Searching for Yield Abroad: Risk-Taking through Foreign Investment in U.S. Bonds

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Abstract

The much discussed risk-taking effects of low interest rates have been hard to document due to a paucity of data and challenges in identification. Analyzing unique, comprehensive, security-level data that capture 25 economies' entire investments in U.S. corporate bonds allows us to accurately characterize shifts in risk and help detect the causal mechanism. We show that declining home-country interest rates lead investors to shift their portfolios toward riskier bonds in non-crises times. A 200 basis points decline leads investors to seek a 43 additional basis points yield pick-up, with effects even stronger when home interest rates reach very low levels.

1 Introduction

Over the decade since the Global Financial Crisis (GFC), interest rates in many advanced economies have been at historic lows. Although low interest rates help support economic recovery, persistently low rates have raised concerns about the incentives of households, banks, and other investors to take more risks. Investors could seek to offset the lower returns on safer assets through either risk-increasing portfolio shifts or greater risk-taking in new investments (Dell'Ariccia and Marquez, 2013, review analytically the causes). Analysis on risk-taking is challenging, however. This is in part because the necessary granular data to detect risks taken in investment decisions is often unavailable. Especially in an international context, most analyses are limited to using aggregate data. Even when granular data are used, e.g. in some studies for the United States, the data are only available for a small subset of investors. In addition, it can be hard to identify the causal mechanism. Importantly, interest rates depend on macroeconomic conditions, which also determine the relative riskiness of various borrowers as well as their demand for external financing. In addition, spreads and financing conditions for individual borrowers more generally are affected by investors' risk-return preferences, which also depend on macroeconomic and general financial conditions, including interest rates. The joint determination of these factors can make it hard to identify the role of low interest rates in risk-taking.

In this paper, we aim to detect risks taken in investment decisions related to changes in interest rates using novel data that are granular, allowing us to accurately characterize shifts in portfolio risks; comprehensive in terms of coverage; and from a broad range of countries. Specifically, we examine how interest rates affect the portfolio choices of investors by analyzing the extent to which investors from a variety of countries shift the composition of their U.S. corporate bond holdings in response to changes in their home interest rates. We use unique security-level data on holdings of U.S. corporate bonds by private investors from

25 foreign economies for the period 2003-2016 from the U.S. Treasury International Capital (TIC) annual surveys. Given the mandatory reporting, the holdings data are comprehensive, i.e., they capture countries' entire portfolios of U.S. securities held by all types of investors. The aggregate value of the holdings we analyze is $1.7 trillion at the end of the sample period. The data thus allow us to explore the question of risk-taking in an international context, without limiting the analysis to investors from just one country. Our detailed holdings data and the significant heterogeneity in movements in investor-country interest rates allow us to reliably identify how interest rates affect risk-taking. Importantly, in our cross-section of countries, interest rates are not directly influenced by the economic and financial conditions that determine the riskiness of U.S. corporate bond issuers. And since the foreign investments into the United States represent only small shares of the total external financing of each issuer, they are unlikely to drive issuers' overall financing conditions or riskiness. Together, the very granular dataset and cross-country evidence sheds new light on the determinants of risk-taking and the drivers of capital flows, while also overcoming concerns about reverse causality and omitted variables.

We find that the lower the interest rate in the investors' home country, the more investors allocate their holdings towards corporate bonds with higher yields and wider spreads. These effects are economically important. Consider a 200 basis-point decline in the home interest rate, roughly the difference between the drop in the 1-year composite euro-area and Japanese home rates between 2003 and 2016. Our regression coefficients imply a shift towards riskier securities with an average pick-up in yield of 43 basis points, with effects about two and a half times greater when the home interest rate reaches very low levels, as happened in many countries in the latter part of our sample. Most of these yield increases for investors from low-rate countries come through taking on more credit risk, as reflected in the higher spreads of the U.S. corporates over the corresponding Treasury curve (32 basis points on average), with an associated decline in credit quality of a half rating notch. In a few specifications, we

also find that lower home-country interest rates lead investors to invest more in longer-dated bonds, commensurately taking on more duration risk. Overall, we interpret our findings as evidence consistent with search-for-yield behavior by investors.[1]

In adjusting their U.S. corporate bond investments in response to changes in home rates, we find in sample splits that while foreign investors undertake significant trading in secondary markets, their responses are even stronger in their investment choices in newly issued bonds, i.e., in primary markets, possibly as transaction costs are lower for such purchases. In robustness checks, we confirm that the risk-taking coinciding with low interest rates cannot be attributed to other home-country characteristics, such as forward exchange rate premiums, bank CDS premiums, or expected earnings growth in investor countries' corporate sector. Our findings are also robust to different country samples, including focusing only on advanced economies, specification choices for the countries' home interest rate, as well as variations in econometric approach.

In addition to the significant influence of home interest rates, we also find that foreign investors shift toward higher-yielding bonds when the overall market price of U.S. corporate default risk declines, as reflected in a lower index for high-yield credit default swap premiums. The flip-side of this effect is a retrenchment when risk perceptions are high. Our security-level results are thus also consistent with the literature on flight to safety and flight home (Giannetti and Laeven (2012); and De Haas and Van Horen (2012, 2013)), which has focused on aggregate or firm-level bank flows. Similarly, in a 2008-2012 crisis-period subsample we find that risk-taking is unresponsive to changes in domestic interest rates.[2]

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[1]While the term search-for-yield (or reach-for-yield) is commonly used in the literature and popular press, there is no uniform definition. In this paper we use the term to refer to the kind of reaching-for-yield that stems from low interest rates, similar to Rajan (2005), Yellen (2011), and Stein (2013), who all raised concerns that investors are incentivized to reach-for-yield when interest rates are low to meet obligations and stay solvent. This differs from Becker and Ivashina (2015) who use reach for yield to refer to regulatory arbitrage: investors' propensity to buy riskier assets within regulatory brackets, thus achieving higher yields without raising their capital requirements.

[2]Similarly, Becker and Ivashina (2015) find that U.S. insurance companies pulled back from higher-yielding bonds during the GFC, in contrast to their pre-crisis practice of overweighting higher-yielding bonds that

By analyzing granular portfolio choices within an important asset class held by a very broad set of investors on a cross-border basis, something no previous paper has done, we can make two novel contributions to the literature on risk-taking. By using unique security-level data on investments in corporate bonds, we can analyze precisely the effects of (low) interest rates on investment portfolios. Most of the empirical literature of the effect of interest rates on risk-taking has focused on banks, and more specifically on their lending portfolios because detailed loan-level data is more typically available. In contrast, the empirical evidence on the effect of (low) interest rates on investors' portfolio holdings is scarcer, and often limited to analyses of aggregate asset allocations due to a lack of detailed data. We contribute by analyzing risk-taking in this important asset class. Besides these benefits, we also overcome the typical challenges in identifying casual relationships when using data from a single country. Does a subdued economic and financial environment mean a low interest rate with related shifts in saving and investment behavior and possibly greater corporate-sector credit risk; or, does a low interest rate lead to more risk-taking in lending and investment decisions? Using detailed data on capital inflows to the United States from a cross-section of countries with a wide variety of changes in home interest rates, yet with investments representing a modest fraction of outstanding U.S. securities, we can overcome these problems.

The possibility of search-for-yield by investors has been long recognized in theoretical models (e.g., Fishburn and Porter, 1976; Adrian and Liang, 2018, review the literature).[3] In a traditional portfolio choice model, e.g., with mean vs. variance preferences, risk-taking incentives for bond investors are typically not affected by a common downward shift in the distributions of all asset returns. However, as papers have pointed out and along the same lines as the general bank risk-shifting channel, search-for-yield incentives can arise for intermediaries with long-term liabilities and shorter-term assets, such as life insurance companies

were risky relative to their regulatory capital treatment.

[3]For further explanations of risk-taking, see Borio and Zhu (2012) and European Systemic Risk Board (2016).

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and pension funds (e.g., Chodorow-Reich (2014); Dell'Ariccia and Marquez (2013) review). These intermediaries may switch to riskier assets with higher expected yields when lower interest rates compress their margins and challenge their ability to meet their obligations, with this effect more pronounced for lower-capitalized institutions (see Domanski, Shin, and Sushko (2017) for life insurers). With fixed operating costs or some costs to reporting low or negative nominal net income, incentives to shift into riskier assets could be even stronger when rates overall are very low or even negative. And Lian, Ma, and Wan (2017) show that reaching-for-yield is consistent with preferences that incorporate reference-dependent loss aversion, as in prospect theory. As noted by many observers, this could possibly contribute to a buildup of vulnerabilities that can make a financial crisis more likely.

