# 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, driven by growing portfolio allocations, foreign investors increased their holdings of USD securities by sixfold over the past two decade. After the financial crisis of 2007-09, foreign investors maintained 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 find that foreign investors' USD holdings and hedging patterns are largely consistent with mean-variance optimization, and show that hedging demand is strongly correlated with the cross-section of CIP deviations.

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

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# 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.

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

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

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 three stylized facts on dollar holding and hedging practices by foreign investors. First, we find that foreign investors increased their preference for dollar assets over the past two decades. The size of foreign holdings of USD securities increased by sixfold 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 higher portfolio allocations toward USD securities. Compared to pre-GFC, mutual funds, insurance, and pensions increased the share of USD securities in their overall portfolios by 7.7 percentage points post-GFC, and increased the share of USD securities in their non-domestic investments by 6.6 percentage points. In the aggregate, foreign investors show a preference for bonds over equities and hold a disproportionately high share of the non-US issued USD bonds.

Second, foreign investors, especially those in actively managed industries, hedge a substantial amount of their USD currency risk post-GFC. The hedge ratios for insurance companies, pension funds, and mutual funds were 44%, 35%, and 21%, respectively, as of 2020. The total hedging demand from these three sectors alone amounted to almost $2 trillion per annum. These investors' hedge ratios were on average 14.7 percentage points higher post-

[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.

GFC than pre-GFC. This new hedging regime developed despite elevated and fluctuating deviations from covered interest rate parity (CIP), which increased the cost of hedging. In fact, the intensity of foreign investors' hedging activities tends to be higher when deviations from CIP are also wider. We calculate that the cost of hedging due to short-term CIP deviation averaged $2.7 billion per annum between 2017 and 2020 for the insurance and pension industries.

Third, we document that hedge ratios exhibit considerable heterogeneity. This heterogeneity manifests across geographies and between security types. The level of hedge ratio spans a wide range even within the same sector. More systematically, investors tend to hedge USD bonds at higher ratios than they hedge equity, consistent with the predictions of Campbell, Serfaty-De Medeiros, and Viceira (2010) based on an analysis of minimizing portfolio volatility.

To investigate the drivers of foreign investors' USD holdings and hedging practices, we study a mean-variance investor's portfolio choice over both asset allocation and currency hedging. The investor's problem can be thought of allocating a portfolio over three assets: a local currency asset, a USD asset without currency hedging, and a USD asset hedged by rolling over short-term FX forwards. The main insight from our three-asset model is that the attractiveness of FX exposure crucially depends on the relative strength of the covariance between currency return and local asset return and the covariance between currency return and USD asset return. All else equal, the mean-variance investor prefers the asset that has a lower covariance with the rest of his portfolio. Consequently, to not hedge but to take on USD risk makes sense only if the FX return covaries more negatively with the USD asset return than with the domestic asset return.

Taking the observed post-GFC covariance structure between asset returns as given, we

derive comparative statics of total USD asset allocation and unhedged USD asset allocation with respect to the difference in relative investment opportunities and in the cost of hedging.[3] The comparative statics shows that a higher expected USD asset return over the USD risk-free rate relative to foreign assets leads to a higher total USD allocation by foreign investors; a slightly higher unhedged USD allocation for advanced economy and a lower unhedged USD allocation for emerging markets; and an overall higher hedge ratio for USD assets across all countries. We find that investors' observed portfolios are broadly consistent with these model predictions, both in responding to pre vs. post-GFC differences and in responding to higher-frequency changes in investment opportunities. From the perspective of foreign investors hedging USD assets, the cost of hedging can be intuitively understood as forgoing the excess FX returns of going long in USD (funded by shorting their domestic currencies) and instead paying for the CIP basis. The comparative statics shows that, all else equal, a higher cost of hedging would decrease total USD allocation, increase unhedged USD allocation, and decrease the hedge ratio. In the data, however, foreign investors increase their USD hedge ratios when hedging costs rise in virtually all sample currencies. This positive correlation between hedging cost and hedge ratio suggests that FX derivatives are priced at the equilibrium of investors' hedging demand and an upward sloping hedging supply.

We enrich the frictionless mean-variance model with an intermediary sector that supplies FX hedging services subject to balance sheet constraint. Due to the balance sheet constraint, the intermediary charges the CIP deviations as the cost of providing hedging services, and such cost rises as more hedging services are provided, similar to Ivashina, Scharfstein, and Stein (2015). This model of constrained intermediary delivers the prediction that the hedg-

[3]We proxy the relative investment opportunity with the difference in the yield curve slopes between the U.S. and the local country. We proxy the cost of hedging with the 3M IBOR CIP deviations.

ing cost rises in the hedging demand. Moreover, because the intermediary's balance sheet is segmented across currencies in the spirit of Siriwardane, Sundaram, and Wallen (2022), shocks to local hedging demand explain the cross-sectional variations in the CIP basis. Consistent with this prediction, we show for each of our sample currencies that, its aggregate hedging demand, normalized by GDP, is strongly and negatively correlated with its average 3-month CIP basis. The cross-sectional R-squared of the relationship is equal to 0.76.

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 (Adler and Dumas (1983); 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 model highlights the importance of relative covariance between asset returns and FX returns as a driver of hedging decisions. Using our hand-collected data, we show empirically that this consideration is consistent with investors' increased USD hedging post-GFC. By studying different types of non-US investors' preferences for USD assets, we complement existing studies that consider portfolio allocation by public investment funds (e.g., Mitchell, Piggott, and Kumru (2008), Lucas and Zeldes (2005)), that examine global investors' preferences for sovereign debt (e.g., Fang, Hardy, and Lewis (2022)), that investigate US investors' currency hedging of non-USD exposures (e.g., Sialm and Zhu (2022)), that look at portfolio allocation of institutional investors in Europe (e.g., Faia, Salomao, and Veghazy (2022), and that study the currency composition of mutual funds' portfolios (e.g., Maggiori, Neiman, and Schreger (2020)).

In addition, our paper complements the active literature on CIP deviations. 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)). This paper illuminate two important outstanding questions. First, we show that CIP deviations impose significant direct financial cost to investors seeking to hedge their USD assets.[4] Second, we show that investors' hedging demand offers an explanation for the cross-sectional variations in the CIP basis. The cross-sectional difference in CIP deviations is puzzling in a world where intermediaries arbitrage across markets. We make progress by introducing hedging supply from an intermediary with segmented balance sheets, which reconciles the positive correlation between hedging activities and magnitude of the CIP deviations. In considering hedging demand as a driver for the cross-section of CIP deviations, we build on Borio et al. (2016), which argues that the hedging demand from banking sector helps explain variations in CIP deviations in eight advanced economies. By enriching the estimate of hedging demand with data from mutual funds, insurance, and pensions, we account for the cross-section of CIP deviations in a much wider set of countries, including emerging economies. Our results highlight that hedging demand is not solely originated from banks but can arise from institutional investors.

Our paper is directly connected to the growing literature that attempts to estimate the impact of asset demand on exchange rates. In the absence of clear evidence, 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), Bräuer and Hau (2022), and Ben Zeev and Nathan (2022b) 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

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

estimations of the demand-system based asset pricing models where foreign investors are often treated as a homogeneous group (for example, Koijen, Richmond, and Yogo (2020)).

Finally, our paper contributes to the large literature on dollar safe assets (for example, Caballero, Farhi, and Gourinchas (2017); Gourinchas, Rey, and Sauzet (2019); Jiang, Krishnamurthy, and Lustig (2021); Eren and Malamud (2022)). Theories have examined how a deep and liquid U.S. Treasury and corporate bond market contributes to dollar's sustained dominance (He, Krishnamurthy, and Milbradt (2016); Coppola, Krishnamurthy, and Xu (2023)). The rise in the currency-hedged USD allocation suggests that the characteristics of the USD currency returns is not the sole driver of foreign demand for USD assets. Instead, we underscore that a higher expected return on the USD assets beyond the expected return on currency as a more fundamental driver of foreign investors' ever-higher allocation to USD securities.

Our paper is organized as follows. Section 2 describe our data sources and estimation methodology. Section 3 discusses three stylized facts on foreign USD holdings and hedging practices. Section 4 rationalizes the observed patterns using a mean-variance optimizing agent's portfolio allocation when facing a constrained intermediary. Section 5 concludes.

## 2 Methodology and Data Construction

We now describe our data construction. We first estimate the aggregate and the country-sector-specific amount of foreign-held USD securities using a large variety of data sets. We then estimate country-sector-specific hedge ratios and deviations from covered interest-rate parity (CIP) to examine currency hedging practices of foreign investors.

### 2.1 Estimating Foreign USD Security Holdings

We estimate foreign holdings of USD securities from two complementary angles. First, we estimate the total amount of USD bonds and equities held by all non-US residents. Second, we estimate holdings 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 foreign investors' total USD securities holdings, we start with available estimates of 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 from 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 significant investments in USD securities, and we leverage a large collection of sources to estimate country-sector-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 1. We highlight the key aspects of our estimation strategy below, and in Appendix Section

[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) as the primary source 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 1 in Section 3). Our estimate of European insurers' USD bonds holding is therefore likely conservative.

For Denmark and Sweden, we identify country-specific sources rather than EIOPA for more in-depth coverages. Specifically, in Denmark, the Danmarks Nationalbank reports insurers' monthly investment, by currency and by security type, starting 2015. In Sweden, the Sveriges Riksbank reports quarterly breakdowns of insurers' domestic vs. foreign investment

[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.

in its Financial Stability Report.

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 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 six non-US countries: the U.K., the Netherlands, Australia, Canada, Switzerland, and Japan, can be grouped based on their industry structures. Japan, the Netherlands, and Canada 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

[10] Ben Zeev and Nathan (2022a) 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.

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

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. Finally, the two largest pension funds in Canada are the Canada Pension Plan Investment Board (CPP) and Caisse de dépôt et placement du Québec (CDPQ). These two funds have 45% of the AUM of the top eight public pension funds in Canada, which in turn represent two thirds of all pension assets in Canada.[13] We collect from CPP's and CDPQ's annual reports their total assets, investments in USD or the U.S., and the split between debt and equity in the foreign portfolio or the target portfolio.

For Australia, Switzerland, the U.K., Denmark, Sweden, Israel, Chile, and 9 other mostly Latin American countries, we obtain statistics on pension funds published by the respective national or regional authority. These statistics allow us to track pension funds' total portfolio size and USD investments. For countries where portfolio information is available for all foreign investments and not USD specifically, we separately estimate the share of USD investments in pensions' foreign portfolio from various complementary databases. Appendix Section A.2 details our methodology.

### 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.

[12] https://www.pensioenfederatie.nl/website/the-dutch-pension-system-highlights-and-characteristics
[13] https://www.bankofcanada.ca/wp-content/uploads/2016/06/fsr-june2016-bedard-page.pdf

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.[14] 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.[15]

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.

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 and jurisdictions,

[14] 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.

[15] 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.

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.

#### 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 foreign reserve considerations. For banks, any unhedged FX positions on banks' balance sheets are associated with hefty regulatory capital charges. Therefore, the foreign banking sector likely fully hedges their FX risk to the first-order approximation, either through dollar liabilities or FX derivatives.[16] For the official sector, FX hedging is

[16]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.

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.[17]

In contrast, currency hedging by insurances, pensions, and mutual funds likely reveals 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 A1, 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 also discuss the implication of these limits on hedging inSection 3.

**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.[18] 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, Israeli, Danish, and Swedish 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

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

[18]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.

insurers. Similarly, Bank of Israel's *Institutional Investors' Foreign Exchange Exposure* shows insurers' portfolio FX exposure before and after hedging. The Danmarks Nationalbank publishes monthly the aggregate FX exposure and hedging for various currencies, including USD. Finally, the Financial Stability Report of the Sveriges Riksbank contains monthly USD hedging of life insurers starting 2019.

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

For Canada, the two pension funds that we study adopt different reporting formats. For CPP, we analyze its extensive discussions of hedging strategy. CPP conducts no currency hedging between 2004-2007 and after 2015. Between 2008 and 2014, it hedges only bond investments. CDPQ, on the other hand, reports unhedged (or net) USD exposure starting 2013. We estimate CDPQ's hedging as the difference between total USD exposure and unhedged USD exposure.

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 Danish, Swedish, and Israeli pension funds are estimated in a manner that is similar to that for the insurers in these countries.

Finally, for Chile, we collect pensions' aggregate currency exposure and management from Superintendencia de Pensiones' quarterly reports. The Superintendencia reports aggregate FX exposure and how much of the FX exposure is hedged for various currencies.

**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 that we do not observe the exact hedge ratio of mutual fund investments.

### 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 $X^{c,\$}_{t,\tau}$, the $\tau$-month tenor CIP basis of foreign currency $c$ vis-à-vis the USD as

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

and the log version as $x^{c,\$}_{t,\tau} = \ln\left(1 + X^{c,\$}_{t,\tau}\right)$. We use $R^{c}_{t,\tau}$ 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 $x^{c,\$}_{t,\tau} = X^{c,\$}_{t,\tau} = 0$, which occurs when the forward exchange rate is priced based on the interest rate differential. If the cross-currency basis $x^{c,\$}_{t,\tau}$ is negative (positive), then the forward exchange rate is priced too low (high) relative to the prevailing interest rates, or the risk-neutral fair value of the derivative. 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, or negative (positive) CIP bases, thus translate to more (less) expensive hedging.

