Granular Investors and International Bond Prices: Scarcity-Induced Safety*

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Abstract

Institutional investors' mandates determine bond demand, which, through granularity, affects bond prices. Leveraging on a unique dataset that includes *all* corporate bonds held by euro-area investors, we explore the impact of investor's demand on currency pricing. Institutional investors have different mandates, with insurance and pension funds exhibiting home asset and currency biases, and mutual funds displaying neither. This neat segmentation, alongside the fact that our investors are subject to the same monetary policy, motivates our identification strategy. We estimate, in a currency hedged and unhedged specifications, investors' residual in euro-dollar yield differentials for the same security and issuer, and for investors facing the same monetary stance. The euro-dollar residual differential declines during our sample period, indicating an erosion of dollar convenience yields. This suggests that the scarcity of euro bonds induced by ECB asset purchases against the rising demand of those assets by insurance and pension funds produced the decline. The ensuing fall in duration risk, in turn, induces those investors to rebalance their portfolio weights toward euro assets. A model of optimal portfolio choice by institutional investors can explain the time- varying residual, through the heterogeneous loss-averse preferences of their clients.

JEL codes: F3, G2, G4. Keywords: insurance funds euro bias, heterogeneous investors, market segmentation, portfolio securities data, uncovered and covered interest rate parity, local supply channel, duration extraction channel, scarcity, asset safety.

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1. Introduction

One of the implications of the rise in capital flows is that large institutional investors, who intermediate most of the international capital flows, can have a big impact on bond prices across currencies, and hence on their safety and on firms' funding costs.[1] In this paper we evaluate these impacts by leveraging on a unique (confidential) dataset with securities-level information on holdings of all bonds issued by non-financial corporations held in the euro area. To assess the role of institutional investors' mandates on the pricing of currency risk, we match each security held in the euro area portfolio with information on bond's characteristics and prices. Since these investors are granular, their mandates affects cross-currencies bond excess demand and equilibrium currency pricing. [2]

We start by examining investors holding patterns and document that different types of institutional investors have distinct preferences for bond's currency denomination and issuer country. These facts motivate our econometric design: we estimate euro-dollar yields differentials for the same security issued in different currencies to identify the contribution of investors' excess demand in currency prices.[3] The estimates, which we dub as investors' residual, are negative for most of our sample (2013-2021), implying that euro denominated yields are lower than the dollar ones, a sign of erosion in the dollar safety premium. Importantly the residual starts to decline in 2013 and follows a path that mirrors the build in the stock of European Central Bank (ECB) asset purchases. These facts makes us conclude that the scarcity of euro-denominated securities induced by the purchases, against a high and rising demand from insurance and pension funds, produced the rise in euro bonds' prices and the decline in its yields.[4] The asset purchase program provides an experimental setting for identifying the pricing consequences of excess investor demand. The engineered fall in yields at longer maturity, and hence of duration risk, induced a further portfolio rebalance of insurance funds toward the program eligible securities; a reflection of a duration extraction channel. Finally, we show that a simple model of portfolio allocations where investors' preference heterogeneity for currency-denomination,

1 See Lane and Milesi-Ferretti (2018)

2 The terminology for granular agents, as opposed to atomistic ones, has been introduced in Gabaix (2011).

3 Our econometric methodology builds on recent advances by Liao (2020), Caramichael et al. (n.d.) and Coppola et al. (2020), who use bond issuance data. We differ from these papers because we focus on portfolio holdings data of investors from the same currency area. Therefore our set up forges the ideal conditions for understating investors preferences and price impact of shocks. Furthermore by having portfolio shares we can also measure prices are affected through rebalancing.

4 The importance of scarcity for safety has been theorized in Caballero et al. (2016)

as reflected in the mandate of the chosen intermediaries, affects international pricing and the portfolio shares replicates the empirical findings.

We document investor's heterogeneity in currency holdings by analysing the dynamics of the portfolio shares of dollar and euro denominated corporate bonds across investors and issuers. We do this analysis top down, reporting patterns for all investors and issuers, followed by breaking them down for different investors and issuers. First, we find that overall euro area investors hold a large share—over 70%—of their debt securities denominated in euros, even though about half of their debt portfolio is held in securities issued by non-euro area firms. Thus considering all securities and all investors together, euro area investors display a strong local currency-bias but not the well documented home country asset bias.[5] Furthermore, during the sample period considered, which starts in 2013, the importance of the euro denominated securities continues to grow, reaching 75% of the holdings.

Once we break down currency holding patterns per issuer country, we find that the growth of euro denominated securities is centered on U.S. issuers, whose euro denominated share went from 18% in 2013 to 37% in 2021, while the dollar denominated share of European issuers stayed low (from 2% in 2013 to 3% in 2021). This, as we argue in this paper, is a direct consequence of the European Central Bank (ECB) asset purchase programs, which raised the demand for euro denominated securities directly, through said purchases, and indirectly through a reduction in maturity risk. When we cut across both issuer types and find that different types of institutional investors have heterogeneous holding patterns with respect to currency and issuer country. While insurance and pensions funds (ICPF) exhibit both home (euro-area) firm and local currency securities biases, other financial institutions (OFI), which include mutual funds, exhibit neither. This stark segmentation confirms heterogeneity in institutional investors' mandates, which is a reflection of the preference heterogeneity for currency-denomination among the clients that they represent. Most importantly, jointly ICPF and OFI hold 86% of euro-area held corporate bond portfolio, so they are large players in this market. This granularity implies that their demand affects prices.

To examine the role of the investor base for euro-dollar yields differentials, we devise a security level specification which, for given security and firm, allows us to estimate

5 Home currency bias is examined in Maggiori et al. (2019) but for investors investing abroad in their domestic currency. See French and Poterba (1991), Tesar and Werner (1995)for home bias in equities.

the residual role of investors' demand in currency pricing.[6] The identification strategy is based on estimating the euro-dollar yield differential for each bond and controlling for bond maturity, rating and firms' fixed effects. Importantly, our investors are all euro area residents, and arguably subject to the same aggregate shocks and monetary policy stance, with the latter being an important determinant of the yield curve. Taken together, those assumptions guarantee that the estimated residual of our specification identifies heterogeneity in investor demand for different currency denominations.

To evaluate the impact of investors' demand in currency pricing in the corporate bond market, we estimate different specifications of the euro-dollar residual, controlling (or not) for exchange rate movements (using both survey expectations and derivative contracts). First, using the bond yields in euros and dollars, without controlling for future exchange rate movements, we find that the investors' residual is negative and declines during the sample: that is investors require a lower return for euro-denominated securities relative to dollar ones. This finding signals towards an erosion of the dollar safety yield. Noteworthy is the fact that the results remain robust even when we correct for exchange rate survey expectations or hedge for exchange rate movements using swaps. In other words investors' demand and preferences, can lead to deviations on the uncovered and covered interest rate parity condition (UIP and CIP).[7]

Another pillar of our identification strategy consists of focusing on a time period in which asset purchase programs were in place (2013-2021). This allows us to dissect the channels behind the changes in corporate bond prices. Throughout our time sample the ECB had conducted asset purchase programs, one of which was directed to buy Treasuries and another was more specifically targeted to corporate bonds. Those two programs are also the ones behind the two channels that explain our results and we twist our identification strategy precisely to test those two channels.

First, the corporate bond asset purchase was targeted at euro denominated assets issued by euro area firms and preferably at long maturities. In presence of segmented markets those type of interventions are particularly effective at flattening the yield curve by affecting the local supply of the securities.[8] The assets under target are precisely the

6 Our methodology studies the role of granular investors for prices by controlling for both demand and supply effects. Gabaix and Koijen (2020) proposed an alternative methodology to study the role of granular investors for pricing focusing on the role of only demand elasticities.

7 See Du and Schreger (2021) for the various motives for CIP deviation.

8 Our data contains bonds at all maturities so it is well-suited to capturing the impact of monetary policy on the yield curve.

assets preferred by euro oriented investors. The ensuing rise in excess demand pushed euro bond prices up and yields down, relative to dollar yields. The consistent drain of supply of those securities coupled with the rising demand from institutional investors provides an experimental setting apt for identifying investors' excess demand. To corroborate the presence of this channel, we repeat our estimates by including an interacted dummy that progressively selects securities eligible for the program and find that the investors' residual decline is stronger for securities issued by euro area firms, held by ICPF and for securities at long maturities. Note that this type of scarcity mechanism is akin to the local supply channel which has been found to explain the link between asset purchases and the yield curve.[9] Its implications for bond's currency pricing have thus far never been discussed.

The second channel behind our results is the duration extraction or rebalancing channel. By purchasing bonds, both corporate and Treasuries, monetary policy flattened the yield curve, both by reducing the safe rate and the term premium. The decline in yields, especially at long maturities, brought along a decline in maturity risk for institutional investors, such as ICPF, whose portfolios are heavily skewed toward securities eligible for the purchase program. This in turn induce those investors to rebalance even further toward eligible assets.[10] This is indeed what we observe. By comparing the baseline estimates of the investors' residuals with those weighted by actual portfolio shares[11], we find that in the latter the euro-dollar yield decline is more pronounced, especially when we focus on the sample of securities held by ICPF and issued by euro area firms. This is due to an increase in the share of euro-denominated securities issued by euro area firms and held by those respective investors.

We conclude by presenting a simple model of international portfolio optimization performed by institutional investors based on the mandates that they receive from clients with heterogeneous preferences. The purpose of the model is threefold: the first is to show how differences between euro and dollar investor preferences and demand elasticities can provide a microfounded relation for the international returns' differentials that maps exactly the specification estimated in the data and its investor differential. Second, we show that a simulated version of the model can replicate the euro dollar relative decline observed in the data. Third, we discuss the monetary policy channels uncovered in the data through their impact on investors' SDF. Building on a recent literature that

9 See for instance D'Amico and King (2013).

10 See also Koijen et al. (2017) for evidence on the duration extraction channel.

11 We compute portfolio weights with prices at issuance. This allows us to purge for changes in the valuation effects so that changes in shares correspond to rebalance.

rationalizes parity deviations with time-varying risk-aversion, clients in the model hold reference dependent preferences with loss aversion, something which in itself induces time-varying UIP deviations.[12] If euro and dollar investors[13] also exhibit different degree of loss aversion, their SDFs, hence the price that they attach to euro and dollar assets, will respond differently to the same macro shock. More generally heterogeneity in loss aversion between euro and dollar investors generates differences in their demand for euro and dollar assets and in the required returns. Analytically we show that the difference in SDFs parallels the investor residual in our empirical specification and that results hold also under a more general definition of mandates that includes regulation. Different preferences also lead to different elasticities in the adjustment of portfolio shares, something which accounts for the rebalance observed in the data. Finally, we show that simulations from a calibrated version of the model can replicate the euro-dollar relative decline observed in the data.

Our results go beyond the specific episode and time period considered and have broader implications on the role of investor bases for pricing and safety of bonds, for the determinants of UIP and CIP deviations and of convenience yields.

Literature Review. Our paper links first and foremost to the literature studying the determinants of cross-currency returns' differentials or UIP/CIP using more dis-aggregated data. Curcuru et al. (2008) and Curcuru et al. (2011) estimate return differentials per type of asset.[14] Other papers focused on estimated covered and uncovered interest parity deviations. The more traditional specifications focused on macro data (Hassan (2013), Lustig and Verdelhan (2007) and Lustig et al. (2011), Du and Schreger (2016)) or Kalemli-Özcan and Varela (2021) for emerging market economies). Our analysis goes one step further by estimating security level specifications and distinguishing across type of investors and issuers.

Indeed our econometric approach builds on methodologies recently adopted to study cross-currency yields differentials using highly dis-aggregated data (Liao (2020), Caramichael et al. (n.d.) and Coppola (2021)). Liao (2020) and Caramichael et al. (n.d.) employ traded bond data to analyse the role of currency pricing in firms' issuance decision. We use portfolio data as our focus is on the role of investors' preferences in impacting currency

12 See Verdelhan (2010) employs reference dependent utilities to explain parity deviations. Our parametrization goes a step further by modeling investors' behaviour in the loss domain as well.

13 The first represent our ICPF in the data, the second the OFI.

14 They use the Treasury International Capital data and distinguished return differentials from debt and equities.

pricing and holdings decision.[15] Differently from Caramichael et al. (n.d.), we examine securities issued by firms based in the U.S., the Euro area, and the rest of the world, and held by euro area investors. This is crucial for a clean identification of our local supply channel: if investors were based in different currency areas, they would experience different monetary policy stance. Coppola (2021) assembles a dataset with portfolio holdings of mutual and insurance funds and examines the role of investor base on bond pricing around specific events but does not consider the impact on currency pricing as it focus on dollar denominated bonds.

Our paper links also to recent studies exploiting the role of investors' granularity for asset pricing. Gabaix and Koijen (2020) proposed a methodology that focuses on the role of demand elasticities. Papers applying this line of econometric design to international securities data include Koijen et al. (2017) or Koijen and Yogo (2020). An advantage of their methodology is the use of the large investors' estimated demand as an instrument. Our econometric design on the other side helps to control for both demand and supply effects.

The link of asset scarcity to its safety relates our paper to a large literature on the conditions that make assets safe. Caballero et al. (2016)'s model closely captures the channel highlighted in our paper. Our own model highlights the role of the time-varying price of risk of heterogenous granular investors. For long asset safety was considered one of the drivers of the dollar dominance (see Goldberg and Tille (2009) or Gopinath and Stein (2021) among others). The erosion of the dollar convenience yields implied by our results, is also being increasingly discussed: see for instance Du and Schreger (2021) or Gourinchas (2021). The documented portfolio rebalancing toward the safer asset links our evidence to a literature studying the impact of monetary policy on the yield curve and on long rates (see Cochrane (2009) or Hanson and Stein (2015)) and in particular to a recent literature discussing the local supply channel (see D'Amico and King (2013)) and the duration extraction channel of asset purchases (see Koijen et al. (2017) and Koijen et al. (2021)).

Our results reveal a strong local currency bias by the aggregate euro area investors, as in French and Poterba (1991), Hale and Spiegel (2012). The bias is a manifestation of the familiarity bias, which has been found in several areas of portfolio investment (see for instance Huberman (2001), Zhu (2002) or Feng and Seasholes (2004). This bias

15 Our data allows us to compute exactly the portfolio weights for each security, thereby providing a direct measurement of investors' composition and demand.

has recently been examined for different types of investors by Burger et al. (2018) or Maggiori et al. (2018)). Although those authors apply a somewhat different definition (probably more tailored to their data): they look at the share of foreign investment in local currency.[16] We use a traditional definition, namely the share of bonds in local currency over the total portfolio, and our data include the entire universe of euro area investors.

Consistent with Hau and Rey (2004), Hau and Rey (2008) and Maggiori et al. (2018), we find that mutual funds have a dollar bias, and in line with Koijen et al. (2017), we find that insurance funds have a euro bias. Interestingly, when we cut our data by issuer country of residence, we do not find a home country bias in our data (see among others French and Poterba (1991), Tesar and Werner (1995), Baxter and Jermann (1997), Cooper and Kaplanis (1994) or more recently Coeurdacier and Gourinchas (2016)).

The deviation from covered and uncovered interest parity that we estimate links our paper to a literature explaining those deviations through the segmented market hypothesis (see Bacchetta and Van Wincoop (2006) or more recently Itskhoki and Mukhin (2021)) or preference with time-varying risk (see Verdelhan (2010)). Our model preference specification follows a long tradition and has been successfully employed in explaining asset price facts.[17]

2. Data

Our data is mainly sourced from Securities Holdings Statistics by Sector (SHSS) which has been collected by the European System of Central Banks (ESCB) on a quarterly basis since Q3 2013. SHSS covers two main types of securities: debt and equities. The data encompasses all holdings of securities by investors resident in the euro area, such as households in Germany or monetary financial institutions in France, and is reported at a disaggregated level i.e. security-by-security.[18]

The magnitude of the data is rather substantial. Total holdings by euro area investors amounted to € 23.4 trillion at the end of June 2014, covering holdings of both securities issued by euro area residents (around €18.3 trillion) and those issued by non-euro area residents (around € 5.1 trillion). We have aggregate information on holders of each

16 Burger et al. (2018) use TIC data, Maggiori et al. (2018) use mutual funds data from Morningstar.

17 Loss averse preferences have been uncovered experimentally by Kahneman and Tversky (1979), introduced in savings problems by Kőszegi and Rabin (2009) and in asset pricing by Pagel (2016) and Curatola and Faia (2021).

18 More details on the dataset are in A.

security (by institutional sector and/or country level, i.e. not by individual holder). We group the types of SHSS investors, in total 22, into six sectors: 1) monetary financial institutions (MFI); 2) insurance corporations and pensions funds (ICPF); 3) other financial institutions (OFI) which includes: investment funds, money market funds, financial vehicle corporations and other financial corporations; 4) households (HH); 5) government (GOV); and 6) non-financial corporations (NFCs).