Most of the empirical literature of the effects of interest rates on risk-taking has focused on banks, starting from the observation that low interest rates tend to put downward pressure on banks' net interest margins and profitability.[4] Consistent with banks seeking to offset these negative effects, empirical studies have found that banks tend to make riskier loans and lower their lending standards, or documented indirect evidence of bank risk-taking, when interest rates are low (e.g., Ioannidou, Ongena, and Peydro (2009), Maddaloni and Peydro (2011), Aramonte, Lee, and Stebunovs (2015), Altunbas, Gambacorta, and Marques-Ibanez (2014), Kandrac and Schlusche (2016), Dell'Ariccia, Laeven and Suarez (2017), Jimenez et al (2014)).

Outside of bank lending, evidence on the effect of low interest rates on investors' risk-taking is scarcer, and often limited to analyses of aggregated data of the investors' portfolio choices.[5] Choi and Kronlund's (2018) study of U.S. corporate bond mutual funds is a key

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[4]See Covas, Rezende, and Vojtech (2015), Borio, Gambacorta and Hofmann (2015), and Claessens, Coleman and Donnelly (2018)

[5]For example, Hau and Lai (2016) show that investors in countries with declining real interest rates shift their investments out of money market funds and into riskier equity funds, while Frame and Steiner (2017) document that rapid growth in highly leveraged U.S. mortgage REITs coincided with quantitative easing in the United States. Other papers focus on regulatory arbitrage mechanisms not explicitly linked to levels or changes in safe interest rates (Efing (2016), Becker and Ivashina (2015), Kirti (2017)). Maggiori, Neiman, and

exception. Like our paper, the authors use security-level data to assess risk-taking responses to interest rates. Their central result is that lower rates coincide with the funds investing more in bonds with relatively higher yields, controlling for rating and duration. In their interpretation, the authors emphasize fund managers' incentives to produce returns and offer yields that generate inflows, implying that ultimately it is the funds' customers that choose riskier bond portfolios in response to lower rates. We differ in that we find risk-taking to be evident for foreign investors in their cross-border portfolios. In addition, since our findings pertain to the investment choices of the sum of various types of investors, our data capture countries' entire portfolios of U.S. corporate bonds. An additional contribution is that, for identification purposes, Choi and Kronlund (2018) must abstract from any impact that the behavior of the funds and their customers have on corporate bond yields or interest rates on other investment opportunities. We, in contrast, rely on the more conservative assumption that the interest rate in the home country of our foreign investors is exogenous to the conditions in the U.S. corporate bond market.

Although our work focuses on risk-taking related to interest rates, as a study of international portfolio choice, it is also relevant to the literature on determinants of capital flows. Much of this push-pull literature has emphasized the effects of financial conditions in source countries on capital flows.[6] Almost all papers have focused on the effects of financial conditions in the United States on capital outflows, with most papers focusing on the impact of flows to emerging markets. Very few studies have focused on how interest rates in other countries affect capital flows to the United States (an exception is Paligorova et al. (2017)

Schreger (2018) study the currency of bond denomination using security-level data, but not with reference to interest rates and risk-taking. In an event study, di Maggio and Kacperczyk (2017) document that U.S. money market funds invested more in riskier asset classes and held less diversified portfolios after 2008-2012 FOMC announcements signaling U.S. rates would remain near zero for a longer period (forward guidance).

[6]See Calvo, Leiderman, and Reinhart (1993, 1996), Chuhan, Claessens, and Mamingi (1998), Portes and Rey (2005), Milesi-Ferretti and Tille (2011), Forbes and Warnock (2012), Fratzscher (2012), Broner et al. (2013), Bruno and Shin (2015a and 2015b), Rey (2015), Fratzscher, Lo Duca, and Straub (2016, 2018), Ahmed and Zlate (2014), and Passari and Rey (2015).

who show, using aggregate data, that monetary policy in various source countries is an important determinant of cross-border bank flows).

Most of these papers use only aggregate data, thus allowing little scope to assess accurately investors' risk-taking behavior. Only a few papers besides ours use instrument-level data to assess risk-taking in an international context, and so far most of these papers focus on bank lending, rather than debt securities (Lee, Liu, and Stebunovs (2017), Bruning and Ivashina (2017), Baskaya et al. (2018), Morais, Peydro, and Ruiz (2017)). Bruno and Shin (2017) do focus on borrowing in the forms of bonds, but they analyze the effects of dollar carry-trade conditions for borrowing by emerging market non-financial corporations. Boermans and Vermeulen (2016) consider determinants of euro-area investors' security-level holdings, but their cross-sectional analysis cannot address risk-taking in response to changing financial conditions. Ammer et al. (2019) show that low interest rates in foreign countries increase cross-border investments into the United States in both Treasury and aggregate U.S. corporate bonds, but with more pronounced effects for corporate bonds. Their analysis suggests investors take on more risk when faced with less profitable investment opportunities at home, but, as it is at the aggregate level, relates more to the role of safe assets in driv-ing cross-border investment. In this paper, we analyze the risk-taking within the corporate portfolio by using the detailed security-level data that underlie the aggregate flows.[7]

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[7]In terms of identification strategy, our paper is closely related to Morais, et al. (2018) which uses Mexican bank loan-level data to document risk-taking by foreign banks' subsidiaries in response to lower home-country interest rates.

2 Data

We use a unique source of security-level data: the annual U.S. Treasury International Capital (TIC) surveys of foreign holdings of U.S. securities for the period 2003 to 2016. The data are collected by the U.S. Department of the Treasury as part of the TIC reporting system. Given the mandatory reporting by custodians and issuers, the holdings data are comprehensive, i.e., they capture countries' entire portfolios of U.S. securities at the individual security level. Country-level holdings data for broad categories of assets, aggregated from these detailed annual surveys, are published on the Treasury Department's website, although without distinguishing between private and government holdings.

Data are reported (confidentially) at the security level at the time of the survey date, June 30 of each year, differentiating each country holder of that security, i.e., at those times we observe the holdings of security i by country j. Characteristics reported include general security description and identifier, issue and maturity dates, coupon rate, currency, industry type, and amount held (face and market value). We use in our analysis primarily the face values reported in the TIC surveys, thus abstracting from price change effects. Since data differentiate holdings by foreign official institutions and private investors, we are able to focus in our analysis on holdings of foreign private investors only, as motivations of official investors (e.g., central bank reserve managers) may differ from those of private investors. In practice, foreign official institutions' holdings of corporate bonds are relatively small compared to their holdings of government bonds and to private holdings of corporate bonds. Individual country-bond holdings that are never above $10 million in the sample period are excluded. Most bonds held by foreigners are denominated in U.S. dollars. To also prevent exchange-rate effects from complicating the analysis, we drop the limited number of bonds in other currencies.[8] Since our analysis is based on bond yields, we also exclude floating coupon

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[8]Maggiori, Neiman, and Schreger (2018) find that cross-border mutual fund investments are concentrated in bonds that are denominated either in the investor's home currency or in U.S. dollars.

bonds and focus on fixed rate bonds, which constitute 72% of total corporate holdings.

Data are reported on a resident basis, i.e., we observe the direct owner of these investments as reported by the custodians, but not the ultimate owner. This is an important issue, especially for financial centers that hold substantial amounts of securities on behalf of investors from other countries. By studying the euro-zone as a single economy, instead of the individual euro-zone countries, we mitigate this problem as it consolidates the significant amounts of securities held on behalf of investors from mostly European countries by intermediaries in countries like Belgium, Ireland, and Luxembourg. Besides summing up the individual euro-zone countries' bond holdings, we use averages (weighted by GDP) for the explanatory variables such as sovereign interest rates.[9]

Our final sample comprises over 215,000 individual corporate bond holdings by investors in the 25 economies (see Figure 3 for the economies included in our analysis) in a total of almost 15,000 unique bonds, with an aggregate value that rises from $268 billion in 2003 to $1.7 trillion in 2016 (Figure 1). After a sharp increase in the years leading up to the GFC, aggregate foreign inflows into U.S. corporate debt declined sharply during the GFC and remained weak during the subsequent euro sovereign debt crisis, reflecting the "flight home" and "search-for-safety" during those periods, well documented in the literature. To avoid having these factors affect our results, we exclude in most of the regressions the crises years 2008-2012. As interest rates further declined in many foreign economies after 2013, inflows into corporate bonds rebounded, suggesting that these investors were trying to make up for declining returns at home by purchasing more (risky) U.S. corporate debt.

Although sizable, the 2016 aggregate foreign holdings represent only 11.4% of total outstanding U.S. corporate bonds, which is the largest corporate bond market in the world.[10]

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[9]Our results are robust to taking an average of just the largest euro-area countries for the composite yield calculation.

[10]Data from the Bank for International Settlements (2017) indicate that the amount of outstanding corporate bonds issued within the United States is roughly seven times the corresponding amounts for Japan and the United Kingdom, the two next largest corporate bond issuers.