We measure $R$ using IBOR in different countries, and focus on the 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.

### 2.3 Other data and sample currencies

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, as well as the Debt Securities

Statistics. From the World Bank, we obtain public stock market capitalizations. From Preqin, we obtain the total assets under management (AUM) by U.S. and global 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 and the major equity index in the U.S. and 12 other countries. We use these data and the FX market data from Bloomberg to study the historical correlations between bond yields and currency returns. The 12 countries that we study are Australia (AUD), Canada (CAD), Switzerland (CHF), Denmark (DKK), Germany (EUR), the United Kingdom (GBP), Japan (JPY), Norway (NOK), Sweden (SEK), Chile (CLP), Israel (ILS), and Taiwan (TWD). These 12 countries/currencies form the core of our sample country/currency because we are able to obtain for each, hedging data in both mutual funds and at least one of insurance or pensions. Our coverage includes 9 advanced economies and 3 emerging economies.

## 3 Stylized Facts on Foreign USD Holdings and Hedging

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

**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.

We estimate that the overall foreign holdings of USD securities grew six-fold 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. We explore foreigners' preference for USD securities from three angles: first, the type of USD securities that foreigners hold; second, foreigners' USD holding as a share of their portfolios; and finally, the place of issuance for the USD securities that foreigners hold.

As illustrated in Figure 2, foreigners consistently hold more USD bonds than USD equities. In the aggregate, foreigners hold about 2/3 of their USD securities in bonds and 1/3 in equities (Panel (a)). Foreigners' holding of USD bonds in fact makes up a larger share of the total amount of USD bonds outstanding compared to the share of USD equities held by foreigners (Panel (b)).[19] From Panel (b), we further see that foreign holdings make up an increasingly large share of the total amount outstanding, both in equity and in debt. This 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.

In Figure 3, we illustrate the portfolio allocation to USD securities in three industries over time, where portfolio allocation is defined as the ratio of USD bonds and equities to total asset.[20] Panel (a) explores this allocation in the insurance sector. Total USD allocation 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

[19] 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. We estimate the total amount outstanding equities to be the sum of the market cap of U.S. listed stocks and AUM of U.S. private equity funds.

[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.

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 and at lower levels: by the end of 2020, allocation to USD bond and equity is 16% in Sweden, 14% in Denmark, 12% in UK, and a little under 4% in all other EU countries. The lower allocation to USD reflects EU insurers' preference for euro-denominated assets. Indeed, insurers in the 19 Eurozone countries[21] 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, pensions in Canada, Japan, the Netherlands, Chile, and Australia all had more than 20% of their total assets in 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.

Non-US mutual funds' total USD allocations appear in panel (c). In aggregate, equity mutual funds increased their USD allocation from 6% in September 2007, on the eve of the financial crisis, to 21% in September 2020. Similarly, fixed income mutual funds increased their USD allocations from 13% just before the financial crisis in 2007, to 27% in September 2020.

We analyze foreign private investors' USD allocation decisions jointly in Table 2. Models (1) and (2) examine the gross USD allocation by insurers, pensions, and mutual funds in our 12 sample countries (9 advanced economies and 3 emerging economies, see Section 2.3). From

[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 exceptions are the U.K., which shows a mild decrease in allocation post the Financial Crisis of 2007-09; and Chile, which significant reduced its USD exposure in 2018 and 2019 but increased its dollar holdings again starting in March 2020.

Model (1), we see that post-GFC, investors on average increased their portfolio allocation to USD securities by 7.7 percentage points. From Model (2), we see that there is moreover a strong, linear trend in investors' total USD allocation. Investors' increased USD allocation is not simply a reflection of diminished home-bias. In Appendix Figure A1, we plot the share of USD bonds in global bond market and the share of US equity in global equity market, neither shares significantly increased post-GFC relative to pre-GFC. Looking at Models (3) and (4), however, investors increased USD holdings as a share in their foreign investment. On average, the share of USD securities in investors' foreign portfolio is about 6.6 percentage point higher post-GFC, and again, there is a linear trend, albeit with a flatter slope compared to the growth in gross USD allocation.

Finally, foreigners hold a disproportionate share of non-US issued USD bonds. As show in Figure 4, non-US issued USD bonds have been increasing 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. Moreover, foreign-issued USD bonds make up a large 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 dashed green line. Yet we find that the share of foreign-issued USD bonds in foreign portfolios, indicated by the solid orange line, is consistently about 20 percentage points higher than the dashed green line. This suggests that what appeals to foreign investors is the dollar denomination of securities and not necessarily the domicile of the issuing entity.

**Fact 2: There is substantial amount of hedging in actively-managed industries post-GFC despite rising hedging cost.**

As of June 2020, we estimate that the hedge ratio for insurance, pensions, and mutual funds was 44%, 35%, and 21%, respectively. Collectively, hedging demand from these three sectors was over $2 trillion. Figure 5 illustrates this snapshot of hedging practices. Our hand-collected, industry-level data account for 60% of all foreign-held USD debt and equity, suggesting that our results are unlikely driven by small sample bias.

Table 3 examines the general trend in FX hedging using our micro data. The unit of observation in these regressions is currency-industry-time. Models (1) and (2) show that the hedge ratio, or the share of investors' USD securities that is hedged, increased post-GFC. After controlling for industry by currency fixed effect, hedge ratio significantly increases by about 14.8 percentage points on average post-GFC. Investors' increased hedging activities are corroborated with aggregate data on FX derivative trading. In Appendix Figure A2, we plot the daily average turnover in FX markets using the BIS Triennial Central Bank Surveys. Transactions in FX forward and FX swap that have USD as one of the two transacting currencies have been steadily increasing between 2001 and 2022, outpacing the increase in spot transactions. In particular, this trend holds within the sample of FX derivatives transactions where one party is an institutional investor. Transactions by institutional investors most closely relate to hedging activities from insurance, pensions, and mutual funds.[23]

However, we note that despite the large increase in investors' hedging tendency, investors' dollar exposure rose. Model (3) of Table 3 shows that investors' unhedged USD allocation,

[23]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)

or their dollar exposure, went up by 6.6 percentage points post-GFC. In other words, the increase in hedge ratio tempered but did not neutralize the growth in investors' total USD allocation, which grew by 7.7 percentage from pre- to post-GFC (Model (2) of Table 2).

Interestingly, investors' FX hedging is more concentrated when the cost of hedging is high. FX hedging is predominantly done through FX forwards or FX swaps. The CIP condition governs the pricing of these FX derivative contracts 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. The more negative the CIP basis, the more costly it is to hedge USD proceeds back to domestic currency. Yet hedge ratio loads negative on the 3-month cross-currency basis (Models (4) and (5)). This positive correlation between the hedge ratio and the cost of hedging (negative correlation between the hedge ratio and CIP basis) suggests that institutional investors' hedging demand is not completely deterred by the rising hedging cost[24] and that there could be substantial financial cost to hedging.[25]

To illustrate, consider Taiwanese insurers. Panel (a) of Figure 6 shows that the amount of hedging done by Taiwanese insurers steadily climbed even as the USD-TWD CIP basis opened up. This leads to substantial total hedging cost, which we plot in panel (b). We estimate the total hedging cost as the product as hedging volume and the negative of CIP basis.[26] This cost peaked at $1.7 billion per annum in 2017. In recent years, this cost has

[24]Investors are not moving away from FX forward and swaps to other FX derivatives because of larger CIP deviations. In Appendix Figure A4, we plot the share of non-forward and non-swap FX derivatives as a share of all FX derivatives, and find that this share has been stable. If anything, this share has been decreasing since 2013.

[25]Investors' rising hedging activity cannot be fully explained by regulations. Mutual funds generally do not face regulations curtailing their FX exposure. In Appendix Table A1, 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.

[26]Specifically, we use the quarterly snapshot of hedging volumes and quarter-average of daily CIP 3M basis. The use of 3M IBOR CIP basis in this calculation assumes that investors use short-term forwards to hedge and continuously roll over these short-term hedges, which is consistent with industry practices.

come down to about $0.8 billion per annum only because the USD-TWD CIP basis has mellowed.

Overall, for just the pensions and insurers in our sample, the total hedging cost due to CIP deviations amounted to $4 billion, $2.7 billion, $2.1 billion, and $2.1 billion for each of 2017, 2018, 2019, and 2020 . The average annual hedging cost over these four years is about $2.7 billion, which is about 0.1% of all the USD securities that these two sectors manage.[27] 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.

**Fact 3: Hedging behaviors exhibit heterogeneity across geographies.**

While most countries and sectors have been increasing their hedge ratio, there is considerable heterogeneity in the observed hedge ratios. This heterogeneity manifests across currencies and sectors, as well as between bonds and equities.

Figure 7 illustrates hedge ratios across different countries for insurance, pensions, and mutual funds. Even within the same industry, hedge ratios span a wide range cross countries. This is particularly pronounced in pensions (Panel (b)), where hedge ratios can be as low as 5% in Japan, and as high as 80% in Denmark. Mutual funds (Panel (c)) has the smallest range, but hedge ratios still range from near 0 to almost 30%. One potential explanation for this disparity is that different investors have different mixes of USD bond vs. equity, and

[27]For the purpose of calculating the cost of hedging, we assume that countries other than Denmark and Sweden but are covered by EIOPA hedge at the industry average. Similarly, we assume that pension in the U.K. hedge at the industry average. For insurers in the U.K., we estimate the cost of hedging using the 2016Q1-2020Q4 average hedge ratio estimated by Czech et al. (2022).

hedge different types of securities differently.

Campbell, de Medeiros, and Viceira (2010) find that, for advanced economies, hedging for bonds should be greater than hedging for equities. Although most investors in our sample do not breakout hedge ratio separately for bonds and equities, we do find suggestive evidence supporting the prediction of Campbell, de Medeiros, and Viceira (2010) among those investors that do report this detail. In Figure 8, we show that fixed income mutual funds hedge at substantially higher hedge ratio than equity mutual funds (Panel (a)), and Australian and Dutch pensions hedge their bonds at a higher ratio (Panel (b)).

# 4 Mean-Variance Portfolio Problem and Constrained Intermediary

Foreign investors show increasing preference for dollar-denominated securities and they hedge a substantial amount of their USD FX exposure. Moreover, USD hedging has increased post-GFC despite rising hedging cost and hedging practices exhibit considerable heterogeneity across countries. In this section, we compare investors' portfolio allocation to a mean-variance benchmark to study the effect of expected asset returns and highlight notable deviations. We introduce a financial intermediary with possible balance-sheet constraints to reconcile the positive correlation between hedging activity and cost, and we study implications of hedging for the cross-section of CIP deviations.

## 4.1 Investor's problem

We start by studying a mean-variance investor who allocates his portfolio between domestic assets and USD assets in a frictionless world. The foreign investor has a portfolio of size $A_l$, and he chooses the share of his portfolio invested in the USD assets, and decides whether to take the currency risk associated with the USD assets.

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

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

where $r_{t+1}^{lb}$ is the log return on the local currency asset 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 asset as

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

where $r_{t+1}^{\$b}$ is the log USD return on the USD asset 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, and his local currency return on holding the USD asset depends on his currency hedging strategy. If the foreign investor does not hedge the currency risk, the unhedged excess returns of investing in the USD asset 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 asset and the currency returns of going long the USD risk-free rate, and shorting the local currency risk-free rate.

If instead, the foreign investor decides to hedge the currency risk of the USD asset, then

the hedged return over the local currency risk free rate becomes

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

Therefore, the hedged return for the foreign investor is approximately equal to the sum of the log USD excess return and the cross-currency basis. A negative cross-currency basis reduces the hedged return for foreign investors in the USD asset. The approximation is needed because the expression ignores a second-order FX hedging error. As investors are unable to perfectly forecast the price of the dollar asset at $t+1$, so the dynamic FX hedging position based on current exposure might under or over hedge the dollar proceed next period.

The foreign investor maximizes a CARA utility over his portfolio returns. The investor has risk aversion parameter $\gamma$, and he chooses $w_{US}$, the portfolio share in total USD asset, and $w_{NH}$, the portfolio share in unhedged USD asset. The investor's portfolio share in the hedged USD asset is thus given by $w_{US} - w_{NH}$. The investor takes the cost of entering into hedges, $x$, as given, even though in equilibrium $x$ may depend on investors' portfolio allocation.

The investor maximizes:

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

where $rx^P_{t+1}$ is the log excess return of the entire portfolio given by:

$$\begin{aligned} rx^P_{t+1} &= (1-w_{US})rx^{lb}_{t+1} + w_{NH}(rx^{\$b}_{t+1} + rx^{FX}_{t+1}) + (w_{US}-w_{NH})(rx^{\$b}_{t+1} + x_t) \\ &= (1-w_{US})rx^{lb}_{t+1} + w_{US}rx^{\$b}_{t+1} + w_{NH}rx^{FX}_{t+1} + (w_{US}-w_{NH})x_t. \end{aligned}$$

The expected return and the variance of the portfolio are:

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

where $\bar{z}$ is the expected return on $z_{t+1}$, $\sigma_{A,B}$ is the covariance between asset A's return and asset B's return, and $\sigma^2_C$ is the variance of asset C's return. By extension, $\sigma^2_{lb-\$b}$ is the variance of the difference between $rx_{lb}$ 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.