While in our analysis initially examines all investors' categories, we progressively focus on OFI and ICPF for several reasons. First, they hold a large and rising fraction of the corporate bond market in the euro area: together they held almost 90% of the market in 2021. Therefore, they are granular, hence large enough to affect bond pricing. Second, these institutional investors are intermediate clients who sort across them, indirectly channeling investor preferences.

We focus on euro area investors and exclude non-euro area investor holdings reported in SHSS.[19] This is for two reasons: first, in our analysis portfolio weights are crucial to assess the role of investor demand for each type of security: we can compute those only for securities held by euro area investors, as for them we have all holdings. Second, our econometric identification strategy, which is spelled out in Section 4, aims at isolating the role of investors' demand for euro-dollar yield differentials from firms and bonds characteristics, but also from other confounding factors, such as aggregate shocks and monetary policy. Focusing on euro area investors guarantees that all types of investors experience the same aggregate conditions and the same monetary stance.

While SHSS reports holdings of all equity and debt securities, including government bonds, we focus on euro and dollar-denominated non-financial corporate debt securities since our goal is to disentangle the role of investor preferences from firms' characteristics. These bonds are also largely intermediated by granular institutional investors such as ICPF and OFI, which are the focus of our analysis. The data spans from Q3 2013 to Q1 2021, with euro and dollar-denominated corporate debt securities being equivalent to 8.3% of the euro area investor's debt portfolio at the end of June 2014 totalling a nominal value of around €1.1 trillion. At that date, the data consist of approximately 18,200 bonds issued by about 5700 firms from 87 countries. We focus on euro and dollar bonds as these comprise 95% of the total corporate debt holdings by euro area investors.

The data includes the International Securities Identification Number (ISIN) of each

19 SHSS reports only partial information of the total holdings by non-euro area investors.

security which allows us to merge security holdings with a number of other datasets. First, we use this identifier to enrich the SHSS data with information from the Centralised Securities Database (CSDB) on security characteristics (security type and price, issuer name and country, maturity date and currency of issuance). Next, using this identifier, we match the securities with ratings from the ECB ratings database which includes information from four rating agencies: Fitch, Moody's, Standard & Poor's (S&P), and DBRS. Finally, to estimate euro-dollar yield differentials we match bond maturities with horizons of both the exchange rate movements by professional forecasters and currency derivatives.

Table A1 in Appendix C reports the mean and median maturities for the bonds in our data and distinguishing residual versus maturity at issuance and between euro and dollar denominated assets. The maturity at issuance is clearly higher for dollar denominated assets, indicating that those usually carry larger risk and term premia.

3. Stylized Facts: Home Asset and Local Currency Holding Patterns Across Investors

In this section we use SHSS data to document holding patterns at securities level. As we described in the previous section, our data is unique because it is highly disaggregated and covers the universe of securities held in the euro area (issued by foreign and domestic firms). Therefore it provides a unique opportunity to study portfolio shares of foreign assets in entire investor portfolios, which informs about investor demand. Furthermore, the data allows for the matching of securities with firm identifiers, making the analysis highly informative on investors' preference for local versus foreign bonds. Importantly, while several cuts of the data are possible, we will focus mostly on the patterns that inform our identification strategy. We aim for instance at isolating the largest institutional investors that exhibit a strong preference for euro-denominated assets issued by euro area firms, namely those eligible for the asset purchase program.

We first document patterns for securities aggregated across all issuers, but broken down across different types of investors and currencies (euro vs. dollar). Next, we classify the securities by issuer residency, aggregating across three groups (Euro Area, United States, and Rest of the World) and study investor and currency segmentation inside each issuer

group. While our focus is on informing our identification strategy, the facts detailed below also enrich previous findings on home asset and local currency biases from a long-standing literature on portfolio allocation.

Investors' Currency Preferences. We examine time-series trends for non-financial corporate debt securities holdings by breaking down all holdings (euro area and foreign issued) per investor type and by currency denomination. We focus on portfolio composition per type of investor, in order to capture potential heterogeneity in their currency preferences.

Figure 1 shows the breakdown of holdings per investor type (left panel) and per currency (right panel) since 2013.[20] The top graph displays the volumes denominated in trillions of euros and the bottom panel shows the shares of holdings. Three main points emerge. First, holdings have increased substantially, doubling since the start of the sample. This growth is consistent with a worldwide increase in savings and in global capital flows (see Lane and Milesi-Ferretti (2018)). Second, the increase has been driven by a rise in institutional investors, grouped in OFI and ICPF. This trend, which has also been noted in recent policy reports (see Board (2019)), is due to a rise in the demand for specialized financial services, particularly by high net wealth investors. Finally, as is clear from the right panel, the euro is the dominant currency for European investors, with over 60% of the holdings. European investors display a clear *local currency bias* in corporate debt holdings. Local currency bias is more generally a manifestation of the familiarity bias, which has been found in several areas of portfolio investment.[21].

Our results on the currency bias are complementary to Burger et al. (2018) and Maggiori et al. (2018)). They apply a somewhat different definition of this bias, probably tailored to their own data: they indeed look at the share of foreign investment in local currency. Burger et al. (2018) uses U.S. claims form the Treasury International Capital Statistics, hence it has mainly a U.S. perspective; Maggiori et al. (2018) employ data for mutual funds from a U.S. custodian, Morningstar, and again look at investment abroad. We instead use a traditional definition, as our data include the entire portfolio of the universe of euro area investors, namely the share of bonds in local currency over the total portfolio. Interestingly our euro area data reveal a strong preference of euro-denominated assets, a

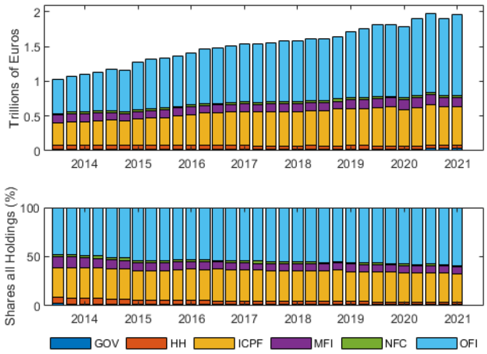
20 Here we focus on euros and dollars. While other currency denominations are also possible, those holdings are very small (less than 5%). For the figure (b) the shares are defined over the sum of euro and dollar denominated securities.

21 See for instance Huberman (2001), Zhu (2002) or Feng and Seasholes (2004)

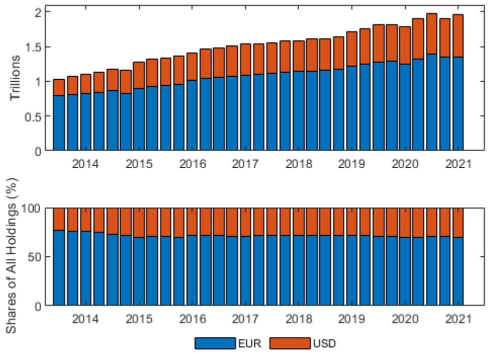
Figure 1

Break down of all non-financial corporate debt securities by type of investor and per currency

Panel (a) left panel shows a break down of all non-financial corporate debt securities by type of investor, namely government (GOV), households (HH), insurance company (ICPF), monetary financial institutions (MFI), non-financial corporations (NFC) and other financial institutions (OFI). Panel (b) shows a breakdown of all non-financial corporate debt securities per euro and dollars denomination. The sample period 2013 Q3 - 2021 Q1. Top panels show volumes in trillions of euro and the bottom panels show shares of holdings for each investor.



(a)
Per investor



(b)
Euro versus Dollars

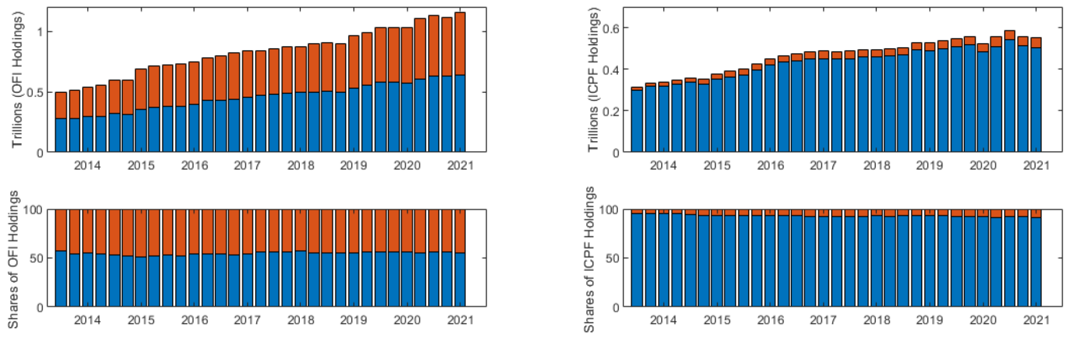
result which stands in contrast with Maggiori et al. (2018) and in line with Koijen et al. (2017).

Figure 1 panel (a) shows that OFI and ICPF are the largest investors in the corporate bond market, with a growing bond portfolio. In panel (b) we observe the growth of the euro denominated securities during our sample period which coincides with the ECB asset purchase program duration. The home currency bias for the securities as a whole may mask a more nuanced picture once we dissect the data per investors' type. Figure C1 in Appendix C presents the breakdown by currency for all six investor categories.There we observe that ICPF and OFI have quite a distinct share of dollar holdings. Because these are the two largest players in the market we focus on them next. Figure 2 shows the break by currency of the debt securities held by OFI and ICPF respectively. The top panels show volumes in trillions of euro and the bottom panels show shares. The comparison between the left and right panels shows that dollar denominated securities are largely held by OFI, while euro-denominated securities are largely held by ICPF.

The dollar bias of OFI, which includes mutual funds, is compatible with previous findings by Maggiori et al. (2018) or Camanho et al. (2018), among others. These studies have the advantage of using fund level data across many countries but can not compare across different types of investors. We observe the portfolios of all types of investors:

Figure 2
Debt in non-financial corporations by currency for OFIs and ICPFs

Break down of all non-financial corporate debt securities in U.S. dollars and euros held by other financial institutions (OFI) in figure 1a and insurance companies (ICPF). The sample period 2013 Q3 - 2021 Q1. For each panel, the top sub-panel shows volumes in trillions of euros and bottom sub-panel shows shares.



(a)
OFIs

(b)
ICPFs

this allows us to better flesh out the currency segmentation across investors, enriching previous results. The euro bias of insurance funds has recently been noted also by Koijen et al. (2017) and Koijen et al. (2021) and is compatible with those institutional investors' mandates.

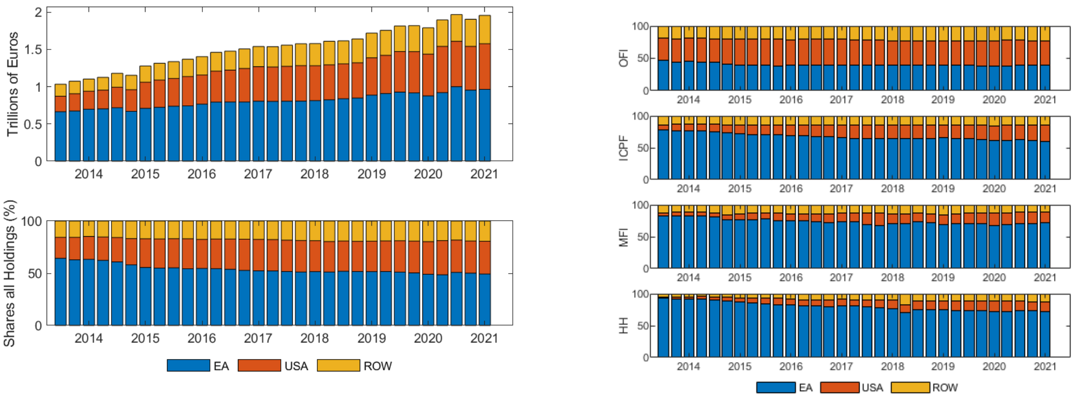
Overall this stark market segmentation reveals large heterogeneity in institutional investor mandates, which ultimately reflects preference heterogeneity in the clients they represent. For instance, Bertaut et al. (2021) notes that mutual funds tend to intermediate high net wealth investors with a preference for timing the dollar. The opposite is true for ICPF.

Investors' Preferences for Issuers and Currencies. A useful aspect of our data is that securities also report the issuers' identifiers. In this section we will use this information to condition securities holdings on issuers' residence. This allows us to uncover investors' preferences for home versus foreign country bonds.

Figure 3 panel (a) shows the the breakdown of all securities by residence of the issuing firm, which we group in Euro Area (blue), the U.S. (red) or the Rest of the World (yellow). Top panel shows volumes and the bottom panel shows shares. We see that the home asset bias (preference for securities issued by local firms) was mild at the beginning of the sample and has vanished in recent years. This pattern is surprising in light of the general perception from past literature of a marked home asset bias. Part of the international

Figure 3
Break down of debt in non-financial corporations by issuer residence

Panel (a) shows the breakdown of debt in non-financial corporations by residence of the issuing firm, which can be from the euro area, from the U.S. or from the rest of the world. Top panel shows volumes in trillions of euros and the bottom panel shows shares. Panel (b) shows the break down (in terms of shares) of debt in non-financial corporations by type of investors, focusing on other financial institution (OFI, first panel from the top), insurance corporations and pensions funds (ICPF, second panel from the top), monetary financial institutions (MFI, third panel from the top) and households (HH, last panel from the top). Sample period 2013-2020.



finance literature has long been debating the extent of the home country bias in assets. Early works documented and theoretically rationalized the presence of this bias in equity.[22] Most of the debt is issued by either Euro Area or U.S. firms (precisely it is 36%), while the rest of the world accounts for a minority share. A preferential cross-holdings of assets among Western economies may again be linked to the familiarity with the respective financial systems. This may indicate that U.S. firms are perceived as safer than others among euro area investors (see also recent evidence by Caramichael et al. (n.d.)).

Panel (b) of 3 shows the shares of securities of the three issuers across four main types of investors, and confirms investors' heterogeneity also in the prefence for home country assets. While home asset bias is clearly visible to increasing degrees in ICPF, MFI, and HH, OFI exhibit no such bias. Again taken in isolation some of the results confirm previous findings. For instance the preference for foreign securities by mutual funds was noted also by Hau and Rey (2008). Since our data contain all type of investors and their portfolio shares, it is better equipped to highlight heterogeneity in the demand for securities.

To fully assess investors' segmentation we next break down securities per currency denomination, per residence of issuer and across various type of investors. Figures 5 shows

22 See for instance French and Poterba (1991), Tesar and Werner (1995) or Baxter and Jermann (1997)). More recently some authors argued that the full picture could be gathered only by considering other types of assets, such as debt bonds (see Coeurdacier and Gourinchas (2016)).

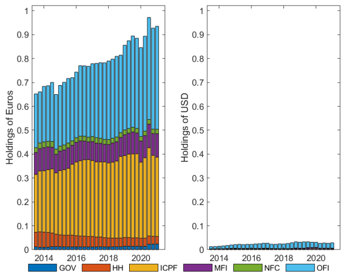
volumes (top panels) and shares (bottom panels) by breaking down the debt securities by currency (U.S. dollars in each left sub-panel and euro denominated securities in each right sub-panel) and by type of investors. The two left figures focus on euro area issuers, the two middle figures focus on U.S. issuers and the two on the right on issuers from the rest of the world. Figure 6 shows a similar break-down but focusing solely on OFI and ICPF, which are relevant for their granularity in this market. Taken together, the two figures show that all investors who prefer euro-denominated securities also prefer euro area issuers (see for instance left panels of Figure 5) and that investors who prefer foreign securities also prefer dollar-denominated securities (see middle and right panel of Figure 5). The segmentation is even more evident between OFI, which prefer dollar-denominated securities of foreign firms, and ICPF, which prefer euro-denominated securities issued by euro area firms. Note that the ICPF demand for those securities is also on the rise. Its consequences are very salient for the yield curve: as we argue below the asset purchase programs had specifically targeted euro-denominated securities issued by euro area firms, namely those in high and rising demand by investors.

Finally, Figure 7, which shows the breakdown of securities by currency denomination, dollars versus euros, and across the three issuers, confirms that firms tend to issue in the currency preferred by main investors. Euro area firms (left panel) for instance predominantly issue euro-denominated securities. Overall the importance of the euro has increased over time also for foreign issuers. For U.S. firms the share of euro-denominated securities is approaching 50% and for firms from the rest of the world is above 50% for a large part of the sample. This is again likely the result of the asset purchase program enacted during the entire period by the European Central Bank. While the ECB did not buy securities issued by foreign firms, the decline in the yields of euro-denominated securities – which we discuss in the next section – fuelled their demand, hence their issuance. We discuss those channels further in the next section.

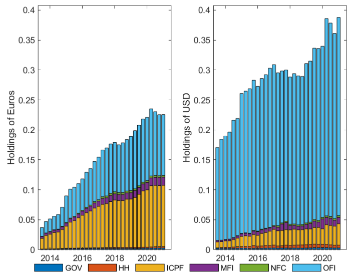
The observed currency and asset segmentation across institutional investors are likely to have consequences for the pricing of international bonds, even more so as the investors holding larger shares of those bonds are granular. We explore this next by estimating euro-dollar yields' differential at securities level. If investors have different preferences for assets which are roughly the same and are issued by the same firms but differ in their currency denomination, the investor base should also matter for bond pricing across currencies.

