

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 estimate of foreign investors' U.S. dollar (USD) security holdings and currency hedging practices. We document three stylized facts. First, driven by growing portfolio allocations, foreign investors increased their holdings of USD securities by six-fold in the past two decades. Second, after the financial crisis of 2007-09, foreign investors increased their USD hedge ratio by 15 percentage points on average, despite higher hedging costs implied by large and persistent deviations from covered-interest rate parity. Third, there is considerable heterogeneity in hedging practice across countries and sectors. We develop a simple mean-variance framework to examine the drivers of currency hedging, and show empirically that hedging demand significantly deviates from the mean-variance framework. Furthermore, 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

¹Following 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. There are no standardized data sources on investors’ dollar holding and hedge across countries or sectors, we therefore comb through company filings and industry statistics to generate the first by-sector account of foreign dollar holdings and hedging. 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 significantly increased their preference for dollar assets over the past two decades. The size of foreign holdings of USD securities increased by six-fold 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 com-

²IMF’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.

panies, 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-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, 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 start with a simple mean-variance investor's portfolio for the optimal currency hedging. The investor's problem can be thought of allocating a portfolio over the local-currency risk-free asset, a risky USD asset, and the short-term FX forward to hedge USD currency risk. We show that under general conditions, the optimal hedge ratio increases in the volatility of FX risk, and in the covariance between FX risk and the U.S. asset return. Moreover, the optimal hedge ratio is affected by deviations from uncovered interest rate parity (UIP) and CIP. In particular, the optimal hedge ratio decreases in the expected return on the FX trade of going long USD and short the local currency, or the UIP deviation, and decreases in the additional

cost of hedging USD back to the local currency beyond the interest rate differential, or the CIP deviation. Finally, the optimal hedge ratio also increases in the excess return on the U.S. asset over the U.S. risk-free rate, all else being equal.

After deriving the main insights for the optimal hedge ratio, we compare the drivers of hedging in the model with the data. In the time series, the rise in the hedge ratio is consistent with a rising expected return on the U.S. asset and rising USD allocation. However, in the cross section, using a panel regression with industry fixed effects, we see that the regression coefficients of the hedge ratio on the expected FX returns, the covariance between FX and U.S. asset returns, and the cross-currency basis are all of the opposite signs compared to the predictions of the mean-variance framework. The inconsistency between theory and data suggests that hedging demand is likely driven by factors beyond the mean-variance considerations, such as regulatory constraints, institutional mandates, liability-driven hedging demand.

Finally, 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 hedging 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. Compared to previous works that consider currency hedging in portfolios, for example, [Campbell and Viceira \(2002\)](#) and [Campbell, de Medeiros, and Viceira \(2010\)](#), our model highlights the impact of UIP and CIP deviations on the FX hedging decision, in addition to the usual variance-covariance hedging motive. Moreover, we are able to use data to highlight where investors' behavior align versus diverge from theoretical predictions. 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 study the currency composition of mutual funds' portfolios (e.g., [Maggiori, Neiman, and Schreger \(2020\)](#)), that look at portfolio allocation of institutional investors in Europe (e.g., [Faia, Salomao, and Veghazy \(2022\)](#)), 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 \(2022\)](#)), and that documents investors' home bias when deciding to invest abroad (e.g., [French and Poterba \(1991\)](#))

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.³ Second, we show that investors' hedging demand offers an explanation for the cross-sectional variations in the CIP basis. The cross-

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

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.⁴ 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 does not originate solely 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 ([Kojien 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 estimations of the demand-system based asset pricing models where foreign investors are often treated as a homogeneous group (for example, [Kojien, Richmond, and Yogo \(2020\)](#)).

Finally, our paper contributes to the large literature on dollar safe assets (for example,

⁴[Diamond and Van Tassel \(2021\)](#) resolves the cross-section of CIP basis using market-specific option-implied box-rate. Their results similarly imply segmentation within intermediaries. Our results posit hedging as a reason why intermediaries within each market become constrained.

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

$$\begin{aligned} &= \text{Foreign USD Holding of U.S. Issuers} + \text{Foreign USD Holding of Non-U.S. Issuers} \\ &= (\text{TIC Foreign Holding of U.S. Securities} - \text{TIC Foreign Holdings of Non-USD Securities}) \\ &+ (\text{USD Securities Outstanding Outside the U.S.} - \text{U.S. Investors' Cross-border USD Holdings}). \end{aligned}$$

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 [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 Japan⁷ 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

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

⁶High-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.

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>

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 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.

⁹EIOPA 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.

¹⁰Ben 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.

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 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

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

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>

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.

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

¹⁴We 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.

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, 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.

¹⁵This 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.

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 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

¹⁶From 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.

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

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 in Section 3.

Foreign Insurance Companies’ Hedging

We estimate Japanese insurers’ hedging practice directly from company-level filings on FX derivatives positions, available at the semiannual 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 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.

¹⁸This 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.

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

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

and the log version as $x_{t,\tau}^{c,\$} = \ln(1 + X_{t,\tau}^{c,\$})$. We use $R_{t,\tau}^c$ to denote the annualized spot gross τ -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 τ -month forward exchange rate at time t is $F_{t,\tau}$.

The classic CIP condition is that $x_{t,\tau}^{c,\$} = X_{t,\tau}^{c,\$} = 0$, which occurs when the forward exchange rate is priced based on the interest rate differential. If the cross-currency basis $x_{t,\tau}^{c,\$}$ is negative (positive), then the forward exchange rate is priced too low (high) relative to the prevailing interest rates, 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 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

¹⁹We 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.

²⁰In 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.

countries²¹ 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 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,

²¹Croatia adopted the euro on January 1, 2023. Because our data ends in June 2021, Croatia is not considered a Eurozone country.

²²The only exceptions are the U.K., which shows a mild decrease in allocation post the Financial Crisis of 2007-09; and Chile, which significantly reduced its USD exposure in 2018 and 2019 but increased its dollar holdings again starting in March 2020.

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, 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

²³BIS 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)

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 cost²⁴ 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 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

²⁴Investors 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.

²⁵Investors' 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.

²⁶Specifically, 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.

²⁷For 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).

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 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' hedging decisions to a mean-variance benchmark to study the extent that mean-variance trade-off rationalizes data. We then introduce a financial intermediary with possible balance-sheet constraints to reconcile the positive correlation between hedging activity and cost, and 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 a local risk-free asset and a USD asset in a frictionless world. The foreign investor has a portfolio of size A_l . He chooses the share of his portfolio invested in the USD asset, and decides whether to take the currency risk associated with the USD asset.

We denote the log return on the local risk-free asset as rf . The log return on the USD asset measured in dollars is given by $r_{t+1}^{\$}$, referred to as the "U.S. asset return", and the USD risk-free rate is given by $rf_t^{\$}$. The foreign investor cannot directly earn $r_{t+1}^{\$}$, and the return in her local currency on holding the USD asset depends on her 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

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

which is equal to the sum of U.S. asset return over the USD risk-free rate, $rx_{t+1}^{\$}$, and the currency returns of going long the USD risk-free rate, and shorting the local currency risk-free rate, rx_{t+1}^{FX} , which we refer to as the “USD FX return.”

If instead, the foreign investor decides to fully hedge the currency risk of the USD asset by selling USD forward using a forward contract in exchange for local currency, then the hedged excess return over the local currency risk-free rate becomes

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

Therefore, the hedged return for the foreign investor is approximately equal to the sum of the U.S. asset 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 a risk aversion parameter γ . The investor he chooses w_{US} , the portfolio share in total USD asset, and w_{NH} , the portfolio share in unhedged USD asset, and leaves $1 - w_{US} - w_{NH}$ in the local risk-free rate asset.

The mean-variance investor maximizes:

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

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

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

The expected return and the variance of the portfolio are:

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

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 σ_C^2 is the variance of asset C's return. 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.