And shares held in individual U.S. corporate bonds by any individual foreign country are generally much smaller still. In particular, as Table 1 shows, the mean share of an individual foreign country's bond holding relative to the bond's outstanding amount is only 3.65% in our sample, with a 99th percentile value of 22.44%. This helps with identifying the effects of lower interest rates since we can safely assume that foreign investors are essentially price-takers in U.S. corporate bond markets and do not have a strong effect on the supply of financing to U.S. corporations and respective yields. To further reduce this possibility, we exclude from the regressions those (handful) of observations where the share of an individual security held by investors from one country is greater than 45%; this precaution also excludes extreme observations that could reflect data recording errors.

We use CUSIP and ISIN identifiers to match the TIC holdings to additional security-level information from other sources.[11] We collect bond credit ratings from Moody's and from the supplementary data that Bank of America/Merrill Lynch (BofAML) provides for the constituents of its bond indexes. BofAML reports a composite bond rating using all available ratings. When these composite ratings are not available (i.e., when a bond is not featured in the indexes) we use the bond's Moody's rating. We use Thomson One Reuters and BofAML corporate bond indexes for data on each bond amount issued and outstanding, and whether it pays a fixed or floating rate coupon. Using FINRA's TRACE data on reported trading activity, we compute a measure of bond liquidity. Following Becker and Ivashina (2015), we calculate it as the total transaction volume during the month of June of the survey year as a share of amount outstanding. From prices and payment terms, we calculate the bonds' yield-to-maturity and duration at each end-June date. We calculate the bond's spread relative to Treasury yields, choosing the closest duration matched bond in the BofAML U.S. Treasury indexes.

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[11]The security identifier in the TIC surveys is usually either a CUSIP or an ISIN, but in some cases it is a reporter's internal code, in which case we extract a CUSIP or an ISIN from this internal code.

2.1 Bond characteristics and portfolio shifts

Figure 2 compares our data on foreign holdings of U.S. corporate bonds to a benchmark, the Bank of America Merrill Lynch (BofAML) corporate bond indices, in terms of yield spread and duration. The left-hand panel compares the weighted-average yield spread of the foreign portfolio of U.S. corporate bonds, calculated using the time-varying weights from our data, to the weighted-average spread of the BofAML benchmark. The two move together fairly closely, indicating that the foreign investor as a whole does not invest much differently from the U.S. investor in U.S. corporate bonds. But the spread on the foreign portfolio moved above that on the BofAML benchmark towards the end of the period. In terms of duration, the right-hand panel shows that the foreign portfolio was shorter than that of the BofAML benchmark early in the period, with a difference of about one year in 2009. While both increased their duration over the period, the foreign investors' duration rose more steeply over time, with the gap with the benchmark narrowing to less than a few months.

Table 1 summarizes a number of bond characteristics and their distributions across our entire 2003-2016 data panel. The average yield is just under 5%, but varies between 1% and 13%. The average spread over a U.S. Treasury security matched on duration is 2.6% and varies from 0.46% to more than 11%. The duration of the bonds foreigners invest in is generally between 1 and 16 years, but can go up to 50 years. Corporate bonds are in general not heavily traded; on average, only 4.1% of the outstanding amounts changes hands in the month of June in the survey years.

Table 2 summarizes the main bond characteristics for 2003 and 2016, dividing the sample into six ranges of credit ratings. Although corporate yields declined, Treasury yields fell by more, so that yield spreads increased slightly on net across all ratings. For both years, lower credit ratings are always associated with wider yield spreads, suggesting that spreads roughly capture similar ex ante information about credit risk as ratings do. But corporate bond yields reflect compensation for both credit and duration risk. Yields are essentially

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a combination of a credit spread (over an equivalent duration Treasury) and a duration compensation. We explore in most of our regressions the extent to which search-for-yield involves risk-taking associated with the spread and/or duration dimensions of the yield.

2.2   Domestic interest rates

Our analysis is based on countries' home interest rates across economies and over time. For this, we collect sovereign yields at 1-year and 5-year maturities from Bloomberg, taking the average yield for each June, which coincides with the timing of the holdings surveys. Figure 3 captures the range of home rates in our data panel, showing for each economy the median, maximum and minimum. It shows the large dispersion in rates and the differences in movement over time and across economies. Sovereign yields in general declined over the sample period. The cross-sectional variation remains substantial throughout, however, even as the median is below 1 percent at the end of the period. For example, rates in Japan have been low for most of the 2003-2016 period, while rates in many (non-euro zone) European countries have varied considerably, in most cases falling to low levels only after the financial crises. And rates have not been consistently low in the majority of emerging markets. This heterogeneity in the panel is important in identifying the effects of low interest rates on risk-taking.

One could also consider using the rate on a corporate bond index for the home-country yield measure, but this has some drawbacks. For one, it is difficult to obtain for a long enough period of time and for a broad set of countries corporate bond index series measured and defined in ways that are consistent over time in terms of maturity and credit risk. Consistency across countries is another challenge. In some countries, for example, mortgage bonds are more important than corporate bonds as an alternative to government bonds. Also, smaller countries tend to have very few domestic-currency corporate bonds. For example, the market for euro-area corporate bonds has become a fairly unified market, thus precluding

using distinct national corporate bond markets (see Burger, Warnock, and Warnock, 2017; and Maggiori, Neiman, and Schreger, 2018). These yields are likely endogenous to investors' behavior, i.e., as risk-taking increases in a country with lower interest rates, local corporate rates are likely to decline as well, making them less useful to identify risk taking due to lower interest rates.

In robustness checks, we also investigate whether risk-taking is driven by financial and economic developments in the investors' home countries other than local interest rates. For this, we use (i) the aggregate credit default swap (CDS) spread for the local banking system, constructed from Markit quotes and (ii) the expected earnings growth in the overall corporate sector, obtained from IBES. One additional possibility is that investors hedge their returns against possible exchange rate movements, which might mean that the local sovereign interest rate should be converted into a common currency to best capture the risk-reward considerations for investment in U.S. bonds. To allow for this, we obtain the U.S. dollar equivalent of the home sovereign rate, constructed using Bloomberg data on 12-month forward premiums for the U.S. dollar against the investors' home currencies and then calculate the synthetic dollar yields foreign investors would obtain if they hedged their home-currency 1-year sovereign bonds into the U.S. dollar.

3   Methodology and Results

As a first look at the data, we show how countries' sovereign yields relate to how risky their aggregate portfolio of U.S. corporate bonds is. As an aggregate measure of riskiness we use individual countries' weighted average yield of their portfolios of U.S. corporate bonds. Figure 4 presents binned scatter plots of these countries' weighted average bond yields and their domestic sovereign yield. The figure also plots the best linear fit line constructed

from an OLS regression that includes country and time fixed effects.[12] The left hand side panel uses the change in countries' domestic sovereign yields, while the right hand side panel uses the level of the domestic sovereign yield. The figure shows there is a strong negative correlation between (changes in) domestic sovereign yields and the U.S. corporate portfolio yield for these foreign countries.

3.1 Methodology

To fully investigate the relationship between countries' domestic sovereign yields and the yield of their portfolio of U.S. corporate bonds, we proceed to our main analysis that uses the security-level data. We focus on changes in the holdings of a specific security by a given country (or group of countries in the case of the euro area). We scale these holdings by the amount outstanding at the security level. This accounts for the fact that we can expect more foreign investment in U.S. securities with larger outstanding amounts. Our dependent variable is then the change in the holdings position (i.e., a flow) of bond i by country j as a ratio to the overall amount outstanding of the specific security i. We use the face values of holdings reported in the TIC survey to match the denominator, which is also a face value. This also abstracts from the effects of price changes and thus accurately captures new investments and portfolio shifts.

For our main test, we rely on an interaction term between the change in the home-country sovereign yield and the yield on the specific U.S. corporate bond. This interaction captures whether the foreign investors' propensity to choose U.S. investments with a different yield is affected by the change in the returns on their home-country investment alternatives, of which

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[12]Binned scatter plots are a non-parametric visualization of the conditional expectation function, as in Chetty, Freidman, and Rockoff (2014). To construct these binned scatter plots we divide the domestic sovereign yields observations into twenty equal-size bins after absorbing year and country fixed effects, compute the mean of the sovereign yields and the weighted average yield of U.S. corporate bond holdings within each bin and create a scatter plot of these data points, weighting by countries' total holdings of U.S. corporate bonds. The linear fit line is from an OLS regression of the weighted portfolio yield on the domestic sovereign yield using time and country fixed effects.

government bonds typically are the most important. That is, we test if foreign investors'
allocations across different categories of riskiness vary inversely with the change in their
interest rate at home. We then interpret a negative coefficient as evidence of a search-for-
yield motive since it implies that a lower interest rate at home increases relative investment
in U.S. corporate bonds with a higher yield. Since, besides higher credit risk, longer duration
is another way for investors to take on risk, in this case maturity risk, we also test risk-taking
by including interaction terms of the sovereign rate with both bond yield spread and bond
duration.