Figure 5
Debt in non-financial corporations by currency and investors

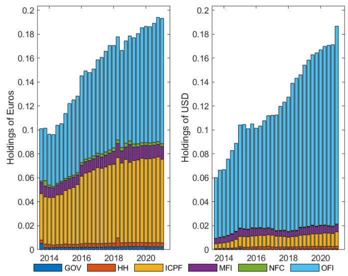
Figure 5 shows the breakdown (in levels) of debt in non-financial corporations by currency denomination, U.S. dollars (left sub-panels) versus euro (right sub-panels), and types of investor in different colors. Debt held by governments (GOV) is in blue, by households (HH) in orange, insurance corporations and pensions funds (ICPF) in yellow, monetary financial institutions (MFI) in purple, non-financial corporations (NFC) in green and other financial institutions in light blue. Top top three sets of panels show levels and the bottom panels show shares. Panels (a) and (d) show only securities issued by firms resident in the euro area, Panels (b) and (e) show only securities for issuers residents in the U.S. and Panels (c) and (f) show securities for issuers residents in the rest of the world. All figures show volumes. The sample period is 2013 Q3 - 2021 Q1.



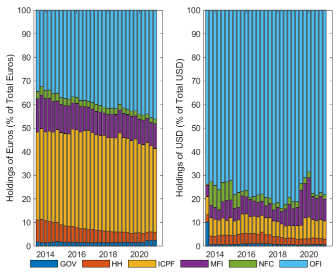
(a)
Euro area issuers



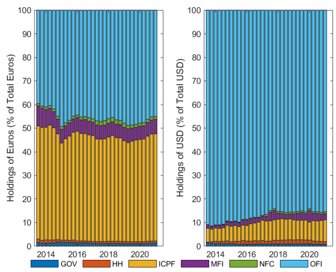
(b)
U.S. issuers



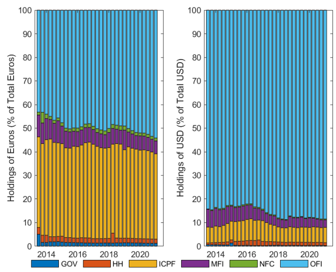
(c)
Rest of the World issuers



(d)
Euro area issuers



(e)
U.S. issuers



(f)
Rest of the World issuers

4. Returns' Differentials: The Role of the Investor Demand

To exploit the richness of our data set we use a securities level specification to calculate the dollar-euro yield differentials with the aim of identifying the role of the investor's demand for the pricing of currency risk.

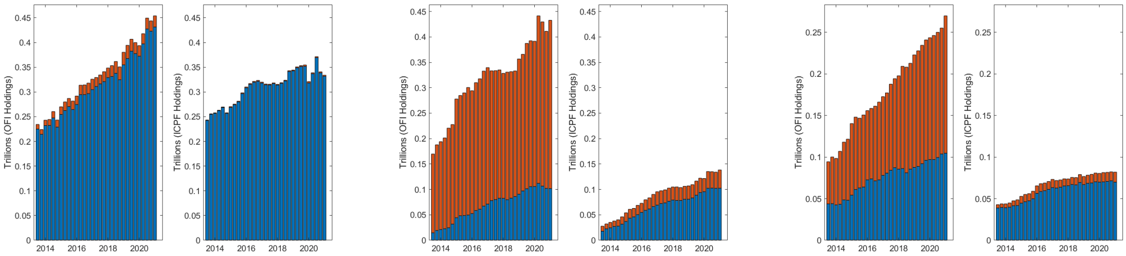
A first tenet behind this identification rests on institutional investors being granular, and hence large enough to have a meaningful impact on prices.[23] As we shown in the previous section, investors such as OFI and ICPF hold almost 90% of the non-financial corporate debt. Furthermore, these investors exhibit a clear and distinct alignment between euro

23 The role of institutional investors' demand for portfolio holdings has been highlighted also in Koijen and Yogo (2019) and Koijen and Yogo (2020).

Figure 6

Debt in non-financial corporations for OFIs and ICPFs by currency

Figure 6 shows the break down of debt in non-financial corporations per currency denomination, the U.S. dollar in red and the euro in blue. Investors are only OFI and ICPF. The top left panel shows only securities issued by firms resident in euro area, the top right panel shows only securities for issuers resident in the U.S. and the bottom panel shows securities for issuers resident in the rest of the world. All figures show shares.



(a) Euro area issuers

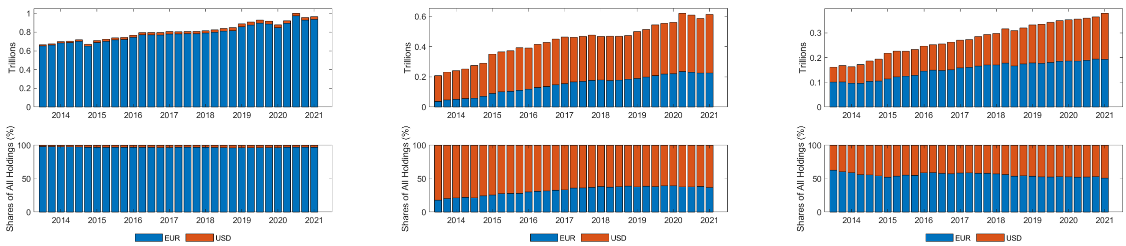
(b) U.S. issuers

(c) Rest of the World issuers

Figure 7

Break down of debt in non-financial corporations per currency denomination

Figure 7 shows the breakdown of debt in non-financial corporations per currency denomination, U.S. dollars versus euro. Top left panels shows only securities issued by firms resident in euro area, the top right panels shows only securities for issuers resident in the U.S. and the bottom panels shows securities for issuers resident in the rest of the world.



(a) Euro area issuers

(b) U.S. issuers

(c) Rest of the World issuers

and dollar assets. These facts motivate the identification strategy described next followed by the results and the underlying channels.

4.1. Identification Strategy

The equilibrium price of a security depends on investor demand, firm issuance, bond characteristics (such as maturity), and underlying shocks. Our goal is to purge any other factor, apart from investors' demand, which ultimately captures preferences. Our strategy rests on three pillars.

The first pillar is to purge the estimated pricing differential from issuance characteristics

and other factors that affect the yields. This is implemented by controlling for bond characteristics (maturity, rating) and for firm fixed effects. With this the estimated residual captures the euro-dollar differential that relates to anything that is left, including aggregate shocks, monetary policy and investors' demand.[24]

The second pillar rests on only selecting securities held by euro area investors. Those investors are arguably subject to the same aggregate shocks, in particular monetary policy stance, which is likely the most significant determinant of yields, and the object of our econometric analysis. The focus on euro area investors ensures that the residual is capturing solely investors' equilibrium demand.

The last pillar focuses on shocks that affect the supply of euro-denominated bonds. Conveniently enough, the monetary policy stance of the euro area during our entire time sample was characterized by large asset purchase programs, which were directed specifically at euro-denominated securities at long maturities. This stance creates the conditions for a drain in supply, which, given investor demand, translates into an excess demand for those securities. If so, euro-denominated bond prices rise and their yields fall. This type of monetary shock is particularly apt in highlighting investors' heterogeneity and provides a natural experiment with the potential to shed light on the relative price elasticities of bonds.

Given our strategy, the estimated intercept captures changes in the differential demand for the same security, issued by the same firm, but denominated in different currencies. If an investor that is more conservative – or who has a business model that discourages holding currency risk, such as pension funds or insurance companies – demands a larger share of euro denominated securities we would observe that, in equilibrium, the yields of this type of security falls relatively more in response to drains in supply. Conjecturally, any observed fall in investor contribution to the yield should mirror the rise in the stock of asset purchases by the ECB.

4.1.1. Econometric Specifications

We estimate several variants of a baseline econometric specification which reads as follows:

$$y_{i,t} = \alpha_t \mathcal{I}_{EUR,i} + \beta_{f,t} + \gamma_{m,t} + \delta_{r,t} \tag{1}$$

24 Recent work by Liao (2020) or Caramichael et al. (n.d.) also measures bond return differentials controlling for bond maturity and rating using traded data. They argue that the residual can capture several things from monetary policy, to investor preferences to firms' observed risk at issuance.

$y_{i,t}$ is the yield for bond i at time t and is the only variable that changes across specifications, α_t is the coefficient on the indicator variable $\mathcal{I}_{EUR,i}$, which equals one if bond i is denominated in the euro. $\beta_{f,t}$, $\gamma_{m,t}$, $\delta_{r,t}$ are fixed effects for firm f, maturity bucket m and rating bucket r at date t. Maturity control refers to residual maturity.[25] Regressions are estimated in the cross-section at each date t and standard errors are clustered on the fixed effect variable. The data is truncated on the dependent variable below 1% and above 99% at each quarter to control for outliers (see Appendix B for details). The coefficient of interest is α_t. This captures the differential currency price impact of investor demand on after purging for all bond and firm characteristics.

We estimate three variants of the baseline specification, equation (1): a *raw* yield differential that compares the yields without adjusting for exchange rate movements, a *survey adjusted* yield differential that controls for expected exchange rate movements using survey forecasts, and a *hedged* yield differential that hedges the currency risk using derivatives. From now on we refer to them as: raw, unhedged, and hedged. The second specification is equivalent to a measure of deviations from uncovered interest parity (UIP), while the third is equivalent deviations from covered interest parity (CIP).

In the raw specification, y is the annualized yield to maturity of the bond from the secondary market and is expressed in euros or dollars depending of the currency of the bond. For the unhedged and hedged specifications we define the yield as:

$$y_{i,t} = \begin{cases} y_{i,t} & if\ euro \\ (1+y_{i,t})(\frac{E(S_{t+n})}{S_t})^{1/n} - 1 & if\ dollar\ \&\ unhedged \\ IRS_{euro,n,t} + BS_{euro,usd,n,t} - IRS_{usd,n,t} + y_{i,t} & if\ dollar\ \&\ hedged \end{cases} \quad (2)$$

where S_t is the spot rate at time t, $E(S_{t+n})$ is the consensus forecast in time t of the expected spot rate (euro per dollar) at time of maturity of the contract (in n years). $IRS_{euro,n,t}$ is the interest rate swap in euros that swaps fixed euro cash flow for floating euro cash flow (like Eurolibor), $BS_{euro,usd,n,t}$ is the cross currency basis swap that swaps floating euro rate into USD floating (Libor) rate, $IRS_{USD,n,t}$ is the interest rate swap in dollars that swaps fixed dollar cash flow for floating dollar cash flow (Libor).

Following Du et al. (2018) we performed the hedged adjustment using swap rates. As

25 Using residual maturity instead at issuance is consistent with the nature of our data, we have portfolio holdings and secondary market prices.

currency forwards are less liquid at maturities greater than one year, we construct the corporate basis with currency swaps, which are more liquid at the longer maturities observed in our data. Details on this adjustment are reported in appendix D. Results for the hedged ones are reported also for forward rates in C6.

In all specifications, the estimated coefficient α_t is the residual component of the euro-dollar yield differential at time t after purging for maturity, bond rating and firms' fixed effects. It captures the estimated average difference in the yields required by investors for bonds in euros versus dollars, hence their SDFs. In other words this component captures the average difference in the demand of euro and dollar investors, hence in their preferences.

Next, we vary our specifications further to isolate the elasticity of different investors in response to shocks and to dissect the channels behind the changes in investors' demand with a primary attention to the role played by the asset purchase programs. The latter was indeed consistently and continuously enacted during our sample period and it was targeted toward specific type of assets, hence it provides a quasi-experimental setting for the identification of the elasticities.

Selecting Eligible Assets. The Scarcity Channel. The first and most immediate channel that may affect investors' demand on the margin is a local supply or scarcity channel. By buying euro denominated assets issued by euro area firms the ECB corporate bond purchase program directly affects the yields of those securities by engineering a simple imbalance between the supply, being drained by the purchased, and the rising demand of those assets by investors such as ICPF. To test this channel, and the investor elasticity in response to this shock, we devise specifications in which double interactions progressively select the securities eligible for the program. More specifically we extend our our baseline specification as follows:

$$y_{i,t} = \alpha_{1,t}\mathcal{I}_{EUR,i} + \alpha_{2,t}\mathcal{S}_{type} + \alpha_{3,t}\mathcal{I}_{EUR,i} * \mathcal{S}_{type} + \beta_{f,t} + \gamma_{m,t} + \delta_{r,t} \tag{3}$$

where $\mathcal{S}_{type}$ is a dummy capturing alternatively investors' types or issuers' types and the term $\alpha_{3,t}\mathcal{I}_{EUR,i} * \mathcal{S}_{type}$ is the effect of that specific sub-sample on the investors' residual. Our coefficient of interest is $\alpha_1 + \alpha_3$. The first captures the average difference in euro and dollar investor demand and the second captures the elasticity.

The Rabalancing Channel and the Portfolio Weighting Strategy. A second

channel through which the asset purchase program can affect the yield curve is the duration extraction or rebalancing channel. By buying bonds, both corporate and Treasuries, the ECB reduces its duration risk. This induces institutional investors, whose portfolios are heavily skewed toward those securities, to increase the demand of eligible bonds even more. The latter in turn reduces yields even further. Portfolio rebalancing is another manifestation of differential changes in investor demand in response to the same shocks.

To dissect this channel, we present below our estimated investor residual both in unweighted and weighted specifications, using actual portfolio shares available in our data. Importantly changes in our portfolio shares truly capture active rebalancing, rather than changes in the value of the shares under a passive portfolio strategy. The reason being that we weight them with nominal values or yields of the securities at issuance. This implies that changes in the shares can only be due to actual changes in the number of securities, rather than in their value.

Following Curcuru et al. (2008) we employ total lagged investor's holdings of each security as weights which avoids endogeneity between prices and portfolio holdings.[26] A rise in the euro weight for instance, following a previous period decline in the euro yield, will capture a rebalance toward this currency. Portfolio weights are measured as follows:

$$\overline{y}_c = \sum_{j=1}^{N} w^c_{j,t-1} y^c_{j,t} \tag{4}$$

where $w^c_{j,t-1}$ is the holdings weight for security j at the end of period $t-1$ and $y^c_{j,t}$ is the period t yield on security j for currency c, and N is the number of investor's holdings for a given security in our data.

In the results we plot our intercept residual both in weighted and unweighted form. The difference between the two allows us to uncover the presence of portfolio re-balancing or changes in investor demand. Larger declines in the yields indicate that investors are also leaning more toward the asset whose yields are falling.

4.2. Results for the Investor Residuals

We start by describing our results and then discuss the underlying channels. The results are presented by plotting the estimated investors' residual, namely the α_t coefficient in

26 Results are similar when we use the contemporaneous holdings.

(1). As we have argued, its dynamic captures the relative changes in investor demand between euro and dollar assets for the same asset, issued by the same firm and with the same underlying aggregate shock.[27]

We display the residual under the three specifications described earlier, namely the *raw*, *unhedged*, and *hedged*. All figures in the main text are based on estimates with bonds above one year of residual maturity. We exclude shorter maturities as those are not well aligned with exchange rate professional forecasts. For robustness we repeat in Appendix C we repeat all estimations with bonds above six month maturity. .

Figure 8 shows results over the sample period 2013 Q3 - 2021 Q1. In each panel the black line is the unweighted residual and the red line is the weighted variant. The first panel shows the *raw*, the second the *unhedged* and the third the *hedged*.[28] Dashed lines indicate plus and minus one standard deviation.

The first panel shows a steady and quantitatively sizable decline of the euro-dollar residual during most of the period. In equilibrium investors require lower yields on euro-denominated securities relative to the dollar denominated ones. Since we controlled for bond characteristics and firms unobservables, the relative lower euro yields are unrelated to firms and security risk. The residual arising from the specification adjusted by the change in the expected exchange rate, in the second panel, also lies comfortably in negative territory. The yield differentials are not an outcome of expectations of the future value of the two currencies. The deviation from the zero dotted line indicates a violation of the UIP. Lastly, the residual in the third panel, while smoother and smaller than in the other two cases, still declines of around 50 basis points. This represents a significant violation of the CIP condition. Results for the CIP are reported here for the baseline swap adjustments; robustness with forward rates adjustment is reported in C6. In all cases the decline in the residual is stronger when weighted by the portfolio shares, indicating a rebalancing toward the currency and exhibiting lower yields. Later, we discuss the channels underlying the decline in the euro yield and the rebalancing toward them.