4.1.1 Optimal Portfolio Allocation and Hedging

From the investor's first-order conditions, we derive the investor's optimal allocation in the USD asset and FX exposure:

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

$$w_{NH}^* = \frac{(\overline{rx}^{FX} - x)\sigma_{\$}^2 - (\overline{rx}^{\$} + x)\sigma_{FX,\$}}{\gamma(\sigma_{FX}^2\sigma_{\$}^2 - (\sigma_{FX,\$})^2)}. \quad (3)$$

With the optimal portfolio shares solved, the optimal hedge ratio is given by

$$HR^* = 1 - \frac{w_{NH}^*}{w_{US}^*} = \frac{(\overline{rx}^{\$} + x)(\sigma_{FX}^2 + \sigma_{FX,\$}) - (\overline{rx}^{FX} - x)(\sigma_{\$}^2 + \sigma_{FX,\$})}{(\overline{rx}^{\$} + x)\sigma_{FX}^2 - (\overline{rx}^{FX} - x)\sigma_{FX,\$}}. \quad (4)$$

To understand the intuition of the hedge ratio, we define a few important parameters to simplify the expression:

$$\begin{aligned} \lambda &\equiv \sigma_{FX}^2/\sigma_{\$}^2, \\ \beta &\equiv \sigma_{FX,\$}/\sigma_{\$}^2, \\ \phi &\equiv \frac{\overline{rx}^{FX} - x}{\overline{rx}^{\$} + x}. \end{aligned}$$

First, the parameter λ denotes the ratio of the volatility of the USD FX return over the volatility of the U.S. asset return. Second, the parameter β denotes the regression coefficient of the USD FX return on the U.S. asset return, an important measure of the correlation between currency risk and U.S. asset return. Third, the parameter ϕ denotes the ratio of the USD FX return (going long USD and shorting the local currency using an FX forward)

over the hedged U.S. asset return. We note that the cross-currency basis, x , enters into the expression for both the numerator and the denominator. This is because the investor in the model cannot directly long or short the U.S. risk-free interest rate. Instead, both currency hedging and speculation have to use the FX forward, and the cross-currency basis acts as a wedge for both the USD FX return and the FX-hedged U.S. asset return. A negative cross-currency basis reduces the FX-hedged U.S. return, but increases the USD FX return.

We can now rewrite the hedge ratio only in terms of these three parameters,

$$HR^* = 1 + \frac{\beta - \phi}{\lambda - \phi\beta}. \quad (5)$$

Therefore, the optimal hedge ratio depends on the volatility of the FX return relative to the return of the underlying U.S. asset, the correlation between the FX return and the U.S. asset return, and how the expected FX return compares to the FX-hedged U.S. asset return.

4.1.2 Comparative Statistics of the Optimal Hedge Ratio

We study the drivers of the investor's optimal hedge ratio by examining its comparative static with respect to its various components. Compared to the portfolio problem in [Campbell, de Medeiros, and Viceira \(2010\)](#), which minimizes the portfolio variance without taking into account the effect on the portfolio returns, our framework allows for the expected return differential between hedged and unhedged return and the cost of hedging to also affect the optimal hedge ratio.

In particular, the comparative static with respect to ϕ shows the impact of returns on the hedge ratio, while comparative statics with respect to λ and β inform the effect of the variance-covariance structure of returns on the hedge ratio. We start by examining the effect

of ϕ :

$$\frac{\partial HR^*}{\partial \phi} = \frac{\beta^2 - \lambda}{(\lambda - \phi\beta)^2} \propto \text{sign}((\sigma_{FX,\$})^2 - \sigma_{FX}^2 \sigma_{\$}^2) < 0.$$

Therefore, given $\phi \equiv \frac{\bar{r}^{FX} - x}{\bar{r}^{\$} + x}$, the mean-variance investor's optimal hedge ratio increases in the FX return, decreases in the USD asset return, and decreases in the hedging cost.

$$\frac{\partial HR^*}{\partial \bar{r}^{FX}} < 0, \quad \frac{\partial HR^*}{\partial \bar{r}^{\$}} > 0, \quad \frac{\partial HR^*}{\partial x} > 0. \quad (6)$$

These comparative statics with respect to expected returns and the cost of hedging are intuitive. An increase in the expected USD FX return increases the incentive to leave the USD asset unhedged, reducing the hedge ratio. A more negative cross-currency basis ($x \downarrow$) increases the cost of hedging currency risk, also reducing the hedge ratio. Finally, an increase in the expected U.S. asset return increases total allocations to U.S. asset (w_{US}) but, all else equal, does not increase unhedged allocation (w_{NH}) commensurately, leading to a higher hedge ratio.

Next, we examine the effect of β on the hedge ratio:

$$\frac{\partial HR}{\partial \beta} = \frac{\lambda - \phi^2}{(\lambda - \phi\beta)^2} \propto \text{sign} \left(\frac{\bar{r}^{\$} + x}{\sigma_{\$}} - \frac{\bar{r}^{FX} - x}{\sigma_{FX}} \right)$$

The partial of the hedge ratio with respect to β informs the comparative static with respect to the covariance between FX risk and the U.S. asset return. The sign of the comparative statistic depends on the relative Sharpe ratio of the FX-hedged U.S. asset return, and the Sharpe ratio of the FX return. The intuition is as follows. The mean-variance investor wants to minimize portfolio variance holding all else is equal. An increase in the covariance between the FX return and the U.S. asset return is not desirable. The investor thus wants to reduce

her exposure to either the U.S. asset or the USD FX exposure. If the FX-hedged U.S. asset has a higher Sharpe ratio, the investor reduces the dollar FX exposure by hedging more.

Thus, the hedge ratio increases in the covariance between the FX return and U.S. asset return

$$\frac{\partial HR^*}{\partial \sigma_{FX,\$}} > 0 \quad \text{if} \quad \frac{\overline{rx}^{\$} + x}{\sigma_{\$}} > \frac{\overline{rx}^{FX} - x}{\sigma_{FX}}. \quad (7)$$

Empirically, given the large FX volatility, the Sharpe ratio of going long USD and shorting a single foreign currency is generally inferior to the Sharpe ratio of the broad U.S. bond and equity returns, so the condition $\frac{\overline{rx}^{\$} + x}{\sigma_{\$}} > \frac{\overline{rx}^{FX} - x}{\sigma_{FX}}$ typically holds well in the data.

Finally, we examine the effect of λ on the hedge ratio:

$$\frac{\partial HR}{\partial \lambda} = \frac{\beta - \phi}{(\lambda - \phi\beta)^2} \propto \text{sign} \left(\frac{\overline{rx}^{\$} + x}{\sigma_{\$}^2} - \frac{\overline{rx}^{FX} - x}{\sigma_{FX,\$}} \right)$$

Therefore, we know that FX volatility increases the hedge ratio given another Sharpe ratio comparison:

$$\frac{\partial HR}{\partial \sigma_{FX}^2} > 0 \quad \text{if} \quad \frac{\overline{rx}^{\$} + x}{\sigma_{\$}^2} > \frac{\overline{rx}^{FX} - x}{\sigma_{FX,\$}} \quad (8)$$

Building on the earlier discussion that $\frac{\overline{rx}^{\$} + x}{\sigma_{\$}} > \frac{\overline{rx}^{FX} - x}{\sigma_{FX}}$ generally holds in the data, a sufficient condition for the comparative statics to be unambiguously positive is that FX volatility is more volatile than the U.S. asset return ($\sigma_{FX} > \sigma_{\$}$).

4.1.3 Model predictions and portfolio allocations in practice

The comparative statics of the mean-variance investor's optimal portfolio in expressions (6)-(8) imply predictions about the data in the time-series and for the cross-section. In the time-series, we abstract from time variation in the variance-covariance structure of returns

and examine the effects of time-varying expected returns. In particular, the comparative static of hedge ratio with respect to expected USD asset returns leads to the following prediction.