We use local currency sovereign bond rates since these represent the best overall proxy for
investment opportunities in the home markets and consequently how lower home sovereign
rates can drive residents to invest more in risky securities, including abroad.[13] In a robustness
test, however, we study the effects of possible currency-hedging using the synthetic dollar
yields. Our sample excludes financial centers such as the Caribbean banking centers for two
reasons related to our focus on the effect of home investment opportunities on investors'
risk-taking. First, as noted, these countries do not have much sovereign debt outstanding
and therefore lack reliable sovereign rates. Second, their investments are predominantly held
on behalf of a diverse group of non-residents, for whom the interest rate to use is ambiguous.
While our baseline regressions treat the euro area as one economy for this reason as well, in
robustness checks we include all the individual euro-area economies.

In all specifications, we use time*economy fixed effects, which control for any time-
invariant and time-varying country differences that may affect the general degree of invest-
ment into the United States. This means that time-invariant control variables used in the
international portfolio choice "gravity" type models, such as the distance to and common

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[13]We focus on asset composition and not on funding conditions. This means we ignore motives related
to carry-trade, i.e., where foreign investors obtain funding in low interest rate countries to invest elsewhere.
We do not expect such factors to be large for the type of investments we study as carry trade is typically
not done with corporate bonds, which tend to be less liquid.

language with the United States, are already absorbed in the fixed effects, and that all time-varying global and country characteristics are controlled for.[14] We include as a time-varying, security-specific variable the liquidity of each corporate bond to proxy for transaction costs. We weigh the regressions using the bonds' outstanding amounts.

By using time*economy fixed effects, changes in the overall economic and financial environment, including general changes in U.S. interest rates, are already accounted for. The GFC and the European sovereign crisis, however, entailed major disruptions to many financial markets and the stresses during these periods could have made investors reluctant to invest in U.S. corporate bonds in general and especially those with higher yields and risks. Indeed, as shown in Figure 1, during both the GFC (2008-2009) and the European debt crisis (2010-2012), foreign investment in U.S. corporate bonds was unusually weak. To control for this possibility, we include the change in the average CDS spread of U.S. high-yield corporate bonds interacted with the specific corporate bond's yield (or yield spread). The average CDS spread of U.S. high-yield corporate bonds spiked during the crises periods (Figure 5). If investors are reluctant to buy corporate bonds with higher yields (or yield spreads) in times of heightening overall corporate stress, then the coefficient on this interaction should be negative. Controlling for this effect in a way common to all the economies in our sample, we can then analyze the presence of search-for-yield behavior, and whether it varies across economies with different changes in home interest rates. To fully account for any possible unusual relationships during the years of major financial crises, in most of the specifications we simply exclude observations for the years 2008-2012 from the sample.

The baseline empirical specification of the model we estimate is then:

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[14]In robustness checks (not reported), however, we drop the time*economy fixed effects, and include the following time-varying economy-specific variables instead: bilateral trade (sum of imports and exports, and imports and exports separately), and financial linkages, both as proxies for interconnectedness with the United States; and the change in the bilateral exchange rate, as a proxy for both shifts in investment related to carry-trade and other exchange rate related opportunities. Our main results related to risk-taking are similar.

$$\Delta\mathrm{H}_{i,j,t}/\mathrm{Outstanding}_{i,t} = \kappa + \alpha\mathrm{Risk}_{i,t} + \beta\mathrm{Risk}_{i,t}\Delta\mathrm{Sov}_{j,t} +$$
$$+ \gamma\Delta\mathrm{CDS}_t^{\mathrm{US}}\mathrm{Risk}_{i,t} + \theta\mathrm{Liquidity}_{i,t} + c_{j,t} + \epsilon_{i,j,t} \tag{1}$$

where the dependent variable, $\Delta\mathrm{H}_{i,j,t}/\mathrm{Outstanding}_{i,t}$, is the change in holdings by residents of country j in year t of U.S. security i. $\Delta\mathrm{Sov}_{j,t}$ is the change in economy j's sovereign yield, which here is the 1-year sovereign yield as of June of each year. In addition to the change in sovereign yields, we also explore the role of the level of the sovereign yields. $\mathrm{Risk}_{i,t}$ is security i's risk measure defined either as yield-to-maturity (Bond yield) or yield spread (Bond spread), or as the yield-to-maturity spread over the Treasury yield of similar duration and duration (Duration). Our main variable of interest is the interaction between the security's risk measure(s) and the change in the sovereign yield, $\mathrm{Risk}_{i,t}\Delta\mathrm{Sov}_{j,t}$. So our key coefficient is β which determines the search-for-yield effects through the credit-risk channel. A negative coefficient ($\beta < 0$) suggests that the more the home rates decline, the more investment is shifted towards riskier U.S. corporate bonds. $\Delta\mathrm{CDS}_t^{\mathrm{US}}$ is the change in the average CDS spread of U.S. high-yield corporate bonds (D.CDS (US)); $\Delta\mathrm{CDS}_t^{\mathrm{US}}\mathrm{Risk}_{i,t}$ is its interaction with security i's risk measure. We also control for the security's liquidity, $\mathrm{Liquidity}_{i,t}$, measured as the log of the trading volume recorded in TRACE as a share of the bond outstanding amount (Traded share). Using the log of the unscaled volume instead in our regression specifications does not change our regression results.[15] All regressions include economy*time fixed effects, denoted by $c_{j,t}$ and we also allow the economy fixed effects to differ for newly-issued and seasoned bonds. We estimate the model parameters by Ordinary Least Squares (OLS), reporting heteroscedasticity-consistent standard errors generated from the Hubert-White "sandwich" estimator for the variance-covariance matrix.

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[15]Results are also robust to winsorizing the dependent variable.

3.2 Results

Table 3 reports the baseline regression results on how changes in interest rates at home affect the degree to which foreign investment moves into riskier U.S. corporate bonds. In column 1, we document our main result that the (scaled) change in a country's total holdings in a given bond is negatively related to our key interaction term, the product of the yield on that bond and the change in the home-country interest rate. This means that the larger the decrease in the interest rate in the home country, the more holdings by this country's investors of higher-yielding U.S. securities increase. Note that the coefficient on bond yield itself has a positive sign, suggesting that a higher yield means more investment in that specific security.

Another result worth pointing out is the negative interaction between the corporate CDS index spread and the bond yield, which means that at times of increasing overall riskiness in the U.S. corporate sector, foreign investors shy away from buying higher-yielding securities. In column 2 we exclude for this reason observations for the years 2008-2012 from the sample. The interaction between the yield on the bond and the home-country interest rate is again negative and statistically significant. Importantly, it is larger in size than in column 1, further suggesting that the risk-taking incentives of lower interest rates can be larger in non-crises times.

In column 3, we add as a control the U.S. corporate bond's liquidity, Traded share. We find that the degree of liquidity positively affects the change in holdings, i.e., foreign investors consider the ability to more easily trade in the security an important characteristic. Our main result on risk-taking remains, with a slightly larger coefficient.

To quantify the economic significance of these results, we can consider the effect of a 200 basis point decline in the home sovereign yield, which corresponds roughly to the difference in the decline between 2003 and 2016 in the sovereign rates of the euro area and Japan (countries where sovereign rates took different paths over the period). We next infer the portfolio shifts that investors from countries with different developments in their

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home sovereign rates would make according to our coefficient estimates for the interaction terms. We then compare several characteristics of the actual average U.S. corporate bond portfolio held by foreign investors over our sample to the hypothetical portfolio that our estimates imply if instead their home interest rates had been 200 basis points lower. This exercise, using the regression results in columns 2 and 3, shows that this reduction in home rates, all else equal, would induce foreign investors to pick up 43 basis points in yield by reweighting their U.S. corporate bond holdings toward higher-yielding bonds. These effects, which are economically significant, pertain to the non-crises period, with lesser effects for the full sample period.

To obtain higher yields on their U.S. corporate bond holdings, foreign investors may be taking on more credit risk, more duration risk (by shifting to longer bonds), or both. To distinguish between these possibilities, we use in columns 4-6 the spread of the specific U.S. corporate bond over the equivalent maturity risk-free rate instead of its yield, and also include the duration of the security. This makes these regressions similar to the ones for the yield, as the credit spread and duration combine to determine the yield. As with the yield, we include both spread and duration on their own and interacted with the change in the home sovereign rates. And in the last two columns we exclude again the crises period. The results show that the spread interacts in a statistically significant negative way with the change in the sovereign rates, consistent with investors taking on more risk in the credit dimension when home interest rates decrease. These interactions remain statistically significant, are of the same sign, and have larger magnitudes when we reduce the sample to the non-crises period (column 5) and add the secondary market liquidity (column 6). There is little evidence for increased incentives to take on more duration risks as the coefficients for those interactions are not statistically significant.[16] Using the same exercise to quantify

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[16]Instead of duration, we also used the term spread, that is the difference between the risk-free yield used to calculate the bond spread and the 3-month US treasury yield, and found similar regression results.

the economic significance of these results, we find that this reallocation towards bonds with higher yield spreads would increase the average spread over U.S. Treasuries by 32 basis points. These effects again pertain to the non-crises period, with lesser effects for the full sample period.