Tables 4 and 5 report the summary statistics for the mean, standard deviation, and Sharpe Ratio for the unehdged and hedged 1M holding period excess returns on 10-year U.S. Treasury bonds and S&P 500, respectively, from the perspective of foreign investors located in our 12 sample countries. When foreign investors are investing in U.S. Treasury bonds, the volatility of the unhedged return tends to be significantly higher than that of the hedged return. Even though the dollar on average has appreciated against most of the sample currencies, the realized Sharpe ratio for hedged return tends to be higher than that

for unhedged returns. In contrast, when foreign investors invest in U.S. equities, the strong negative correlation between the strength of the dollar and U.S. equities return makes the currency a natural hedge for equity investments. The volatility of the unhedged returns on U.S. equities is generally similar to that of hedged returns. Therefore, for a given investment in USD assets, foreign investors in both advanced economies and emerging economies would have stronger incentives to hedge the FX risk if the investment is in bonds rather than equities.

### 4.1.1 Optimal Portfolio Allocation and Comparative Statistics

To derive the investor's optimal allocation in USD assets and FX exposure, we solve the investor's first-order conditions:

$$w^*_{US} = \frac{(\sigma_{\$b,FX} - \sigma_{lb,FX})(\overline{rx}^{FX} - x - \gamma\sigma_{lb,FX}) + \sigma^2_{FX}(\overline{rx}^{lb} - \overline{rx}^{\$b} - x + \gamma\sigma_{lb,\$b} - \gamma\sigma^2_{lb})}{\gamma(\sigma_{lb,FX} - \sigma_{\$b,FX})^2 - \gamma\sigma^2_{FX}\sigma^2_{lb-\$b}},$$

$$w^*_{NH} = \frac{\gamma\sigma_{lb,FX}(\sigma^2_{\$b} - \sigma_{lb,\$b}) + \gamma\sigma_{\$b,FX}(\sigma^2_{lb} - \sigma_{lb,\$b}) + (\sigma_{lb,FX} - \sigma_{\$b,FX})(\overline{rx}^{lb} - \overline{rx}^{\$b} - x) - (\overline{rx}^{FX} - x)\sigma^2_{lb-\$b}}{\gamma(\sigma_{lb,FX} - \sigma_{\$b,FX})^2 - \gamma\sigma^2_{FX}\sigma^2_{lb-\$b}}$$

The optimal portfolio allocation depends on the excess return of assets, the covariance between asset returns, and the investor's risk aversion. Two important factors that could influence the investor's portfolio allocation are, first, the relative return between USD and domestic asset ($\overline{rx}^{\$b} - \overline{rx}^{lb}$) and, second, CIP basis ($x$). We examine the partials of optimal portfolio weights with respect to these two factors to study their impact on USD allocation and hedging.

We first derive the comparative statics for portfolio share in total USD asset ($w^*_{US}$) and

portfolio share in unhedged USD asset ($w^*_{NH}$) with respect to relative asset returns:

$$\frac{\partial w^*_{US}}{\partial \overline{rx}^{\$b} - \overline{rx}^{lb}} = \frac{-\sigma^2_{FX}}{\gamma(\sigma_{lb,FX} - \sigma_{\$b,FX})^2 - \gamma\sigma^2_{FX}\sigma^2_{lb-\$b}} \tag{2}$$

$$\frac{\partial w^*_{NH}}{\partial \overline{rx}^{\$b} - \overline{rx}^{lb}} = \frac{\sigma_{\$b,FX} - \sigma_{lb,FX}}{\gamma(\sigma_{lb,FX} - \sigma_{\$b,FX})^2 - \gamma\sigma^2_{FX}\sigma^2_{lb-\$b}} \tag{3}$$

Similarly, we can derive the comparative statics for total and unhedged USD allocation with respect to CIP basis:

$$\frac{\partial w^*_{US}}{\partial x} = \frac{\sigma_{b,FX} - \sigma_{\$b,FX} - \sigma^2_{FX}}{\gamma(\sigma_{b,FX} - \sigma_{\$b,FX})^2 - \gamma\sigma^2_{FX}\sigma^2_{lb-\$b}} \tag{4}$$

$$\frac{\partial w^*_{NH}}{\partial x} = \frac{\sigma^2_{lb-\$b} + \sigma_{\$b,FX} - \sigma_{lb,FX}}{\gamma(\sigma_{lb,FX} - \sigma_{\$b,FX})^2 - \gamma\sigma^2_{FX}\sigma^2_{lb-\$b}} \tag{5}$$

The comparative static for optimal portfolio allocation depends on the covariance structure between asset returns. It is an empirical question what the optimal portfolio responses are for investors in different countries. Assuming a stationary covariance structure between returns, we estimate the covariance between $rx^{\$b}$, $rx^{lb}$, and $rx^{FX}$ for all 12 sample currencies for which we have hedging data in both mutual funds and one of pension or insurance (see definitions in Section 2.3). As proxies for asset returns, 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.[28] Specifically,

$$\begin{aligned} rx^{lb}_{t+1} &= 12(p_{9\frac{11}{12}Y,t+1M} - p_{10Y,t}) - r_{1M} \\ &\approx y_{10Y,t} - r_{1M,t} - 119(\Delta y_{10Y,t+1}) \\ rx^{FX}_{t+1} &= (rf^{\$}_t - rf_t) + \Delta 12 s_{t+1} \end{aligned} \tag{6}$$

Our estimation period is the post-GFC decade from 2010 July to 2021 June. We use month-end non-overlapping returns and we proxy both $r_{1M}$ and $rf_t$ with 1M IBOR in the appropriate currency. Recall that the spot exchange rate $S_t$ is defined as units of local currency per dollar, so that when USD appreciates, $rx^{FX}$ increases.

We report the estimated optimal portfolio responses with respect to relative asset returns and CIP basis in Table 6. Looking first at the effect of relative asset returns, because the denominator in the comparative statics is negative, $\frac{\partial w^*_{US}}{\partial \overline{rx}^{\$b} - \overline{rx}^{lb}}$ in Equation 2 have unambiguously positive signs across currencies (Column 1). This is intuitive: if there is higher expected excess return in USD assets, then investors would allocate more of their portfolios to overall USD assets.

In contrast, the effect of asset returns on unhedged USD asset allocation depends on the relative covariance between currency and domestic vs. US bond returns, and varies across countries (Column 2). $\frac{w^*_{NH}}{\partial \overline{rx}^{\$b} - \overline{rx}^{lb}}$ in Equation 3 is positive if $\sigma_{\$b,FX} < \sigma_{lb,FX}$. That is, if $rx^{FX}$ covaries less with USD asset, then $rx^{FX}$ is a better natural hedge for USD asset, thus when $rx^{\$b} - rx^{lb}$ is high, the investor wants not only more overall USD asset allocation but also more unhedged USD asset exposure. The covariance between FX return and asset returns

[28] We focus on the covariance structure between sovereign bond returns and FX returns because this is largest class of assets held by foreigners. Foreigners hold about 2/3 in bond and 1/3 in equity (Fact 1), and within bonds, about 2/3 in government securities and 1/3 in corporate debt (TIC).

is illustrated in Appendix Figure A5. For all advanced economies, $\sigma_{\$b,FX} < \sigma_{lb,FX}$. When the local short-term rate rises, local bond returns decrease and local currency appreciates, creating positive $\sigma_{lb,FX}$. Yet rate hikes in the U.S. would strengthens the USD against local currency just when the USD bond return compresses, making the FX return from going long USD a natural hedge for holding the USD bond. For emerging markets, the relative covariance flips sign, we have $\sigma_{\$b,FX} > \sigma_{lb,FX}$. This is because their bond return and currency both do poorly in bad times, leading to more negative covariance between FX return and local bond returns, $\sigma_{lb,FX}$.[29]

We summarize the effect of relative returns on portfolio allocation in the following prediction:[30]

**Prediction 1.** *Using the variance-covaraince matrix based on realized returns, the mean-variance model predicts that higher dollar asset return relative to domestic asset return increases overall USD asset allocation, and increases unhedged USD asset allocation for advanced economy but decreases unhedged USD allocation for emerging economies.*

We next turn to the impact of CIP basis on portfolio allocation (Columns 3 and 4). The CIP basis can be thought of as additional return to investing in USD asset and it is earned only when the investor foregoes $\overline{rx}^{FX}$. Hence, $\frac{\partial w^*_{US}}{\partial x} = \frac{\partial w^*_{US}}{\partial \overline{rx}^{\$b} - \overline{rx}^{lb}} - \frac{\partial w^*_{US}}{\partial \overline{rx}^{FX}}$ and $\frac{\partial w^*_{NH}}{\partial x} = \frac{\partial w^*_{NH}}{\partial \overline{rx}^{\$b} - \overline{rx}^{lb}} - \frac{\partial w^*_{NH}}{\partial \overline{rx}^{FX}}$. For allocations in total USD asset, the effect of relative asset

[29]There is in fact distinction among advanced economies as well. Although $\sigma_{\$b,FX} < \sigma_{lb,FX}$ for all advanced economies, $\sigma_{lb,FX}$ is particularly low for safe haven currencies such as JPY and CHF. This is because these safe haven currencies tend to appreciate against USD in bad times, thus attenuating the positive covariance normally observed between FX return and local bond returns.

[30]From the effect of relative returns on total and unhedged USD allocation, we can further calculate the impact on hedge ratio, which we summarize in Appendix Table A2. The USD hedge ratio unambiguously increases for emerging economies because higher USD asset return reduces unhedged USD allocation even as it increases total USD allocation. For advanced economies, the sign depends on the relative strength of $\frac{\partial w^*_{US}}{\partial \overline{rx}^{\$b} - \overline{rx}^{lb}}$ and $\frac{\partial w^*_{NH}}{\partial \overline{rx}^{\$b} - \overline{rx}^{lb}}$. The partial of $w_{US}$ is proportion to $\sigma^2_{FX}$. This is much larger than $\sigma_{\$b,FX} - \sigma_{lb,FX}$, which is proportion to the partial of $w_{NH}$. Empirically, if the starting hedge ratio is not extremely elevated, then an increase in relative asset return would increase USD hedge ratio for all advanced economies.

return always dominates the effect of FX returns. For allocations in unhedged USD asset, the opposite is true and the effect of FX return always dominates the effect of USD asset allocation. We summarize these effects below:

**Prediction 2.** *All else equal, when the CIP basis is more positive, the mean-variance investor would optimally increase overall USD allocation and decrease unhedged USD allocation.*

#### 4.1.2 Investor's empirical portfolio allocation

We now compare institutional investors' empirically observed portfolios to the mean-variance investor's optimal portfolio. Specifically, we regress changes in investors' portfolio allocation on changes in investors' expected relative asset returns or changes in CIP basis. We assume that $\mathbf{E}[rx] = y_{10Y,t} - rf_t$, 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 estimate these expectations using daily data and take quarterly averages. Two simplifying assumptions underlie our empirical strategy. First, we are assuming that the return profile of government bonds sufficiently captures that of the much broader investment universe available to the investor. This assumption is supported by investors' revealed preference for bond but may introduce wedges between model predictions and observed allocations. Second, we are assuming that the investor faces only domestic and USD assets while in reality their investment universe is much larger. This assumption is supported by the strong secular trend in increased USD allocation; however, it may similarly lead to deviations between theory and practice.

Figure 9 shows that that the difference between expected USD asset returns and expected local asset returns tends to be larger post-GFC.[31] If investors have mean-variance preference,

[31] In panel (b) of Figure 9, we also check the expected asset returns in equity. We proxy expected equity

then following Prediction 1, investors' post-GFC portfolio would have higher total USD allocation and higher unhedged USD allocation, as in Tables 2 and 3.

We summarize the comparison between the predictions and the empirical portfolio allocation in Table 7. Red indicates that the sign of empirical portfolio adjustments coheres with the theoretical prediction. Investors' portfolio allocation is directionally consistent with Prediction 1, in that the difference between expected USD bond return and expected local bond return are positively correlated with changes in total USD allocation (Column 1). The correlation between changes in expected relative return and changes in unhedged USD allocation is more mixed (Column 2), though there is still the pattern of positive correlation among advanced economies and negative correlation among emerging economies.

The effect of CIP basis is summarized in Columns 3 and 4. Investors' total USD allocation is largely consistent with mean-variance prediction (Column 3), suggesting that investors perceive CIP basis as a potential additional component of the return from investing in USD assets, and increase USD allocation when CIP basis is more favorable. However, investors' actual hedging behaviors are exactly opposite of what CIP basis would predict. When CIP basis is more positive, it is cheaper to hedge and the mean-variance investor would decrease unhedged USD exposure ($w_{NH}$), but investors' empirical unhedged USD exposure exhibits a positive correlation with CIP basis. This positive correlation highlights two limitations in taking the mean-variance predictions to data. First, there could be factors beyond asset returns' mean-variance trade-off that influence the investor portfolio. These factors are likely sector-specific, e.g., liabilities of insurers and pensions, and currency-specific, e.g., country-level shocks to FX hedging demand. Second, irrespective of the nature of shocks to the investors' hedging demand, the positive correlation between CIP basis and hedging suggests

return with rolling 5Y realized equity returns. Similar to bonds, the difference between USD equity return and local equity return is larger post-GFC.

that investors are not facing a perfectly elastic supply of FX hedging. This motivates us to introduce a financial intermediary who provides FX hedges to investors. The supply of hedges from intermediary and the demand of hedges from investors jointly pin down FX derivative pricing and the level of CIP basis.

