Granular Investors and International Bond Prices: Scarcity Induced Safety*

Ester Faia†
Goethe University Frankfurt and CEPR

Juliana Salomao‡
University of Minnesota, NBER and CEPR

Alexia Ventula Veghazy§
European Central Bank

January 21, 2022

Abstract

Institutional investors' mandates determine bond excess demand, which in turn, through granularity, affects their prices and safety. We explore this hypothesis by leveraging on a large confidential dataset of foreign and domestic corporate bonds held by euro-area investors. Insurance and pension funds exhibit home asset and currency bias, mutual funds display neither. This neat segmentation motivates our identification strategy of the impact of heterogeneous investors' excess demand on currency pricing. We estimate, in hedged and unhedged specifications, investors' residual in euro-dollar yield differentials for the same security and issuer, and for investors facing same monetary stances. The euro-dollar residual differential declines, an *erosion* of dollar convenience yields. 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 heterogenous 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.

*Contacts: The opinions expressed are those of the authors and do not necessarily reflect the view of the European Central Bank.

†faia@wiwi.uni-frankfurt.de
‡jsalomao@umn.edu
§Alexia.Ventula_Veghazy@ecb.europa.eu

1. Introduction

The rise in capital flows implies, among other things, that large institutional investors, who intermediate most of the international bond markets, 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 leverage on a unique (confidential) dataset with securities level information on portfolio holdings of all bonds issued by non-financial corporation and held in the euro area. We match security holdings with the bonds' pricing and other characteristics and with their issuers identifier to assess the role of institutional investors' mandates on cross-currencies bond excess demand and, through the granularity of the latter, on the pricing of currency risk.

We start by documenting investors holding patterns, finding that different types of institutional investors have distinct preferences for currency denomination and issuer country. These facts motivate our econometric design. We estimate euro-dollar yields differentials for the same security and issuer to identify the contribution of investors' excess demand in currency prices.[2] The latter, which we dub the investors' residual, is negative for most of our sample (2013-2020), a sign of erosion in the dollar yield. Importantly the residual starts to decline in 2013 and follows a path that mirrors the build in the stock of ECB asset purchases. The scarcity of euro-denominates securities induced by the latter, against a high and rising demand of insurance and pension funds, produced the rise in euro bonds' prices and the decline in the yields.[3] The asset purchase program provides indeed an experimental setting to identify the pricing consequence of investors' excess demand. The engineered fall in yields at longer maturity, hence of duration risk, induced a further portfolio rebalance of insurance funds toward the program eligible securities; a reflection of a duration extraction channel. A simple model of portfolio allocations where investors' preference heterogeneity for currency-denomination, as reflected in the mandate of the chosen intermediaries, affect international pricing and the portfolio shares replicates the empirical findings.

Our paper starts with some motivating evidence gathered by examining the dynamics of the portfolio shares of dollar and euro assets across investors and issuers. First, we find

1 See Lane and Milesi-Ferretti (2018)

2 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 from U.S.. By focusing on portfolio data of investors from the same currency area we forge the conditions for isolating the differential of the securities demand in response to the same monetary policy stance.

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

that euro area investors hold a large share—over 70%—of their debt securities denominated in euros, albeit about half of their debt portfolio is held in securities issued by non-euro area firms. Hence considering all securities investors display a strong local currency-bias but not the well documented home asset bias.[4]

During the sample period considered, which starts in 2013, the importance of the euro denominated securities has been growing. This growth is centered on U.S. issuers, whose euro share went from 18% in 2013 to 37% in 2021, while the dollar share of European issuers stays low (from 2% in 2013 to 3% in 2021).This, as we argue further in this paper, is a direct consequence of the European Central Bank (ECB) asset purchase programs, which raised the demand of euro denominated securities directly, through the purchases, and indirectly by reducing maturity risk. Most importantly when cutting across investors' and issuers' types we find that insurance and pensions funds (ICPF) exhibit both locally issued and local currency securities biases, while other financial institutions (OFI), which includes mutual funds, exhibit neither of the two. This stark segmentation confirms a large heterogeneity in institutional investors' mandates, which is merely a reflection of the preference heterogeneity for currency-denomination among the clients that they represent. Jointly ICPF and OFI hold 86% of the total privately issued bonds so their granularity also implies that their demand affects euro-dollar bonds' yields.

To examine the role of investors' base for euro-dollar yields differentials, we devise a security level specification which, for given security and firm, allows us to estimate the residual role of investors' demand. The identification strategy is based on estimating the euro-dollar yield differential for each bond and by controlling for bond maturity, rating and firms' fixed effects. Importantly, our investors are all euro area residents, hence 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 solely heterogeneity in investors' demand for different currency denominations. Estimating various specification we find that the investors' residual declines, that is investors require a lower return for euro-denominated securities relatively to dollar ones. This is also a sign of erosion of the dollar yield. Noteworthy is the fact that the decline remains robust even when we correct for for exchange rate survey expectations, namely an uncovered interest parity specification, or for forward rates, namely a covered interest rate parity version. In other

4 For investor currency choice also recent evidence by Maggiori et al. (2019). See French and Poterba (1991), Tesar and Werner (1995)for home bias in equities.

words investors' residual, hence their demand and preferences, can account for both UIP and CIP deviations[5].

Another pillar of our identification strategy consists of focusing on a time period in which asset purchase programs were in place. This is important for dissecting the channels. Throughout our time sample the ECB program was targeted at euro denominated assets issued by euro area firms, with the intent to affect their yield at all maturities.[6] Those are precisely the assets liked by ICPF and a large platform of euro oriented investors. The ensuing rise in excess demand pushed euro bond prices up and yields down, relative to dollar ones. The consistent drain of supply of those securities coupled with the rising demand from ICPF provides an experimental setting apt to identify investors' excess demand. This mechanism is akin to the local supply channel which has been found to explain the link between asset purchases and the yield curve.[7] Its implications have so far never been discussed for international bond pricing.

The decline in the yield of euro securities has further implications for portfolio rebalancing. By comparing the baseline estimates of the investors' residuals with those weighted by actual portfolio shares, we find that in the latter the euro-dollar yield decline is even larger, especially when we focus on the sample of securities held by ICPF and issued by euro area firms. This is due to increase in the share of euro-denominated securities issued by euro area firms and held by those type of investors. The decline in the yield, especially at long maturities, brought along a decline in maturity risk for institutional investors whose portfolios are heavily skewed toward securities eligible for the purchase program. This in turn induced the observed portfolio rebalance of those investors toward euro securities.

We conclude by presenting a simple model of international portfolio optimization made by institutional investors that represent clients with heterogeneous preferences. Building on a recent literature that rationalizes parity deviations with time-varying preferences, our investors hold reference dependent preferences with loss aversion. [8] Investors with lower loss aversion hold more of the foreign currency denominated securities. Heterogeneity in loss aversion between euro and dollar investors generates differences in stochastic discount

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

6 Our data has bonds at all maturities, hence is well-suited to capture the impact of monetary policy on the yield curve.

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

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

factors that replicate the empirical counterpart of our investors' residual. Different preferences also lead to different elasticities in the adjustment of portfolio shares, which accounts for the rebalance observed in the data.

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

Literature Review. Our paper links first and foremost to the literature studying the determinants of cross-currency returns' differentials. Traditionally the literature estimating covered and uncovered deviations adopted macro data and specifications (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). Curcuru et al. (2008) and Curcuru et al. (2011) started to estimate return differentials per type of asset, hence at a more disaggregated level.[9] Our analysis goes one step further by estimating security level specifications and distinguishing across type of investors and issuers.