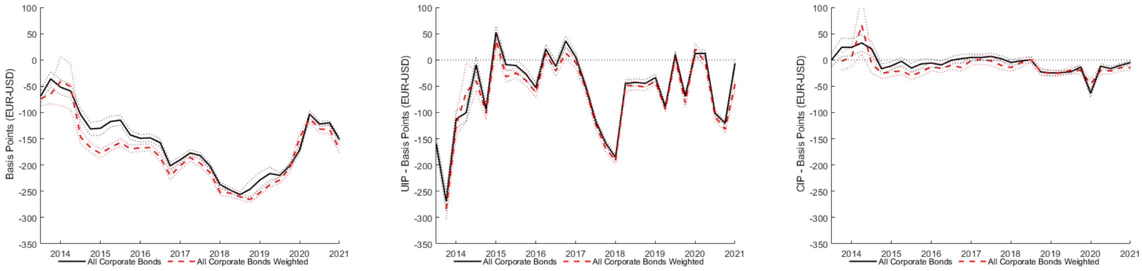
We would also like to note that the decline in the yield, by making euro bonds cheaper for both domestic and foreign firms, is clearly in line with the rise in the issuance by all issuers observed in 7).

27 Our estimates are done on a yearly basis. This is equivalent to including a time fixed effects.

28 The raw differentials, though measured in different units, are still informative about the underlying channels. They capture the stylized situation of fully segmented markets in which each investors can only buy assets in their own currency.

Figure 8
Euro-dollar yields differential, UIP and CIP on SHSS sample

Figure 8 plots estimates for residual intercept for the raw specification (left panel), for the uncovered interest rate party (middle panel) and for the covered interest rate parity (right panel) using the SHSS corporate bond sample from 2013 Q3 - 2021 Q1, including all bonds with a maturity above 1 year. Each panel compares the residuals weighted with portfolio weights (red dashed line) with the un-weighted (black solid line). Econometric specification is: $y_{i,t} = \alpha_t \mathcal{I}_{EUR,i} + \beta_{f,t} + \gamma_{m,t} + \delta_{r,t}$, where $y_{i,t}$ is the local currency yield for bond i traded in the secondary market at time t. α_t is the coefficient on the indicator variable $\mathcal{I}_{EUR,i}$, which equals one if bond i is denominated in the euro. $\beta_{f,t}, \gamma_{m,t}, \delta_{r,t}$ are fixed effects for firm f, maturity bucket m and rating bucket r at date t. The regressions are estimated in the cross-section at each date t. Standard errors are clustered at the fixed effect variable.



(a) Raw

(b) Unhedged

(c) Hedged

Estimates over Sub-samples of Assets with Eligib le Characteristics. To further corroborate our results and to provide further evidence of the channels, here we present the estimated residual across sub-samples of investors and issuers. Given the econometric specification in 3, the coefficient of interest is $\alpha_1 + \alpha_3$. The first captures the average difference in euro and dollar investor demand and the second captures the elasticity. The figures below plot this coefficient for each sub-sample.[29]

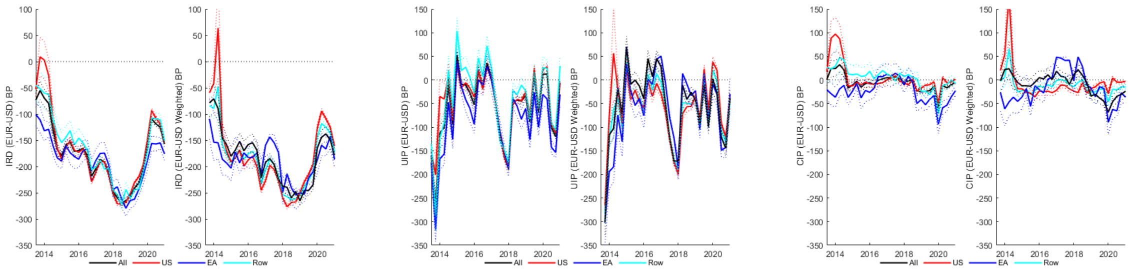
As before, the first two panels show the results for the raw euro-dollar residuals, the next two for the survey adjusted (unhedged) and the last two, the hedged.[30] The blue line, which corresponds to securities issued by euro area firms, shows that for most of the sample euro-dollar residual declines by more for those firms relative to others. Securities eligible under the asset purchase program, namely euro-denominated and issued by euro area firms, should have the largest excess demand. If so, we should expect their yields to decline more than those of the euro-denominated securities issued by U.S. firms or firms from the rest of the world. Figure 9 shows that this is indeed the case.

29 Our results don't include the $\mathcal{S}_{type}$ dummy due to collinearity as it is already controlled for by the other baseline controls. Our extended specification is equivalent to the baseline specification (1) for different sub-samples.

30 An alternative perspective on the same type of data cut is shown in C2 in Appendix C.

Figure 9
Euro-dollar yield differential, UIP and CIP - Break down by residence of issuing firm

Figure 9 plots estimates of the intercept residual, in the raw specification (left panel), in the uncovered interest rate parity specification (middle panel) and in the covered interest rate parity specification (right panel). Results are shown for the baseline specification (black line) and for the one that includes an interacted dummy for issuers, namely U.S. firms (red line), euro area firms (dark blue line) and rest of the world (cyan line). Sample period is 2013 Q3 - 2021 Q1 and samples included all bonds with a maturity above 1 year. Econometric specification is: $y_{i,t} = \alpha_{1,t}\mathcal{I}_{EUR,i} + \alpha_{2,t}\mathcal{S}_{type} + \alpha_{3,t}\mathcal{I}_{EUR,i} * \mathcal{S}_{type} + \beta_{f,t} + \gamma_{m,t} + \delta_{r,t}$, where $y_{i,t}$ is the local currency yield for bond i traded in the secondary market at time t. α_t is the coefficient on the indicator variable $\mathcal{I}_{EUR,i}$, which equals one if bond i is denominated in euro. $\beta_{f,t}, \gamma_{m,t}, \delta_{r,t}$ are fixed effects for firm f, maturity bucket m and rating bucket r at date t and $\mathcal{S}_{type}$ is the issuer dummy. The regressions are estimated in the cross-section at each date t. Standard errors are clustered at the fixed effect variable. Results shown correspond to $\alpha_1 + \alpha_3$.



(a) Raw

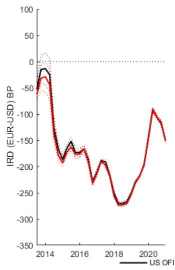
(b) Unhedged

(c) Hedged

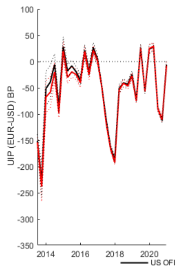
We aim to detect whether portfolio rebalancing has taken place among the larges investors, again focusing on ICPF and OFI. To see this we leverage on the possibility given by our data of computing the portfolio weights. Any change in the latter would provide an indication of the direction of the rebalance. Figure 10 plots the residual of intercept differentials for securities held by two different types of investors, namely OFI (black line in each panel) and ICPF (red line in each panel) and for issuers from the U.S. (first row of panels) and from the rest of the world (second row of panels). As usual we present the raw, the unhedged, and the hedged residuals. The common pattern is that the red line, namely the one for securities held by ICPF, tends to lie below the black line, which represents securities held by OFI. In sum ICPF, even when buying securities of foreign firms tend to rebalance toward lower yield the euro-denominated securities.

Figure 10
Euro-dollar returns differential, UIP and CIP - Break down by type of investor

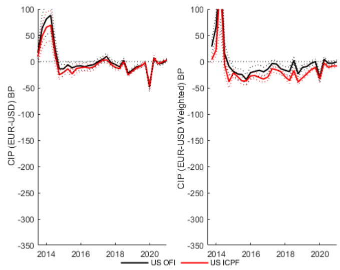
Figure 10 plots estimates for the intercept residual in the raw specification (left panel), in the uncovered interest rate parity specification (middle panel) and in the covered interest rate parity specification (right panel). All regressions include an interacted dummy for investors' type, more specifically for OFI (black lines) and ICPF (red line). Top three panels shows estimations for securities issued by for U.S. firms, bottom panels instead for securities issued by firms from the rest of the world. Sample period is 2013 Q3 - 2021 Q1 and samples included all bonds with maturity above 1 year. Each panel compares the residual weighted with portfolio weights (red and dashed line) with the un-weighted (black and solid line). Econometric specification is: $y_{i,t} = \alpha_{1,t}\mathcal{I}_{EUR,i} + \alpha_{2,t}\mathcal{S}_{type} + \alpha_{3,t}\mathcal{I}_{EUR,i} * \mathcal{S}_{type} + \beta_{f,t} + \gamma_{m,t} + \delta_{r,t}$, where $y_{i,t}$ is the local currency yield for bond i traded in the secondary market at time t. α_t is the coefficient on the indicator variable $\mathcal{I}_{EUR,i}$, which equals one if bond i is denominated in the euro. $\beta_{f,t}, \gamma_{m,t}, \delta_{r,t}$ are fixed effects for firm f, maturity bucket m and rating bucket r at date t and where $\mathcal{S}_{type}$ is the investors' dummy. The regressions are estimated in the cross-section at each date t. Standard errors are clustered at the fixed effect variable. Results shown correspond to $\alpha_1 + \alpha_3$.



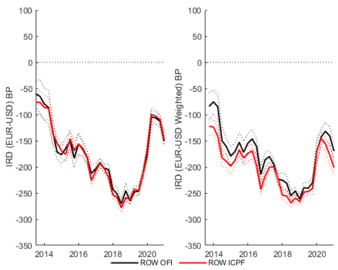
(a)
Raw - U.S. Firms



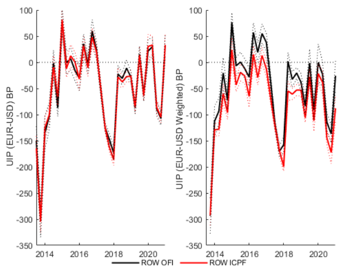
(b)
Unhedged - U.S. Firms



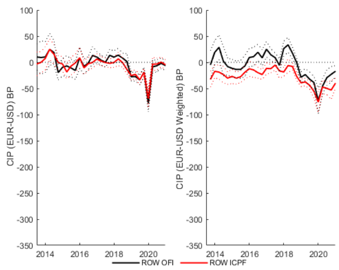
(c)
Hedged - U.S. Firms



(d)
Raw - R.o.W. Firms



(e)
Unhedged - R.o.W.. Firms



(f)
Hedged - R.o.W. Firms

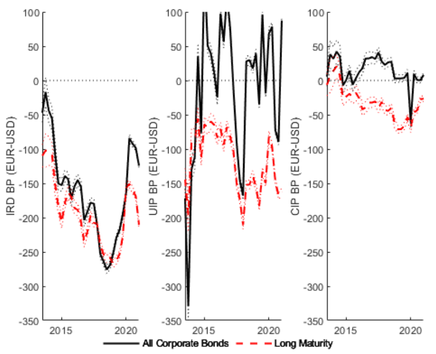
The last analysis we focus only in a sample of long maturity bonds (above 6 years of residual maturity). Figure 11 shows results comparing the baseline investor's residual,using a specification that includes the long maturity dummy and the interaction of the euro denomination identifier with the long maturity dummy. The three panels in the left show the unweighted residual, while the three panels on the right show the weighted one. In both cases the residual declines significantly more for long bonds (implying that the interaction term is more negative). This is so in all three specifications, raw, unhedged and hedged. Note that the decline under the hedged specification is larger than in the other cases. This suggest a clear role for specific type of bonds in driving the excess demand of investors, even beyond any adjustment for exchange rate fluctuations. We will discuss the

economic channels behind this results too in the next section. It suffices to note now, as it will become relevant later on, that those too are assets particularly palatable under the ICPF mandates and at the same time eligible for the ECB asset purchase program. So for those assets the conditions for scarcity materializes strongly. At last, note that in this case the decline is larger for the weighted particularly so for the hedged specification, indicating that certain institutional investors had titled their portfolio by increasing the fraction of long maturity securities, even if covering for exchange rate risk.

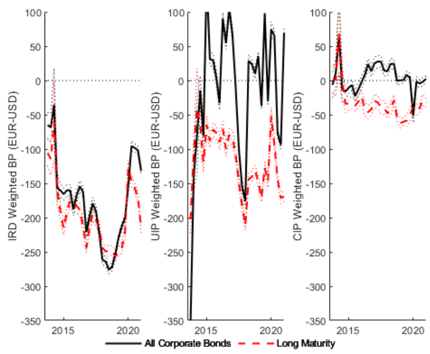
Figure 11

Euro-dollar yield differential, UIP and CIP - Break down per security maturity

Figure 9 plots estimates of the intercept residual (left panel) under a specification that includes a long maturity dummy. The three panels on the left depict the unweighted residual, while the three panels on the right plot the weighted one. In each group of three panels, the left panel plots the raw residual, the middle panel plots the one for the uncovered interest rate parity specification and the right panel plots the one for the covered interest rate parity specification. Black line is the baseline residual and the red line includes the interacted term with the long maturity. Sample period is 2013 Q3 - 2021 Q1 and samples included all bonds with maturity above 1 year. Econometric specification is: $y_{i,t} = \alpha_{1,t}\mathcal{I}_{EUR,i} + \alpha_{2,t}\mathcal{S}_{type} + \alpha_{3,t}\mathcal{I}_{EUR,i} * \mathcal{S}_{type} + \beta_{f,t} + \gamma_{m,t} + \delta_{r,t}$, where $y_{i,t}$ is the local currency yield for bond i traded in the secondary market at time t. α_t is the coefficient on the indicator variable $\mathcal{I}_{EUR,i}$, which equals one if bond i is denominated in the euro. $\beta_{f,t}, \gamma_{m,t}, \delta_{r,t}$ are fixed effects for firm f, maturity bucket m and rating bucket r at date t, and $\mathcal{S}_{type}$ is the long maturity dummy. The regressions are estimated in the cross-section at each date t. Standard errors are clustered at the fixed effect variable. Results shown correspond to α_1 and $\alpha_1 + \alpha_3$.



(a)
Long maturity securities - unweighted



(b)
Long maturity securities - weighted

The Channels: Local Supply and Duration Extraction. It is now instructive to discuss the channels behind the euro-dollar return decline more in detail and also in relation to the dynamic of the asset purchase programs.

We start by noting that during the entire time period considered here[31], the European Central Bank enacted extensive asset purchase programs directed toward Treasuries but also euro-denominated corporate bonds with long maturities.[32] The intent was to affect

31 If the events had been episodic this would have warranted an event study analysis, but the program had been continuously enacted during the full sample period.

32 For a description of the program see: https://www.ecb.europa.eu/mopo/implement/app/html/index.en.html.

the yield curve at all maturities. Recall that all our investors are residents of the euro area, and the underlying shock affecting euro yields relative to dollar yields is therefore common across all investors. This is the tenet that allows us to assign the estimated α solely to changes in investor demand for the same security.

We start by discussing the scarcity or local supply channel, as this provides the first and most immediate impact on the corporate bond yields, namely the securities in our dataset. As noted earlier the corporate purchase program were directed solely towards euro-denominated securities issued by euro area firms. This induced a drain in supply of this specific type of security in particular, namely our scarcity shock, creating an environment close to that of a natural experiment with the potential to shed light on the relative price elasticities of investor bond demand. This drain in supply, for given demand, drives up the price of the eligible bonds, namely euro-denominated securities issued by euro area firms, and compresses their yields by a larger magnitude relative to dollar bonds and to bonds issued by foreign firms.

The role of the asset purchase program in engineering the emergence of excess demand is confirmed by the fact that the bell shape of our estimated residuals mirrors the inverse bell shape of the purchases. Figure 12 compares the dynamic of the asset purchases (top panel) with the dynamic of our baseline estimated differentials (bottom panel). First, the decline of the residual differential reaches a peak in all our plots around in 2018, namely the date with the pick in the stock of purchases[33], starts to rise again when the phase in of the program starts and declines back again the last part of the sample when the program is reactivated to counteract the pandemic recession. This last decline in the euro-dollar yield residual is however not so large like those in the previous years, since in the post pandemic period asset purchase programs have been put in place also by the Federal Reserve and also resulted in declines of dollar assets duration risk and yields. Second, the decline of the differential follows the build up of the purchases, signalling that it is primarily the increase in the stocks that mostly affects prices. The mechanism described thus far has already been uncovered in studies linking asset purchase programs in the U.S. to yield curve changes (see D'Amico and King (2013)) and has been labelled as the *local*

See also speech by Philip Lane for a description of the channels behind the impact on yields: https://www.bis.org/review/r191126d.pdf.

33 For convenience let us recall that monthly purchases averaged 60 billion euros from March 2015 to March 2016, 80 billion euros from April 2016 to March 2017, 60 billion euros from April 2017 to December 2017, 30 billion euros from January 2018 to December 2018, and 15 billion euros from October 2018 to December 2018.

supply channel. Its implications for yield differentials across currencies have never been examined.