### 4.2 Intermediary's problem

To hedge his dollar exposure, the foreign investor can go into FX forward or FX swap contracts with a financial intermediary. The intermediary sets the price on FX derivative contracts. Because the intermediary can offset the FX risk of providing dollar hedges by borrowing dollars in the cash market, offering FX derivative contracts carries no risk but expands the size of the balance sheet. The intermediary thus needs to earn CIP deviations to offset the cost of balance sheet imposed by regulations. We assume that the intermediary faces a total leverage constraint, so that in the short-term term, the size of intermediary's balance sheet consisting of $H$, the net notional amount of FX derivative, and $I$, the amount of other investment, must not exceed the a fixed balance sheet size $W$.[32] Furthermore, we assume that the intermediary in our model operates with a segmented balance sheet across currency $l$:

$$\begin{aligned} |H_l| + I_l &= W_l, \\ H_l &= A_l \cdot (w_{US} - w_{NH}), \\ \sum_l W_l &= W \end{aligned}$$

[32]Intermediary's balance sheet size is fixed in the short-run due to capital market frictions that prevent it from raising outside equity quickly and cheaply.

The segmented intermediary balance sheet assumption is consistent with evidence in Siriwardane, Sundaram, and Wallen (2022). For example, trading desks in different countries might be allocated with different balance sheet capacity, depending on the size of the market and investment opportunities. Due to frictions within large banking organizations, balance sheet space allocation does not flexibly adjust and investment opportunities are not perfectly equalized across countries. We use $f(I)$ to denote the risk-adjusted return of the intermediary's other investments. In particular, $f(I)$ is net of other regulatory costs such as risk-weighted capital requirements, which apply to other investments but not FX derivatives.

The intermediary offers FX derivative contracts to maximize its risk-adjusted total return subject to its balance sheet constraint:

$$\max_{H_l} \mathbb{E}[x_l H_l + f(I_l)],$$
$$\text{s.t. } |H_l| + I_l = W_l.$$

We use $x$ to denote the compensation that the intermediary expects for offering balance-sheet intensive FX derivative contracts. Post-GFC, new regulations on balance sheet size lead to the intermediary equating, at the margin, $|x^*| = f'(I^*)$. This $x$ corresponds to CIP basis in practice and follows the same sign as the net FX derivative position, $H$.[33] If there were no regulations on balance sheet size, then there would be no trade-off between offering FX derivatives contracts and doing other investments, and the intermediary would optimally maximizes $H$ and $I$ separately. The pricing of $H$ in the absence of regulatory constraint would be governed by CIP and the supply of H would be perfectly elastic.

[33]To illustrate, if the intermediary uses USD as the reference currency, and investors demand to buy USD today and sell USD tomorrow to hedge, then because the intermediary takes the opposite trade, its net derivative position $H_l$ is negative today. In this instance, the intermediary would demand $x_l < 0$ as compensation.

Following Ivashina, Scharfstein, and Stein (2015), a convenient simple case is where $f(I) = \theta \log(I) - I$. This leads to:

$$|x_l^*| = \frac{\theta}{W_l - |H_l^*|} - 1.$$

Because $x$ is compensation for using the balance sheet, $x$ is 0 when there is no net demand for FX derivatives. This amounts to saying that $\theta = W$. With this,

$$x_l^* = \frac{H_l^*}{W_l - |H_l^*|} \tag{7}$$

From Equation 7, we see that the value of CIP basis depends on the amount of net FX derivative contracts that investors in country $l$ demands. This accords with the evidence in Table 3, where periods of higher hedging volume are precisely those when the CIP basis is more negative, or larger in absolute terms. This also reconciles the tension between the empirical portfolio allocation and Prediction 2.

Equation 7 moreover shows that, what matters to the intermediary is not simply the absolute amount of net FX derivative contracts demanded, but that demand relative to the size of the balance sheet the intermediary has made available to country $l$. This leads to a prediction about CIP basis in the cross-section.

**Prediction 3.** *CIP basis is not uniform in the cross-section. The more net FX derivative a country demands relative to the intermediary's balance sheet available for that country, the larger CIP basis is in absolute terms.*

We empirically test the relationship between the cross-section of CIP basis and hedging demand. To do so, we assume that the intermediary segments its balance sheet in proportion

to GDP because GDP is often correlated with the depth of financial markets and availability of investment opportunities. We collect trading assets by geography for two large global banks, Citi and JP Morgan, and verify in Appendix Table A3 that there is a strong and positive cross-section correlation between GDP and banks' trading asset allocation.

Figure 10 shows that there is indeed a striking linear relationship between the time series average of country-specific CIP 3M basis and GDP-normalized hedging volume.[34,35] In the cross-section, the linear correlation between CIP basis and normalized hedging demand has an $R^2$ of 0.76. Importantly, this relationship holds across advanced and developing economies. In Table 8, we confirm the cross-section relationship using all available data. Column (1) shows that in general, CIP basis becomes more negative (larger in absolute value) when there is more GDP-normalized hedging demand. Column (2) shows that this is true in the cross-section. In fact, after controlling for time FE, the negative correlation is stronger in magnitude and in statistical significance.

[34]In our analysis of hedge ratios, we focus on actively managed industries, namely insurance, pensions, and mutual funds. To study the relationship between CIP basis and total hedging volume, we further include FX hedging done by banks to be comprehensive. Results are largely similar if banks are excluded, but are significantly different if only banks are include and other investors are excluded.

[35]We include banks' hedging demand in the total hedging volume, and we estimate it using an approach adapted to the new BIS reporting format based on Borio et al. (2016) and Borio et al. (2018). For countries where BIS LBS consolidated reporting is available by headquarters, we estimate their USD hedging demand as the difference between total USD claims and total USD liabilities. This statistics includes both local and cross-border claims and liabilities of all bank branches whose headquarter is in a particular country. This statistics is available for Canada, Japan, Sweden, Switzerland, the United Kingdom, and six countries in the EU (Belgium, France, Germany, Italy, Netherlands, Spain). For those that don't have BIS LBS consolidated reporting available by headquarters, we use BIS LBS reporting for all banks located in a particular country. These countries and regions are Australia, Chile, Denmark, Norway, and Taiwan. For Japan, we adjust the BIS LBS consolidated reporting by headquarter to remove the net USD assets from trust banks because trust banks are custodials who do not hedge mismatch in assets and liabilities.

## 5 Conclusion

We collect an immense array of industry statistics and company filings to study foreign investors' holding and hedging of USD securities. We document a sixfold increase in foreign investors' USD holding, driven by investors' increasing portfolio allocation to USD securities. We show that investors hedge a substantial amount of their USD exposure post-GFC despite large CIP deviations, which leads to substantial financial cost. We further find that there is considerable cross-country heterogeneity in hedging practices.

We use these facts to motivate a model of mean-variance investor allocating portfolios when facing a possibly constrained financial intermediary with segmented balance sheet. The model offers predictions about investors' portfolio allocation that are broadly consistent with empirical observations. The model moreover points to a relationship between hedging demand and the cross-section of CIP basis, which is strongly supported in the data.

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 frictions in managing dollar exposure. We view this paper as complementary to the large body of theoretical work on this topic, and as paving the way for continued work to more closely integrate theory and empirics.

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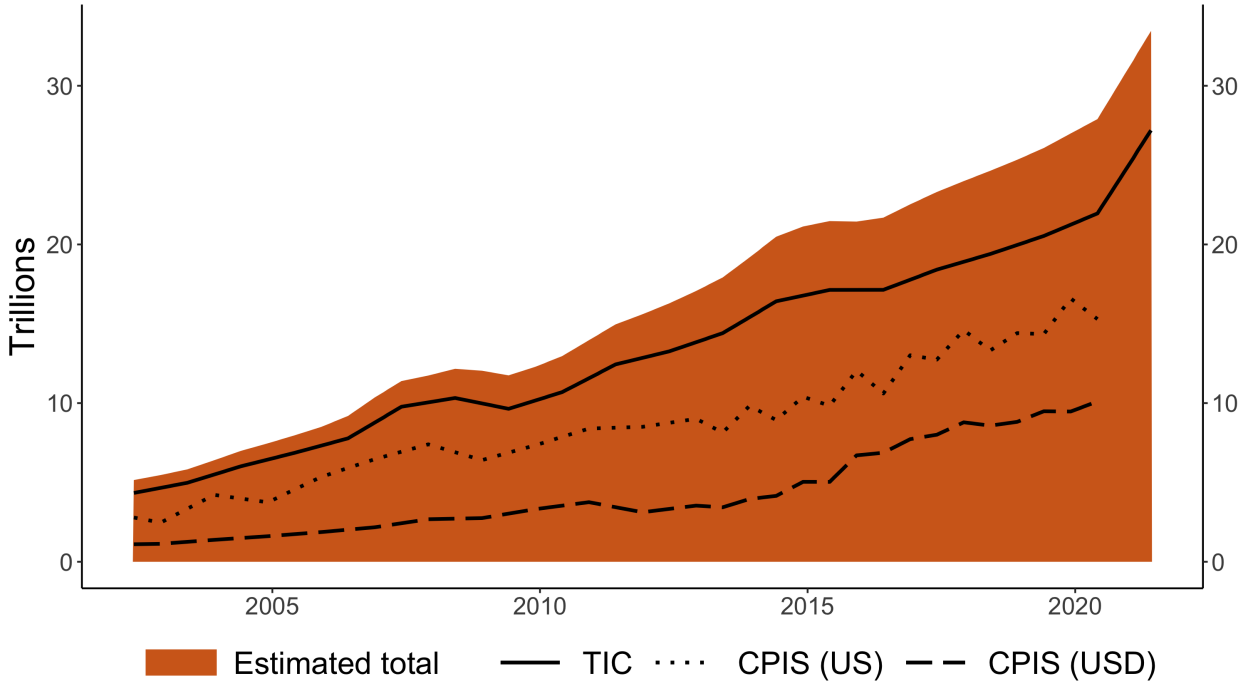
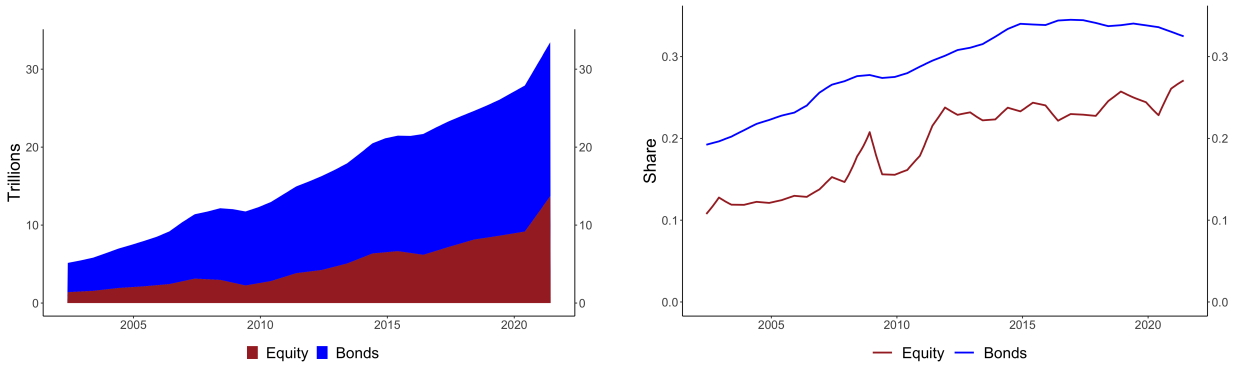
## Figures and Tables

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




*Notes*: This figure plots different estimates of foreign holding of USD securities. Plotted in orange shade 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.

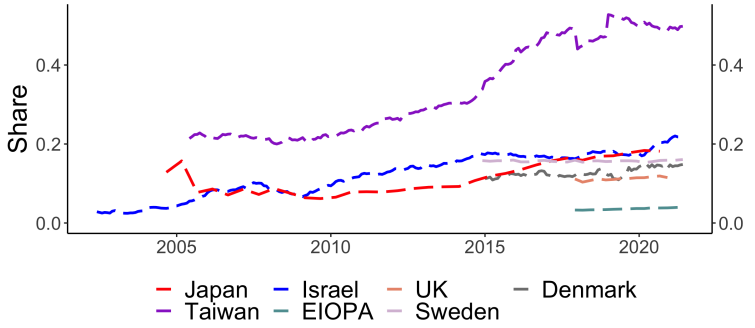
Figure 2: **Foreign USD holding by security type**



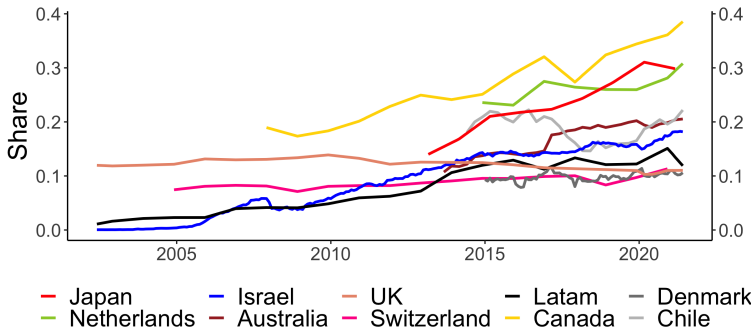

(a) **Volume** (b) **Share of total outstanding**

*Notes*: This figure plots estimated foreign-held USD securities by type. Panel (a) is volume of securities. Panel (b) is the share of total USD bonds and USD equity held by foreign investors. Total USD bond holdings are estimated as outstanding 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. The sample period is June 2002 to June 2021.