Recent estimates of the cross-currencies yields differentials (Liao (2020), Caramichael et al. (n.d.) and Coppola (2021)) also employ security level specifications. Liao (2020), Caramichael et al. (n.d.) employ traded bond data since they wish to isolate the role of firms' risk at issuance and examine only firms from the rest of the world issuing in either euros or dollars. We use portfolio data as our focus is on the role of investors' base.[10] Also differently from the previous literature, we examine securities issued by firms residing in the U.S., 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. Our euro area investors hold securities in different currencies, however only euro securities were eligible for asset purchases, leading to an experimental setting. Coppola (2021) assembles a dataset from various sources with portfolio holdings of mutual and insurance funds and examines the role of investors' base for (dollar only) bond pricing around specific events. Once again, and also differently from Coppola (2021), our investors inhabitate the same area and experience the same monetary stance, thereby allowing us to isolate the role of investors' preferences from other monetary confounding factors.

9 They use the Treasury International Capital data and distinguished returns' differentials for debt and equities.

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

Our main channel linking asset scarcity to asset safety links our paper to a large literature studying the conditions that make assets safe: the model that more closely captures the channel highlighted in our paper is Caballero et al. (2016). Our own model highlights the role of time-varying price of risk of heterogenous granular investors. The erosion of the dollar convenience yields which we find is being increasingly discussed: see for instance Du and Schreger (2021) or Gourinchas (2021). And the portfolio rebalancing toward the safer asset that we uncover 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 data shows that ICPF investors have a local currency bias as in French and Poterba (1991), Hale and Spiegel (2012), Burger et al. (2018) or Maggiori et al. (2018)). 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). Consistently with Hau and Rey (2004) and Hau and Rey (2008) we find that mutual funds have a dollar bias and consistently with Koijen et al. (2017) we find that insurance funds have a euro bias. Interestingly, when we cut our data per issuer level, we do not find a home asset 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 uncovered and covered interest parity that we uncover 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.[11]

11 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).

2. Data

Our main data is sourced from Securities Holdings Statistics by Sector (SHSS) which is 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.[12]

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 security (by institutional sector and/or country level, i.e. not by individual holder). We group the SHSS investors' type, which are in total 22, see A, 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); 6) non-financial corporations (NFCs).

While in our analysis we initially look at all these investors' categories, we progressively focus on OFI and ICPF. This is for several reasons. First, they hold a large fraction of the bond market and their role has been rising: together they held almost 90% of the market as of 2021. Second, the role of institutional investors like them is key for two reasons. First, they intermediate clients who sort across intermediation models, hence they indirectly channel investors' preferences. Second, they are granular, and hence as we see in section 4, they are large enough to also affect international bonds' pricing. We focus on euro area investors and exclude non-euro area investor holdings available in SHSS.[13] This is for two reasons. First, in our analysis portfolio weights are crucial to assess the role of investors' demand for each type of securities. We can compute those only for securities held by euro area investors, as for the latter 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 yields' differentials from firms and bonds characteristics, but also from other confounding factors, such as aggregate shocks and

12 More details on the dataset are in A.

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

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 has 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 investors' preferences from firms' characteristics. Also these bonds are 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 consists 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 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 forwards.

Table A1 in Appendix C reports the mean and median maturities for the bonds in our datasets and by 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 document holding patterns at securities level. The SHSS dataset 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 the entire investors' portfolio, which informs above investors' demand. Furthermore, the data allows the matching of securities with firm identifiers. This is 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 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 type 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 bias from a long-standing literature on portfolio allocation.

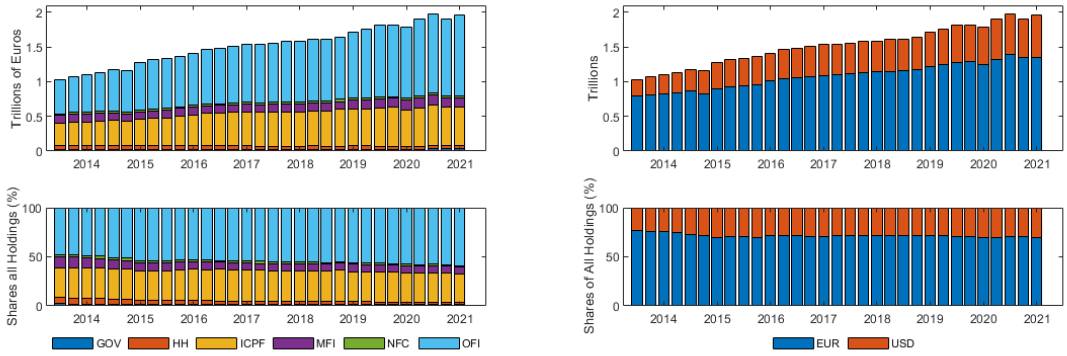
Investors' Currency Preferences. We examine time-series trends for non-financial corporate debt securities holdings by breaking down all holdings (European and foreign issued) per investor type and by the currency-denomination. We focus on portfolio composition per type of investors, in order to capture 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.[14] 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 of 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 of 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

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

Figure 1
Break down of all non-financial corporate debt securities by type of investor and per currency

Left panel shows a break down of all non-financial corporate debt securities by type of investor, namely government (GOV), households (HH), insurance companies (ICPF), monetary financial institutions (MFI), non-financial corporations (NFC) and other financial institutions (OFI). Right panel shows breakdown of all non-financial corporate debt securities per euro and dollars denomination. Sample period 2013 Q3 - 2021 Q1. Top panel shows volumes in trillions of euros and bottom panel shows shares of holdings for each investor.



(a)
Per investor

(b)
Euro versus Dollars

the holdings. European investors display a clear *local currency bias* in corporate debt holdings, in line with the one documented for American investors by Burger et al. (2018) or Maggiori et al. (2018). Local currency bias is more generally a manifestation of the familiarity bias, which has been found in several areas of portfolio investment.[15]

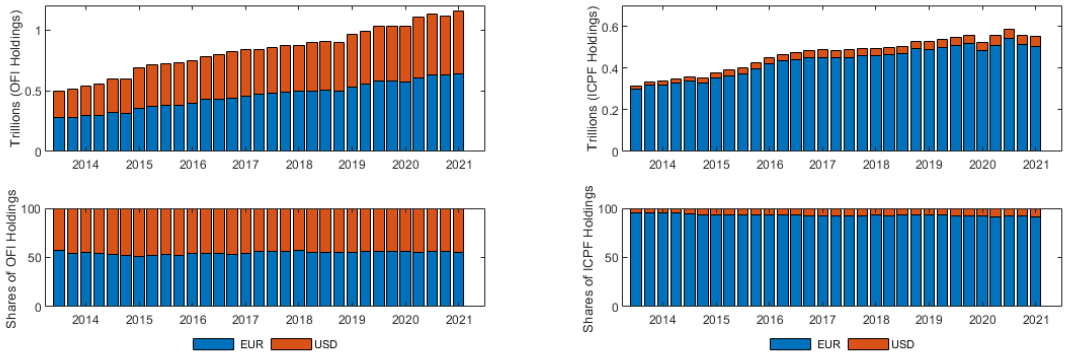
The home currency bias for the whole of securities may mask a more nuanced picture once we dissect the data per investors' type. Figure C1 in Appendix C presents the breakdown per currency by including all six investors' categories. The right panel shows the growth of the euro denominated securities during the entire period of the ECB asset purchase program, which started in 2012 and continued uninterrupted until 2018. The left panel shows that OFI and ICPF are the largest investors in the corporate bond market, with a growing bond portfolio. Therefore, going forward we focus on those two and examine their currency preferences. Figure 2 shows the break per currency of debt securities held respectively by OFI and ICPF. The top panels show volumes in trillions of euros and the bottom panels show shares. The comparison between the left and right panel shows that dollar denominated securities are largely held by OFI, while euro-denominated securities are largely held by ICPF.