Prediction 1. *Comparing investor’s portfolio over time, a higher expected return on the U.S. asset leads to a higher hedge ratio.*

In contrast, in the cross-section, currency area have distinct interest rate regime, leading to differences in expected FX return, FX return volatility, and the covariance between FX return and USD asset. The comparative statics of hedge ratio with respect to \bar{r}^X , β , and λ lead to the following prediction:

Prediction 2. *Suppose the exchange rates are sufficiently volatile, comparing investor’s mean-variance portfolio across geography, the FX hedge ratio for USD assets decreases in the expected USD FX return, increases in FX volatility, and increases in the covariance between FX return and USD asset return.*

Finally, CIP basis fluctuates over time and exhibits persistent cross-country differences. The comparative static of hedge ratio with respect to CIP basis leads to the following prediction:

Prediction 3. *In the time-series and in the cross-section, the mean-variance investor’s hedging exhibits a positive correlation between CIP basis and hedge ratio.*

We estimate empirical covariance matrix for FX returns and proxies of USD asset returns. We focus on annualized one-month (1M) holding period excess returns. For bonds, we use ten-year (10Y) US government bonds,²⁸ and for equity, we look at the S&P stock market

²⁸According to TIC, foreigners’ US bond holding is primarily in government securities, about 2/3.

index. We estimate the following:

$$\begin{aligned}
rx_{t+1}^{bond} &= 12(p_{9\frac{11}{12}Y,t+1M} - p_{10Y,t}) - r_{1M,t} \\
&\approx y_{10Y,t} - r_{1M,t} - 119(\Delta y_{10Y,t+1}) \\
rx_{t+1}^{equity} &= 12(\Delta p_{t+1}) - r_{1M,t} \\
rx_{t+1}^{FX} &= (rf_t^{\$} - rf_t) + 12(\Delta s_{t+1})
\end{aligned}$$

Our estimation period is the two decades between 2002 June and 2021 June, corresponding to our sample period and inclusive of the GFC. We use month-end non-overlapping returns and we proxy both $r_{1M,t}$ and rf_t with 1M IBOR.

We now compare institutional investors' empirically observed portfolios to predictions based on the mean-variance investor's optimal portfolio. Facts 1 and 2 in Section 3 detailed changes in investors' portfolio over time. Specifically, foreign investors have been holding more USD assets and hedging more. These two facts are jointly consistent with Prediction 1. That is, changes in investors' empirical portfolio allocations over time can be rationalized with mean-variance trade-off if the expected return on USD asset increased.

We next examine investors' hedging practice in the cross-section. Predictions 2 and 3 highlight that in the cross-section, four variables could vary: expected FX return, variance of FX return, covariance between FX return and USD asset return, and CIP basis, or the additional cost of hedging. We regress investors' hedge ratios on proxies of all four variables, controlling for time and industry fixed effects. Our estimation sample for covariance is from 2002 June to 2021 June, corresponding to our sample period and captures the behavior of local currency performance during the GFC. We use the interest rate differential between the USD and local currency as the proxy for the expected USD FX return. We consider several

proxies for USD asset returns in estimating the relevant covariance, including USD bond returns, equity returns, and portfolio USD asset returns constructed using investor-specific bond-equity portfolio split.

Table 5 presents panel regression results with time and industry fixed effects. In all of these specifications, the hedge ratio increases in interest rate differential while Prediction 2 postulates a negative correlation. Moreover, the covariance between returns is negatively correlated with hedge ratio, and in one specification, statistically significantly so, contradicting Prediction 2. Only $var(FX)$ always enters with the sign that's consistent with Prediction 2 (positive). The comparative static of hedge ratio with respect to FX return volatility is unambiguously positive when the volatility of FX return is larger than the volatility of USD asset return, which is most likely true for bonds. In Model (5), we restrict our sample to insurance companies and fixed income mutual funds. Insurance companies in our sample on average hold 80% in bonds and fixed income mutual funds by mandate invest only in bonds. In Model (5), the signs on interest rate differential continues to be opposite of Prediction 2, suggesting that factors other than mean-variance determinants are needed to fully rationalize investors' hedging behavior. These additional factors need to vary in the cross-section. Some potential candidates include risk aversions, agency frictions, e.g., difference in mandates, and considerations for higher moments of returns, driven perhaps by liability-matching concerns.

Finally, we consider the correlation between hedge ratio and CIP basis. Model (4) of Table 3 shows that the correlation between CIP basis and hedging is negative in the time-series. Table 5 moreover shows that this correlation is negative in the cross-section. If the hedging demand from the mean-variance investor is met with a perfectly elastic supply, then the correlation would be positive, as in Prediction 3. The observed negative correlation therefore suggests that the supply of FX hedging is upward sloping. Furthermore, the positive

correlation in the cross-section suggests that there is segmentation in the supply and that investors face a localized, upward sloping FX hedging supply. We implement this missing supply and derive further predictions for the data.

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 .²⁹ Furthermore, we assume that the intermediary in our model operates with a segmented balance sheet across currency l :

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

The segmented intermediary balance sheet assumption is consistent with evidence in [Siriwardane, Sundaram, and Wallen \(2022\)](#). For example, trading desks in different countries

²⁹Intermediary’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.

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:

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

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 .³⁰ 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 maximize 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.

Following [Ivashina, Scharfstein, and Stein \(2015\)](#), a convenient simple case is where

³⁰To 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.

$f(I) = \theta \log(I) - I$. 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,

$$x_l^* = \frac{H_l^*}{W_l - |H_l^*|} \quad (9)$$

From Equation 9, 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 3.

Equation 9 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 4. *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 A2 that there is a strong and positive cross-section correlation between GDP and banks' trading asset allocation.

Figure 9 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.^{31,32} 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 6, 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.

³¹In 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. We estimate FX hedging by banks as the difference between USD assets and USD liabilities (deposits). This hedging demand from banks captures hedging in other sectors of the economy. Results are largely similar if banks are excluded, but are significantly different if only banks are include and other investors are excluded.

³²We estimate banks' hedging demand by adapting the approach in [Borio et al. \(2016\)](#) and [Borio et al. \(2018\)](#) to the new BIS reporting format. 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 custodians 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 six-fold 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 document that there is considerable cross-country heterogeneity in hedging practices.

We present a simple mean-variance framework for the optimal currency hedging decision, where the hedge ratio depends on the volatility of FX, covariance between FX and USD asset returns, together with UIP and CIP deviations. We show substantial deviations of the empirically observed hedge ratio from the mean-variance framework in the cross-section of our sample countries. Nevertheless, once we allow for a constrained financial intermediary with segmented balance sheet, the model 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' holdings together with FX hedging practice for USD assets. The large and rising hedge ratio of foreign investors suggests that an important driver of cross-border demand for the USD assets is not attributed to getting exposure to the USD currency risk, but rather the intrinsic demand for the underlying asset.