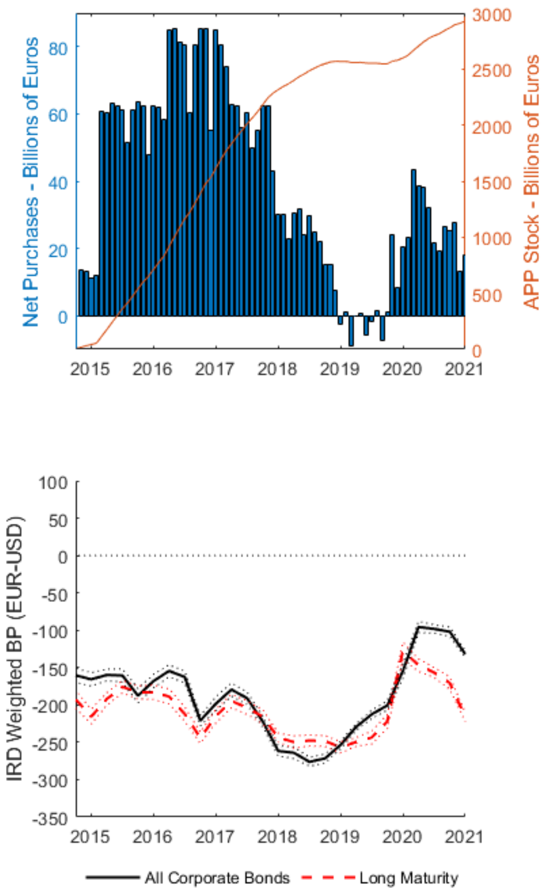
The supply scarcity can explain why the euro yields decreased more relative to the dollar, but to fully examine the role of heterogeneity in investor demand we must also examine the changes in actual portfolio weights, the availability of which represents a unique feature of our data. Figure 10 shows that even when ICPF buy securities from foreign firms, they tend to raise the share of euro-denominated securities. Optimal portfolio shares in standard mean-variance portfolio theory signal changes in the risk that investors attach to each of the securities. Hence, the previously documented reduction in the euro securities yields implies a reduction in their duration risk, hence an overall reduction in risk for investors whose portfolios are more skewed toward those. This in turn leads the investors to optimally increase the share of the securities with lower duration risk. The most revealing evidence for this channel is the fact that we find larger declines of the investors' residual precisely for long maturity bonds (see our figure 11). This indeed shows that it is precisely for those bonds that investors' excess demand is starker. This channel, known as duration extraction, has also been highlighted within SSH data by Koijen et al. (2017) and Koijen et al. (2021), albeit with the analysis of a different econometric methodology and focusing on sovereign bonds. In our data too the decline in the duration risk of the Treasuries spills over to the corporate bonds: as the rate of safer securities declines, the entire yield curve shifts down and it does so for all securities.

5. A Simple Model: Investor Heterogeneity and Yield Differentials

Our analysis has uncovered that investors hold different portfolio shares of euro and dollar bonds and have different demand shifts in response to shocks. This generally leads to a sizable pricing of currency risk even when considering the same asset issued by the same firm and the dynamic of returns under the same macro shock, such as an expansionary monetary policy. The notion that heterogeneity of investor preferences or risk-attitudes may matter for returns' differentials across countries has already been spelled out in Gourinchas et al. (2010) who attribute changes in international returns from exorbitant privilege to exorbitant duty to difference in risk aversion across countries. In this model we move a step forward by exploiting also investor preferences that feature time-varying

Figure 12
Asset purchases and return differentials

Figure 12 shows in the top panel the flows and cumulative stocks of the asset purchase program and in the bottom panel the baseline return differentials. Sample period is 2013-2019.



risk-attitudes: this, as we explain below, adds further insights also on the time variation of elasticities.

In this section we therefore propose a simple model which captures the main insights that emerged from our empirical analysis, namely the existence of deviations in international return differentials linked to investors' preferences, namely our α, their time-varying nature and the portfolio rebalance toward securities leaning toward lower yields. The purpose of the model is threefold. The first is to show how differences between euro and dollar investor preferences and their SDF can provide a microfounded relation for the international returns' differentials mapping exactly the specification estimated in the data and its investor differential. Second, we show that a simulated version of the model can replicate the euro dollar relative decline observed in the data under a general class of

parametrized preferences featuring time-varying risk attitudes.. Third, we discuss the role of asset purchase programs on each of the component of investor SDFs in a way that reflects the channels we discussed in the data.

The model background is devised to reflect, as closely as possible, the different features of the investors in our data. Specifically, the model features large institutional investors, each of whom, performs a portfolio optimization across bonds in different currencies[34] based on a mandates by their clients.[35] The mandates primarily reflect the preferences or risk-attitudes of the atomistic investors that sort into each of the institutional investors. Therefore, the portfolio optimization is done by maximizing the utility of their clientele subject to their wealth evolution. Hence, and to fix ideas, if atomistic investors sorting into insurance and pension funds hold preferences averse to currency risk or to risk in general, this will be reflected in the portfolio choice done by the respective institutional investors. Mandates can include more broadly also regulation: we consider that in a variant of our model and show how results remain consistent with that. It is also reasonable to foresee that clients sort themselves across institutional investors also based on the closeness between the constraints imposed by regulation on portfolio choices and their own preferences.

Portfolio Optimization. The supply of each of those securities in euros or dollars is taken as given. We focus on the optimization problem of the institutional investor choosing between the same bond denominated in two different currencies. The investor chooses the euro denominated bond, $B_{h,t}$, and the dollar denominated bond, $B_{f,t}$, to maximize the expected discounted utility, $\sum_{t=0}^{\infty}\beta E_t[U(C_t)]$, subject to their clientele budget constraint:

$$P_t C_t + \frac{B_{h,t}}{(1+i_t)} + \frac{e_t B_{f,t}}{(1+i_t^*)\Theta(e_t B_{f,t})} = B_{h,t-1} + e_t B_{f,t-1} + Y_t$$

where E_t is the expectation operator with respect to the information set at time t, β is the time discount, P_t is the price level in the domestic economy, $B_{f,t}$ is holding of foreign bonds, $B_{h,t}$ is holding of domestic bonds, e_t is the euro-dollar nominal exchange rate, $\Theta(e_t B_{f,t})$ is a loss given default that characterizes the security and captures firms' risk and where Y_t is exogenous nominal income.[36] Investors in this model also have cash holdings.

34 For ease of exposition in the model we consider two: euros and dollars.
35 This is a traditional perspective in household finance. See Campbell (2006)
36 This cost is akin to the default premia or the portfolio adjustment costs introduced in Schmitt-Grohé

The role of money is necessary to pin down the price level, which in turn pins down the nominal exchange rate across countries. The classical Helpman-Lucas cash in advance assumption is that all money must be used to purchase good and all purchases of each country n must be made in local currency, even when carried out by foreign residents. Given M_t the money balance of local residents, the price level is determined as follows: $P_t = \frac{M_{t-1}}{C_t}$. In turn the nominal exchange rate is given by ratio of the price levels across countries: $e_t = \frac{P_t}{P^*}$. Cash money balances also enter the full investors budget constraint when making consumption decision: we do not carry it over for notational convenience and as this does not affect the portfolio decision.

Note that those investors are living in the same currency areas, their budget constraint is expressed in one currency, say euros. We will refer to those investors as domestic investors or euro area investors. First order conditions for this optimization problem read as follows:

$$\frac{U_{c,t}}{P_t} = (1+i_t)\beta E_t(\frac{U_{c,t+1}}{P_{t+1}}); \tag{5}$$

$$\frac{U_{c,t}}{P_t} = (1+i_t^*)\Theta_{B_{f,t}}(e_t B_{f,t})\beta E_t(U_{c,t+1}\frac{e_{t+1}}{e_t P_{t+1}}) \tag{6}$$

where $U_{c,t}$ is the marginal utility of consumption, $\Theta_{B_{f,t}}(e_t B_{f,t})$ is the derivative of the default premium with respect to foreign debt. From equations 27 and 6 one obtains the stochastic discount factor in nominal terms of the euro area investors holding euro and dollar assets respectively:

$$\frac{1}{(1+i_t)} = Q_{t,t+1}^{euro,euro} = \beta E_t(\frac{U_{c,t+1}P_t}{U_{c,t}P_{t+1}}) \tag{7}$$

$$\frac{1}{(1+i_t^*)} = Q_{t,t+1}^{euro,\$} = \Theta_{B_{f,t}}(e_t B_{f,t})\beta E_t(\frac{U_{c,t+1}P_t e_{t+1}}{U_{c,t}P_{t+1}e_t}) \tag{8}$$

Given the above we can define the real discount factor as:

$$\frac{1}{(1+r_t)} = M_{t,t+1}^{euro,euro} = \beta E_t(\frac{U_{c,t+1}}{U_{c,t}}) \tag{9}$$

Equalizing the marginal rate of substitution and expressing in real terms delivers:

$$Q_{t,t+1}^{euro,euro} = \frac{e_t}{e_{t+1}} Q_{t,t+1}^{euro,\$} \qquad M_{t,t+1}^{euro,euro} = \frac{q_t}{q_{t+1}} M_{t,t+1}^{euro,\$} \tag{10}$$

and Uribe (2003). They can also be interpreted as fees charged by the intermediaries and related to their risk bearing capacity.

where the real exchange rate is expressed as: $S_t = \frac{e_t P_t^*}{P_t}$. To eventually obtain analytical expressions of the euro dollar yield differentials it is convenient to loglinearize equations. Let us define x_t as the natural logs of variable X_t and by $\hat{x_t}$ the change of the natural logarithm of X_t from its steady state value. Loglinearizing equations 6 we obtain:

$$\hat{r}_t = \hat{u}_{c,t} - \hat{u}_{c,t+1} = \hat{m}^{euro}_{t,t+1}; \hat{r}^*_t = \hat{u}_{c,t} - \hat{u}_{c,t+1} + \hat{s}_t - \hat{s}_{t+1} - \epsilon\hat{b}_t \tag{11}$$

where ϵ is the log change of the derivative of the default premium. Substituting into each other the two equations in 11 delivers: $\hat{r^*}_t = \hat{r} + \hat{s}_t - \hat{s}_{t+1} - \epsilon\hat{b}_t = \hat{m}^{euro}_{t,t+1} + \hat{e}_t - \hat{e}_{t+1} - \epsilon\hat{b}_t$. Note that foreign or dollar bonds, $B_{f,t}$, are also held by foreign investors. Those two perform a portfolio choice and price this asset. Their first order condition delivers the following nominal and real stochastic discount factors:

$$\frac{1}{(1+i^*_t)} = Q^{\$}_{t,t+1} = \beta E_t\left(\frac{U_{c^*,t+1}P^*_t}{U_{c^*,t}P^*_{t+1}}\right) \qquad \frac{1}{(1+r^*_t)} = M^{\$}_{t,t+1} = \beta E_t\left(\frac{U_{c^*,t+1}}{U_{c^*,t}}\right) \tag{12}$$

Once again loglinearizing equation 12 delivers: $\hat{r}^*_t = \hat{u}^*_{c,t} - \hat{u}^*_{c,t+1} = \hat{m}^{\$}_{t,t+1}$ and for ease of exposition we are assuming that foreign investors do not face default costs. [37] By non-arbitrage, the price of the dollar bond across countries is equalized. This implies (we employ the log-linear expressions directly):

$$E_t(\hat{u}_{c,t+1} - \hat{u}_{c,t} + \hat{s}_{t+1} - \hat{s}_t + \varepsilon\hat{b}_t) = E_t(\hat{u}^*_{c,t+1} - \hat{u}^*_{c,t}) \tag{13}$$

Equation 28 is a traditional uncovered interest rate parity, or UIP. This can be seen by substituting the ratios of marginal utilities across periods with the interest rate:

$$\hat{r}_t + \hat{s}_{t+1} - \hat{s}_t + \varepsilon\hat{b}_t = \hat{r}^*_t \tag{14}$$

Using instead the expressions for the stochastic discount factors we can re-write 28 as:

$$E_t(\hat{s}_{t+1} - \hat{s}_t) = E_t(\hat{m}^{euro}_{t,t+1} - \hat{m}^{\$}_{t,t+1} + \varepsilon\hat{b}_t) \tag{15}$$

where εb_t represents the default risk of the bond and $\hat{m}^{euro}_{t,t+1} = (\hat{u}_{c,t+1} - \hat{u}_{c,t})$ and $\hat{m}^{\$}_{t,t+1} = (\hat{u}^*_{c,t+1} - \hat{u}^*_{c,t})$. The euro-dollar yield differential in equation 14 is in line with our previous

37 The model can be easily extended to include default costs for foreign investors. Those however would be different than default costs borne by euro investors, as redeploying rights presumably differs across countries or currency areas.

econometric specification, equation 1. The interest rate differential for one specific asset equals the expected exchange rate changes and bond default risk. Our evidence, as well as a long standing literature, argue for the emergence of UIP deviations. Recent literature (see Verdelhan (2010), Colacito and Croce (2013) or Bacchetta and Van Wincoop (2006) among others) argue that those emerge from the risk premia that investors require on specific assets and that are hence linked to investors' SDF. To capture those we therefore focus on equation 16, which expresses the same UIP condition but in terms of SDF. Employing different types of preferences and computing the respective SDFs we show under which conditions those deviations arise, and under which conditions they resemble our α residuals, namely differences in investors' price of risk.

Baseline preferences. We start to derive the UIP deviation with standard CES preferences, $\frac{C_t^{1-\sigma}}{1-\sigma}$. In this case $\hat{m}^{euro}_{t,t+1} = \hat{u}_{c,t} - \hat{u}_{c,t+1} = \sigma\hat{c}_t - \sigma\hat{c}_{t+1} = \sigma\Delta\hat{c}_{t+1}$ and $Var(\hat{m}^{euro}_{t,t+1}) = \sigma^2 Var(\Delta\hat{c}_{t+1})$. If consumption growth, $\Delta\hat{c}_{t+1}$, follows a normal distribution, the SDF, which is a logarithmic function of consumption, follows a lognormal distribution. Using the expected value of the SDF and the relation $\hat{r}_t = \hat{m}^{euro}_{t,t+1}$ it follows: $\hat{r}_t = E_t(\hat{m}^{euro}_{t,t+1}) - \frac{1}{2}[var(\hat{m}^{euro}_{t,t+1})]$. Replicating the same steps for foreign investors delivers: $\hat{r}^*_t = E_t(\hat{m}^{\$}_{t,t+1}) - \frac{1}{2}[var(\hat{m}^{\$}_{t,t+1})]$. The last two relations imply that investors' SDFs can be written as the interest rate on the security plus a premium for risk: $E_t(\hat{m}^{euro}_{t,t+1}) = \hat{r}_t + \frac{1}{2}[var(\hat{m}^{euro}_{t,t+1})]$ and $E_t(\hat{m}^{\$}_{t,t+1}) = \hat{r}^*_t + \frac{1}{2}[var(\hat{m}^{\$}_{t,t+1})]$. We can then substitute those expressions foe the expected SDF into 16 to obtain:

$$E_t(s_{t+1} - s_t) = \hat{r}_t - \hat{r}^*_t + \frac{\sigma^2}{2}[Var(\Delta\hat{c}_{t+1}) - Var(\Delta \hat{c^*_{t+1}})] + \varepsilon\hat{b}_t \tag{16}$$

Remark 1. *Differences in investors SDFs,* $\hat{m}^{euro}_{t,t+1} - \hat{m}^{\$}_{t,t+1} = \hat{r}_t - \hat{r}^*_t + \frac{\sigma^2}{2}[Var(\Delta\hat{c}_{t+1}) - Var(\Delta \hat{c^*_{t+1}})]$*, captures the difference in average returns required by euro and dollar investors, hence it maps the* α *of the empirical specification. It features two components, a differences in safe rates,* $\hat{r}_t - \hat{r}^*_t$*, and a difference in risk premia,* $\frac{\sigma^2}{2}[Var(\Delta\hat{c}_{t+1}) - Var(\Delta \hat{c^*_{t+1}})]$.

Few considerations are worth. First, the risk premia generally capture precautionary savings of investors: as consumption variability raises, so do the risk premia. Their size and dynamic depend on the type of investor preferences and we will consider three cases further below. Second, while UIP deviations are often obtained through correlation of portfolio returns, those are typically second orders and are unlikely to account for

our estimated investor differential, namely the α, which instead captures a first order difference in average returns across investors. Our log-linear specification instead highlights precisely the role of first order deviations. Second, and most important for our purposes both components of the inflation differential can be affected by monetary policy or asset purchases programs. We devote a more extensive discussion on this further below, but for now it suffices to note that Treasuries asset purchase can reduce the safe rate, hence flatten the whole yield curve. On the other side purchases targeted to specific securities, such as corporate bonds, by improving liquidity in certain asset segments can reduce risk and stabilize consumption volatility. The latter in turn further reduces the returns required by investors.

Next, we move to examine the exact specification of the consumption volatility differentials under different preference parametrization. An earlier literature (Verdelhan (2010) among others) noted that reference dependent utilities, by inducing time-varying risk attitudes, are more pat to capture certain features of the UIP differentials. We consider the role of those preferences by comparing them to classical CES ones and we also move a step further from traditional habit by considering the extended class of S-shaped preferences with loss aversion. The latter allows us to fine tune changes in investor demand both in booms and in the loss domain.

Remark 2. *If investors hold exactly the same CES preferences, the deviation in the uncovered interest rate parity can only arise from differences in consumption risk across investors buying euro or dollar assets, on top and above the bonds' default risk.*

Recall once more that the investors in our portfolio data live in the same currency area and are therefore arguably subject to the same consumption risk and the same consumption inflation dynamics. Therefore the above hypothesis is unlikely to be a driver for the dynamic of our empirical α.