The dollar bias of mutual funds, which are included in our OFI, is also compatible

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

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 the left panel and insurance companies (ICPF). 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

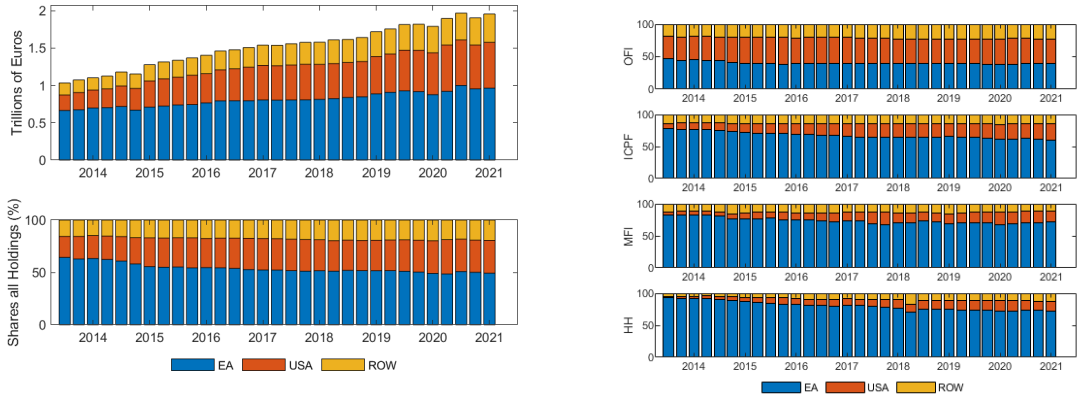
with previous findings by Maggiori et al. (2018) or Camanho et al. (2018), among others. These studies typically use fund level data across many countries, an advantage compared to our own securities. On the other side, we can observe portfolios of all types of investors: this allows us to better flesh 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 investors mandates, which ultimately reflects preference heterogeneity in the clients that they represent. Bertaut et al. (2021) for instance note 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 securities. Figure 3 shows in the left panel 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. The right panel of 3 shows instead the shares

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

Left panel 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. Right panel 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.



of securities of the three issuers across four type of main investors, namely OFI, ICPF, MFI, and HH.

First, from the left panel we see that the home asset bias (preference for securities issued by local firms) was mild at the beginning of the sample and 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 finance literature has been long debating about the extent of the home country bias in assets. Early works documented and theoretically rationalized the presence of this bias in equity.[16] Second, most of the debt is issued by either Euro Area or U.S. firms (precisely it is 36%), while the rest of the world counts 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.)). Finally, the right panel, confirms investors' heterogeneity. While home asset bias is clearly visible at increasing degrees in ICPF, MFI, and HH, while OFI exhibit no such bias. Again taken in isolation some of the results confirm previous findings. For instance the preference for foreign securities by

16 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)).

mutual funds was noted also in Hau and Rey (2008). Our dataset that contains all type of investors and their portfolio shares is better equipped to highlight heterogeneity in the demand of securities.

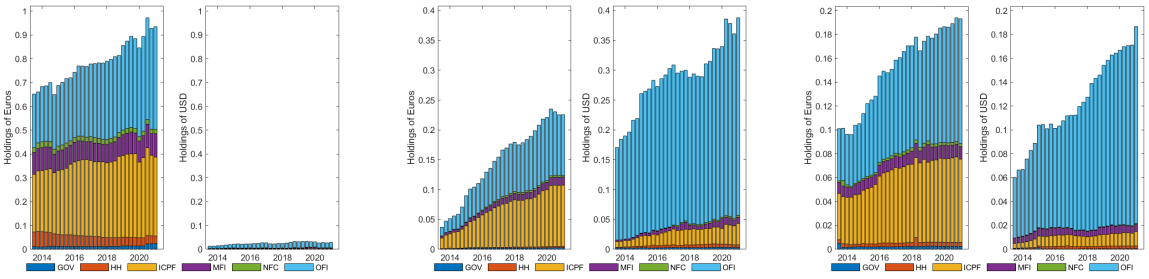
To fully assess investors' segmentation we now break down securities per currency denomination, per residence of issuer and across various type of investors. Figures 5 shows volumes (top panels) and shares (bottom panels) by breaking down the debt securities per currency (U.S. Dollars in each left sub-panel and euro denominated securities in each right sub-panel) and type of investors. The two left figures focus on euro area issuers, the two middle figures focus on U.S. issuers and the two right on issuers from the rest of the world. Figure 6 shows a similar break-down but now focusing solely on OFI and ICPF, for the reasons mentioned elsewhere. 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 figures 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. The ICPF demand of 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 targeted exactly euro-denominated securities issued by euro area firms, namely those in high and rising demand by ICPF and many other 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 their main holders. Hence for instance euro area firms (left panel) 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'

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

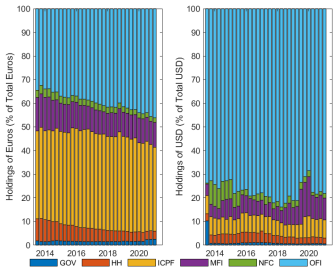
Figure 5 shows the breakdown (in levels) of debt in non-financial corporations by currency denomination, U.S. Dollars (left sub-panels) versus euro (right sub-panels), and type of investors differentiated by colors. Debt held by governments (GOV) are in blue, by households (HH) in orange, insurance corporations 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 three panels show levels and bottom panels show shares. Panel (a) and (d) show only securities issued by firms resident in euro area, Panel (b) and (e) show only securities for issuers residents in the U.S. and Panel (c) and (f) show securities only for issuers residents in the rest of the world. All figures show volumes. Sample period 2013-2021.



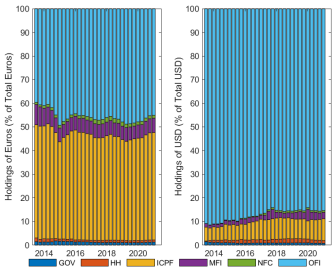
(a) Euro area issuers

(b) U.S. issuers

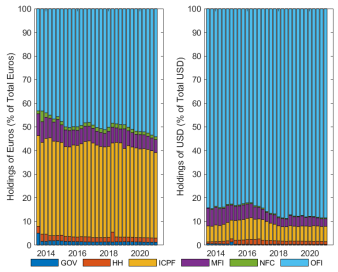
(c) Rest of the World issuers



(d) Euro area issuers



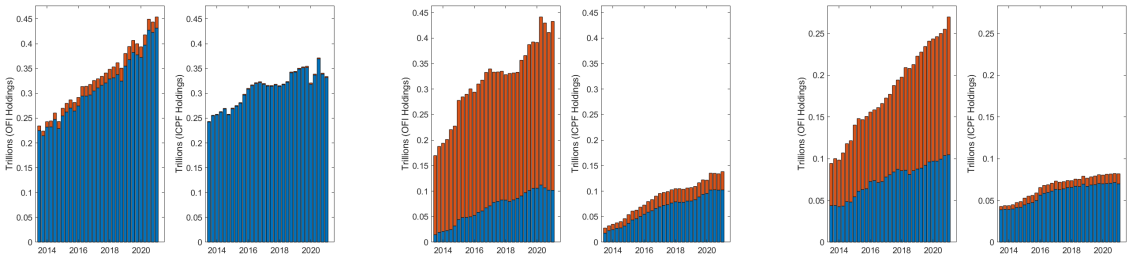
(e) U.S. issuers



(f) Rest of the World issuers

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 investors' base shall also matter for bond pricing across currencies.

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, U.S. Dollars in blue versus euro in red . Investors are only OFI and ICPF. Top left panel shows only securities issued by firms resident in euro area, top right panel shows only securities for issuers residents in the U.S. and the bottom panel shows securities only for issuers residents in the rest of the world. All figures show shares.