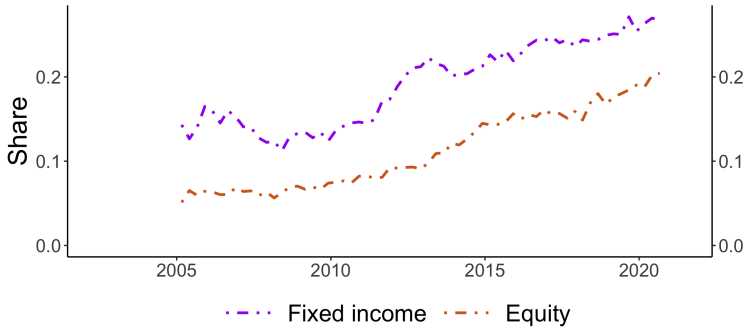
Figure 3: **Portfolio allocation to USD across industries**




(a) **Insurance**



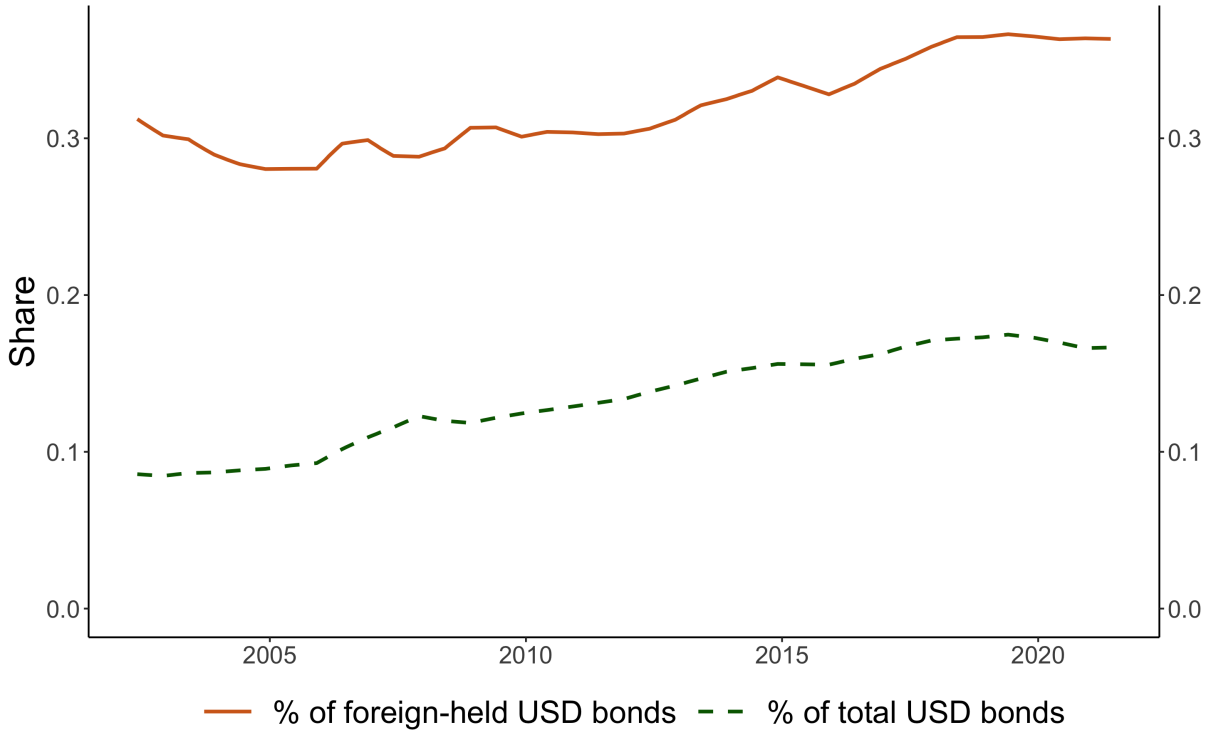

(b) **Pensions**




(c) **Mutual funds**

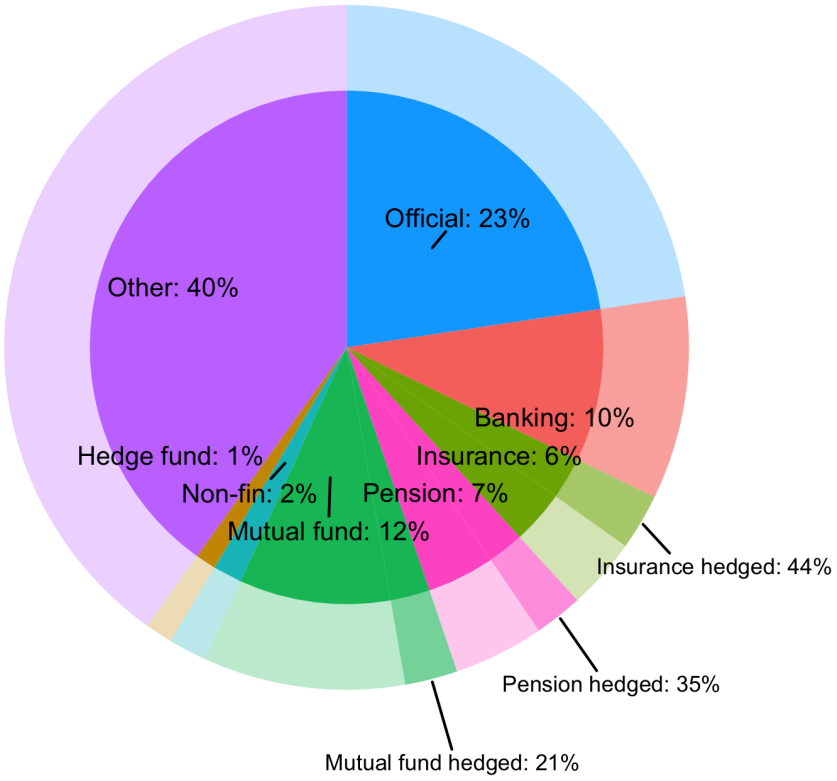
*Notes*: This figure plots foreign investors' portfolio allocation to USD asset. Allocation is estimated as the ratio of USD securities to total assets. See Table 1 for sample period coverage of different series. This figure is best viewed in color. Each country is plotted in the same color across different panels.

Figure 4: **Share of non-US issued USD debt in overall USD bond and in foreign investors' USD bond portfolio**



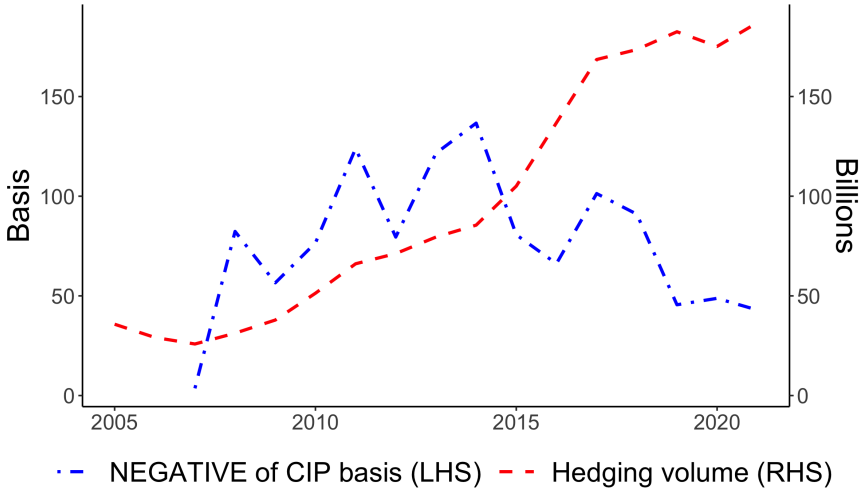

*Notes*: This figure plots USD bonds issued by non-US residents as a share of total USD bonds and as a share of all foreign-held USD bonds. "% of total USD bonds" is estimated as total foreign-issued USD divided by total USD bonds outstanding. "% of foreign-held USD bonds" is estimated as foreign-issued USD held by foreign investors divided by total foreign-held USD bonds. The sample period is from June 2002 to June 2021.

Figure 5: **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 6: **Taiwanese insurers' hedging**

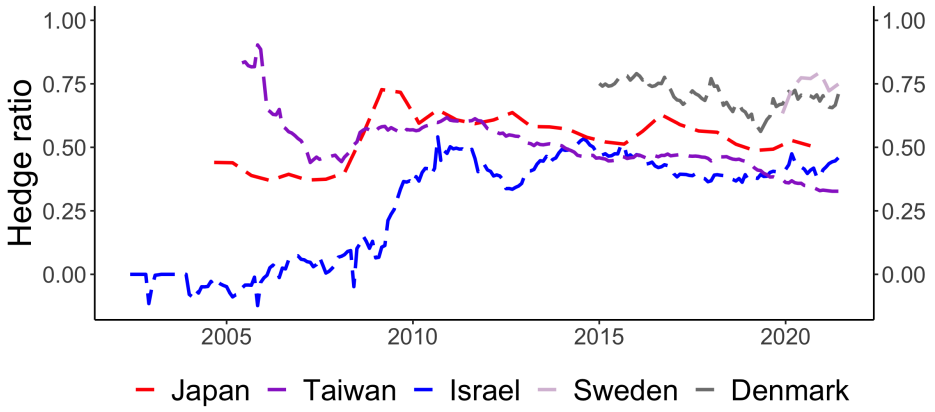



(a) **CIP basis vs. hedging amount**

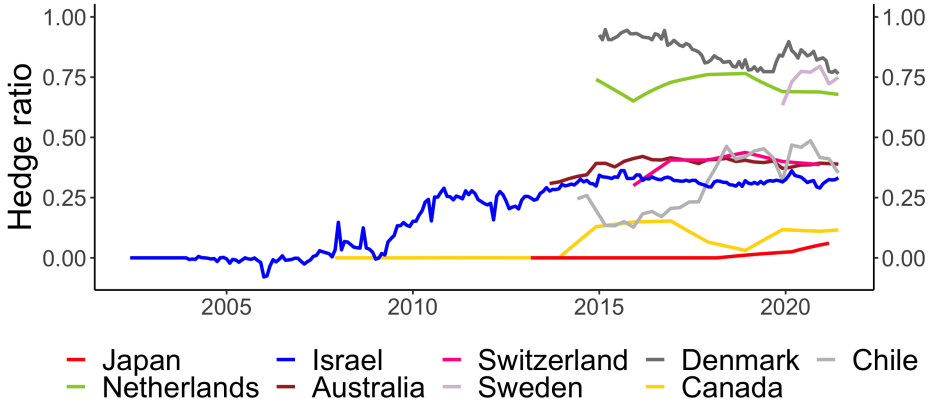

(b) **Total hedging cost**

*Notes*: This figure plots Taiwanese insurers' hedging volume against CIP basis, and their CIP-induced total hedging cost. Hedging cost is annualized and is estimated by assuming that the currency hedges are done by rolling over 3-month FX forward or swaps. CIP basis is calculated using TAIBOR.

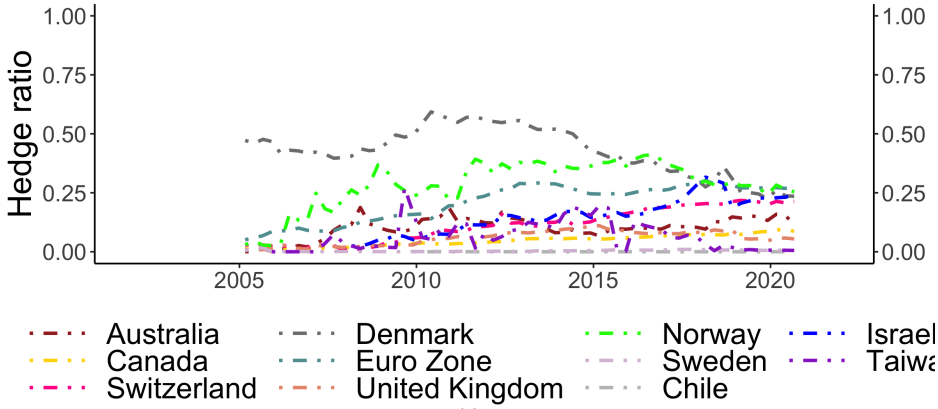
Figure 7: **USD hedging across industries**




(a) **Insurance**



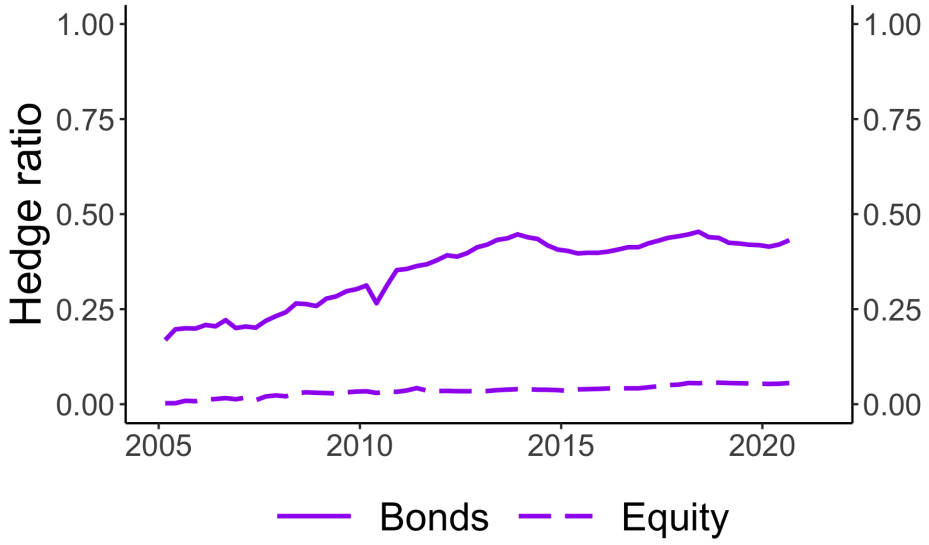

(b) **Pension**



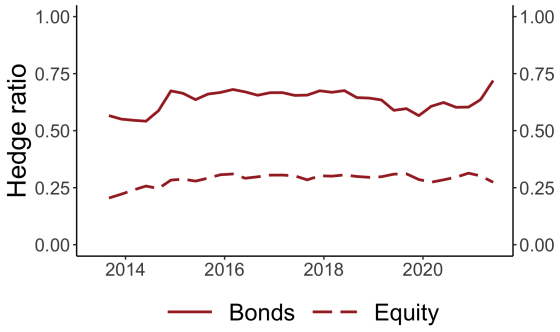

(c) **Mutual funds**

*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.