We would like to note that under the CES assumption, our UIP would account for the Fama (1984) puzzle, namely an estimated coefficient on returns' differentials larger than one, only if $cov(\hat{r}_t - \hat{r}^*_t, \frac{\sigma^2}{2}[Var(\Delta\hat{c}_{t+1}) - Var(\Delta\hat{c^*}_{t+1})]) \neq 0$. Recent literature (see Verdelhan (2010), Colacito and Croce (2013) or Bacchetta and Van Wincoop (2006)) has argued that an alternative solution to the Fama (1984) puzzles is obtained under preferences that induce time-varying SDFs and one such class of preference is the reference-dependent utilities. Motivated by these lateral empirical arguments we move to explore

the consequences of this class of preferences for the UIP deviations and more specifically for our α.

Preferences with Time-Varying Risk-Attitudes. We consider two parametric variants within the general class of reference-dependent utilities. The first is the habit preferences from Campbell and Cochrane (1999) and Verdelhan (2010). The second is a more general reference-dependent utility that includes loss-aversion, namely increasing risk-aversion in the loss-domain (see Kahneman and Tversky (1979), Kőszegi and Rabin (2009) among others).

Reference dependent utility. We start with reference dependent utility a' la Campbell and Cochrane (1999) or Verdelhan (2010). Investors' preferences depend upon the deviation of consumption from a reference level, which is given by past consumption[38]. The deviation of consumption from the habit, or the surplus consumption ratio, reads as follows $X_t = \frac{C_t - H_t}{C_t}$, where H_t represents the habit. Employing the classical constant elasticity specification, the instantaneous utility function in this case reads as: $U(C_t) = \frac{(C_t - H_t)^{1-\sigma}}{1-\sigma}$. The SDF in real terms for this case reads as:

$$M_{t,t+1} = \beta \left(\frac{C_{t+1} - H_{t+1}}{C_t - H_t} \right)^{-\sigma} = \beta \left(\frac{X_{t+1} C_{t+1}}{X_t C_t} \right)^{-\sigma} \tag{17}$$

The link between marginal utility and past consumption induces a time-varying absolute risk aversion coefficient. The larger the change of consumption deviation from the reference level, due for instance to an expansionary shock, the more risk-tolerant is the investor. As before, we derive the loglinear expression for the SDF. Loglinearizing 17 we get: $\hat{m}_{t,t+1} = \sigma(\Delta \hat{x}_{t+1} - \Delta \hat{c}_{t+1})$. Next, following Campbell and Cochrane (1999) and Verdelhan (2010)[39], consumption growth is normally distributed and the log of the consumption surplus, $x_t = log(X_t)$, which moves according to the following Markov process: $x_{t+1} = \nu x_t + (1-\nu)\overline{x} + \lambda(x_t)(\Delta \hat{c}_{t+1})$, where $\lambda(\hat{x}_t)$ is a parameter that determines the sensitivity of the surplus consumption ratio to consumption growth. Using $\hat{m}_{t,t+1} = \sigma(\Delta \hat{x}_{t+1} - \Delta \hat{c}_{t+1})$, the process for the surplus consumption growth and the fact that consumption growth follows a normal distribution, we can write the SDF as:

$$\hat{m}_{t,t+1} = \hat{r}_t + \frac{1}{2} var(\hat{m}^{euro}_{t,t+1}) = \hat{r}_t + \frac{1}{2}\sigma^2 (1 + \lambda(\hat{x}_t)) var(\Delta \hat{c}_{t+1}) \tag{18}$$

38 See also Brabant (2021) for models of UIP with various preferences.

39 Both studies also assume a positive consumption growth in the long run. We set this to zero as we have a short sample in our data.

Investors' risk-attitudes are defined by the relative coefficient of risk aversion, which in this case reads as $\sigma_t^2(1+\lambda(\hat{x}_t))$ and is clearly time-varying. When the surplus consumption ratio grows, the relative risk aversion coefficient changes too. The fact that in our data investors assign different portfolio shares to different assets is a clear indication of a difference in risk-attitudes. Investors may exhibit both different σ and different λ. Since our evidence shows time-varying yields, we focus on the time varying coefficient of relative risk aversion, namely λ, and assume that the latter is different between euro and dollar investors. Let us define as $\lambda(\hat{x}_t)$ and $\lambda^*(\hat{x}_t)$ the sensitivity of consumption surplus to consumption growth respectively for the euro and the dollar investors. To map our evidence it is plausible to assume that ICPF, which largely invest in euro-denominated securities issued by euro area firms, tend to have larger risk-aversion coefficients than mutual funds. Substituting then the respective SDF in the uncovered interest rate differential, 16, we obtain:

$$E_t(\hat{s}_{t+1}-\hat{s}_t) = E_t\{\hat{r}_t - \hat{r}_t^* + \frac{1}{2}\sigma_t^2[(1+\lambda(\hat{x}_t))^2 var(\Delta\hat{c}_{t+1}) - (1+\lambda^*(\hat{x}_t))^2 var(\Delta\hat{c}_{t+1}^*))] + \varepsilon\hat{b}_t\} \tag{19}$$

If investors are resident in the same area then we can impose $\hat{c}_{t+1}^* = \hat{c}_{t+1}$.

Remark 3. *The model based SDF investor residual $\lambda(\hat{x}_t)var(\Delta\hat{c}_{t+1}) - \lambda^*(\hat{x}_t)var(\Delta\hat{c}_{t+1})$ maps the α intercept residual in the empirical specification for the uncovered interest rate differential. As before bond and firm risk are captured by the term $\epsilon\hat{b}_t$.*

Reference-dependent utility with loss aversion. Next, we consider an extension of reference-dependent utilities that includes loss-aversion, namely increasing risk-aversion in the loss domain.[40] An expanding literature has shown that those preferences are successful in explaining a number of asset price facts[41], but they have never been used in international asset pricing. The functional form for the utility in this case reads as follows $U(C_t, X_t) = \alpha U(C_t) + (1-\alpha)\mathcal{W}(C_t, X_t)$, where $U(C_t)$ is the standard CRRA utility and where:

$$\mathcal{W}(C_t, X_t) = \begin{cases} \frac{\left(\frac{(C_t)^{(1-\gamma)}}{1-\gamma} - \frac{(X_t)^{(1-\gamma)}}{1-\gamma}\right)^{1-\theta}}{1-\theta}, & \text{if } C_t \geq X_t \\ -\Lambda\frac{|\frac{(C_t)^{(1-\gamma)}}{1-\gamma} - \frac{(X_t)^{(1-\gamma)}}{1-\gamma}|^{1-\theta}}{1-\theta}, & \text{if } C_t < X_t, \end{cases} \tag{20}$$

The parameter Λ captures the degree of loss aversion and X_t is again a consumption

40 Kahneman and Tversky (1979) first found lab evidence for those preferences. Kőszegi and Rabin (2009) introduced them in a consumption-saving problem.

41 See Bordalo et al. (2018), Pagel (2016) and Curatola and Faia (2021).

reference level. As before this can be given by past consumption. The stochastic discount factor reads as: $M_{t+1} = \beta G_{t+1}^{-\gamma} \frac{k(Y_{t+1})}{k(Y_t)}$, where $G_{t+1} = C_{t+1}/C_t$ and $Y_{t+1} = C_{t+1}/X_{t+1}$ and:

$$k(Y_t) = \begin{cases} (\frac{C_t^{1-\gamma}}{1-\gamma} - \frac{X_t^{1-\gamma}}{1-\gamma})^{-\theta} & for\ Y_t \geq 1 \\ \lambda \mid \frac{C_t^{1-\gamma}}{1-\gamma} - \frac{X_t^{1-\gamma}}{1-\gamma} \mid^{-\theta} & for\ Y_t < 1 \end{cases} \tag{21}$$

These preferences too exhibit time-varying SDF. A parameter θ lower than one implies a declining marginal utility in the gain domain, $Y_t > 1$. Losses instead, $Y_t > 1$ resonate more than gains, when Λ is larger than one.[42] As before derive the expected SDF. The derivation is now slightly more involved as we now need to specify a distribution of consumption in both the gain and loss domain. Following Tallarini (2000) and Yogo (2008), log consumption growth, g_t, is modelled as a normal distribution $N(\mu, \sigma^2)$ at any date t. Upon defining $\kappa_{t+1} = x_{t+1} - c_t = -\log(b) + s_t$., where all small letters now indicate logs. Under this assumption it holds that:

$$\mathbb{E}_t \left[\exp(g_{t+1}) \mid g_{t+1} > \kappa_{t+1} \right] = \exp\left\{ \mu + \frac{\sigma^2}{2} \right\} \frac{F(-(\kappa_{t+1} - \mu - \sigma^2)/\sigma)}{F(-(\kappa_{t+1} - \mu)/\sigma)} \tag{22}$$

$$\mathbb{E}_t \left[\exp(g_{t+1}) \mid g_{t+1} < \kappa_{t+1} \right] = \exp\left\{ \mu + \frac{\sigma^2}{2} \right\} \frac{F((\kappa_{t+1} - \mu - \sigma^2)/\sigma)}{F((\kappa_{t+1} - \mu)/\sigma)} \tag{23}$$

where F is the cumulative conditional distribution of the standard normal. The SDF implied by given by 21 can be written in logarithms as follows:

$$m_{t,t+1} = \begin{cases} \frac{\Lambda \rho \exp\{-\gamma g_{t+1}\}}{k(y_t)} & \text{if } g_{t+1} < \kappa_{t+1}, \\ \frac{\rho \exp\{-\gamma g_{t+1}\}}{k(y_t)} & \text{if } g_{t+1} > \kappa_{t+1}, \end{cases} \tag{24}$$

Given the above we can compute the first moment of $m_{t,t+1}$ as follows:

$$\begin{aligned} \mathbb{E}_t \left\{ m_{t,t+1} \right\} &= \frac{\rho}{k(y_t)} (F(\gamma\sigma + \frac{(\kappa_{t+1} - \mu)}{\sigma}) \mathbb{E}_t \left[\exp\left\{ -\gamma g_{t+1} \right\} \mid g_{t+1} > \kappa_{t+1} \right] + \\ & +\Lambda F(\gamma\sigma + \frac{(\kappa_{t+1} - \mu)}{\sigma}) \mathbb{E}_t \left[\exp\left\{ -\gamma g_{t+1} \right\} \mid g_{t+1}^b < \kappa_{t+1} \right]) \end{aligned} \tag{25}$$

42 This value was initially uncovered by Kahneman and Tversky (1979) and confirmed in subsequent experimental evidence.

Using formulas in 22 and 23 we can rewrite 25 as follows:

$$\mathbb{E}_t \left\{ m_{t,t+1} \right\} = \frac{\rho}{k(y_t)} \exp \left\{ \gamma\mu + \frac{(\gamma\sigma)^2}{2} \right\} \times \left[1 + (\Lambda - 1) F(\gamma\sigma + \frac{(\kappa_{t+1} - \mu)}{\sigma}) \right]$$

We embed preference heterogeneity by assuming that certain investors, say ICPF, are more loss-averse, hence have higher λ, while OFI are less. This is plausible and also naturally generates a difference in the SDF of euro-keen and dollar-keen investors. Thus a difference in λ, ξ generates a time-varying difference in m_{t+1}^{euro}, $m_{t+1}^{\$}$.

Remark 4. *The investors' residual given by* $(\Lambda^{euro} - \Lambda^{\$}) F(\gamma\sigma + \frac{(\kappa_{t+1} - \mu)}{\sigma})$ *maps the residual intercept* α *of the empirical counterpart. As before, bond and firm risk are captured by the default premium* εb_t.

Regulatory Constraints and Investors' Mandates. So far we have linked the investors' residual to specific time-varying component of their clientele's SDF. However institutional investors' demand depends more broadly on their mandates and this may include also regulatory constraints. For instance Article 188 of the Solvency regulation, which applies to insurance and pension funds in Europe, requires additional capital charges for investment in foreign currency. There are general guidelines on how to cover currency risk, but the exact regulatory requirement eventually depends on the institutional investors exposure to currency risk, as represented by the type of debt instruments used, by the risk model adopted internally and by the type of hedging strategies. Hence, while it is possible to design one single prudential constraint, its general formulation is that of a cap on foreign currency exposure.

Those type of regulatory constraints do affect institutional investors excess demand, hence the residual, and can induce additional deviations from arbitrage. Eventually we see those constraints and clientele preferences as aligned and both equally contributing to the investors' residual: presumably clientele sort into intermediaries also based on their regulatory frameworks. Anyhow, we show here how those additional specifications of the mandate could impact the euro-dollar investors' residual. Consider again the portfolio optimization problem outlined in 5. Capital or cost surchages on dollar investment can be

formalized through an additional constraint that imposes a cap on the share of foreign currency investment and that reads as follows:

$$\frac{B_{f,t}}{B_{f,t}+B_{h,t}}=\kappa \tag{26}$$

If we define as μ_t the Lagrange multiplier on this new constraint the adjusted Euler equation on foreign bonds reads as follows:

$$U_{c,t}P_t=(1+i_t^*)\Theta_{B_{f,t}}(e_tB_{f,t})\beta E_t(U_{c,t+1}\frac{e_{t+1}}{e_tP_{t+1}})+\mu_t(1-\kappa) \tag{27}$$

Expressing again in real terms and loglinearizing delivers $\hat{r}_t^*=\hat{u}_{c,t}-\hat{u}_{c,t+1}+\hat{\mu}_t+\hat{s}_t-\hat{s}_{t+1}-\epsilon\hat{b}_t$. The above implies an adjusted UIP which reads as follows:

$$E_t(\hat{u}_{c,t+1}-\hat{u}_{c,t}+\hat{\mu}_t+\hat{s}_{t+1}-\hat{s}_t+\varepsilon\hat{b}_t)=E_t(\hat{u}^*_{c,t+1}-\hat{u}^*_{c,t}) \tag{28}$$

The Lagrange multiplier in this case contributes to the investors' residual, namely the estimated α in the data.

Note that the considerations above suggest that investor demand may respond also to changes in regulation. In this paper we focused on the response to asset purchases, which has been a major development in the euro area and has direct impact on securities prices. Beyond that, it is important to note that investors are well aware of the constraints imposed on various institutional investors and as such they sort themselves into the one that best fits their own preferences. Hence, from this point of view the two aspects may represent observationally equivalent manifestation of difference in investor demand.

Portfolio Rebalancing. An important insight from our empirical analysis is that following the change in yields, investors also tend to rebalance their portfolios, even more so toward the security by their preferred security, whose yields have been decreasing (hence their values have been increasing). The rebalance is also an important component of the duration extraction channel. We therefore move on to rationalizing this observation through the lens of the model.

Given the securities equilibrium prices, which can be obtained from investors' SDFs, portfolio weights can be derived by resorting on a market clearing condition[43]. In our stylized world with two assets, demand is represented by the sum of the euro, $B_{h,t}$, that of

43 See also Koijen and Yogo (2019) for a similar strategy.

the dollar, $B_{f,t}$, and securities at any point t. The demand of each security is equivalent to its portfolio share, call it ω_{it} for each security i, times total investor wealth, W_t: hence $B_{h,t} = \omega_{1t} W_t$ and $B_{f,t} = \omega_{2t} W_t$. To fix ideas we assume the supply of each security to be constant at time t and we set it equal to: $\overline{B}_{h,t}$ and $\overline{B}_{f,t}$. This is a reasonable assumption, as issuance does not occur at every period. This is however without loss of generality, as we could have supply being equally depleted by the ECB asset purchases: as we explain below the portfolio adjustment will follow the same path envisaged in this example and would be even stronger. Market clearing condition is then given by:

$$m_{t+1}^{euro}\overline{B}_{h,t} + m_{t+1}^{\$}\overline{B}_{f,t} = \omega_{1t}W_t + \omega_{2t}W_t \tag{29}$$

Note that supply is multiplied by securities price, which we assume the firm sets equal to the one that clears demand, hence equal to the investors' SDF. From the above we obtain the euro as follows:

$$\omega_{1t} = \frac{m_{t+1}^{euro}\overline{B}_{h,t} + m_{t+1}^{\$}\overline{B}_{f,t} - \omega_{2t}W_t}{W_t} \tag{30}$$

It follows that any rise in the price of euro securities, and thus a decline in their yields, would induce a rise in portfolio shares.

The Channels of Asset Purchases. In our empirical evidence we discussed tow main channels for the transmission of asset purchases onto yields, namely the local supply or scarcity channel and the duration extraction. While an exact division between the two is not possible, we can discuss through the lens of our model the impact of each channel on the SDF components.

Remark 5. *The purchase of Treasuries by reducing the safe rate, induces a decline in the $\hat{r}_t - \hat{r}_t^*$ component of the international return differentials. The purchases of targeted securities, by stabilizing liquidity in segmented markets, reduces consumption volatility of euro investors relatively to dollar investors and through it the risk premia,* $\frac{\sigma^2}{2}[Var(\Delta\hat{c}_{t+1}) - Var(\Delta\hat{c^*_{t+1}})]$.