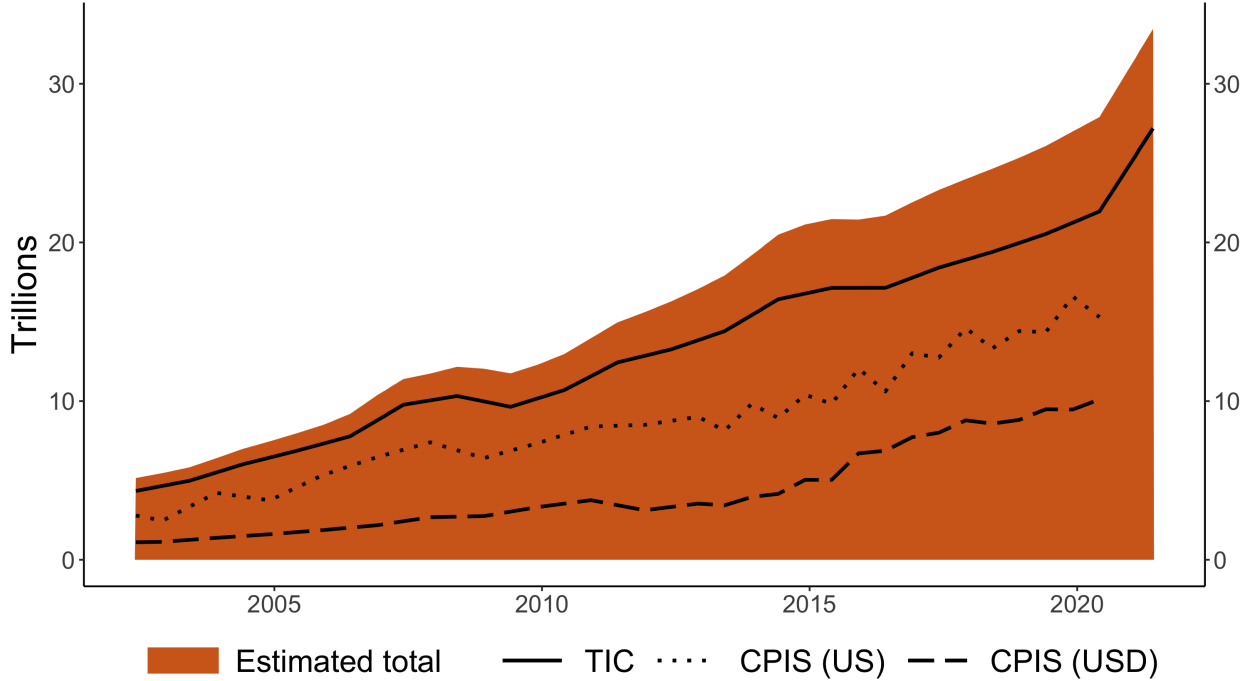
Bibliography

- Ben Zeev, N., and D. Nathan. 2022a. The persistent widening of cross-currency basis: When increased fx swap demand meets a shortage of global arbitrage capital. Working paper.
- . 2022b. Shorting the dollar when global stock markets roar: The equity hedging channel of exchange rate determination. Working Paper.
- Bertaut, C. C., and R. Judson. 2014. Estimating us cross-border securities positions: New data and new methods. *FRB International Finance Discussion Paper* .
- BIS. 2022. Triennial central bank survey: Otc foreign exchange turnover in april 2022.
- Borio, C., M. Iqbal, R. McCauley, P. McGuire, and V. Sushko. 2018. The failure of covered interest parity: Fx hedging demand and costly balance sheets. Working Paper.
- Borio, C., R. McCauley, P. McGuire, and V. Sushko. 2016. Covered interest parity lost: understanding the cross-currency basis. *BIS Quarterly Review* .
- Bräuer, L., and H. Hau. 2022. Can time-varying currency risk hedging explain exchange rates? .
- Caballero, R. J., E. Farhi, and P.-O. Gourinchas. 2017. The safe assets shortage conundrum. *Journal of economic perspectives* 31:29–46.
- Camanho, N., H. Hau, and H. Rey. 2022. Global portfolio rebalancing and exchange rates. *The Review of Financial Studies* 35:5228–74.
- Campbell, J. Y., K. S. de Medeiros, and L. M. Viceira. 2010. Global currency hedging. *Journal of Finance* LXV:87–122.
- Campbell, J. Y., and L. M. Viceira. 2002. *Strategic asset allocation: Portfolio choice for long-term investors*. Oxford University Press.
- Coppola, A., A. Krishnamurthy, and C. Xu. 2023. Liquidity, debt denomination, and currency dominance. Working Paper.
- Coppola, A., M. Maggiori, B. Neiman, and J. Schreger. 2021. Redrawing the Map of Global Capital Flows: The Role of Cross-Border Financing and Tax Havens. *The Quarterly Journal of Economics* 136:1499–556.
- Czech, R., S. Huang, D. Lou, and T. Wang. 2022. Unintended consequences of holding dollar assets. Working Paper.
- Davila, E., D. Graves, and C. Parlato. 2022. The value of arbitrage. Working paper.
- Diamond, W., and P. Van Tassel. 2021. Risk-free rates and convenience yields around the world. Working Paper.
- Driscoll, J. C., and A. C. Kraay. 1998. Consistent covariance matrix estimation with spatially dependent panel data. *The Review of Economics and Statistics* 80:549–60.
- Du, W., B. Hébert, and A. W. Huber. 2022. Are intermediary constraints priced? *Review of Financial Studies* .
- Du, W., A. Tepper, and A. Verdelhan. 2018. Deviations from covered interest rate parity.

- Journal of Finance* 73:915–57.
- Eren, E., and S. Malamud. 2022. Dominant currency debt. *Journal of Financial Economics* 144:571–89.
- Faia, E., J. Salomao, and A. V. Veghazy. 2022. Granular investors and international bond prices: Scarcity-induced safety. Working Paper.
- Fang, X., B. Hardy, and K. K. Lewis. 2022. Who holds sovereign debt and why it matters. Working Paper.
- French, K. R., and J. M. Poterba. 1991. Investor diversification and international equity markets. *American Economic Review* 81:222–6.
- Gourinchas, P.-O., H. Rey, and M. Sauzet. 2019. The international monetary and financial system. *Annual Review of Economics* 11:859–93.
- Hau, H., P. Hoffmann, S. Langfield, and Y. Timmer. 2021. Discriminatory pricing of over-the-counter derivatives. *Management Science* 67:6660–77.
- He, Z., A. Krishnamurthy, and K. Milbradt. 2016. What makes us government bonds safe assets? *American Economic Review* 106:519–23.
- ICI. 2021. The japanese retirement system.
- Ivashina, V., D. S. Scharfstein, and J. C. Stein. 2015. Dollar funding and the lending behavior of global banks. *The Quarterly Journal of Economics* 130:1241–81.
- Jiang, Z., A. Krishnamurthy, and H. Lustig. 2021. Foreign safe asset demand and the dollar exchange rate. *The Journal of Finance* 76:1049–89.
- Koijen, R. S., R. J. Richmond, and M. Yogo. 2020. Which investors matter for equity valuations and expected returns? Working Paper, National Bureau of Economic Research.
- Koijen, R. S., and M. Yogo. 2020. Exchange rates and asset prices in a global demand system. Working Paper, National Bureau of Economic Research.
- Liao, G., and T. Zhang. 2020. The hedging channel of exchange rate determination. *International finance discussion paper* .
- Lucas, D., and S. Zeldes. 2005. How should public pension plans invest? *American Economic Review: Papers Proceedings* .
- Maggiore, M., B. Neiman, and J. Schreger. 2020. International currencies and capital allocation. *Journal of Political Economy* 128:2019–66.
- Mitchell, O. S., J. Piggott, and C. Kumru. 2008. Managing public investment funds: best practices and new questions. *Journal of Pension Economics amp; Finance* 7:321–56.
- OECD. 2020. Oecd.stats.
- Sialm, C., and Q. Zhu. 2022. Currency management by international fixed income mutual funds. Working paper.
- Siriwardane, E., A. Sundaram, and J. Wallen. 2022. Segmented arbitrage. Working Paper.
- Swisscanto Pensions. 2021. Swiss pension fund study.

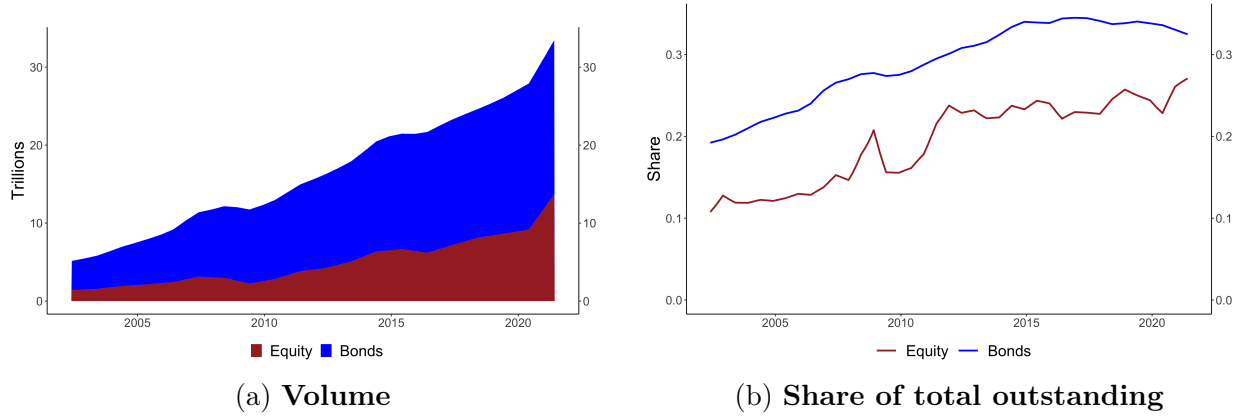
Figures and Tables

Figure 1: Foreign holding of USD securities



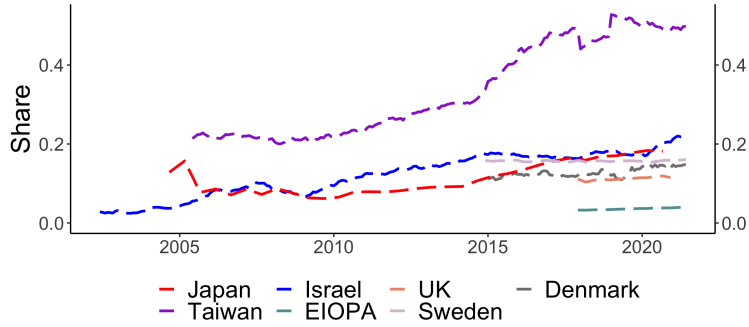
Notes: This figure plots different estimates of foreign holding of USD securities. Plotted in orange shade is our estimate, which builds on the TIC estimate but adjusts for foreign-issued USD securities and US-issued non-USD securities. The solid line is the TIC estimate of foreign holding of securities 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