3.3 Secondary and primary markets

The dependent variable we studied so far is similar to that used previously in the literature on risk-taking for institutional investors in individual countries and on home bias in international portfolio choice. In both these literatures, the focus is typically on changes in (individual) stock positions, i.e., total flows. This means analyses combine secondary (buying or selling currently outstanding bonds) and primary market (buying newly-issued bonds) transactions. This could be the right focus if (foreign) investors consider both currently-held and newly-issued securities for their portfolio shifts year to year. It may, however, be the case that investors can and do adjust their portfolios easily in both markets. Because of transaction costs (e.g., related to low liquidity) or other (internal) constraints, it could be that an investor cannot or does not want to readjust its portfolio continuously in response to changes in interest rates at home. Although we do include in regressions a proxy for the liquidity of the secondary market, and results do not change, we want to allow for the possibility that investors only adjust their portfolios at the margin and do so only by varying the amounts that they buy in the primary market, i.e., newly-issued bonds. More generally, investors may respond differently in the two markets to the level of the home interest rates.

We define the secondary market transactions as the net purchases or sales in a given year of "seasoned" bonds, meaning for our purposes bonds that had already been issued by the time of the previous years' survey date. In notation terms, we use the change in the portfolio held in a particular U.S. security i at time t by country j, scaled by the specific size outstanding of that bond at time t. Primary market flows are defined as the purchases

of a particular newly-issued security (i.e., issued since the previous years' survey date) that are added to the specific country-investors' portfolio. Here, the dependent variable is thus the investment of country j in year t in a newly-issued U.S. corporate bond i. To control for issuance size, we calculate these purchases as a fraction of amount issued, i.e., securities bought by country j out of the total issued of that security in a specific period t. Our definitions of primary and secondary market transactions are similar to those used by Becker and Ivashina (2015) and together comprise the entire change in holdings analyzed above.

Table 4 columns (1)-(2) report the regression results for the secondary market behavior, restricting the sample to the non-crises period. The results are similar to those in the baseline Table 3. The coefficients on the yield spread interactions with the change in the sovereign yields are negative and statistically significant in both specifications (results using bond yields are similar and we omit them from the table for brevity). Furthermore, the coefficients are about as large as in Table 3, suggesting that dynamic portfolio adjustment is an important part of the reach-for-yield dynamics. In the secondary market sub-sample, the interaction of the duration variable with the sovereign yield is now negative and statistically significant. For secondary market transactions, lower interest rates induce an increase in duration of bonds bought, which amounts to about 0.3 years following a 200 basis-point decline in the home interest rate. The coefficients for the other variables keep the same signs and statistical significance. Note that the regression results for the secondary market reflect the net outcome of transactions, i.e., the effect we find could arise from either on net selling less risky or purchasing more risky bonds by foreign investors, or from a combination (portfolio rebalancing).

For the primary market (Table 4 column 3), the dependent variable is the investment in newly-issued securities only. Since much fewer bonds are issued each year than there are outstanding bonds, we have less observations. The right hand side variables are as before, except we can no longer include the secondary market liquidity measure. The coefficient for the

interaction of the change in the home interest rate with the yield spread on the newly-issued securities is again negative and statistically significant. Compared to the secondary market sample, there is no evidence for search-for-yield through longer duration; the coefficient on the interaction term is actually positive and significant. Overall, these results show that the credit risk-taking behavior as interest rates fall documented in the baseline stems from both secondary market trading and purchases of newly-issued securities, but that investors take on duration risk only through secondary market trading.

3.4   Risk-taking over time

As discussed in the previous section, it could be that foreign investors engaged less in risk-taking during the GFC or other periods of financial stress. It could also be that the unconventional policies of major central banks implemented after the crises, such as quantitative easing and asset purchase programs, affected the behavior of investors and made risk-taking more (or less) likely. Since in all specifications we include the U.S. corporate CDS interaction with bonds' yields, we already control for the general effect of changes in stress in the corporate sector. But it can nevertheless be useful to explore whether other factors may have led to results that vary over time and whether the effects we have documented thus far apply to specific periods. In Table 5 we split the sample in three periods: 2003-2007, 2008-2012, and 2013-2016, where the middle period includes both the GFC and the euro sovereign crisis. Otherwise, the specifications are the same as in Table 3, columns 5 and 6.

We find evidence of reach-for-yield through taking on more credit risk only in the non-crises years: the statistically significant negative spread interaction terms are confined to the 2003-2007 and 2013-2016 periods (columns 1, 2 and columns 5, 6). The risk-taking incentives are stronger in the post-crises period as the coefficient on the yield spread interaction with the home interest rate is more than double that of the pre-crisis period. In the crises period, 2008-2012, the estimated coefficient for the spread interaction is not statistically significant

(columns 3 and 4). This result shows that the flight-home and overall stress dulled much of the incentives to take risks in U.S. corporate bonds related to declining interest rates. We find that foreign investors' reach-for-yield behavior in the form of extending the duration of their U.S. corporate bond portfolios only exists in the pre-crises period. It might be that the unconventional policies of major central banks during and after the crises, which involved purchases of longer-dated instruments, altered the responses of investors with respect to risk-taking through taking on longer duration.

3.5   Impact of the level of the home interest rate

So far, we have explored the hypothesis that risk-taking relates only to a lower home interest rate, irrespective of its level. This presumes that the incentives to adjust investment towards higher yielding securities are mainly related to home interest rates that decline year over year. It thus also assumes that investors from countries where home interest rates have already been low for some time make fewer adjustments to their legacy portfolios from the previous year. Since it could be the case that the level of the interest rate is also important, we now consider how the level of the sovereign interest rate affects risk-taking behavior. For this, we use again the same specification as in Table 3, columns 6, but split the sample into two: observations of countries in a low rate environment and observations of countries in a high rate environment. We do this split in two different ways: first, we define a low rate environment so as to obtain two equally sized subsamples; and second, we use as a cutoffs the 25th percentile for the home sovereign rate (results are similar if we use as a cutoff the median for the full sample). Each year, for each of these two splits, a country-year is then classified in one of two categories, high and low interest rate, based on its prevailing sovereign rate.

The results are shown in Table 6 for both splits. We find consistently that a low level of interest rates is associated with more risk-taking as the coefficients across both splits

are much higher in the low than in the high interest rate environment. Specifically, the coefficient is one and a half times as high in column 2 compared to column 1, and more than twice as high in column 4 compared to column 3. As such, the results suggest that the level of the interest rate matters: when the home interest rate is low, securities with higher spreads see even more investment when the home sovereign interest rate further declines. In economic terms, the search-for-yield effects are also much bigger: comparing the specification in column 2 with that in column 1, a 200 basis points lower home sovereign rate is associated with a 39 basis points pick-up of yield spread in a low interest rate environment compared to 20 basis points in a high interest rate environment.

To further explore the effects of the level of the interest rate, in Table 7 we consider how the level of the sovereign interest rate directly affects the search-for-yield effects we documented in the baseline. We use again equation (1) but interact now the bond yields with the level of the sovereign interest rate rather than with the change in the sovereign interest rate. We find that search-for-yield and search-for-duration effects also relate to the level of the interest rate as the coefficients on the interaction terms are negative and statistically significant.

4   Robustness

We next report on a number of robustness tests.

4.1   Robustness to alternative explanations for search for yield

We first consider the possibility that the change in the sovereign rate may not be the main reason why foreign investors invest in higher yielding (or longer duration) U.S. corporate bonds. We do this by augmenting our baseline regression specification with other investor-country variables. Specifically, we use the CDS of a country's banking system and the

expected earnings growth in its corporate sector. If these variables are also factors driving investment into U.S. corporate securities, yet they are correlated with interest rates, this could have led to spurious results in our baseline regressions. It could be that a decline in the local CDS spread similarly induces investors to search for yield abroad. Or investors may invest more in higher-yielding U.S. assets because they forecast low corporate sector earnings growth at home. If these scenarios were to be the case, we would expect a negative interaction between the banking system CDS (or earnings growth) and the bond's yield; and findings could even overturn the significance of the interest rate interaction. We run regressions with these variables in "horse-races" with the interest rate, all interacted with the specific security's variables (bond spread and duration).

Regression results for the countries for which we have the necessary data (the number of observations drops slightly), reported in Table 8 columns (1)-(2), show that some of the interactions with the banking system CDS and expected corporate sector earnings growth have the expected negative signs, and are most often statistically significant. As such, investments into more risky U.S. securities in part respond to changes in these factors because a more risky banking system or lower corporate sector growth at home makes U.S. securities more attractive. However, the risk-taking effects of the home interest rates that we document above cannot be attributed to these other country characteristics since the inclusion of the interactions of the banking CDS and expected earnings growth do not overturn the result on the interest rate; the sign and statistical significance of the interactions between the change in the sovereign rate and the spread do not change, and the coefficients for the interactions are similar in size.