First, and as discussed previously, note that the extent to which the changes in relative consumption volatility affect the euro-dollar yield depends on the difference in the parameters of euro and dollar investor preferences. Second, the reduction in the risk premia observed in the model is a manifestation of the scarcity channel discussed in the data. As specific securities become scarce investors, who value them most, are willing to tolerate lower yields. On the other side, the impact of the Treasury purchases on

the safe rate captures duration extraction: by flattening the whole yield curve, such an maneuver reduces risk of euro securities at all maturities. The ensuing relabance toward them further reduces the yields.

Beyond time varying differences in preferences, it shall also be noted that during the sample period considered in our study the ECB had started and continued its asset purchase program until 2018, on the contrary the Fed had announced its exit policy from the asset purchase program in 2013. Specifically, on 19 June 2013, Ben Bernanke announced a ”tapering” of some of the Fed's QE policies: the Fed could scale back its bond purchases from \$ 85 billion to \$ 65 billion a month during the upcoming September 2013 policy meeting. Based on our arguments and the specifications of our SDF, we shall expect a decline of m_{t+1}^{euro} and a rise of the $m_{t+1}^{\$}$, which would parallel our evidence.

A Numerical Example. We conclude with a numerical solution to the model aimed at showing visually how investors' preference heterogeneity in response to a common macro shock can lead to a dynamic of the euro-dollar yields which resembles the one found in the data. For our numerical example we choose the more general S-shaped utility with loss aversion. The numerical solution is obtained in response to an aggregate consumption shock. We capture changes in monetary policy through a consumption shock. As discussed above monetary policy affects the SDF through its direct impact on the safe rates and through its impact on consumption variability. We focus on the second as it channels the effects of monetary policy through preferences for risk and precautionary saving.

We model the process consumption as log normal with persistence $\rho_c$and standard deviation σ_c:$ln_t = \rho_c lnC_{t-1} + \varepsilon_t, 0 < \rho_c < 1 \; and \; \varepsilon_t \sim N(0, \sigma_c^2)$. Investors' heterogeneity is introduced as follows. Euro and dollar investors have similar risk aversion and inter temporal substitution, but a different loss aversion parameter, λ. This is indeed a salient parameter for our preference specification. Specifically we assume that euro investors are relatively more loss averse, hence they value more higher returns in the loss domain. Parametrization is set as in Table 1:

Figure 12 displays the numerical results graphically. The left panel shows the expected exchange rate movements for combinations of consumption shocks at times t and $t+1$ (see Appendix E for a more detailed description of the simulation details). If all other parameters are the same, a higher loss aversion from euro investors ($\lambda_{euro} > \lambda_{\$}$) implies that the dollar depreciates $-\frac{e_{t+1}}{e_t} > 1-$ when consumption is expected to drop below the

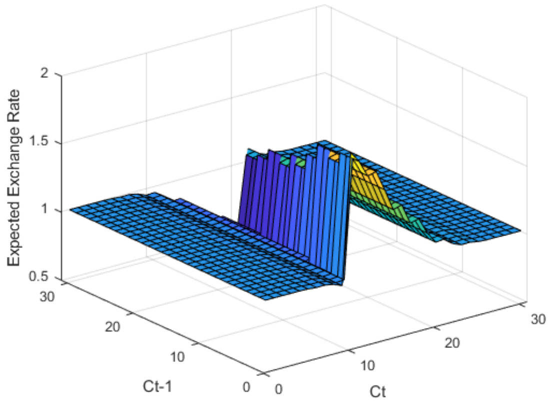
Table 1

Parameters Mnemonics and Values.

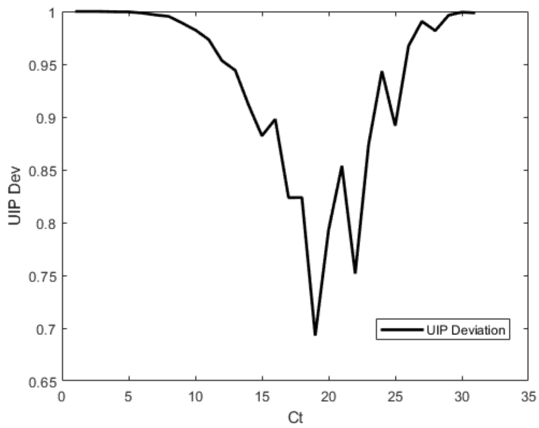
Basic Parameters			Dollar Investors			Euro Denominated		
β	Tim Discount	0.95	γ_{usd}	Risk aversion	1.5	γ_{euro}	Risk aversion	1.5
ρ_c	Persistence	0.9	λ_{usd}	Loss aversion	2.5	λ_{euro}	Loss aversion	5
σ_c	Volatility	0.1	ξ^{usd}	Weight reference	0.35	ξ^{euro}	Weight reference	0.35
			θ_{usd}	Inter-temp sub	0.3	θ_{euro}	Inter-temp sub	0.3

Figure 12

Model Simulations in response to a consumption shock, $ln\ C_t = \rho_c lnC_{t-1} + \varepsilon_t, 0 < \rho_c < 1\ and\ \varepsilon_t \sim N(0, \sigma_c^2)$ and following parameterization in Table 1.



(a)
Expected Exchange Rate Movements



(b)
UIP deviation

reference level after being above ($Y_{t+1} < 1$ and $Y_t > 1$) and appreciates when consumption goes from below the reference level to above it ($Y_{t+1} > 1$and $Y_t < 1$). This is plausibly consistent with a scenario in which the monetary authority commits to conduct asset purchases to affect future expectations.

The right panel of figure 12 shows the UIP deviation. This plots isolates, through the lens of the model, the euro-dollar differentials that are due solely to the differences in investors' SDF, $(\Lambda^{euro} - \Lambda^{\$})F(\gamma\sigma + \frac{(\kappa_{t+1}-\mu)}{\sigma})$, and it indeed maps the empirical counterpart rather well. To understand the channels let us examine the responses in each of the SDF components from equation 26. As euro investors exhibit higher Λ, their SDF rises for each unit of standard deviation of the consumption shock, σ. The interest rate that they require, which is the inverse of their SDF, falls. Intuitively, since they are increasingly risk-averse in the loss domain, they value bonds increasingly more in those states. On average they are then willing to accept lower returns. This is a plausible interpretation of

ICPF business models, which value stable portfolios that repay in every state and for that they are willing to accept lower than average returns on euro-denominated portfolios.

6. Conclusions

Leveraging on a unique confidential securities dataset we study the role of institutional investors' excess demand for the pricing of corporate bonds across currencies. The latter have far reaching consequences for asset safety and for global firms funding conditions. Motivated by a set of stylized facts showing a stark currency preference segmentation between insurance and mutual funds, we devise an econometric methodology that identifies investor demand contribution to the euro-dollar yield differential for the same type of security, issued by the same firm, and held by investors experiencing the same monetary stance. We estimate our specification as both an uncovered and a covered parity.

In both cases the euro-dollar investor residual declines, a sign of the shift of convenience yield from the dollar to the euro. The sample period under consideration is particularly apt for spotlighting the channels underlying the dynamic of the investors' contributions to the yields. The asset program purchases by the European Central Bank have engineered scarcity of euro-denominated securities issued by euro area firms, which were in high and rising demand by large investors such as insurance and pension funds. Excess demand induced a rise in the price of euro bonds and a decline in their yields. The ensuing fall in duration risk induced those investors to a further rebalance toward the euro securities.

The importance of our findings is broader than the specific shocks analyzed, as it speaks to the consequences of stable investor demand for bond pricing and more generally, to yield curve and financial market stability. It also provides insights on the determinants of the UIP and CIP deviations and of asset safety.

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A. Euro Area Confidential Securities Data.

The Securities Holdings Statistics (SHS), collected on a security-by-security basis, provide information on securities held by selected categories of euro area investors, broken down by instrument type, issuer country and further classifications.

Securities holdings statistics The legal basis for collecting SHS data is laid down in Regulation ECB/2012/24. This Regulation is complemented by Guideline ECB/2013/7, which sets out the procedures to be followed by national central banks when reporting to the ECB. SHS data have been collected in full since the fourth quarter of 2013 and cover the two main types of security: debt securities and equity securities (including investment fund shares). Between the first quarter of 2009 and the fourth quarter of 2013, reporting agencies were not obliged to report the data, but many did. The main feature of these data is that holding information is collected at the level of each individual security, i.e. security by security. The SHS Sector data provides information on holdings by investor types.

The SHS by investor type provides aggregate information on the holdings of investor types in line with European regulation. We differentiate in this paper between the following investors: banks, government, money market funds, non-financial corporations, households, insurance companies, investment funds, other investors, pension funds, and non-European Monetary Union investors.

Securities holdings include holdings by (i) investors residing in the euro area, such as banks in Italy or households in France, and (ii) non-resident investors' holdings of euro area securities that are deposited with a euro area custodian, such as US investors' holdings of German securities deposited in Luxembourg. In addition, non-euro area EU countries (Bulgaria, the Czech Republic, Denmark, Hungary, Poland and Romania) also collect SHS investor type data.

The holding information is complemented with the Centralised Securities Database (CSDB) that contains information such as price, issuer name and outstanding amount, precise debt type and issuer information for over six million outstanding debt securities, equities and investment fund shares.

To ensure good data quality, SHS data are regularly checked against comparable data sources. In particular, the data is checked against other ECB databases, such as the integrated euro area financial and non-financial accounts (EAA), Monetary, Financial

Institutions (MFI) balance sheet statistics, insurance corporations and pension fund statistics, investment fund statistics and securities issues statistics, as well as with consolidated banking data. Nonetheless, the data set is massive and still requires considerable effort before it can be used for research purposes. A few common recurring errors include the temporary mislabeling of securities for example in terms of asset class or issuer, a different spelling of issuers over time, and other inconsistencies. We apply some standard cleaning following filters provided by SHSS (TPH filter and security status filter). In addition, securities which have not been redeemed yet, but have a negative residual maturity can still be reported in the investors holdings portfolio. Thus we do not include holdings for securities with negative residual maturity according to CSDB.

In terms of investors' types, the SHS defines 22 different types of investors, which they call "sectors." We group these "sectors" into 10 distinct investor types. Most investor types correspond to the definition in the original dataset. These include banks (e.g., commercial banks, savings banks), investment funds (e.g., open-ended investment funds, closed-ended investment funds, funds of funds, hedge funds), insurance companies, money market funds (MMFs), pension funds, and households (direct holdings). We group related and remaining sectors into the following four investor types: government, non-financial corporations, others (less prominent investors, e.g., non-profit, other financial institutions, or social security funds), and non-euro area investors.

B. Appendix: Data Trimming

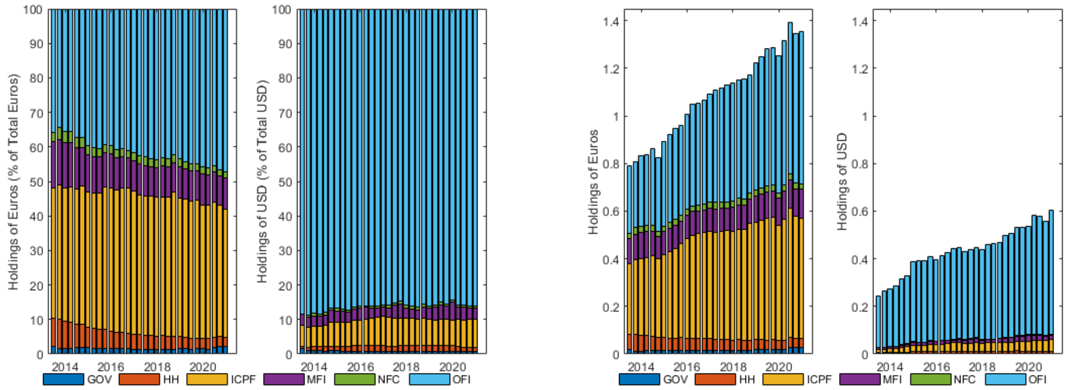
The dataset contains around 16000 unique different ISINs in 2013 Q3. Around 3000 ISINs have to be excluded because of missing pricing information and an additional 2000 ISINs are also excluded because firm FE drops all observations which appear only for one firm. The pattern is more or less the same for all quarters, but we have an increasing number of ISINs and less missing pricing information over time.

The data on the yield variable has been trimmed by dropping observations below 1% and 99% at each quarter to control for outliers. We performed manual checks on these and found that and the outliers exist primarily due to misreporting. This drops only around 10630 observations for the whole panel of about 533,000 observations – around 2% of the whole dataset.

Table A1
Summary Statistics of euro and dollar denominated bonds by maturity

	Full Dataset		Euro Denominated		Dollar Denominated	
	Mean	Median	Mean	Median	Mean	Median
Residual maturity	7.2	4.1	3.6	1.0	10.0	6.0
Original Maturity	10.7	8.0	5.8	4.2	14.6	10.0

Figure C1
Currency Break down of all non-financial corporate debt securities - Type of Investors
Figure C1 shows a break down of all non-financial corporate debt securities in U.S. Dollars and euros and per type of investor, namely government (GOV), households (HH), insurance companies and pension funds (ICPF), monetary financial institutions (MFI), non-financial corporations (NFC) and other financial institutions (OFI). Left panel shows volumes, right panel shows shares. Sample period 2013 Q3 - 2021 Q1. Left panel shows shares denominated in euros and right panel shows shares denominated in Dollars.



C. Other Tables and Figures

Tables C3, C6 and C5 replicate the equivalents in the main text, namely 8, C4 and 10 but considering all bonds with maturity above 6 months. Results remain robust.

Figure C2
Unhedged weighted and un-weighted returns differential on SHSS sample — Issuer Country

Figure C2 shows results for unhedged weighted (with portfolio weights) interest rate differential on SHSS sample. Sample period 2013 Q3 - 2021 Q1. Econometric specification is: $y_{i,t} = \alpha_t \mathcal{I}_{EUR,i} + \beta f, t + \gamma_{m,t} + \delta_{r,t}$, where $y_{i,t}$ is the local currency yield for bond i traded in the secondary market at time t. α_t is the coefficient on the indicator variable $\mathcal{I}_{EUR,i}$, which equals one if bond i is denominated in the euro. $\beta f, t, \gamma_{m,t}, \delta_{r,t}$ are fixed effects for firm f, maturity bucket m and rating bucket r at date t. The regressions are estimated in the cross-section at each date t. Standard errors are clustered at the fixed effect variable. Blue line is for securities issued by U.S. firms, yellow line is for securities issued by euro area firms and grey line is for securities issued by firms residents in the rest of the world.

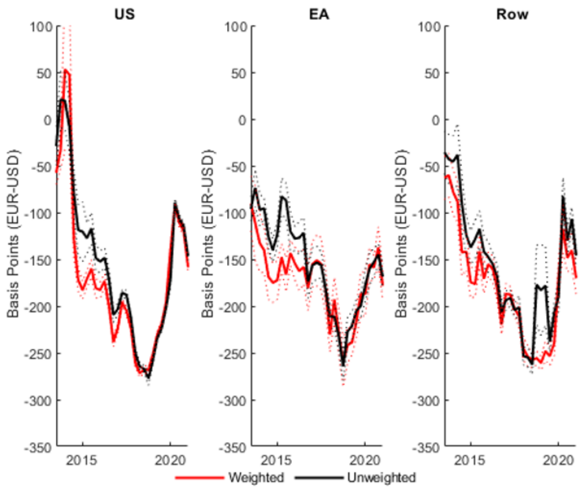
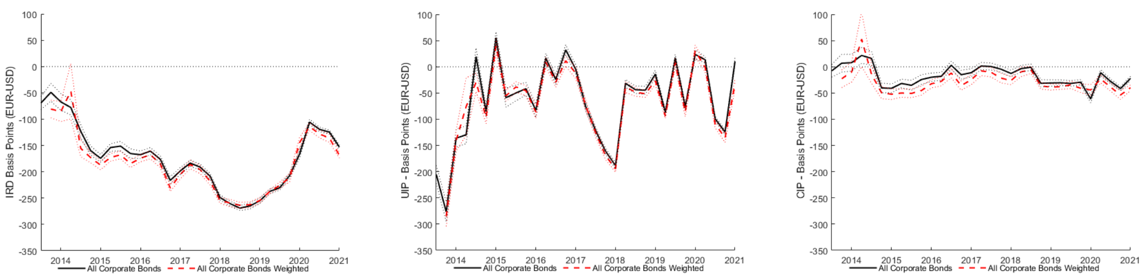


Figure C3
Euro-dollar returns differential, UIP and CIP on SHSS sample

Figure C3 plots results for the un-hedged interest rate differential (left panel), the uncovered interest rate party (middle panel) and the covered interest rate parity (right panel), all estimated on the SHSS sample from 2013 Q3 - 2021 Q1, including all bonds with maturity above 6 months. Each panel compares the differentials weighted with portfolio weights (red and dashed line) with the un-weighted (black and solid line). Econometric specification is: $y_{i,t} = \alpha_t \mathcal{I}_{EUR,i} + \beta_{f,t} + \gamma_{m,t} + \delta_{r,t}$, where $y_{i,t}$ is the local currency yield for bond i traded in the secondary market at time t. α_t is the coefficient on the indicator variable $\mathcal{I}_{EUR,i}$, which equals one if bond i is denominated in the euro. $\beta_{f,t}, \gamma_{m,t}, \delta_{r,t}$ are fixed effects for firm f, maturity bucket m and rating bucket r at date t. The regressions are estimated in the cross-section at each date t. Standard errors are clustered at the fixed effect variable.