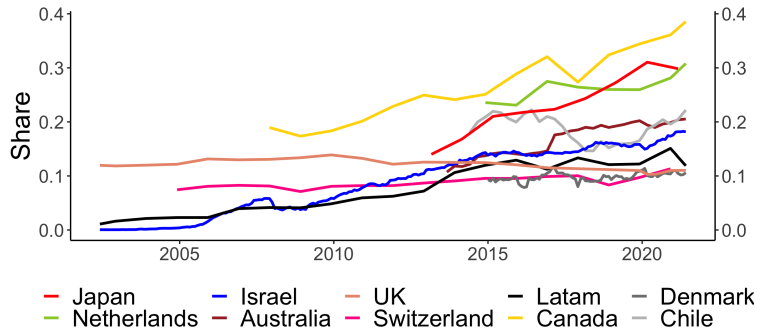


Notes: This figure plots estimated foreign-held USD securities by type. Panel (a) is volume of securities. Panel (b) is the share of total USD bonds and USD equity held by foreign investors. Total USD bond holdings are estimated as outstanding US fixed income securities adjusted for foreign-issued USD 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.

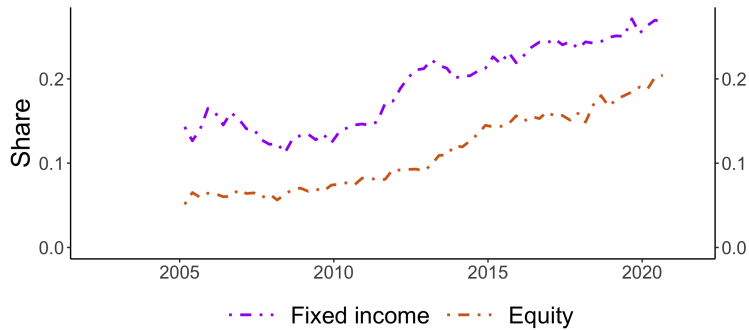
Figure 3: **Portfolio allocation to USD across industries**



(a) **Insurance**



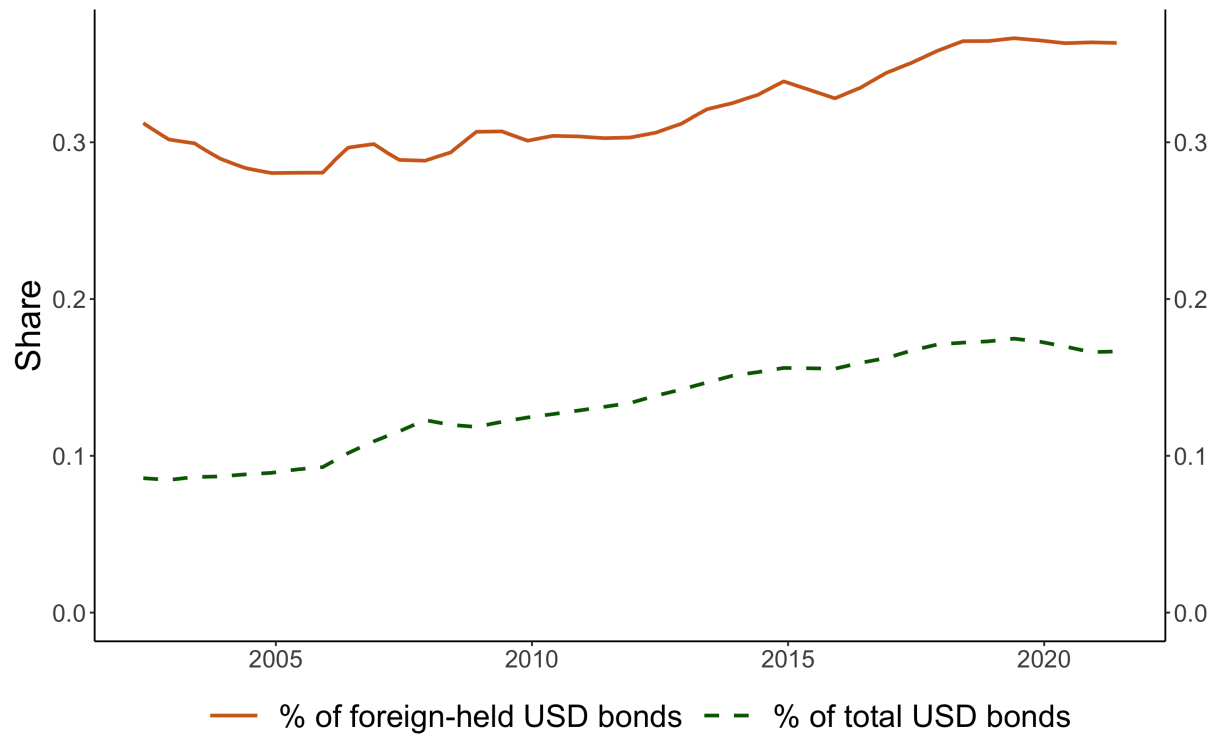
(b) **Pensions**



(c) **Mutual funds**

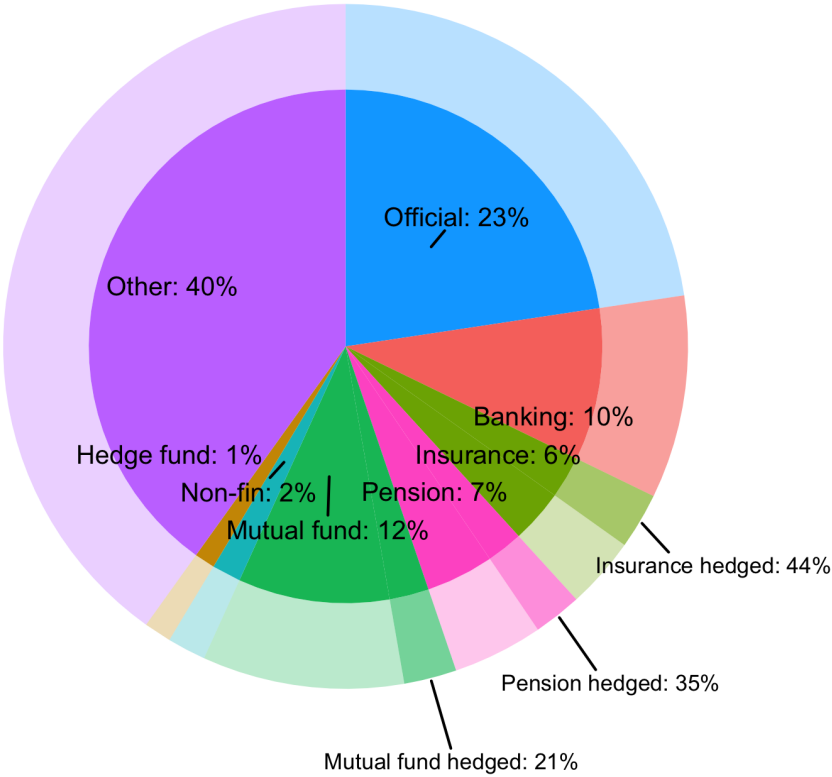
Notes: This figure plots foreign investors' portfolio allocation to USD asset. Allocation is estimated as the ratio of USD securities to total assets. See Table 1 for sample period coverage of different series. This figure is best viewed in color. Each country is plotted in the same color across different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