4.2 Robustness to alternative sovereign rates and country sample

Next, we check if exchange rate risk affects our baseline regression results. For this we use the synthetic dollar yields, i.e., sovereign rates adjusted for the cost of hedging the dollar-

local currency exchange rate risk. Similarly to the regressions with countries' banking sector CDS and expected earnings growth, we run regressions as "horse-races." We obtain results (Table 8 column 3) regarding the effects of the home interest rates similar to our baseline, suggesting that exchange rate risk does not affect our regression results. Our results are also robust to using sovereign rates at other maturities. In a set of tests (not shown), we use the 5-year sovereign bond rates rather than the 1-year rates. The results show that our findings are preserved in that the coefficients for the respective interaction variables are statistically significant and negative for all specifications.

Next, we exclude emerging market economies from the sample to investigate if there are differences between how changes in interest rates in advanced economies versus in emerging markets affect risk-taking as reflected in investing more in U.S. corporate securities markets with higher yields. It could be that from the perspective of an emerging market investor, a lower domestic interest rate does not lead to capital flows to the United States as there are ample domestic securities with high yields as alternative opportunities. This should make the regression results less significant for emerging markets. At the same time, some emerging markets have experienced periods of pronounced sovereign rate changes over the sample period. In Table 9 columns (1)-(3) we show that there is little change in the coefficients on the interaction variables compared to the baseline results in Table 3. As such, it appears that our main findings are not driven by emerging markets.[17]

We have so far treated the euro area as one country. As another robustness check, we include the individual euro-area countries rather than combining them into a single economy and show that our main findings are unchanged (Table 9, columns (4)-(6)). For this robustness check we include the bond holdings of Luxembourg, Belgium, and Ireland, three financial centers that largely cater to investors from other European countries. Since

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[17]For this robustness check we exclude Brazil, Chile, China, Colombia, Czech Republic, South Korea, India, Malaysia, Mexico, Peru, Philippines, and Poland from the sample. Results are similar (not shown) if in addition we also exclude Hong Kong, Israel, Singapore, and Taiwan.

these financial centers act as a conduit for cross-border investment, a composite European yield is likely to be a better choice than their national sovereign yield.[18] For the other euro-area countries we use their national sovereign yields. We define this composite European yield as the average sovereign rate prevailing in four large euro countries (Netherlands, France, Italy, and Spain). Results are robust to including the German sovereign rate in the calculation of this composite rate or to defining the rate using the IMF Coordinated Portfolio Investment Survey (CPIS)-reported investment in these financial centers as weights (not reported).[19] Although CPIS data suggest that these countries' holdings should reflect mostly European investors' decisions, there can still be some reporting issues, and therefore as another robustness check we exclude the bond holdings of Belgium, Ireland, and Luxembourg from our sample altogether (not reported). We again find that our results still hold.

5 Conclusion

We analyze how changes in (and the level of) interest rates can affect risk-taking by examining the extent to which investors have shifted toward riskier assets overseas in response to declining (low) interest rates at home. Detailed security-level data on foreign investors' holdings of U.S. corporate bonds for 25 economies for the period 2003-2016 and a large variety in movements in interest rates in these countries provide for a unique way to analyze risk-taking behavior of investors in response to changes in their home interest rates. Notably, our analysis avoids concerns about reverse causality or omitted variables (e.g., due to asset riskiness or yields being related to macroeconomic and financial conditions that also affect interest rates). And, while these foreign investments are likely affected by economic and

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[18]While entities resident in other countries in our sample may also hold some bonds on behalf of ultimate investors in other countries, Luxembourg, Belgium, and Ireland stand out for having TIC holdings as a percentage of investor-country GDP that are by far the highest (Ammer et al., 2019).

[19]One concern with using the German rate is that it might reflect Germany's safe haven status, rather than (just) investment opportunities in Germany.

financial conditions at home, since they are small from a U.S. perspective, they are unlikely to have affected the financing conditions of the issuers, including spreads.

We find evidence suggesting search-for-yield in that the more the interest rate in the investor's home country declines, the greater the likelihood that the composition of investments into specific U.S. corporate bonds shifts towards higher yielding investments. We find these effects for both changes in the holdings of seasoned bonds and purchases of newly-issued securities. The search-for-yield effects are only present in normal times. At times of increasing overall riskiness in the U.S. corporate sector, foreign investors shy away from buying high-yield securities. We further show that this risk-taking behavior is much stronger at low levels of the home interest rate. In sub-samples, we also find significant evidence of search-for-duration as investors lengthen the duration of their portfolios in response to lower interest rates at home. In robustness tests, we show that these search-for-yield effects cannot be attributed to other country characteristics, such as the CDS of its banking system or expected earnings growth in its corporate sector. We also show that similar results are obtained if we include sovereign rates adjusted for the cost of hedging the dollar-local currency exchange rate risk, suggesting that exchange rate risk does not affect our regression results. The results are also robust to different home interest rates, alternative country samples, and to various econometric robustness checks.

Our contribution to the literature is twofold. First, we overcome the challenges typical in identifying casual relationships when using data from a single country. Using data on capital inflows to the United States from a cross-section of countries with a wide variety of changes in home interest rates, yet with investments representing a modest fraction of outstanding U.S. securities, allows us overcome many identification challenges. Second, the majority of papers on the effect of (low) interest rates have focused on bank loan portfolios and research on the effects of interest rates on investors' general portfolio composition is limited and focused on particular types of investors. In contrast, we analyze granular portfolio choices

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within an important asset class by a very broad set of investors on a cross-border basis, something no previous paper has done. Also, the previous literature on flight to safety has looked at aggregate flows across borders, whereas we investigate the exact security involved to identify the role of various risk characteristics.

Our findings have important policy implications in that they suggest that declining and especially low interest rates can lead to shifts towards riskier types of investments. Although we control for both security and investor-country characteristics, we cannot say whether the investor behavior we observe is the same or differs from patterns in their other investments, since we do not have similar data for the full portfolio of these investors. It could be that these investors invest more aggressively in the United States yet more conservatively at home, and as such their overall portfolio need not become more risky. Extrapolating nevertheless from the part of their behavior we do observe, one could conjecture that foreign investors have made risk-increasing shifts in their portfolios, including elsewhere abroad, that could pose financial stability risks, particularly if the low-rate environment persists. Regardless, our findings suggest that there are cross-border effects from low interest rates through capital outflows directed toward riskier types of securities. Conversely, our findings suggest that if interest rates were to rise, e.g., as monetary policy normalizes in some countries, some adjustments in portfolios towards less risky securities may follow.

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Figure 1: Foreign Holdings of U.S. Corporate Bonds (2004-2016)
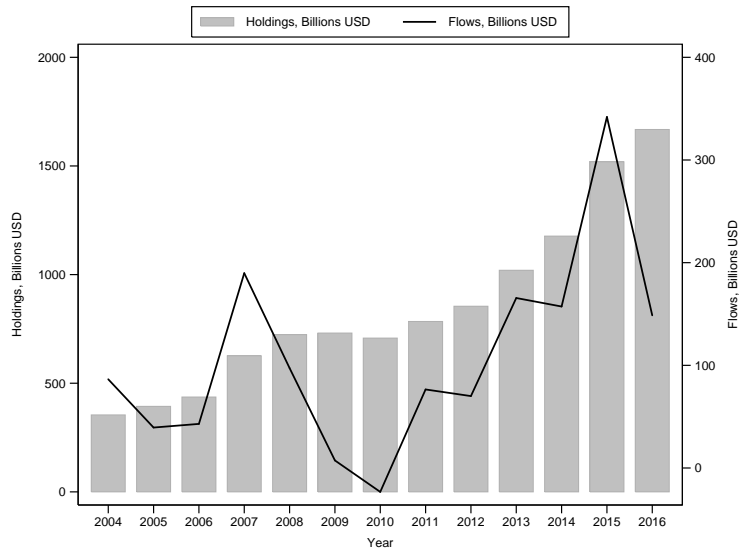
The figure plots foreign investors' annual holdings of U.S. corporate bonds (bars) and the change in these holdings (flows). The holdings are reported in face value and as such do not reflect market prices. Authors' calculations using Treasury International Capital annual survey data (end-June).