(a) Returns Differentials

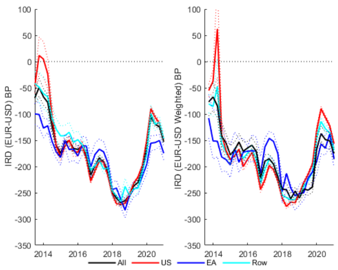
(b) Uncovered interest parity

(c) Covered Interest Rate Parity

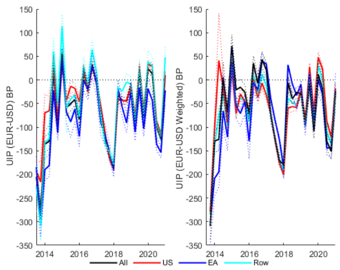
Figure C4

Euro-dollar returns differential, UIP and CIP -Break down per investor type

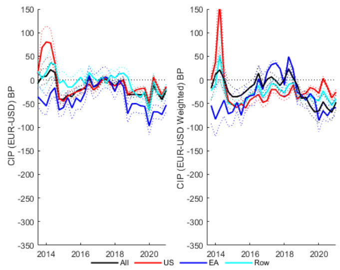
Figure C6 plots results for the un-hedged interest rate differential (left panel), the uncovered interest rate party (middle panel) and the covered interest rate parity (right panel) for all bonds (black line), for the sub-samples of bonds issued by U.S. firms (red line), euro area firms (dark blu line) and rest of the world (light blu line). Sample period is 2013 Q3 - 2021 Q1 and samples included all bonds with maturity above 6 months. Each panel compares the differentials weighted with portfolio weights (red and dashed line) with the un-weighted (black and solid line). Econometric specification is: $y_{i,t} = \alpha_t \mathcal{I}_{EUR,i} + \beta_{f,t} + \gamma_{m,t} + \delta_{r,t}$, where $y_{i,t}$ is the local currency yield for bond i traded in the secondary market at time t. α_t is the coefficient on the indicator variable $\mathcal{I}_{EUR,i}$, which equals one if bond i is denominated in the euro. $\beta_{f,t}, \gamma_{m,t}, \delta_{r,t}$ are fixed effects for firm f, maturity bucket m and rating bucket r at date t. The regressions are estimated in the cross-section at each date t. Standard errors are clustered at the fixed effect variable.



(a)
Returns Differentials



(b)
Uncovered Interest Parity

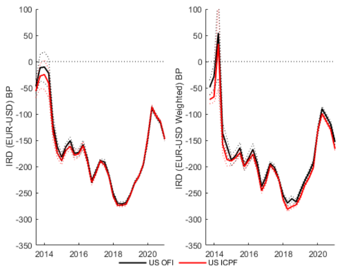


(c)
Covered Interest Rate Parity

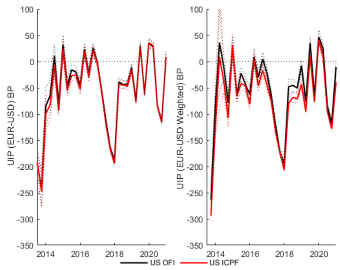
Figure C5

Euro-dollar returns differential, UIP and CIP - Break down per residence of issuer

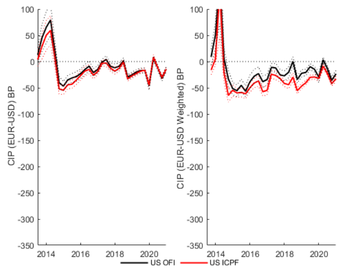
?? plots results for the un-hedged interest rate differential (left panel), the uncovered interest rate party (middle panel) and the covered interest rate parity (right panel) for the sub-samples of bonds held by OFI (black lines) and by ICPF (red line). Top three panels shows estimations on subsample of bonds issued by U.S. firms, bottom panels instead for firms from the rest of the world. Sample period is 2013 Q3 - 2021 Q1 and samples included all bonds with maturity above 6 months. Each panel compares the differentials weighted with portfolio weights (red and dashed line) with the un-weighted (black and solid line). Econometric specification is: $y_{i,t} = \alpha_t \mathcal{I}_{EUR,i} + \beta_{f,t} + \gamma_{m,t} + \delta_{r,t}$, where $y_{i,t}$ is the local currency yield for bond i traded in the secondary market at time t. α_t is the coefficient on the indicator variable $\mathcal{I}_{EUR,i}$, which equals one if bond i is denominated in the euro. $\beta_{f,t}, \gamma_{m,t}, \delta_{r,t}$ are fixed effects for firm f, maturity bucket m and rating bucket r at date t. The regressions are estimated in the cross-section at each date t. Standard errors are clustered at the fixed effect variable.



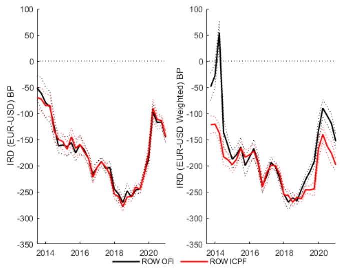
(a)
Returns Differentials - U.S. Firms



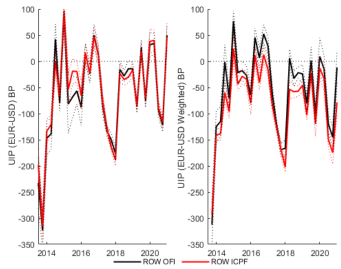
(b)
Uncovered Interest Parity - U.S. Firms



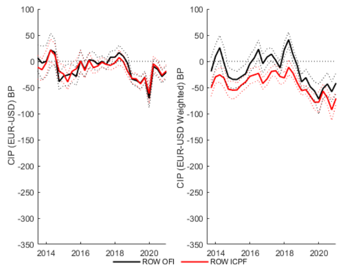
(c)
Covered Interest Rate Parity - U.S. Firms



(d)
Returns Differentials - R.o.W. Firms



(e)
Uncovered Interest Parity - R.o.W.. Firms

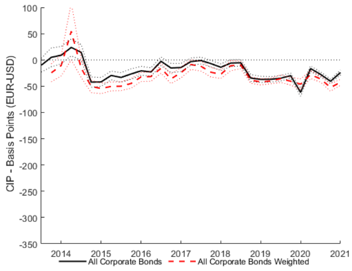


(f)
Covered Interest Rate Parity - R.o.W. Firms

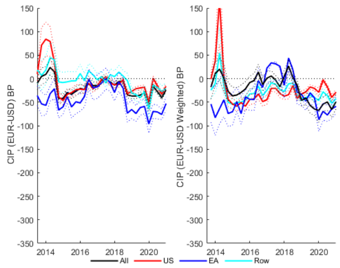
Figure C6

Euro-dollar returns differential, CIP using forward rates - All securities and sub-samples

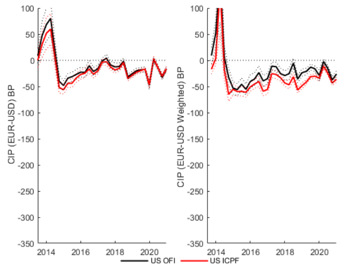
Figure C6 plots results for the hedged interest rate differential using forward rates. Each sub-panel plots results for different samples. Sample period is 2013 Q3 - 2021 Q1 and samples included all bonds with maturity above 1 year. Econometric specification is: $y_{i,t} = \alpha_t \mathcal{I}_{EUR,i} + \beta_{f,t} + \gamma_{m,t} + \delta_{r,t}$, where $y_{i,t}$ is the local currency yield for bond i traded in the secondary market at time t. α_t is the coefficient on the indicator variable $\mathcal{I}_{EUR,i}$, which equals one if bond i is denominated in the euro. $\beta_{f,t}, \gamma_{m,t}, \delta_{r,t}$ are fixed effects for firm f, maturity bucket m and rating bucket r at date t. The regressions are estimated in the cross-section at each date t. Standard errors are clustered at the fixed effect variable.



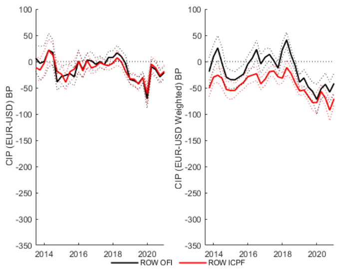
(a)
CIP All securities



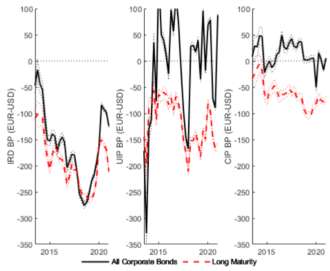
(b)
CIP per area of issuer



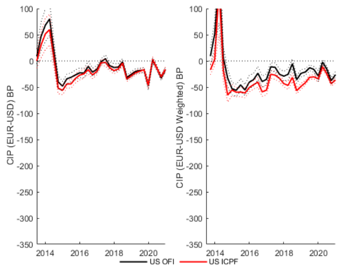
(c)
CIP per investor



(d)
CIP per investor



(e)
CIP for long maturity securities



(f)
CIP for long maturity securities weighted

D. Adjustment by Swap Rates

$$y_{i,t} = \alpha_t \mathcal{I}_{EUR,i} + \beta_{f,t} + \gamma_{m,t} + \delta_{r,t} \tag{D.1}$$

where $y_{i,t}$ is the yield for bond i at time t, and is the only variable that changes across specifications, α_t is the coefficient on the indicator variable $\mathcal{I}_{EUR,i}$, which equals one if bond i is denominated in the euro. $\beta_{f,t}$, $\gamma_{m,t}$, $\delta_{r,t}$ are fixed effects for firm f, maturity bucket m and rating bucket r at date t.

So far we run three types of estimates:

$$y_{i,t} = \begin{cases} y_{i,t} & if\ euro \\ (1+y_{i,t})(\frac{E(S_{t+n})}{S_t})^{1/n} - 1 & if\ dollar\ \&\ unhedged \\ (1+y_{i,t})(\frac{F_{t+n}}{S_t})^{1/n} - 1 & if\ dollar\ \&\ hedged \end{cases} \tag{D.2}$$

To do the swap adjustment, for short bonds we can proxy the currency premium in logs as:

$$\rho_{n,t} = \frac{1}{n}[log(F_{t,t+n}) - log(S_{i,t})] \tag{D.3}$$

measured as FC/USD. Following Du and Schreger (2021), for long bonds we can proxy the currency premium as:

$$\rho_{n,t} = IRS_{euro,n,t} + BS_{euro,usd,n,t} - IRS_{usd,n,t} \tag{D.4}$$

where $IRS_{euro,n,t}$ is the interest rate swap in euros that swaps fixed euro cash flow for floating euro cash flow (like Eurolibor), $BS_{euro,usd,n,t}$ is the cross currency basis swap that swaps floating euro rate into USD floating (Libor) rate, $IRS_{USD,n,t}$ is the interest rate swap in dollars that swaps fixed dollar cash flow for floating dollar cash flow (Libor). Also CIP violation is:

$$Y^{euro}_{n,t} - \rho_{n,t} - Y^{usd}_{n,t} \neq 0 \tag{D.5}$$

E. Numerical Appendix

Simulations are done by obtaining policy functions for the SDF of euro and dollar investors given the current state of consumption and conditional on possible future states. Hence the policy function is derived for every combination of current and future change in

consumption with respect to the reference level. We start by describing this dependence for a general functional form of the SDF.

$$m_{t,t+1} = \begin{cases} \frac{\rho exp\{-\gamma \hat{g}_{t+1}\}}{|\frac{Ct^{1-\gamma}}{1-\gamma} - \frac{X_t^{1-\gamma}}{1-\gamma}|^{-\theta}} & \hat{g}_{t+1} < \hat{\kappa}_{t+1} \ \& \ \hat{y}_t < 0 \\ \frac{\Lambda \rho exp\{-\gamma \hat{g}_{t+1}\}}{(\frac{Ct^{1-\gamma}}{1-\gamma} - \frac{X_t^{1-\gamma}}{1-\gamma})^{-\theta}} & \hat{g}_{t+1} < \hat{\kappa}_{t+1} \ \& \ \hat{y}_t > 0 \\ \frac{\rho exp\{-\gamma \hat{g}_{t+1}\}}{\Lambda |\frac{Ct^{1-\gamma}}{1-\gamma} - \frac{X_t^{1-\gamma}}{1-\gamma}|^{-\theta}} & \hat{g}_{t+1} > \hat{\kappa}_{t+1} \ \& \ \hat{y}_t < 0 \\ \frac{\rho exp\{-\gamma \hat{g}_{t+1}\}}{(\frac{Ct^{1-\gamma}}{1-\gamma} - \frac{X_t^{1-\gamma}}{1-\gamma})^{-\theta}} & \hat{g}_{t+1} > \hat{\kappa}_{t+1} \ \& \ \hat{y}_t < 0 \end{cases} \tag{E.1}$$

For simplicity, lets assume $\theta = 0$

$$m_{t,t+1} = \begin{cases} \rho exp\{-\gamma \hat{g}_{t+1}\} & \hat{g}_{t+1} < \hat{\kappa}_{t+1} \ \& \ \hat{y}_t < 0 \\ \Lambda \rho exp\{-\gamma \hat{g}_{t+1}\} & \hat{g}_{t+1} < \hat{\kappa}_{t+1} \ \& \ \hat{y}_t > 0 \\ \frac{\rho exp\{-\gamma \hat{g}_{t+1}\}}{\Lambda} & \hat{g}_{t+1} > \hat{\kappa}_{t+1} \ \& \ \hat{y}_t < 0 \\ \rho exp\{-\gamma \hat{g}_{t+1}\} & \hat{g}_{t+1} > \hat{\kappa}_{t+1} \ \& \ \hat{y}_t < 0 \end{cases} \tag{E.2}$$

As per equation 16 and assuming for ease of notation a zero bond default rate, exchange rate deviations are driven by changes in the relative SDF of euro and dollar investors. Here we assume that ρ is the same:

$$\frac{m'^{euro}_{t,t+1}}{m'^{\$}_{t,t+1}} = \frac{e_{t+1}}{e_t} = \begin{cases} exp\{-(\gamma^{\$} - \gamma^{euro})\hat{g}_{t+1}\} & \hat{g}_{t+1} < \hat{\kappa}_{t+1} \ \& \ \hat{y}_t < 0 \\ \frac{\Lambda^{euro}}{\Lambda^{\$}} exp\{-(\gamma^{\$} - \gamma^{\$})\hat{g}_{t+1}\} & \hat{g}_{t+1} < \hat{\kappa}_{t+1} \ \& \ \hat{y}_t > 0 \\ \frac{\Lambda^{\$}}{\Lambda^{euro}} exp\{-(\gamma^{euro} - \gamma^{\$})\hat{g}_{t+1}\} & \hat{g}_{t+1} > \hat{\kappa}_{t+1} \ \& \ \hat{y}_t < 0 \\ exp\{-(\gamma^{euro} - \gamma^{\$})\hat{g}_{t+1}\} & \hat{g}_{t+1} > \hat{\kappa}_{t+1} \ \& \ \hat{y}_t < 0 \end{cases} \tag{E.3}$$

Assuming that $\gamma^{euro} = \gamma^{\$}$ we would have that

$$\frac{m'^{euro}_{t,t+1}}{m'^{\$}_{t,t+1}} = \frac{e_{t+1}}{e_t} = \begin{cases} 1 & \hat{g}_{t+1} < \hat{\kappa}_{t+1} \ \& \ \hat{y}_t < 0 \\ \frac{\Lambda^{euro}}{\Lambda^{\$}} & \hat{g}_{t+1} < \hat{\kappa}_{t+1} \ \& \ \hat{y}_t > 0 \\ \frac{\Lambda^{\$}}{\Lambda^{euro}} & \hat{g}_{t+1} > \hat{\kappa}_{t+1} \ \& \ \hat{y}_t < 0 \\ 1 & \hat{g}_{t+1} > \hat{\kappa}_{t+1} \ \& \ \hat{y}_t < 0 \end{cases} \tag{E.4}$$

So, if my interpretation is correct, this would imply that if $\Lambda^{\$} < \Lambda^{euro}$ we would have that $\frac{\Lambda^{euro}}{\Lambda^{\$}} > 1$ - implying the euro appreciates - when consumption was above habit but turns below. And $\frac{\Lambda^{\$}}{\Lambda^{euro}} < 1$ - implying the euro depreciates when it is above habit and was below. This could be made time varying if $\gamma^{euro} \neq \gamma^{\$}$. Would this match the data?

Given the dependence of the reference point from past consumption the state space of our simulations method shall include both the consumption shock and past consumption, the latter as an endogenous state.