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



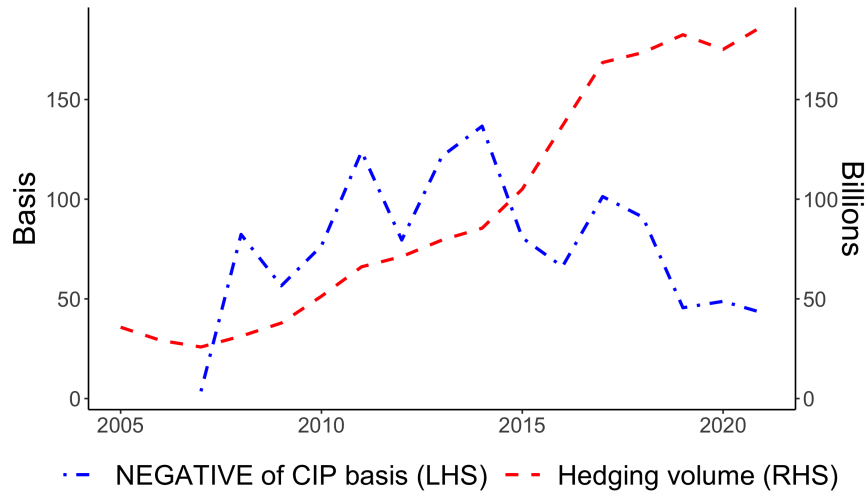
Notes: This figure plots USD bonds issued by non-US residents as a share of total USD bonds and as a share of all foreign-held USD bonds. “% of total USD bonds” is estimated as total foreign-issued USD divided by total USD bonds outstanding. “% of foreign-held USD bonds” is estimated as foreign-issued 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



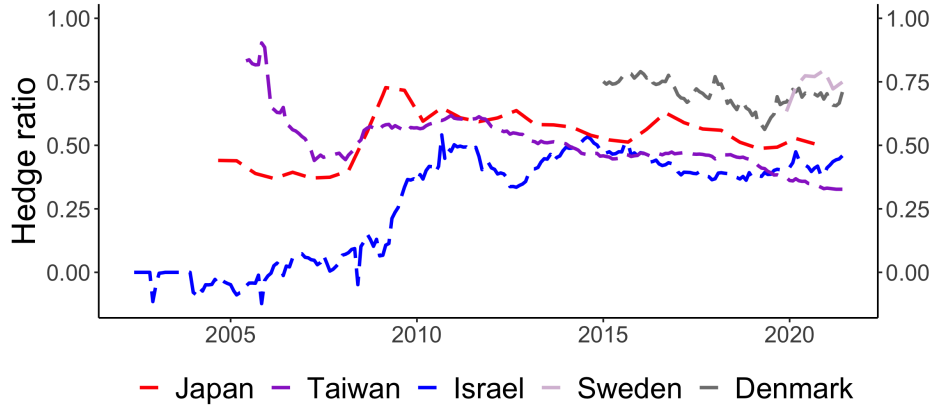
(a) CIP basis vs. hedging amount



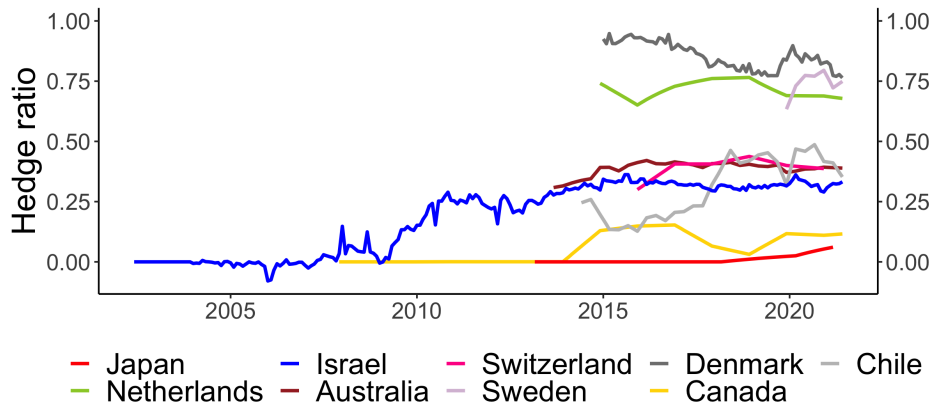
(b) Total hedging cost

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.

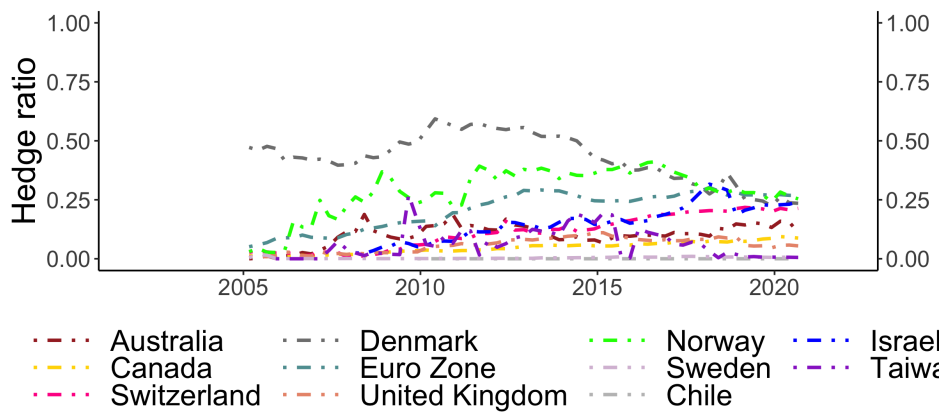
Figure 7: USD hedging across industries



(a) Insurance



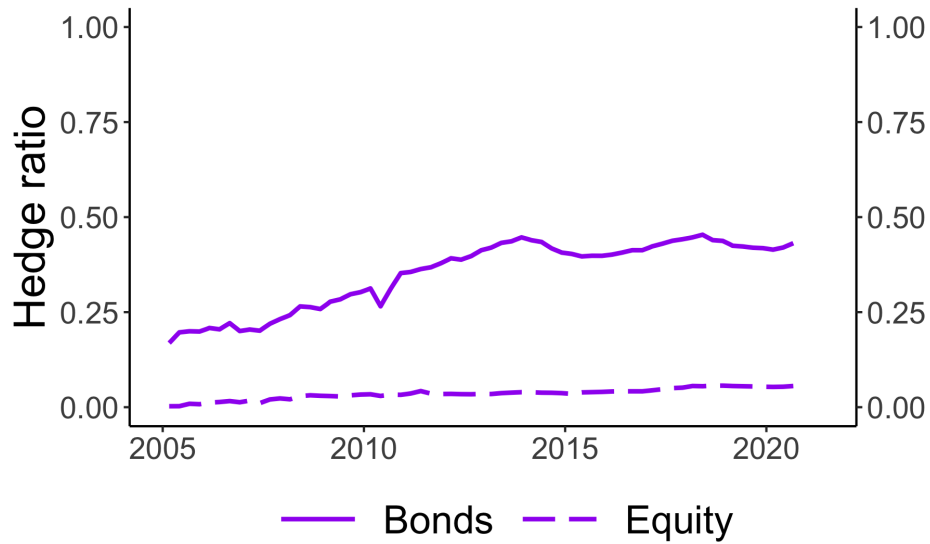
(b) Pension



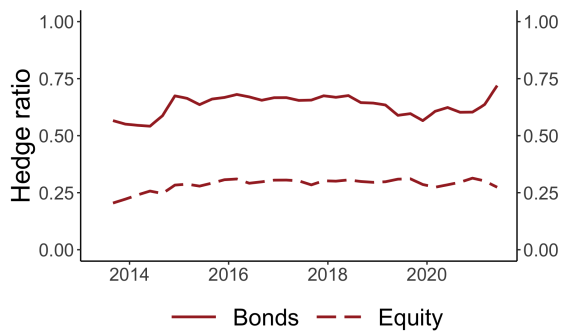
(c) Mutual funds

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.