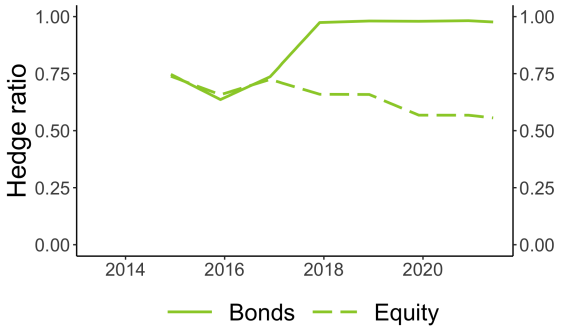
Figure 8: **USD hedging across bond vs. equity mutual funds**




(a) **Mutual funds**



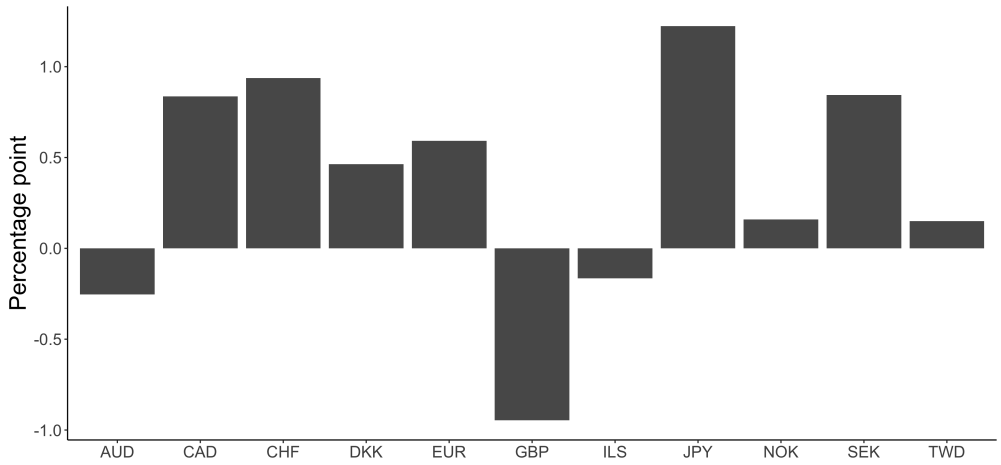

(b) **Australian pensions**



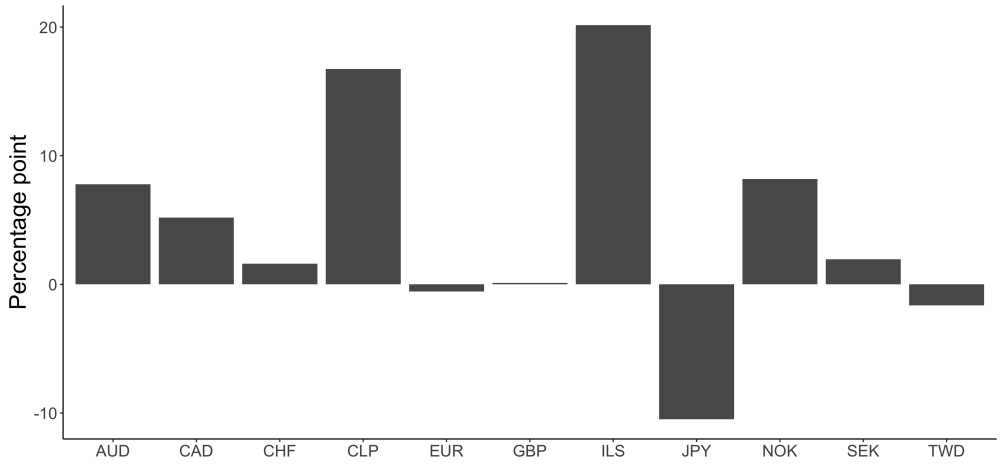

(c) **Dutch pensions**

*Notes*: This figure plots hedge ratios for USD bonds vs. for USD equity in mutual funds, Australian pensions, and Dutch pensions. See Section 2.2 for the estimation methodology of hedge ratios. See Table 1 for sample period coverage of different series.

Figure 9: **Post-GFC and pre-GFC differential in relative returns between USD and domestic assets**



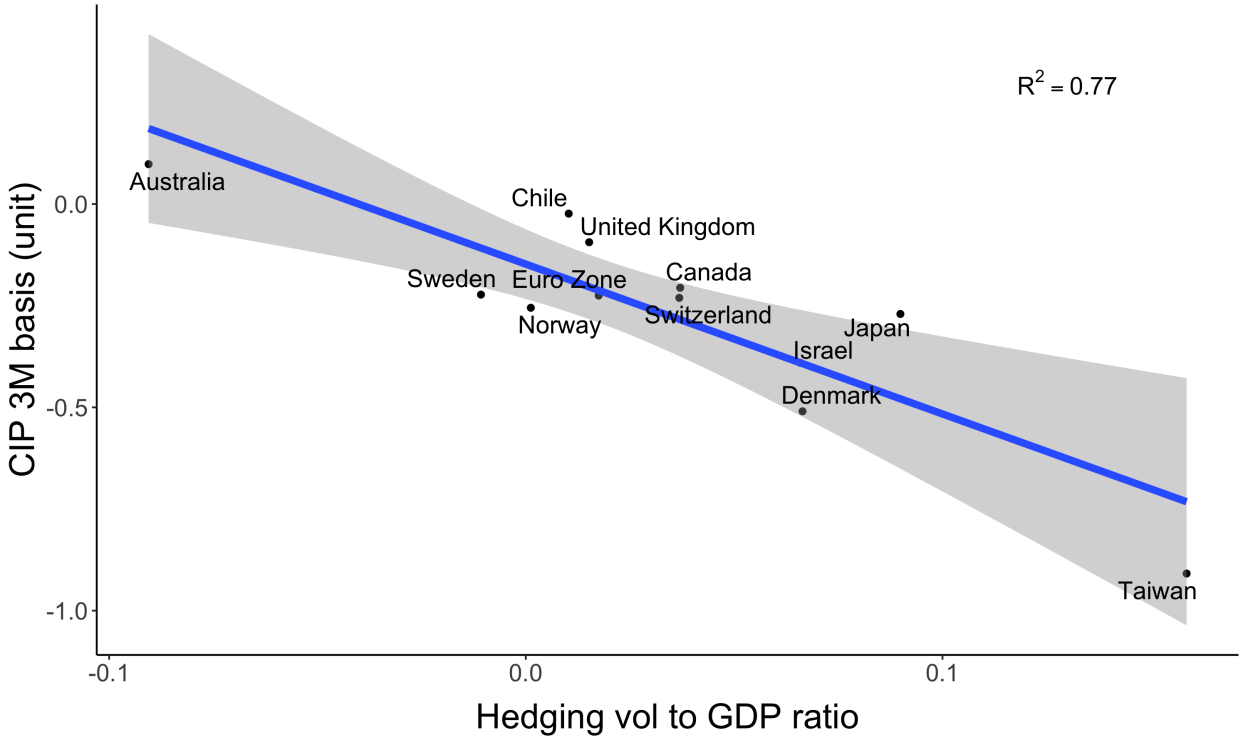

(a) **Yield curve slope**




(b) **Realized equity return**

*Notes*: This figure plots the difference between the post-GFC level and the pre-GFC level of the relative returns between USD and domestic assets. Panel (a) shows post-GFC relative yield curve slope less pre-GFC relative yield curve slope. The relative yield curve slope is measured as the average USD yield curve slope less the average domestic yield curve slope; and the yield curve slope is calculated as the yield on 10-year sovereign debt less the yield on 1-month local IBOR. Chilean peso (CLP) is not included because there is no reliable measure of 1M local IBOR pre-GFC. The post-GFC relative yield curve slope between USD and CLP is 1.27 percentage point. Panel (b) shows post-GFC relative stock return less pre-GFC relative stock return. The relative stock return is measured as the average realized USD equity market 1M return less the average realized domestic equity market 1M return; and the equity market return is measured using the most common benchmark index in respective country. Danish Kroner (DKK) is not included due to data availability pre-GFC. The post-GFC relative stock return between USD and DKK is 7.8 percentage point.

Figure 10: **Cross-section of hedging and CIP-basis**




*Notes*: This figure plots each country's time-series average of 3M IBOR CIP basis against their time-series average of hedging volume to GDP ratio. Sample period is 2010 July to 2020 September.

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

| Industry | Region / Country | Firm 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: Denmark | | Danmarks Nationalbank | 2015 | 2021 | 2015 |
| | Europe: Sweden | | Sveriges Riksbank | 2014 | 2021 | 2019 |
| | Europe: UK | | EIOPA | 2017 | 2020 | 2017 |
| | Europe: Euro 19 countries | | EIOPA | 2017 | 2021 | – |
| | | | SHS | 2013 | 2017 | – |
| | Europe: 6 other EU countries | | EIOPA | 2017 | 2021 | – |
| | ROW: Israel | | Bank of Israel | 2002 | 2021 | 2002 |
| Pensions | Asia: Japan | 1 | | 2013 | 2021 | 2013 |
| | Asia: Australia | | APRA, Australian Bureau of Statistics | 2004 | 2021 | 2013 |
| | Europe: Netherlands | 2 | | 2014 | 2021 | 2014 |
| | Europe: Denmark | | Danmarks Nationalbank | 2015 | 2021 | 2015 |
| | Europe: Sweden | | Sveriges Riksbank | 2014 | 2021 | 2019 |
| | Europe: Switzerland | | Federal Statistical Office | 2004 | 2020 | 2015 |
| | Europe: UK | | Office for National Statistics | 2002 | 2021 | – |
| | NA: Canada | 2 | | 2007 | 2021 | 2010 |
| | ROW: Israel | | Bank of Israel | 2002 | 2021 | 2002 |
| | ROW: Chile | | Superintendencia de Pensiones | 2014 | 2023 | 2014 |
| | ROW: 9 Latam countries | | FIAP | 2002 | 2021 | – |
| Mutual funds | 64 countries | | Morningstar | 2002 | 2021 | 2002 |
| Banking | 48 countries | | BIS Locational Banking Statistics | 2002 | 2021 | – |
| Hedge funds | 53 countries | | 13F, Factset | 2002 | 2021 | – |
| Non-financial | 56 countries | | CPIS | 2002 | 2020 | – |
| Official sector | 237 countries and jurisdictions | | 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 2: **USD allocation in the time-series**

| | Share: USD in Portfolio | | Share: USD in Foreign | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Indicator: Crisis | 0.69** | | 2.8* | |
| | (0.31) | | (1.4) | |
| Indicator: Post-Crisis | 7.7*** | | 6.6*** | |
| | (0.85) | | (1.1) | |
| Counter by Quarter | | 0.23*** | | 0.18*** |
| | | (0.01) | | (0.02) |
| Currency X Industry | Yes | Yes | Yes | Yes |
| Observations | 1,449 | 1,449 | 1,082 | 1,082 |
| $R^2$ | 0.78 | 0.84 | 0.70 | 0.71 |