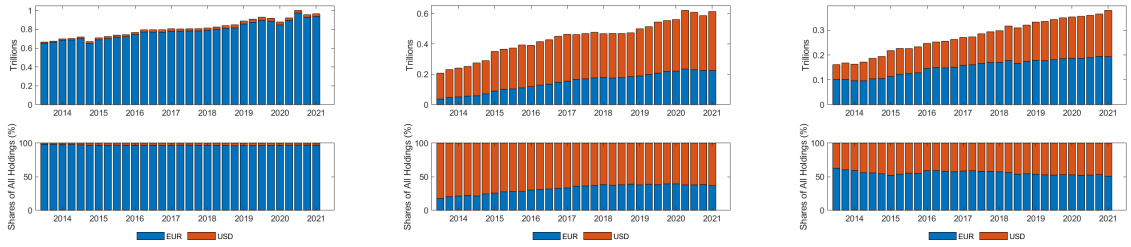


(a) Euro area issuers

(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, top right panels shows only securities for issuers residents in the U.S. and the bottom panels shows securities only for issuers residents in the rest of the world.



(a) Euro area issuers

(b) U.S. issuers

(c) Rest of the World issuers

4. Returns' Differentials: The Role of Investors' Base

Exploiting our securities level data set we devise a disaggregated 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 link rests on institutional investors being granular, hence large enough to have a meaningful impact on prices.[17] Investors such as OFI and ICPF hold almost 90% of the non-financial corporate debt at current dates. Furthermore, in the

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

previous section we have shown that they exhibit a clear distinct alignment between euro and dollar assets. We proceed by describing the identification strategy first and the results, with the underlying channels, next.

4.1. Identification Strategy

The equilibrium price of a security depends on the investor demand, firm issuance, bond characteristics (such as maturity), and other underlying shocks, among which the most important is the monetary policy stance of a currency area which most directly affects the securities yield curve. Our goal is to purge any other factor, apart from investors' demand, which ultimately captures their 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 bonds' characteristics (maturity, rating) and for firm fixed effects. With this the estimated residual captures the euro-dollar differential that relates to anything left, including aggregate shocks, monetary policy and investors' demand.[18]

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

Third 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, for given investors' demand, translates into an excess demand for those securities. If so, euro-denominated bonds' price 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

18 Recent work by Liao (2020) or Caramichael et al. (n.d.) also measures bond returns' differentials controlling for bond maturity and rating using traded data. He indeed argues that his residual can capture anything from monetary policy, to investors' preferences to firms' observed risk at issuance.

for exactly the same security, issued by the same firm, but denominated in different currencies. If an investor that is more conservative – or have a business model that discourages holding currency risk (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 the investors' 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:

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

$y_{i,t}$ 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.[19] 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 price impact of investors' demand after purging for all bonds' and firms' characteristics.

We estimate three variants of the baseline specification, equation (4): 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 forward contracts. From now on we refer to them as: raw, unhedged, and hedged. The second specification is equivalent to a measure of the uncovered interest parity (UIP), while the third is equivalent to the 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:

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

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

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) and F_{t+n} is the forward rate quoted at time t for a contract expiring in n years. The unit of all exchange rates is euros per dollar.

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 difference in the yields required by investors for bonds in each currency denomination, hence their SDFs. Note again that movements in this component may be due either to underlying macro and monetary shocks or to the response of investors' demand to those, namely the elasticity. We argue that our α_t purge for the direct impact of monetary policy, since our sample includes investors from the same currency area. In the specifications that adjust for changes in the exchange rate, the expected spot or the forward, this residual is also purged from currency fluctuations which may be driven from factors other than investors' demand.

Portfolio Weighting Strategy Changes in the yields do trigger further portfolio rebalancing, which is one additional channel we aim to examine. Portfolio rebalancing indeed is another manifestation of differential changes in investors' demand in response to the same shocks. Further below we will therefore present our estimated investors' residual both in unweighted and weighted specification, using actual portfolio shares available in our dataset. Any change in the portfolio weights over time will capture rebalancing.

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.[20] 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:

$$\overline{y}_c = \sum_{j=1}^{N} w_{j,t-1}^c y_{j,t}^c \quad (3)$$

20 Results are similar when we use the contemporaneous holdings.

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 dataset.

In what follows 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's demand. Larger declines in the yields indicate indeed that investors are also leaning more toward the asset whose yields are falling.

4.2. Results for the Investors' 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 (4). For the arguments developed so far its dynamic captures the relative changes in investors' demand between euro and dollar assets for the same asset, issued by the same firm and with the same underlying aggregate shock.[21]

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 the exchange rate professional forecasts. As robustness in the Appendix C we repeat all estimations with bonds above six month maturity. .

Figure 8 shows results over the sample period 2013 Q3 to 2020 Q3. 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 has the *unhedged* and the third panel displays the *hedged*.[22] 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 observable 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 in the future

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

22 The raw differentials, albeit 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.

value of the two currencies. The deviation from the zero dotted line indicates a violation of the UIP. At last, the residual in the third panel, while smoother and smaller than in the other two cases, still declines down of around 50 basis points. This represents a significant violation of the CIP condition. In all cases the decline in the residual is stronger when weighted by the portfolio shares, indicating a rebalancing toward the currency exhibiting lower yields. Next, we will discuss the channels underlying the decline in the euro yield and the rebalancing toward them.

In passing, 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 behind the rise in the issuance by all issuers that we observed in 7).

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

Figure 8 plots results for the raw intercept 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 - 2020 Q3, including all bonds with maturity above 1 year. 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) Raw **(b)** Unhedged **(c)** Hedged

Estimates over Sub-samples. To further corroborate our results and to provide further evidence on the channels, we now present the estimated residual across sub-samples of investors and issuers.

To implement our estimation across sub-samples we extend our baseline specification as follows:

$$y_{i,t} = \mathcal{S}_{type} + \alpha_t(\mathcal{I}_{EUR,i} + \mathcal{S}_{type}) + \beta_{f,t} + \gamma_{m,t} + \delta_{r,t} \tag{4}$$

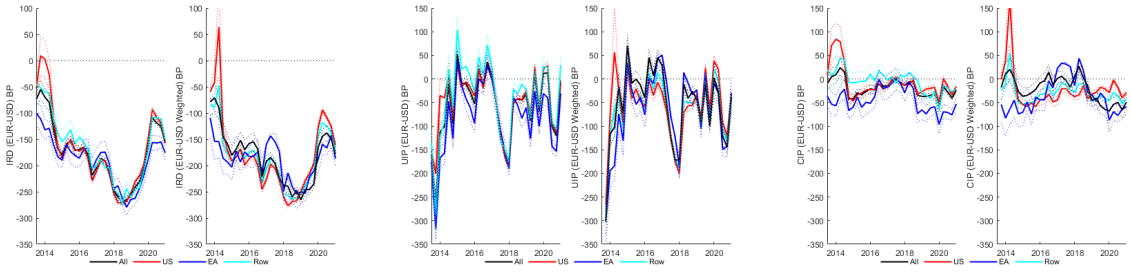
where $\mathcal{S}_{type}$ is a dummy capturing alternatively investors' types or issuers' types and

the term $\alpha_t \mathcal{S}_{type}$ the role of that specific sub-sample for the investors' residual, namely our coefficient of interest. The figures below plot the coefficient of interest for each sub-sample.

First, securities eligible under the asset purchase program, namely euro-denominated and issued by euro area firms, should have the largest excess demand. ECB buys them and their demand by ICPF is on the rise, also as shown in Figure 6. If so, we should expect their yields to decline more than those of the euro-denominated securities but issued by U.S. firms or firms from the rest of the world. Figure 9 shows this is the case. 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 ones.[23] The blue line, which corresponds to securities issued by euro area firms, shows that euro-dollar residual declines by more for those firms relatively to others.