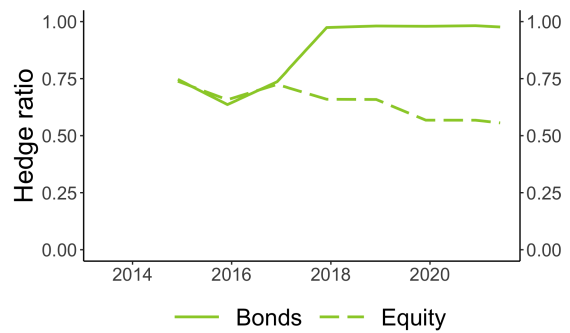
Figure 8: USD hedging across bond vs. equity mutual funds



(a) Mutual funds



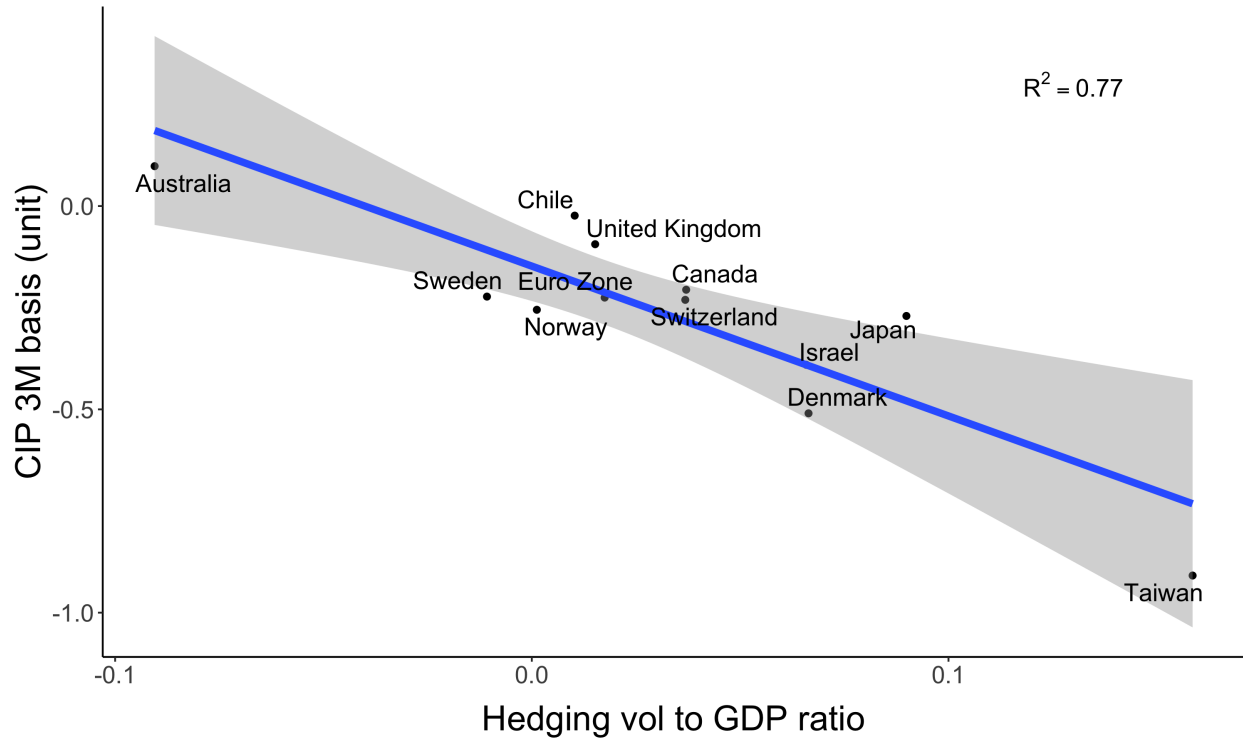
(b) Australian pensions



(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: 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 SHS	2017 2013	2021 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 Office for National Statistics	2004	2020	2015	
Europe: UK				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** (0.31)		2.8* (1.4)	
Indicator: Post-Crisis	7.7*** (0.85)		6.6*** (1.1)	
Counter by Quarter		0.23*** (0.01)		0.18*** (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” is 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 (3)	Hedge Ratio (4)
	(1)	(2)		
Indicator: Crisis	0.052*** (0.016)	0.079*** (0.022)	0.026* (0.014)	
Indicator: Post-Crisis	0.160*** (0.016)	0.147*** (0.017)	0.066*** (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: **Model-implied comparative statics for hedge ratio**

	Bond	Equity
$\overline{rx^{sb}} - \overline{rx^{lb}} \uparrow$	HR \uparrow^*	HR \uparrow^*
$\overline{rx^{FX}} \uparrow$	HR \downarrow	HR \downarrow
$x \uparrow$	HR \uparrow	HR \uparrow

Notes: This table reports comparative statics of the mean-variance agent’s optimal USD hedge ratio with respect to relative asset returns ($\overline{rx^{sb}} - \overline{rx^{lb}}$), with respect to FX returns ($\overline{rx^{FX}}$), and with respect to CIP basis (x). For the comparative statics with respect to relative asset returns ($\overline{rx^{sb}} - \overline{rx^{lb}}$), hedge ratio increases up until a threshold hedge ratio, which is about 85% in bond and 70% in equity; see Appendix Table ??.

Table 5: Hedging behavior in the cross-section

	USD hedge ratio				
	(1)	(2)	(3)	(4)	(5)
Diff USD vs. local 3M ibor	0.061*** (0.009)	0.078*** (0.010)	0.070*** (0.009)	0.070*** (0.008)	0.103*** (0.011)
var(FX)	1.78*** (0.109)	1.74*** (0.182)	1.11*** (0.164)	1.79*** (0.320)	4.21*** (0.249)
cov(\$bond, FX)	-0.827 (0.659)		-3.04*** (0.516)		-0.912 (0.601)
cov(\$stock, FX)		-0.583 (0.374)	-1.95*** (0.244)		
cov(\$portfolio, FX)				-0.201 (0.590)	
CIP basis 3M	-0.153*** (0.016)	-0.142*** (0.021)	-0.114*** (0.022)	-0.152*** (0.018)	-0.271*** (0.035)
Time	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes
Bond only	No	No	No	No	Yes
Observations	934	934	934	934	666
R ²	0.46	0.46	0.47	0.45	0.37

Notes: This table examines cross-section patterns in hedging. “USD hedge ratio” is total volume of hedging as a ratio of total USD securities. “Diff USD vs. local 3M ibor” is calculated as USD 3M ibor less local 3M ibor. “CIP basis 3M” is calculated using ibor as the log of Equation 1. “Cov(rx^{FX} , rx^{asset})” include covariance between FX return and returns on US 10Y sovereign bond, local 10Y sovereign bond, S&P 500 index, and local equity market index. 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 6: CIP deviations and hedging

	CIP 3M Basis	
	(1)	(2)
Hedging vol to GDP ratio	-1.55*** (0.384)	-2.16*** (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.³³ 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

³³Ben 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,³⁴ covering 50% of assets in all Dutch pension funds.³⁵ 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.³⁶ 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

³⁴https://www.investmentoffice.com/Pension_Funds/Netherlands/

³⁵<https://www.pensioenfederatie.nl/website/the-dutch-pension-system-highlights-and-characteristics>

³⁶<https://www.bankofcanada.ca/wp-content/uploads/2016/06/fsr-june2016-bedard-page.pdf>

Swiss publication does not distinguish domestic 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.³⁷

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.

³⁷FIAP also has sparse reporting from Russian Federation, 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.³⁸ 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.³⁹

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

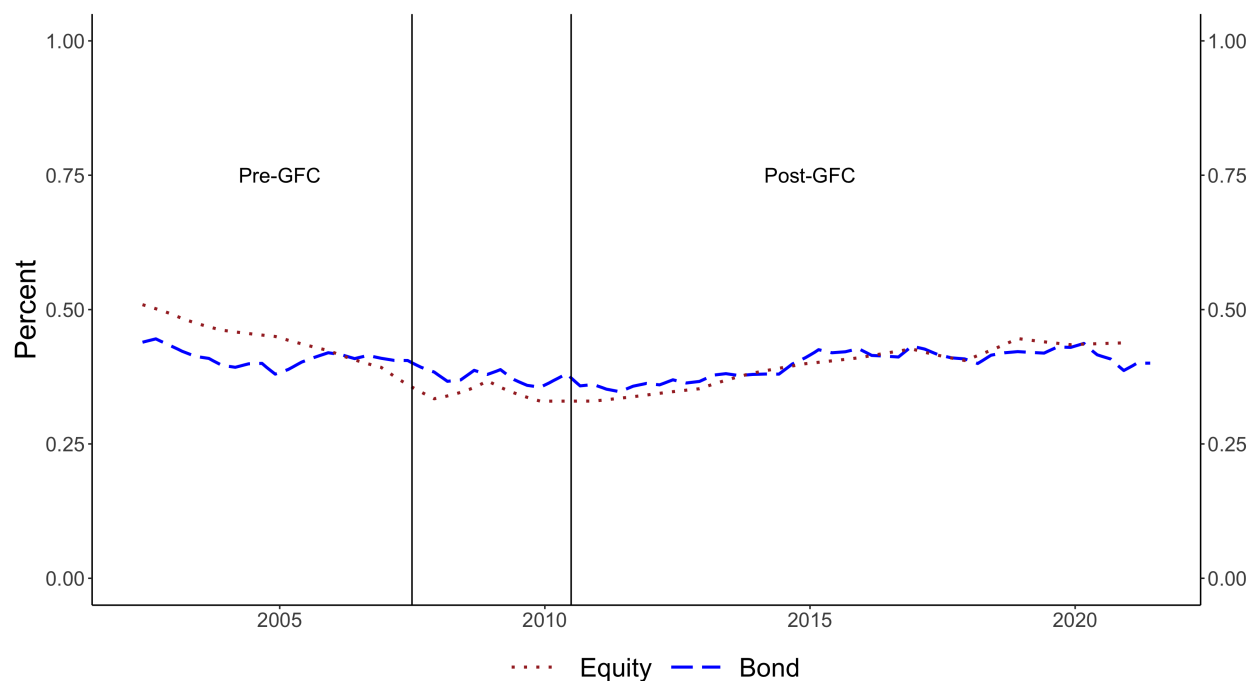
³⁸This information cannot be deduced from United States' reporting to the BIS because the U.S. reports only U.S. banks' loan and deposit positions and does not include debt securities positions.