Figure 2: Average Corporate Yield Spread and Duration in Sample and BofAML Benchmark
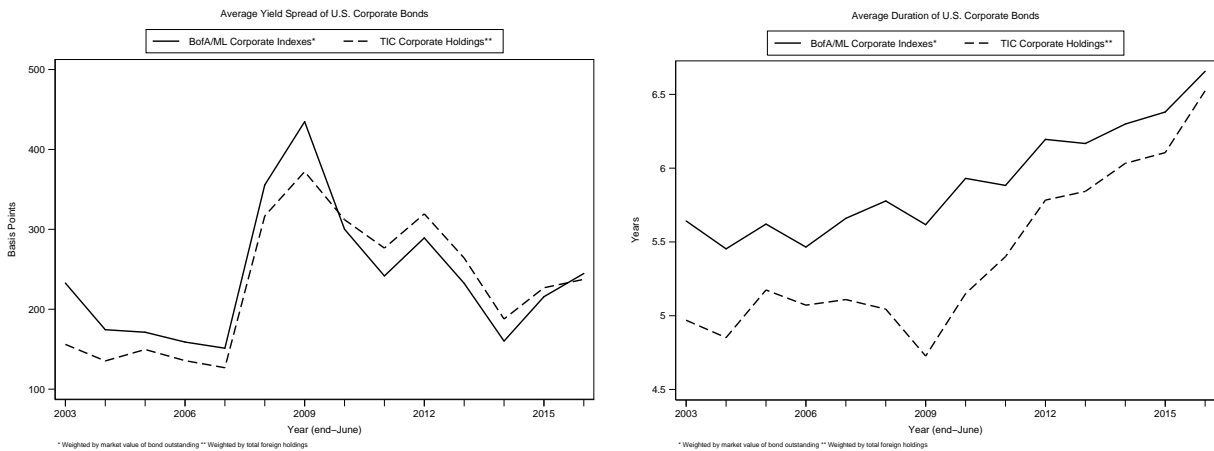
The figures plot the weighted average yield spread and duration of the foreign portfolio of U.S. corporate bonds (dashed lines). The yield spread is calculated as the yield to maturity of U.S. corporate bonds held by foreign private investors less the duration matched Treasury yield. As a reference the figures show the yield spread and duration of the Merrill-Lynch U.S. corporate bond indexes (solid lines), for which we took the weighted average of the high-yield and investment grade Merrill-Lynch U.S. corporate bond indexes. Authors' calculations using data from Treasury International Capital annual surveys and Merrill-Lynch U.S. corporate bond indexes.

Figure 3: Sovereign Yields by Country (2003-2016)
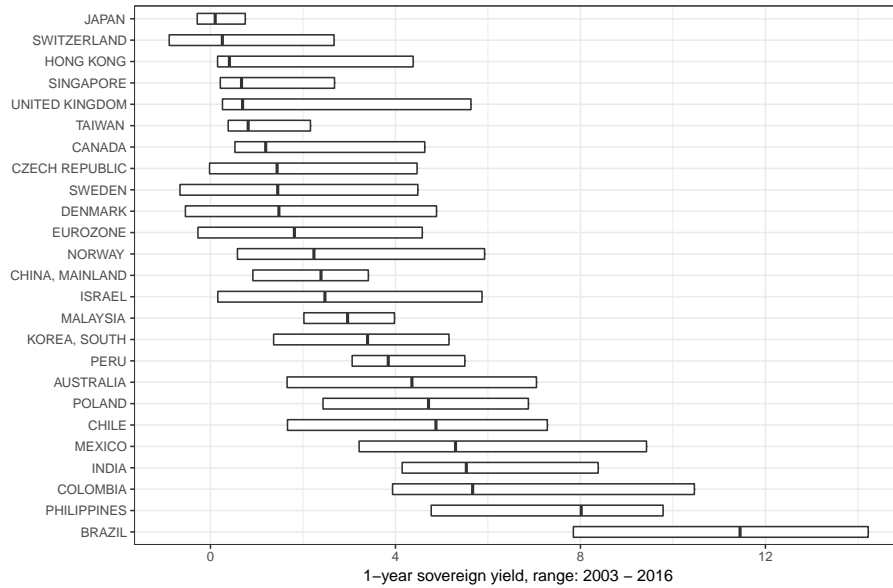
The figure plots the 1-year sovereign yield for all countries in our sample. In our analysis the euro area is included as one country; the yield for the euro area is the weighted (by GDP) average of the sovereign yields of the euro area countries. For each country we plot the median (dot) and the min and the max (boundaries of the box) of the sovereign yield for the period 2003-2016. Authors' calculations using data from Bloomberg.

Figure 4: Yield of countries portfolios of U.S. corporate bonds and their domestic sovereign yield
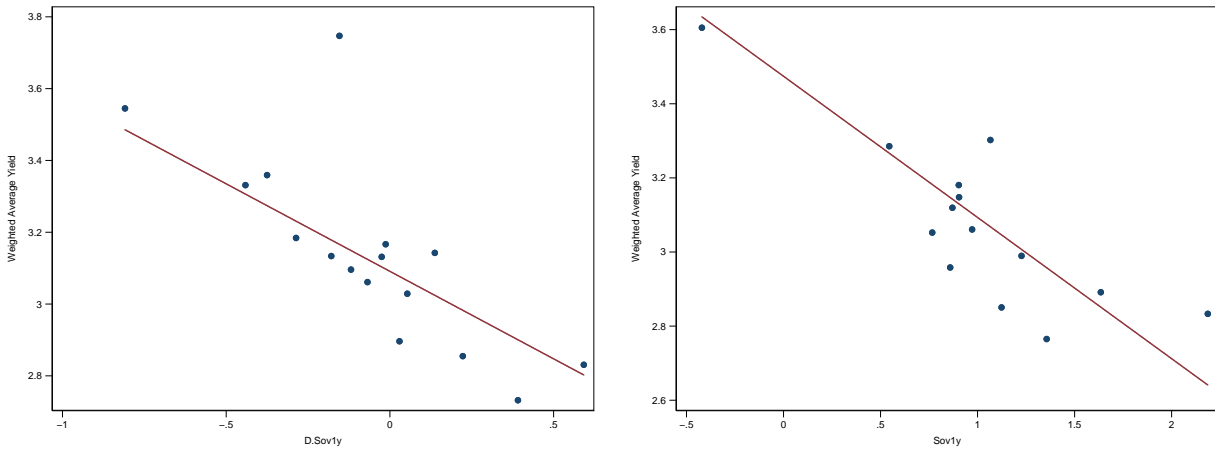
The figure presents binned scatterplots of individual countries weighted average yield of their portfolios of U.S. corporate bonds and the change in (panel 1) or level of their domestic sovereign yield (panel 2). The sample period excludes the crises years 2008-2012. The linear fit line is from an OLS regression of the weighted portfolio yield on the domestic sovereign yield using time and country fixed effects. D.Sov1y is the change in countries' domestic sovereign 1-year yield, Sov1y is the level of the 1-year domestic sovereign yield.

Figure 5: CDS premium U.S. corporate bond index
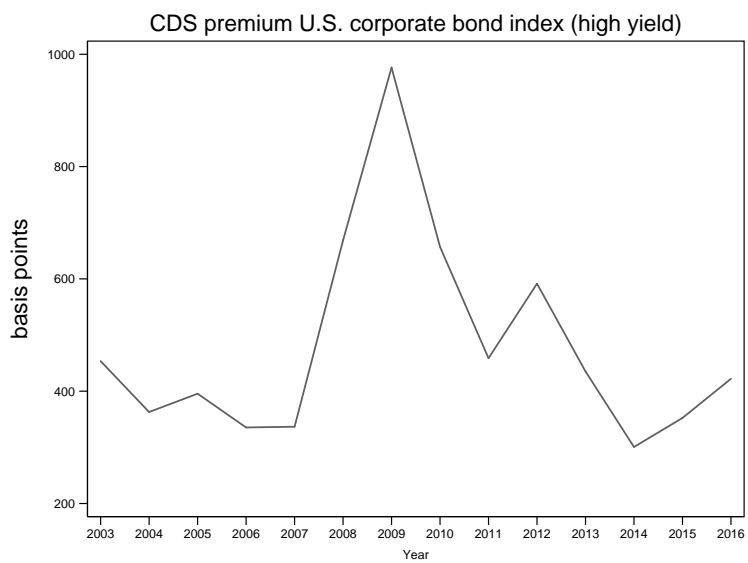
The figure plots the average CDS spread of U.S. high-yield corporate bonds. Source: Bloomberg.

Table 1: Bond Characteristics across Entire Sample (2003-2016)

	Median	Mean	St.Dev	5th p.	10th p.	95th p.	99th p.
Yield (%)	4.85	4.93	2.61	1.11	1.61	9.33	13.24
Yield spread (%)	1.86	2.63	2.31	0.46	0.62	7.27	11.25
Duration (years)	5.02	5.90	3.85	1.12	1.74	13.81	16.18
Traded volume/Outstanding (%)	3.17	4.11	4.10	0.24	0.57	11.07	19.39
H/Outstanding (%)	2.11	3.65	8.37	0.22	0.37	11.75	22.44
Newly-issued H/Outstanding (%)	2.42	3.94	9.00	0.27	0.48	12.30	21.91

Notes: The table reports bond characteristics (yield, yield spread, duration, and a liquidity measure) of the portfolio of foreign holdings of U.S. corporate bonds over the entire sample period 2003-2016. The bond liquidity measure, Traded volume/Outstanding, is the amount traded as reported in FINRA's TRACE database relative to the bond's outstanding amount. The table also reports statistics for foreign countries' holdings of a bond relative to the bond's outstanding amount for all bonds (H/Outstanding) and then separately for newly-issued bonds only (Newly-issued H/Outstanding).