*Notes*: This table examines time-series patterns in portfolio allocation to USD securities. "Share: USD in Portfolio" is the share of USD securities in overall investors' portfolio, stated in percentage points. "Share: USD in Foreign" in the share of USD securities in investors' portfolio that's not invested in locally, stated in percentage points. "Counter by Quarter" is a counter that increases linearly for each passing quarter. Sample period is 2002 June through 2020 September, and observations are industry-currency-quarter, where the industries include insurance, pensions, and mutual funds. Standard errors are calculated using Driscoll and Kraay (1998), and *, **, *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table 3: **Hedging behavior in the time-series**

| | Hedge Ratio | | Unhedged USD alloc | Hedge Ratio |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Indicator: Crisis | 0.052*** | 0.079*** | 0.026* | |
| | (0.016) | (0.022) | (0.014) | |
| Indicator: Post-Crisis | 0.160*** | 0.147*** | 0.066*** | |
| | (0.016) | (0.017) | (0.011) | |
| CIP 3M Basis Qtr Avg | | | | -0.041** |
| | | | | (0.015) |
| Currency X Industry | No | Yes | Yes | Yes |
| Observations | 1,229 | 1,229 | 1,060 | 893 |
| $R^2$ | 0.07 | 0.86 | 0.70 | 0.91 |

*Notes*: This table examines time-series patterns in hedging. "Hedge ratio" is total volume of hedging as a ratio of total USD securities. "Unhedged USD alloc" is the share of the portfolio invested in USD securities and not hedged. Sample period is 2002 June through 2020 September, and observations are industry-currency-quarter, where the industries include insurance, pensions, and mutual funds. Standard errors are calculated using Driscoll and Kraay (1998), and *, **, *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table 4: **Summary statics on hedged and unhedged USD bond returns**

| | | $rx^{USD,unhedged}$ | | | $rx^{USD,hedged}$ | | |
|---|---|---|---|---|---|---|---|
| Currency | Corr($rx^{FX}, rx^{USD}$) | Mean | Stdev | Sharpe | Mean | Stdev | Sharpe |
| USD | | 3.30% | 8.27% | 0.40 | | | |
| AUD | 0.02 | -0.36% | 14.97% | -0.02 | 3.68% | 8.06% | 0.46 |
| CAD | 0.17 | 1.82% | 13.31% | 0.14 | 3.43% | 8.06% | 0.42 |
| CHF | -0.16 | 1.81% | 11.86% | 0.15 | 3.38% | 8.06% | 0.42 |
| CLP | 0.15 | -0.95% | 13.67% | -0.07 | 3.57% | 7.82% | 0.46 |
| DKK | -0.11 | -0.07% | 11.53% | -0.01 | 3.25% | 7.77% | 0.42 |
| EUR | -0.07 | 2.44% | 12.11% | 0.20 | 3.36% | 8.06% | 0.42 |
| GBP | 0.17 | 3.12% | 13.14% | 0.24 | 3.46% | 8.06% | 0.43 |
| ILS | 0.11 | 0.49% | 11.85% | 0.04 | 3.94% | 8.12% | 0.49 |
| JPY | -0.43 | 4.04% | 9.09% | 0.44 | 3.37% | 8.07% | 0.42 |
| NOK | 0.11 | 2.57% | 15.07% | 0.17 | 3.26% | 8.09% | 0.40 |
| SEK | -0.02 | 0.81% | 13.64% | 0.06 | 4.17% | 7.70% | 0.54 |
| TWD | 0.10 | 2.45% | 9.93% | 0.25 | 3.16% | 7.99% | 0.40 |

*Notes*: This table reports the summary statics for annualized 1-month holding period excess return of USD 10Y government bonds in local currencies, hedged and unhedged. Sample period is 2002 June through 2021 June.

Table 5: **Summary statics on hedged and unhedged USD stock returns**

| | | $rx^{USD,unhedged}$ | | | $rx^{USD,hedged}$ | | |
|---|---|---|---|---|---|---|---|
| Currency | Corr($rx^{FX}, rx^{USD}$) | Mean | Stdev | Sharpe | Mean | Stdev | Sharpe |
| USD | | 15.77% | 20.45% | 0.77 | | | |
| AUD | -0.28 | 12.49% | 20.69% | 0.60 | 16.46% | 20.88% | 0.79 |
| CAD | -0.23 | 14.30% | 20.39% | 0.70 | 16.21% | 20.88% | 0.78 |
| CHF | -0.07 | 14.28% | 22.16% | 0.64 | 16.16% | 20.89% | 0.77 |
| CLP | -0.27 | 17.47% | 19.47% | 0.90 | 17.60% | 20.66% | 0.85 |
| DKK | -0.13 | 14.94% | 21.41% | 0.70 | 13.71% | 21.07% | 0.65 |
| EUR | -0.14 | 14.91% | 21.29% | 0.70 | 16.14% | 20.90% | 0.77 |
| GBP | -0.01 | 15.59% | 22.24% | 0.70 | 16.24% | 20.89% | 0.78 |
| ILS | -0.21 | 12.93% | 20.33% | 0.64 | 17.68% | 19.81% | 0.89 |
| JPY | 0.11 | 16.52% | 23.12% | 0.71 | 16.15% | 20.89% | 0.77 |
| NOK | -0.22 | 15.67% | 21.30% | 0.74 | 15.50% | 20.86% | 0.74 |
| SEK | -0.20 | 15.58% | 21.33% | 0.73 | 15.28% | 20.97% | 0.73 |
| TWD | -0.36 | 12.57% | 19.36% | 0.65 | 15.85% | 21.52% | 0.74 |

*Notes*: This table reports the summary statics of annualized 1-month excess return of US S&P equity in local currencies, hedged and unhedged. Sample period is 2002 June through 2021 June.

Table 6: **Model-implied comparative statics**

| Currency | Effect of relative return ($rx^{\$b} - rx^{lb}$) Gross USD allocation ($w_{US}$) | Effect of relative return ($rx^{\$b} - rx^{lb}$) Net USD allocation ($w_{NH}$) | Effect of CIP basis ($x$) Gross USD allocation ($w_{US}$) | Effect of CIP basis ($x$) Net USD allocation ($w_{NH}$) |
|---|---|---|---|---|
| AUD | + | + | + | - |
| CAD | + | + | + | - |
| CHF | + | + | + | - |
| DKK | + | + | + | - |
| EUR | + | + | + | - |
| GBP | + | + | + | - |
| JPY | + | + | + | - |
| NOK | + | + | + | - |
| SEK | + | + | + | - |
| CLP | + | - | + | - |
| ILS | + | - | + | - |
| TWD | + | - | + | - |

*Notes*: This table reports comparative statics of the mean-variance agent's optimal portfolio with respect to relative asset returns ($\overline{rx}^{\$b} - \overline{rx}^{lb}$) and with respect to CIP basis ($x$).

Table 7: **Empirical effects of *changes* in expected asset returns and CIP basis**

| Currency | Effect of relative return ($rx^{\$b} - rx^{lb}$) Gross USD allocation ($w_{US}$) | Net USD allocation ($w_{NH}$) | Effect of CIP basis ($x$) Gross USD allocation ($w_{US}$) | Net USD allocation ($w_{NH}$) |
|---|---|---|---|---|
| AUD | - | - | + | + |
| CAD | + | + | + | + |
| CHF | + | + | - | + |
| DKK | + | + | + | + |
| EUR | - | + | + | + |
| GBP | + | - | - | + |
| JPY | + | + | - | + |
| NOK | + | - | + | + |
| SEK | + | - | - | - |
| CLP | + | + | + | + |
| ILS | + | - | + | + |
| TWD | - | - | + | + |

*Notes*: This table reports the empirical relationship between changes in optimal portfolio allocation and changes in relative asset returns and CIP basis. Red denotes that the sign is consistent with the model prediction in Table 6.

Table 8: **CIP deviations and hedging**

| | CIP 3M Basis | |
|---|---|---|
| | (1) | (2) |
| Hedging vol to GDP ratio | -1.55*** | -2.16*** |
| | (0.384) | (0.246) |
| Time | No | Yes |
| Observations | 492 | 492 |
| $R^2$ | 0.13 | 0.33 |

*Notes*: This table examines the relationship between CIP basis and hedging. All variables are quarter averages. Sample period is 2010 July through 2020 September. Standard errors are calculated using Driscoll and Kraay (1998). *, **, *** 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 Fact 1 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).

Denmark provides more detailed reporting for its insurers. Instead of EIOPA, we use the monthly reporting by Danmarks Nationalbank to track Danish insurers' investment by currency and by security type. We also opt for country-specific reporting for Swedish insurers. The Sveriges Riksbank releases semi-annual Financial Stability Report, where in certain issues, they report the historical quarterly investment holdings by insurance companies. Life insurers have the longest time series from 2009 through 2022, whereas data for non-life and unit-linked insurance products end in 2019. We use the ratio between life and other types of insurers prior to 2019 to impute the size of non-life insurers post 2019. The final series start in 2014 due to an adjustment that Sveriges Riksbank made in 2022. We use the split between debt and equity in the overall portfolio to be informative about the security type split of the foreign portfolio.

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.[36] 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

[36] Ben Zeev and Nathan (2022a) 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.

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,[37] covering 50% of assets in all Dutch pension funds.[38]. We obtain from ABP's and PFZW's annual reports their total assets, USD investments, and the split between USD equities and USD bonds.

The two largest pension funds in Canada are the Canada Pension Plan Investment Board (CPP) and Caisse de dépôt et placement du Québec (CDPQ). These two funds have 45% of the AUM of the top eight public pension funds in Canada, which in turn represent two thirds of all pension assets in Canada.[39] We collect from CPP's annual reports its total assets, investment in the U.S., and target portfolio allocation. CPP stopped investing in foreign bonds after 2015 so that all of its exposure to the U.S. is from equity. We collect from CDPQ's annual report its total asset, foreign portfolio along with the split between debt and equity, and USD exposure. In recent years, CDPQ stopped reporting USD exposure and reports only exposure to the U.S., which we use as an estimate of the former, understanding that this would be a conservative estimate.

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

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

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

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

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.

The Superintendencia de Pensiones of Chile releases quarterly reports on the country's pension sector starting in 2014. Information is detailed and includes total assets, foreign investments, the split of bond vs. equity in the foreign investment portfolio, and currency exposures of investments.

Finally, we also consider pension funds in Denmark, Sweden, Israel and 9 other mostly Latin American countries. The data for Danish, Swedish, and Israeli pensions are from the same sources as those for insurers in these countries, 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, El Salvador, Mexico, Peru, Dominican Republic, Uruguay, and Kazakhstan.[40]

### 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 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.

[40]FIAP also has sparse reporting from Russian Fedration, Poland, and Romania; however, these reports stopped after 2013. For Chile, we use information obtained directly from Superintendencia de Pensiones instead of the aggregate statistics from FIAP.

### 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.[41] 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.[42]

### 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

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 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.

### 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

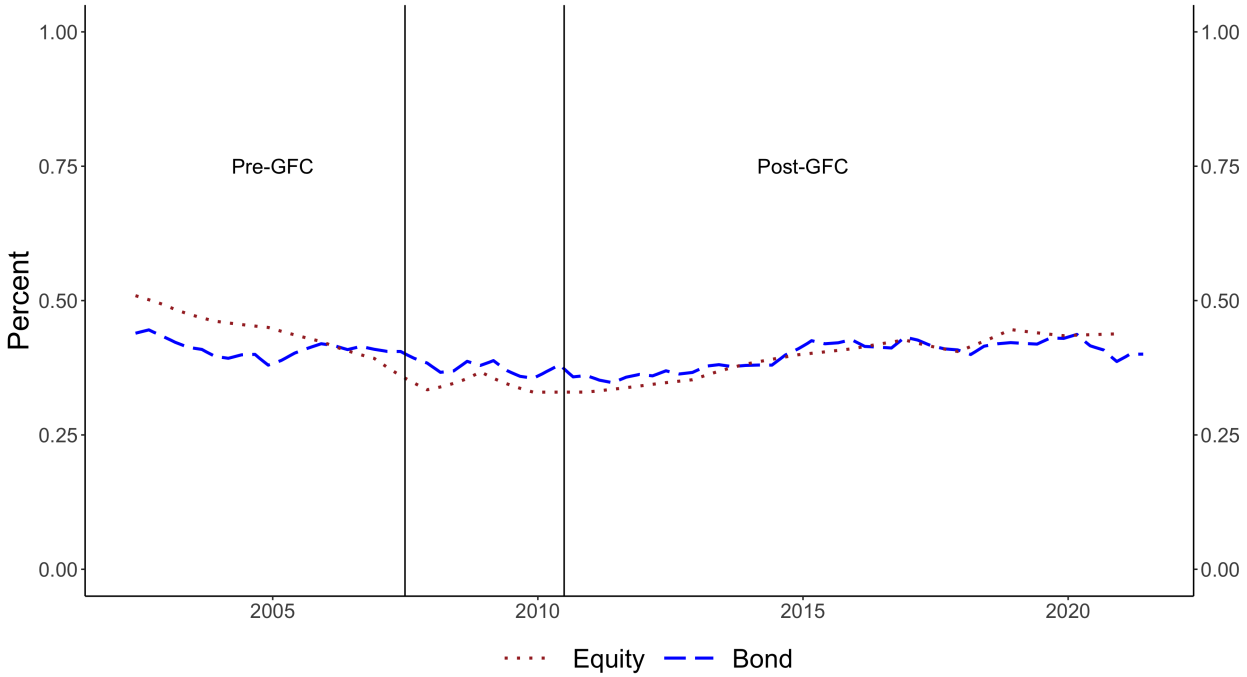
[41] This information cannot be deduced from United States' reporting to the BIS because the U.S. reports only U.S. banks' loan and deposit positions and does not include debt securities positions.