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

Figure 9 plots results for the raw intercept residual (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 blue line) and rest of the world (cyan line). Sample period is 2013 Q3 - 2020 Q3 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) Raw **(b)** Unhedged **(c)** Hedged

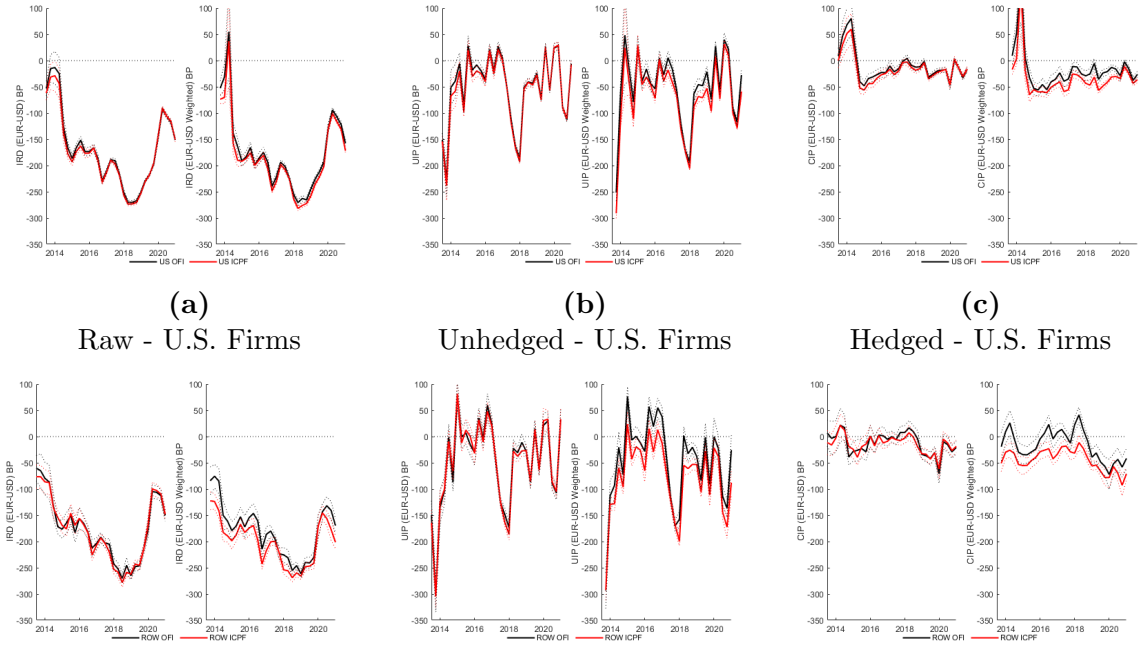
We aim to detect whether any portfolio rebalancing had taken place among the larges investors, again focusing on ICPF and OFI. To see this we should leverage on the possibility given by our dataset of computing the portfolio weights. Any change in the latter would provide indication on the direction 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

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

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, the one for securities held by OFI. In sum ICPF, even when buying securities of foreign firms tend to rebalance more toward the euro-denomination.

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

Figure 10 plots results for the intercept 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 1 year. 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) 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 Channels: Local Supply and Duration Extraction. We now discuss the channels behind our results. As argued earlier our identification conditions tie the estimated euro-dollar differentials to only changes in investors' demand. In addition, the weighted differential being in euros than the unweighted captures the ex-post rebalance in the portfolio weights of the currency with lower yields.

Let's start by noting that during the entire time period considered here, the European Central Bank enacted extensive asset purchase programs directed to euro-denominated

corporate bonds with long maturities.[24] The intent was to affect the yield curve at all maturities. Recall that all our investors are residents of the euro area, therefore the underlying shock affecting the euro yields relatively to the dollar yield is common across all investors. This is the tent that allows us to assign the estimated α solely to changes in investors' demand for the same security. Also note that asset purchase programs were conducted during the whole sample period and directed solely towards euro-denominated securities issued by euro area firms.[25] This induced a drain in supply of this specific type of security particularly, namely our scarcity shock, creating an environment close to a natural experiment for 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 bigger magnitude relative to dollar bonds and to bonds issued by foreign firms. The larger decline of yields for the latter is confirmed by our equation 9.

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. The decline of the residual differential reaches a peak in all our plots at around in 2018, namely the date with the pick in the stock of purchases, and starts to rise again when the phase in of the program starts. For convenience let us recall that monthly purchases averaged 60 billions euros from March 2015 to March 2016, 80 billions euros from April 2016 to March 2017, 60 billions euros from April 2017 to December 2017, 30 billions euros from January 2018 to December 2018, and 15 billions euros from October 2018 to December 2018. A plot of the dynamic of the purchases is provided in Appendix C in Figure C6.

The mechanism described so 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 the *local supply channel*. Its implications for yields differentials across currencies have never been examined.

The supply scarcity can explain why the euro yields went down more relative to the dollar, but to fully examine the role of heterogeneity in investor demand we are bound to also examine the changes in actual portfolio weights, whose availability represents a unique

24 For a description of the program see: https://www.ecb.europa.eu/mopo/implement/app/html/index.en.html. See also speech by Philip Lane for a description of the channels behind the impact on yields: https://www.bis.org/review/r191126d.pdf.

25 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.

feature of our data. Figure 10 shows that even when ICPF buy securities by foreign firms they tend to raise the share of euro-denominated securities. The change in the portfolio shares can only results from changes in the risk that investors attach to each securities. The previously documented reduction in the euro securities yields implies a reduction in their duration risk, hence an overall reduction of the 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. This channel, known as duration extraction, has been highlighted also 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. The consistency of this channel across securities is reassuring.

5. A Simple Model: Investors Heterogeneity and Yields' Differentials

Our analysis has uncovered that investors hold different portfolio shares of euros and dollar bonds currencies 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. The notion that heterogeneity investors' preferences or risk-attitudes may matter for returns' differentials across countries has already been spelled out in Gourinchas et al. (2010), albeit by focusing on the time-variation of the U.S. privilege. In this section we propose a simple model which captures the main insights that emerged from our empirical analysis, namely the existence of deviations linked to investors' preferences, our α, their time-varying nature and the portfolio rebalance toward securities leaning toward lower yields.

The model background is devised to reflect, as closely as possible, the different features of our investors. Specifically, the model features large institutional investors, each of whom, performs a portfolio optimization across bonds in different currencies.[26] They represent certain classes of atomistic investors, who have chosen to be have their holdings intermediated by them. [27]. Therefore, the portfolio optimization is done by maximizing the utility of their clientele subject to their wealth evolution. The utility can change

26 For ease of exposition in the model we consider two: call them euros and dollars.
27 This is a traditional perspective in household finance: see Campbell (2006)

across classes of atomistic investors, and hence across institutional investors representing them: this constitute the investment mandate in the model. [28]

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 among 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:

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

where E_t is the expectation operator with respect to the information set at time t, β is the time discount, $B_{f,t}$ is holding of foreign bonds, while $B_{h,t}$ 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 income.[29] Note that those investors are living in the same currency areas, hence their budget constraint is all expressed in one currency, say euros. Since now one we refer to those investors as domestic investors or euro area investors. First order conditions to this optimization problem read as follows:

$$U_{c,t} = (1+i_t)\beta E_t(U_{c,t+1}); U_{c,t} = (1+i_t^*)\Theta_{B_{f,t}}(e_t B_{f,t})\beta E_t(U_{c,t+1}\frac{e_{t+1}}{e_t}) \tag{5}$$

where $\Theta_{B_{f,t}}(e_t B_{f,t})$ is the derivative of the default premium with respect to foreign debt. Equation 5 defines the stochastic discount factor of the euro area investors buying dollar assets:

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

Equation 5 and 6 give the stochastic discount factor of the price of risk for bonds denominated either in euros or in dollars. To eventually obtain analytical expressions of the euro dollar yield differentials it is convenient to loglinearize equations. Let us define

28 Note that institutional investors strategies may differ also for other reasons such as regulatory constraints. We however focus only on their clientele preferences, as we do not have information on the second.

29 This cost is akin to the default premia or the portfolio adjustment costs introduced in Schmitt-Grohé and Uribe (2003). They can also be interpreted as fees charged by the intermediaries and related to their risk bearing capacity.