³⁹We 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.

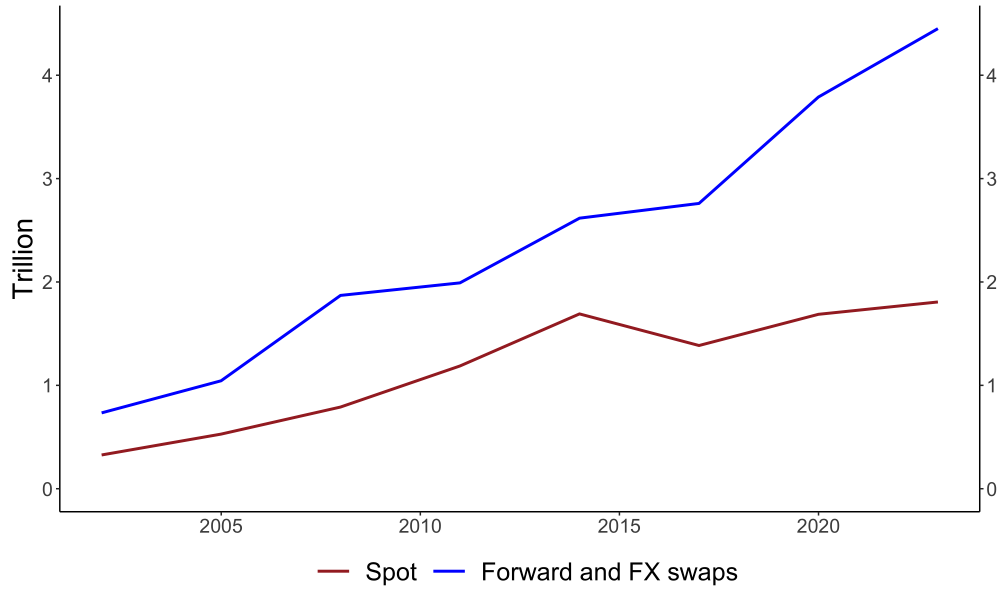
B Additional Figures and Tables

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

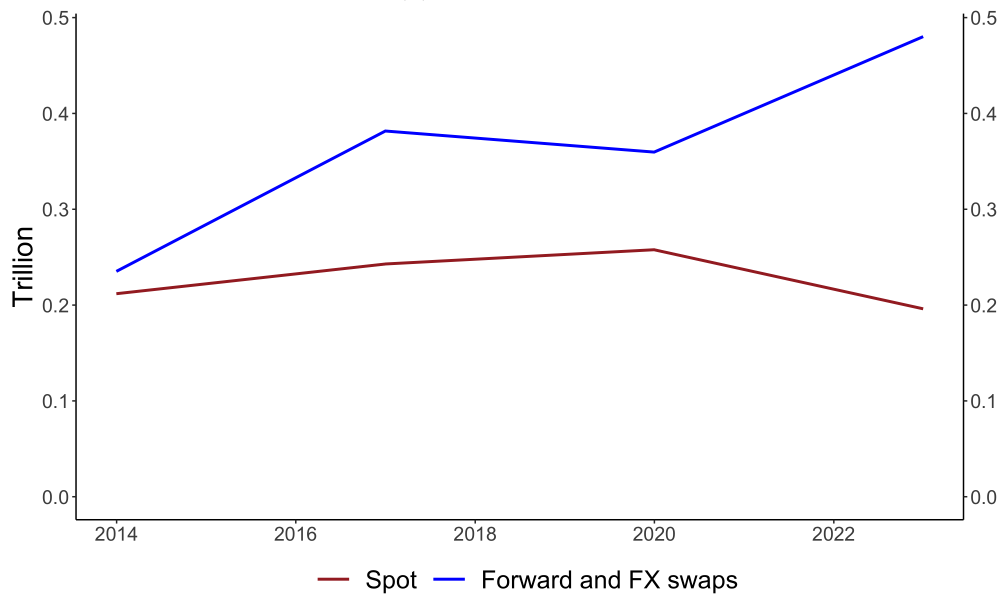


Notes: This figure plots the share of USD debt and equity in global debt and equity markets. Global debt market size is calculated from BIS' debt securities statistics, inclusive of all issue markets. Global equity market is the sum of global public market cap and global private equity AUM. Global public 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**



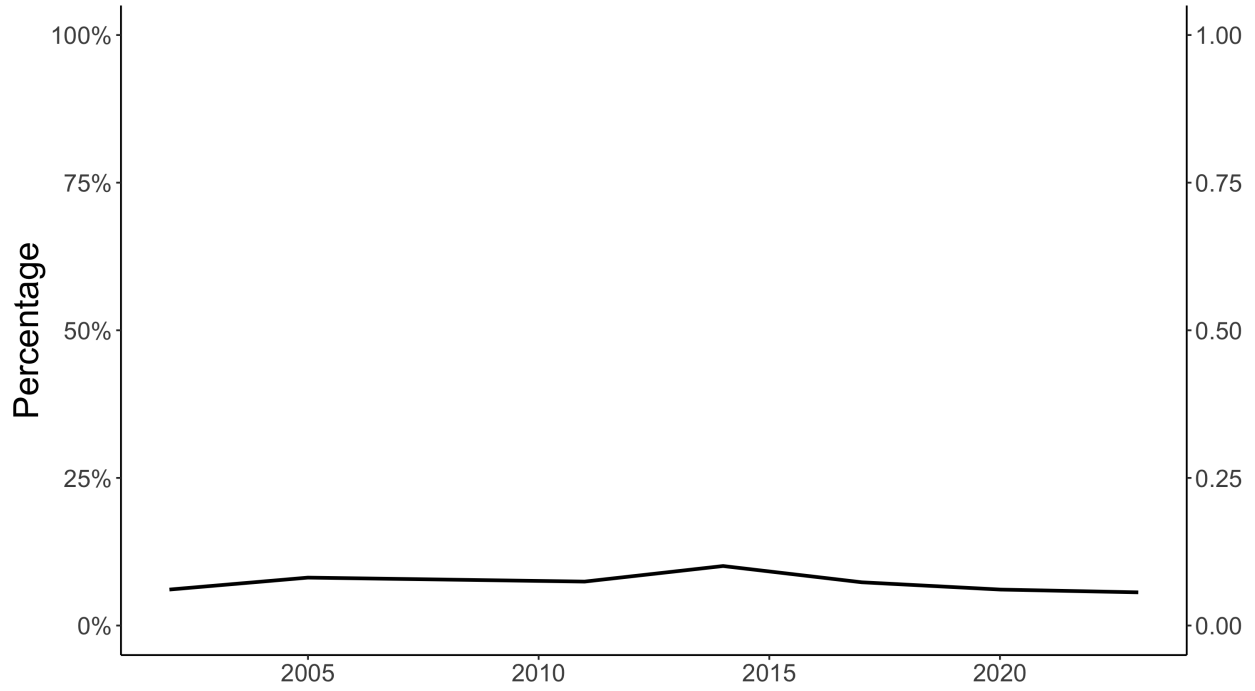
(a) **All volumes**



(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.

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: 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*** (0.013)	0.764*** (0.110)	0.419** (0.091)	1.29*** (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.