[42] 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.

assets from non-US entities. The TIC system reports holding of U.S. securities by the official sector in 237 countries and jurisdictions, separately for equity and bonds.

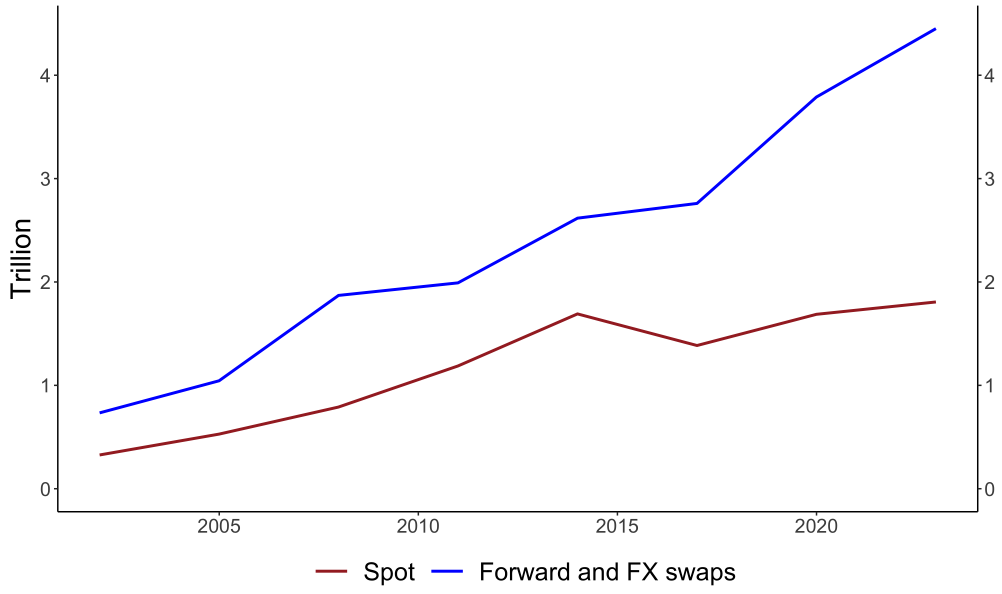
# B Additional Figures and Tables

Figure A1: **Share of USD debt and equity in global debt and equity markets**

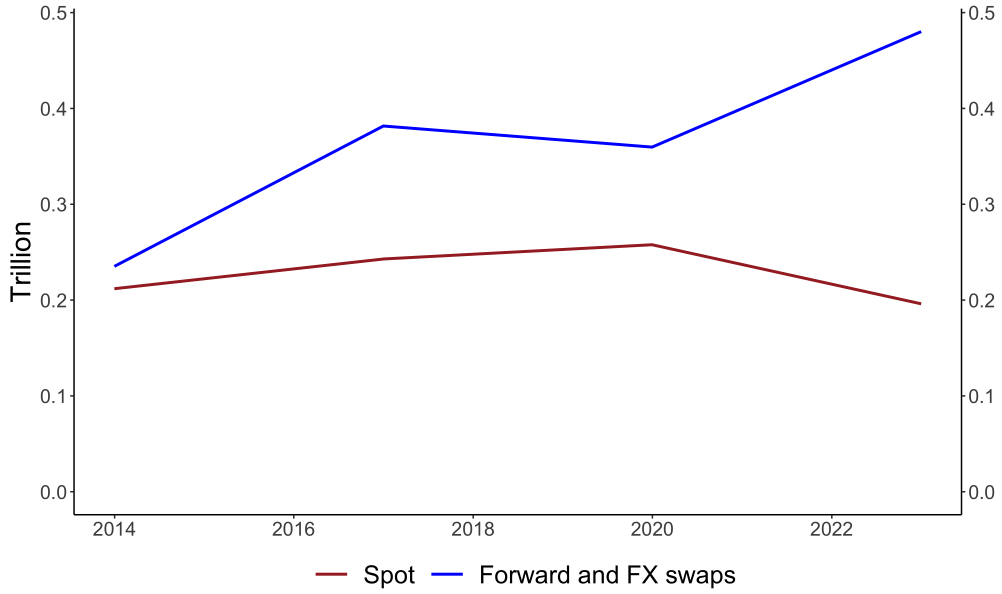



*Notes*: This figure plots the share of USD debt and equity in global debt and equity markets. Global debt market size is calculated from BIS' debt securities statistics, inclusive of all issue markets. Global equity market is the sum of global public market cap and global private equity AUM. Global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

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



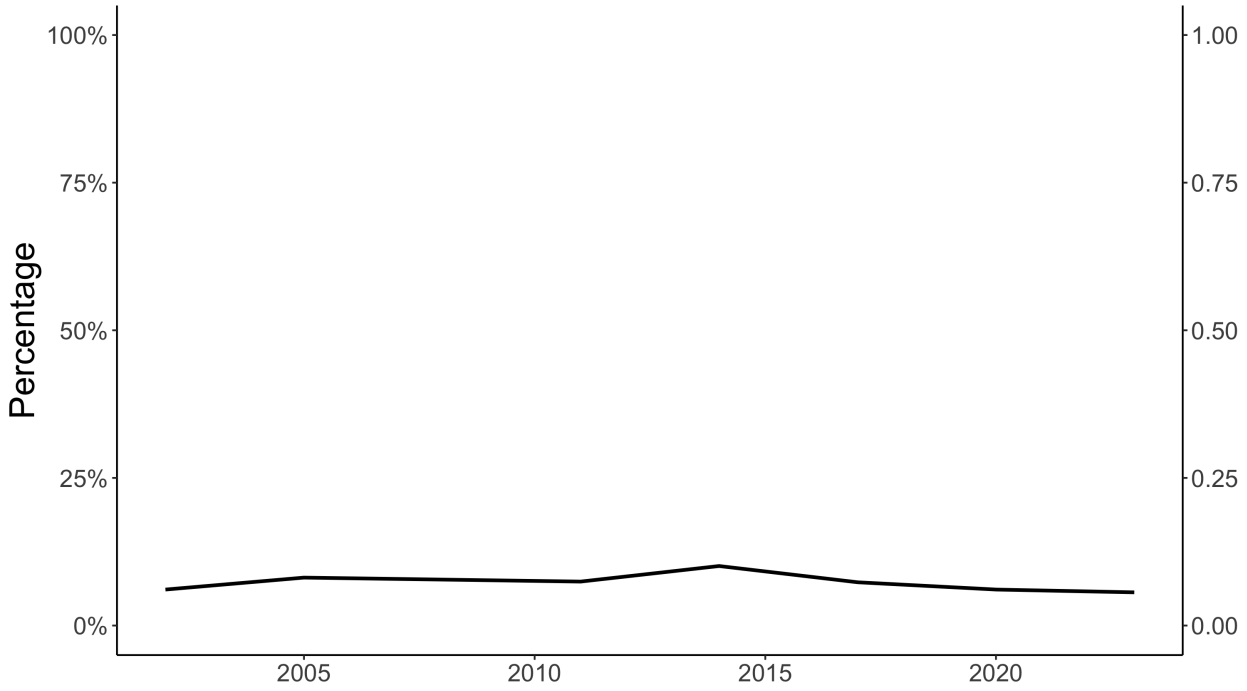

(a) **All volumes**




(b) **Institutional investors**

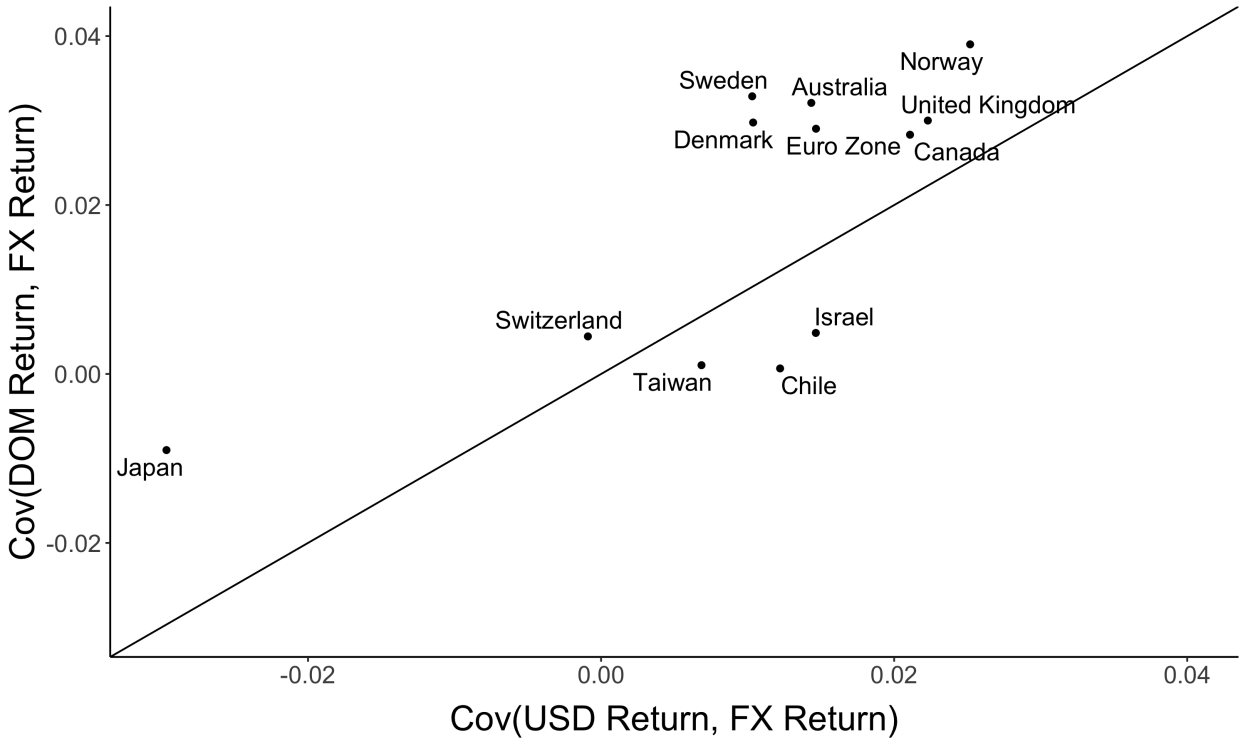
*Notes*: This figure plots the global daily volume of foreign exchange spot vs. forward and FX swaps transactions involving USD. Panel (a) shows the total market volume, and panel (b) shows the volume from transactions involving institutional investors. Daily volume is calculated as the average of all trading days in April of the survey year. The survey is conducted triennially from 2001 to 2022 by BIS.

Figure A4: **Share of non-forward, non-swap FX derivatives**




*Notes*: This figure plots the share of non-forward and non-swap derivatives in all FX derivatives. FX derivatives include in FX forward, FX swaps, FX options, FX futures, and other instruments. Daily volume is calculated as the average of all trading days in April of the survey year. The survey is conducted triennially from 2001 to 2022 by BIS.

Figure A5: **Covariance between FX return and asset returns**




*Notes*: This figure plots the covariance between $rx^{RX}$ and $rx^{lb}$ against the covariance between $rx^{RX}$ and $rx^{\$b}$. Above the diagonal line indicates that $\sigma_{\$b,FX} < \sigma_{lb,FX}$. Covariance estimated using realized 1M holding-period excess 10Y sovereign bondn returns from 2010 to 2021.

Table A1: **Summary of investment limits**

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

*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 A2: **Model-implied comparative statics for hedge ratio**

| Currency | Effect of relative return ($rx^{\$b} - rx^{lb}$) USD hedge ratio ($1 - \frac{w_{NH}}{w_{US}}$) | Cap for increasing hedge ratio | Effect of CIP basis ($x$) USD hedge ratio ($1 - \frac{w_{NH}}{w_{US}}$) |
|---|---|---|---|
| AUD | + | 88% | + |
| CAD | + | 91% | + |
| CHF | + | 94% | + |
| DKK | + | 78% | + |
| EUR | + | 84% | + |
| GBP | + | 91% | + |
| JPY | + | 74% | + |
| NOK | + | 91% | + |
| SEK | + | 82% | + |
| CLP | + | - | + |
| ILS | + | - | + |
| TWD | + | - | + |

*Notes*: This table reports comparative statics of the mean-variance agent's optimal hedge ratio with respect to relative asset returns ($\overline{rx}^{\$b} - \overline{rx}^{lb}$) and CIP basis ($x$). The cap for increasing hedge ratio shows the hedge ratio below which the partial of USD hedge ratio w.r.t. relative asset return is positive.

Table A3: **Correlation between GDP and banks' cross-country trading assets**

| | Trading Assets | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | Citi All | Citi Ex China | JPM All | JPM Ex China |
| GDP | 0.073*** | 0.764*** | 0.419** | 1.29*** |
| | (0.013) | (0.110) | (0.091) | (0.230) |
| Year | Yes | Yes | Yes | Yes |
| Observations | 120 | 115 | 100 | 95 |
| $R^2$ | 0.03 | 0.27 | 0.20 | 0.28 |

*Notes*: This table reports the correlation between GDP and Citi's and JPM's (JP Morgan's) trading assets in reported geographies. Trading assets are measured in billions of USD and GDP is measured in trillions of USD. Sample period is 2018 to 2022, and measurement frequency is annual. Standard errors are calculated using Driscoll and Kraay (1998). *, **, *** denotes significance at the 10%, 5%, and 1% level, respectively.