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 5 we obtain:

$$\hat{i}_t = \hat{u}_{c,t} - \hat{u}_{c,t+1} = \hat{m}^{euro}_{t,t+1}; \hat{i}^*_t = \hat{u}_{c,t} - \hat{u}_{c,t+1} + \hat{e}_t - \hat{e}_{t+1} - \epsilon\hat{b}_t \tag{7}$$

where ϵ is the log change of the derivative of the default premium. Substituting into each other the two equations in 7 delivers: $\hat{i^*}_t = \hat{i} + \hat{e}_t - \hat{e}_{t+1} - \epsilon\hat{b}_t = \hat{m}^{euro}_{t,t+1} + \hat{e}_t - \hat{e}_{t+1} - \epsilon\hat{b}_t$. 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 for foreign debt by foreign investors reads as follows:

$$\frac{1}{(1+i^*_t)} = M^{\$}_{t,t+1} = \beta E_t(\frac{U^*_{c,t+1}}{U^*_{c,t}}) \tag{8}$$

Once again loglinearizing equation 8 delivers: $\hat{i}^*_t = \hat{u}^*_{c,t} - \hat{u}^*_{c,t+1} = \hat{m}^{\$}_{t,t+1}$ and for ease of exposition we are assuming that foreign investors do not face default costs. [30] By non-arbitrage, the price of the dollar bond across countries is equalized. This implies (we employ directly the log-linear expressions):

$$E_t(\hat{u}_{c,t+1} - \hat{u}_{c,t} + \hat{e}_{t+1} - \hat{e}_t + \varepsilon\hat{b}_t) = E_t(\hat{u}^*_{c,t+1} - \hat{u}^*_{c,t}) \tag{9}$$

Equation 9 is a traditional uncovered interest rate parity, or else UIP. This can be seen by substituting the ratios of marginal utilities across periods with the interest rate:

$$\hat{i}_t + \hat{e}_{t+1} - \hat{e}_t + \varepsilon\hat{b}_t = \hat{i}^*_t \tag{10}$$

Using instead the expressions for the stochastic discount factors we can re-write 9 as:

$$E_t(\hat{e}_{t+1} - \hat{e}_t) = E_t(\hat{m}^{euro}_{t,t+1} - \hat{m}^{\$}_{t,t+1} + \varepsilon\hat{b}_t) \tag{11}$$

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 differentials in equation 10 is in line with our previous econometric specification, equation 4. The interest rate differential for one specific asset equals the expected exchange rate changes and bonds' default risk. Our evidence, as

30 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 differ across countries or currency areas.

well as a long standing literature, however argues for the emergence of UIP deviations. A recent literature (see Verdelhan (2010), Colacito and Croce (2013) or Bacchetta and Van Wincoop (2006) among others) argues 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 12, which expressed the same UIP condition but in terms of SDF. Employing different type 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 $\hat{m}_{t,t+1}^{euro} = \hat{u}_{c,t} - \hat{u}_{c,t+1} = \sigma\hat{c}_t - \sigma\hat{c}_{t+1} = \sigma\Delta\hat{c}_{t+1}$ and $Var(\hat{m}_{t,t+1}^{euro}) = \sigma^2 Var(\Delta\hat{c}_{t+1})$. 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 $\hat{i}_t = \hat{m}_{t,t+1}^{euro}$ it follows: $\hat{i}_t = E_t(\hat{m}_{t,t+1}^{euro}) - \frac{1}{2}[var(\hat{m}_{t,t+1}^{euro})]$. Replicating the same steps for foreign investors delivers: $\hat{i}_t^* = E_t(\hat{m}_{t,t+1}^{\$}) - \frac{1}{2}[var(\hat{m}_{t,t+1}^{\$})]$. The last two relations imply that investors' SDFs can be written as the interest rate on the security plus a premium for risk: $E_t(\hat{m}_{t,t+1}^{euro}) = \hat{i}_t + \frac{1}{2}[var(\hat{m}_{t,t+1}^{euro})]$ and $E_t(\hat{m}_{t,t+1}^{\$}) = \hat{i}_t^* + \frac{1}{2}[var(\hat{m}_{t,t+1}^{\$})]$. We can then substitute those expressions foe the expected SDF into 12 to obtain:

$$E_t(e_{t+1} - e_t) = \hat{i}_t - \hat{i}_t^* + \frac{\sigma^2}{2}[Var(\Delta\hat{c}_{t+1}) - Var(\Delta\hat{c^*_{t+1}})] + \varepsilon\hat{b}_t \tag{12}$$

Remark 1. *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, therefore arguably subject to the same consumption risk and the same consumption inflation dynamic. Therefore the above hypothesis is unlikely to be a driver for the dynamic of our empirical α.

In passing by 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 $cov(\hat{i}_t - \hat{i}_t^*, \frac{\sigma^2}{2}[Var(\Delta\hat{c}_{t+1}) - Var(\Delta\hat{c^*}_{t+1})]) \neq 0$. 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 this 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[31]. 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 this case reads as:

$$M_{t,t+1} = \beta \left(\frac{C_{t+1} - H_{t+1}}{C_t - H_t} \right)^{-\sigma} = \beta \left(\frac{X_{t+1} C_{t+1}}{X_t C_t} \right)^{-\sigma} \tag{13}$$

The link between marginal utility and past consumption induces a time-varying absolute risk aversion coefficient. The larger is 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 shall derive the loglinear expression for the SDF. Loglinearizing 13 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)[32], consumption growth is normally distributed and the log of the consumption surplus, $x_t = log(X_t)$, 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 $\hat{m}_{t,t+1} =$

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

32 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.

$\sigma(\Delta\hat{x}_{t+1} - \Delta\hat{c}_{t+1})$, the process for the surplus consumption growth and the fact that consumption growth follows a normal distribution, we can write the SDF as:

$$\hat{m}_{t,t+1} = \hat{i}_t + \frac{1}{2}var(\hat{m}^{euro}_{t,t+1}) = \hat{i}_t + \frac{1}{2}\sigma^2(1 + \lambda(\hat{x}_t))var(\Delta\hat{c}_{t+1}) \tag{14}$$

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 difference in risk-attitudes. Investors may exhibit both different σ and different λ. Since our evidence shows time-varying yields, we focus on the rime 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, that 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, 12, we obtain:

$$E_t(\hat{e}_{t+1}-\hat{e}_t) = E_t[\hat{i}_t-\hat{i}^*_t+\frac{1}{2}\sigma_t^2[(1+\lambda(\hat{x}_t))^2var(\Delta\hat{c}_{t+1})-(1+\lambda^*(\hat{x}_t))^2var(\Delta\hat{c}^*_{t+1}))+\varepsilon\hat{b}_t] \tag{15}$$

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

Remark 2. *The model based SDF differential* $\lambda(\hat{x}_t)var(\Delta\hat{c}_{t+1}) - \lambda^*(\hat{x}_t)var(\Delta\hat{c}_{t+1})$ *maps the the* α *intercept residual in the empirical specification for the uncovered interest rate differential. As before bonds' and firms' 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 lsos domain.[33] An expanding literature has shown that those preferences are successful in explaining a number of asset price facts[34], but they have never been used in international asset pricing. The functional form for the utility in this case reads as follows

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

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

$U(C_t, X_t) = \alpha U(C_t) + (1-\alpha)\mathcal{W}(C_t, X_t)$, where $U(C_t)$ is the standard CRRA utility and where:

$$\mathcal{W}(C_t, X_t) = \begin{cases} \frac{\left(\frac{(C_t)^{(1-\gamma)}}{1-\gamma} - \frac{(X_t)^{(1-\gamma)}}{1-\gamma}\right)^{1-\theta}}{1-\theta}, & \text{if } C_t \geq X_t \\ -\Lambda \frac{|\frac{(C_t)^{(1-\gamma)}}{1-\gamma} - \frac{(X_t)^{(1-\gamma)}}{1-\gamma}|^{1-\theta}}{1-\theta}, & \text{if } C_t < X_t, \end{cases} \tag{16}$$

