms' balance sheets. We therefore impute foreign subsidiaries' security holdings by using subsidiaries' contribution to the parent's pre-tax income. We use Compustat to assess pre-tax income contributions and we obtain U.S. companies' security holdings from Darmouni and Mota (2022).

**Foreign Official Sector's Holdings**

We estimate the foreign official sector's holding of U.S. securities from TIC, as provided by Bertaut and Judson (2014). Our assumption is that the official sector — central banks, sovereign wealth funds, and other public financial agencies — do not obtain significant USD assets from non-US entities. The TIC system reports holding of U.S. securities by the official sector in 237 countries, separately for equity and bonds.