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

$$k(Y_t) = \begin{cases} (\frac{C_t^{1-\gamma}}{1-\gamma} - \frac{X_t^{1-\gamma}}{1-\gamma})^{-\theta} & for\ Y_t \geq 1 \\ \lambda \mid \frac{C_t^{1-\gamma}}{1-\gamma} - \frac{X_t^{1-\gamma}}{1-\gamma} \mid^{-\theta} & for\ Y_t < 1 \end{cases} \tag{17}$$

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.[35] As before we proceed to 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 small letters now all indicate logs. Under this assumption it holds that:

$$\mathbb{E}_t\left[\exp(g_{t+1}) \mid g_{t+1} > \kappa_{t+1}\right] = \exp\left\{\mu + \frac{\sigma^2}{2}\right\} \frac{F(-(\kappa_{t+1} - \mu - \sigma^2)/\sigma)}{F(-(\kappa_{t+1} - \mu)/\sigma)} \tag{18}$$

$$\mathbb{E}_t\left[\exp(g_{t+1}) \mid g_{t+1} < \kappa_{t+1}\right] = \exp\left\{\mu + \frac{\sigma^2}{2}\right\} \frac{F((\kappa_{t+1} - \mu - \sigma^2)/\sigma)}{F((\kappa_{t+1} - \mu)/\sigma)} \tag{19}$$

where F is the cumulative conditional distribution of the standard normal. The SDF implied by given by 17 can be written in logarithms as follows:

$$m_{t,t+1} = \begin{cases} \frac{\Lambda\rho \exp\{-\gamma g_{t+1}\}}{k(y_t)} & \text{if } g_{t+1} < \kappa_{t+1}, \\ \frac{\rho \exp\{-\gamma g_{t+1}\}}{k(y_t)} & \text{if } g_{t+1} > \kappa_{t+1}, \end{cases} \tag{20}$$

35 This value has been initially uncovered by Kahneman and Tversky (1979) and confirmed in subsequent experimental evidence.

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

$$\begin{aligned}\mathbb{E}_t\left\{m_{t,t+1}\right\} &= \frac{\rho}{k(y_t)}(F(\gamma\sigma+\frac{(\kappa_{t+1}-\mu)}{\sigma})\mathbb{E}_t\left[\exp\left\{-\gamma g_{t+1}\right\}\mid g_{t+1}>\kappa_{t+1}\right]+ \\ &\quad +\Lambda F(\gamma\sigma+\frac{(\kappa_{t+1}-\mu)}{\sigma})\mathbb{E}_t\left[\exp\left\{-\gamma g_{t+1}\right\}\mid g^b_{t+1}<\kappa_{t+1}\right])\end{aligned} \tag{21}$$

Using formulas in 18 and 19 we can rewrite 21 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. Hence a difference in λ, ξ generates a time-varying difference in m^{euro}_{t+1}, $m^{\$}_{t+1}$.

Remark 3. *The investors' preference deviation 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 bonds and firms' risk is captured by the default premium εb_t.

Portfolio Rebalancing. An important insights from our empirical analysis is that following the change in yields investors also tend to rebalance their portfolio, even more so toward the security by them preferred and whose yields have been going down. We therefore move on to rationalize through the lens of the model this observation too.

Given the securities equilibrium prices, which can be obtained from investors' SDFs, portfolio weights can be derived by resorting on a market clearing conditions[36]. In our stylized world with two assets, demand is represented by the sum of the euro, $B_{h,t}$, and dollar, $B_{f,t}$, securities at any point t. The demand of each security is equivalent to its portfolio share, call it ω_t, times investors' total wealth, W_t: hence $B_{h,t} = \omega_t W_t$ and $B_{f,t} = (1-\omega_t)W_t$. 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 equally have supply being depleted by the ECB asset purchases: as we explain below the

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

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

portfolio adjustment will follow the same path envisaged in this example and would be even stronger. Market clearing condition is then given by:

$$m_{t+1}^{euro}\overline{B}_{h,t} + m_{t+1}^{\$}\overline{B}_{f,t} = \omega_t W_t + (1-\omega_t)W_t \tag{22}$$

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

$$\omega_t = \frac{m_{t+1}^{euro}\overline{B}_{h,t} + m_{t+1}^{\$}\overline{B}_{f,t} - (1-\omega_t)W_t}{W_t} \tag{23}$$

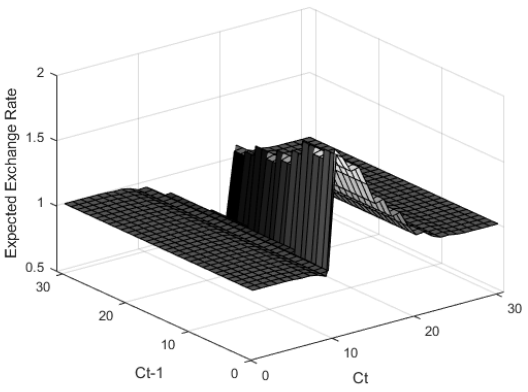
From the above it follows immediately that any rise in the price of euro securities, hence a decline in its yield, would induce a rise in the portfolio shares.

A Numerical Example. We conclude with a numerical solution of the model aimed at showing visually how in response to a common macro shock investors' preference heterogeneity 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. A monetary policy shock is surely going to affect consumption profile, either through aggregate demand or through inflation, and since our investors live in the same currency area they are going to experience the same consumption shock.

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:

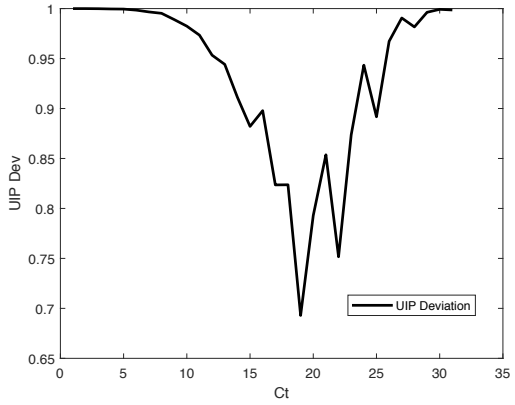
Figure 11

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 safe firms

Figure 11 displays graphically the numerical results. The left panel shows the expected exchange rate movements for combinations of consumption shocks at times t and $t+1$ (see Appendix D 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 the consumption is expected to drop below the 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 future expectations.

The right panel of figure 11 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 indeed it maps the empirical counterpart pretty well. To understand the channels let us examine the responses in each of the SDFs component from equation 22. As euro investors exhibit higher Λ, their SDF rises for each unit of standard deviation of the consumption shock, σ. Hence 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 so in those states. On average they are then willing to accept lower returns. This is a plausible interpretation of ICPF business models, who value stable portfolios, which repay in every states and for that they are willing to accept lower 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's 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 an uncovered and a covered parity.

In both cases the euro-dollar investors' residual declines, a sign of of the shift of convenience yield from the dollar to the euro. The sample period under consideration is particularly apt to spotlight 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 pensions funds. Excess demand induced a rise in the price of euro bonds and decline of 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 analysed as it speaks to the consequences of stable investors' demand for bonds' 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.

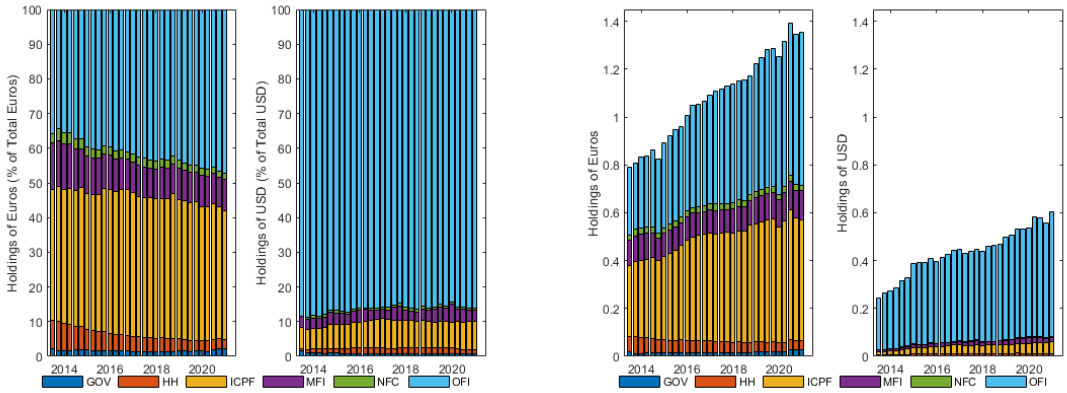
The data on the yield variable has been trimmed by dropping observations below 1% and 99% at each quarter to control for outliers. We performed manual checks on these and found that and the outliers exist primarily due to misreporting. This drops only around 10630 observations for the whole panel of 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, C4 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 - 2020 Q3. 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.

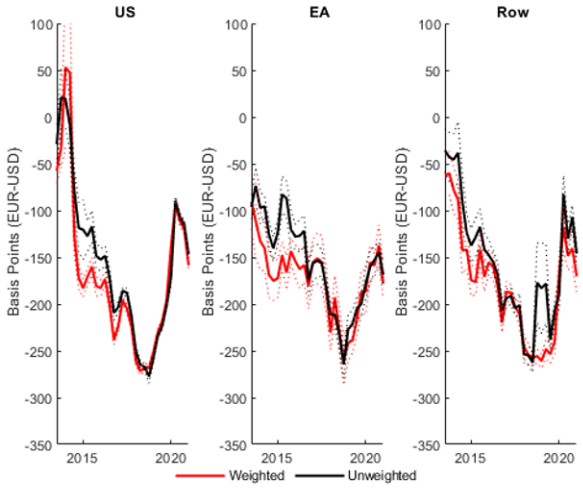


Figure C3
Euro-dollar returns differential, UIP and CIP on SHSS sample

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 - 2020 Q3, 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.



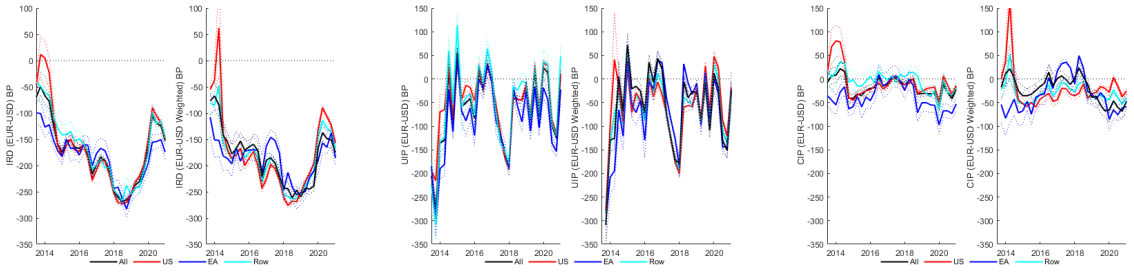
(a) Returns Differentials

(b) Uncovered interest parity

(c) Covered Interest Rate Parity

Figure C4
Euro-dollar returns differential, UIP and CIP -Break down per investor type

Figure C4 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 - 2020 Q3 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.



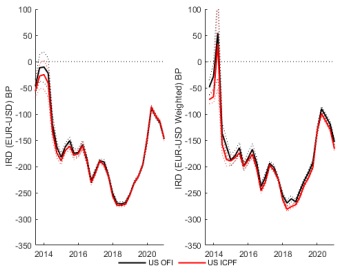
(a) Returns Differentials

(b) Uncovered Interest Parity

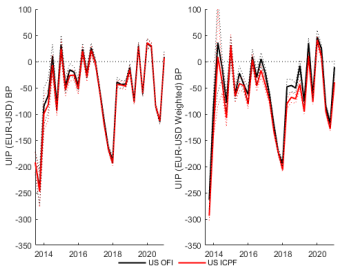
(c) Covered Interest Rate Parity

Figure C5
Euro-dollar returns differential, UIP and CIP - Break down per residence of issuer

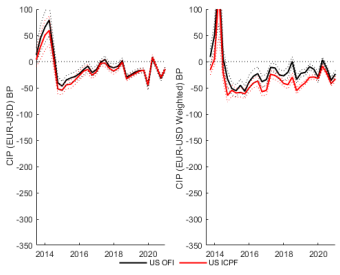
?? plots results for the un-hedged interest rate differential (left panel), the uncovered interest rate party (middle panel) and the covered interest rate parity (right panel) for the sub-samples of bonds held by OFI (black lines) and by ICPF (red line). Top three panels shows estimations on subsample of bonds issued by U.S. firms, bottom panels instead for firms from the rest of the world. Sample period is 2013 Q3 - 2020 Q3 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.



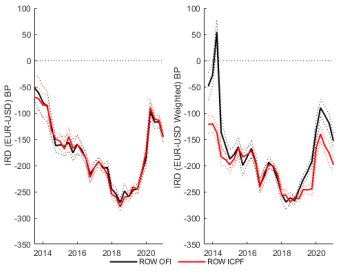
(a) Returns Differentials - U.S. Firms



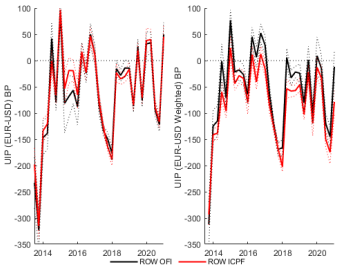
(b) Uncovered Interest Parity - U.S. Firms



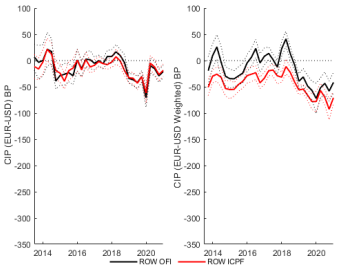
(c) Covered Interest Rate Parity - U.S. Firms



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

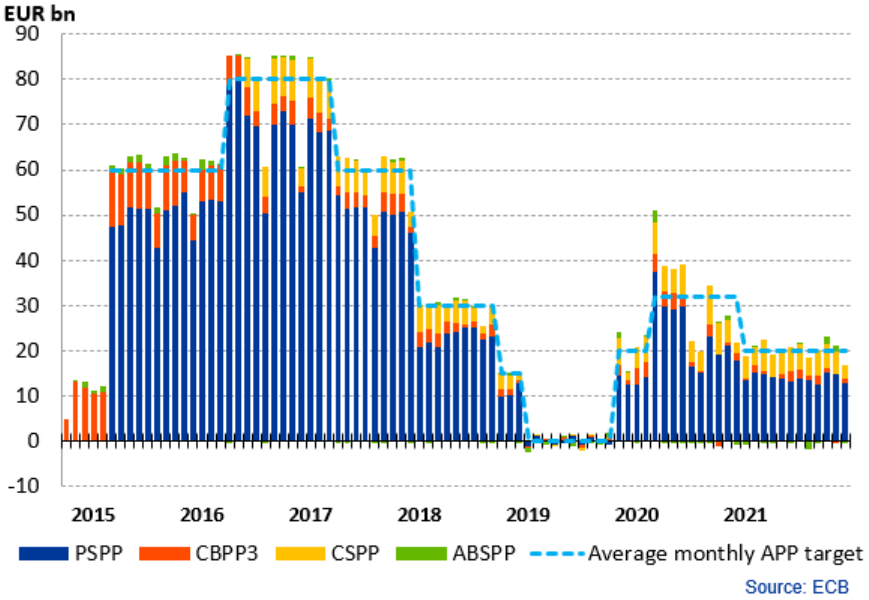


(e) Uncovered Interest Parity - R.o.W.. Firms



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

Figure C6
Dynamic of the European Central Banks Asset Purchase Program.



D. 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.

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

For simplicity, lets assume $\theta = 0$

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

As per equation 12 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:

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

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

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

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.