Table 2: Bond Characteristics across Credit Rating Buckets for 2003 and 2016.

	Credit Rating	2003			2016		
		Yield	Yield spread	Duration	Yield	Yield spread	Duration
1 (highest rating)	AA through AAA	3.56	0.58	5.21	1.95	0.72	6.27
2	A+ through AA-	3.88	0.74	5.83	1.78	0.75	4.63
3	A- through A	4.19	0.90	6.48	2.21	1.13	5.31
4	BBB+	4.60	1.53	5.72	2.53	1.37	5.64
5	BBB through BB	5.21	1.84	6.08	3.71	2.45	5.29
6 (lowest rating)	BB- and below	8.17	5.25	5.28	6.43	5.46	4.32

Notes: For each year of the sample period, all U.S. corporate bonds held by foreign investors are sorted and grouped in six rating categories. For the first and last year of the sample period, 2003 and 2016 respectively, the table reports the median of the yield, yield spread and duration within each of these rating categories. Duration is reported in years; yield and yield spreads are reported in %.

Table 3: **Effect of Change in Home Yield on Risk-taking in U.S. Bonds: Baseline**
The table shows the estimated coefficients for equation (1) in the text. The dependent variable is the change in holdings by country j of bond i at time t scaled by the outstanding amount of the bond i at time t. Sample period: 2003-2016 in columns (1) and (4); we exclude the crises years 2008-2012 in columns (2), (3), (5), and (6). The euro area is included as one country. Countries' sovereign rates are the year-end 1-year sovereign yields; the yield for the euro area is the weighted (by GDP) average of the sovereign yields of the euro area countries. Weighted regressions with bonds' outstanding amounts as weights. All regressions include country*time fixed effects and we allow the country fixed effects to differ for newly-issued and seasoned bonds. For brevity the coefficients for fixed effects and the constant are not reported. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Heteroscedasticity-consistent standard errors are reported in parentheses.

	Bond yield			Spread and duration		
	(1)	(2)	(3)	(4)	(5)	(6)
Bond yield	0.049***	-0.013*	-0.025***			
	(0.005)	(0.007)	(0.008)			
D.Sov1y × Bond yield	-0.041***	-0.222***	-0.261***			
	(0.005)	(0.018)	(0.022)			
D.CDS (US) × Bond yield	-0.045***	-0.077***	-0.087***			
	(0.002)	(0.007)	(0.008)			
Traded share			0.162***			0.156***
			(0.012)			(0.012)
Bond spread				0.077***	-0.002	-0.011
				(0.005)	(0.007)	(0.009)
Duration				-0.015***	-0.016***	-0.021***
				(0.002)	(0.003)	(0.003)
D.Sov1y × Bond spread				-0.045***	-0.302***	-0.350***
				(0.006)	(0.021)	(0.026)
D.Sov1y × Duration				-0.000	0.005	0.002
				(0.003)	(0.007)	(0.009)
D.CDS (US) × Bond spread				-0.052***	-0.113***	-0.132***
				(0.003)	(0.008)	(0.010)
Observations	215274	134715	107831	215274	134715	107831
R-squared	0.34	0.37	0.40	0.34	0.37	0.40
Sample	2003-2016	Ex. 08-12	Ex. 08-12	2003-2016	Ex. 08-12	Ex. 08-12

Table 4: **Risk-taking in U.S. Bonds: Seasoned versus Newly-issued Bonds**
The table shows the estimated coefficients for equation (1) in the text using only seasoned bonds in columns (1)-(2), and only newly-issued bonds in column (3). The dependent variable is the change in holdings by country j of bond i at time t scaled by the outstanding amount of the bond i at time t. Sample period excludes the crises years 2008-2012. The euro area is included as one country. Countries' sovereign rates are the year-end 1-year sovereign yields; the yield for the euro area is the weighted (by GDP) average of the sovereign yields of the euro area countries. All regressions include country*time fixed effects. Weighted regressions with bonds' outstanding amounts as weights. For brevity the coefficients for fixed effects and the constant are not reported. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Heteroscedasticity-consistent standard errors are reported in parentheses.

| | Secondary market | | Primary market |
	(1)	(2)	(3)
Bond spread	-0.011	-0.027***	0.034
	(0.007)	(0.009)	(0.023)
Duration	0.006***	0.010***	-0.144***
	(0.002)	(0.003)	(0.013)
D.Sov1y × Bond spread	-0.167***	-0.183***	-0.554***
	(0.019)	(0.024)	(0.066)
D.Sov1y × Duration	-0.010*	-0.019***	0.216***
	(0.006)	(0.007)	(0.032)
D.CDS (US) × Bond spread	-0.088***	-0.107***	-0.196***
	(0.008)	(0.010)	(0.025)
Traded share		0.127***	
		(0.010)	
Observations	113137	86253	21577
R-squared	0.06	0.07	0.56

Table 5: **Risk-taking in U.S. Bonds: Time Periods**
The table shows the estimated coefficients for equation (1) in the text. The dependent variable is the change in holdings by country j of bond i at time t scaled by the outstanding amount of the bond i at time t. The sample period is split into three sub-periods. The euro area is included as one country. Countries' sovereign rates are the year-end 1-year sovereign yields. All regressions include country*time fixed effects and we allow the country fixed effects to differ. Weighted regressions, bonds' outstanding amounts as weights. for newly-issued and seasoned bonds. For brevity the coefficients for fixed effects and the constant are not reported. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Heteroscedasticity-consistent standard errors are reported in parentheses.

| | 2003-2007 | | 2008-2012 | | 2013-2016 | |
	(1)	(2)	(3)	(4)	(5)	(6)
Bond spread	-0.023	-0.042**	0.140***	0.147***	-0.023***	-0.029***
	(0.016)	(0.019)	(0.008)	(0.009)	(0.009)	(0.011)
Duration	-0.010	-0.010	-0.007*	-0.008*	0.009***	0.011***
	(0.007)	(0.009)	(0.004)	(0.004)	(0.003)	(0.004)
D.Sov1y × Bond spread	-0.150***	-0.177***	0.009	0.004	-0.401***	-0.448***
	(0.023)	(0.029)	(0.006)	(0.006)	(0.041)	(0.051)
D.Sov1y × Duration	-0.032***	-0.047***	0.007**	0.008**	0.133***	0.162***
	(0.008)	(0.010)	(0.004)	(0.004)	(0.014)	(0.017)
D.CDS (US) × Bond spread	-0.090***	-0.121***	-0.040***	-0.041***	-0.108***	-0.125***
	(0.033)	(0.042)	(0.003)	(0.003)	(0.008)	(0.010)
Traded share		0.112***		0.070***		0.133***
		(0.024)		(0.017)		(0.013)
Observations	40387	31145	80559	66014	94328	76686
R-squared	0.20	0.22	0.29	0.32	0.45	0.48

Table 6: **Risk-taking in U.S. Bonds as Home Rates Reach Low Levels**
The table shows the estimated coefficients for equation (1) in the text but here we split the sample into two: countries in a low rate environment and countries in a high rate environment. A low rate environment is when the home sovereign rate falls below either the cutoff that splits the sample roughly equally (columns (1)-(2)), or is below the 25th percentile (columns (3)-(4)). Each year countries are classified in these two categories based on their sovereign rate. The dependent variable is the change in holdings by country j of bond i at time t scaled by the outstanding amount of the bond i at time t. The sample period excludes the crises years 2008-2012. The euro area is included as one country. Countries' sovereign rates are the year-end 1-year sovereign yields; the yield for the euro area is the weighted (by GDP) average of the sovereign yields of the euro area countries. Weighted regressions with bonds' outstanding amounts as weights. All regressions include country*time fixed effects and we allow the country fixed effects to differ for newly-issued and seasoned bonds. For brevity the coefficients for fixed effects and the constant are not reported. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Heteroscedasticity-consistent standard errors are reported in parentheses.

	Equal sample		25th percentile	
	(1) Low	(2) High	(3) Low	(4) High
Bond spread	-0.070***	0.034***	-0.033***	-0.039**
	(0.012)	(0.012)	(0.011)	(0.018)
Duration	0.027***	-0.034***	0.017***	-0.025***
	(0.004)	(0.005)	(0.004)	(0.006)
D.Sov1y × Bond spread	-0.518***	-0.329***	-0.460***	-0.191***
	(0.072)	(0.026)	(0.051)	(0.022)
D.Sov1y × Duration	0.237***	-0.011	0.190***	-0.033***
	(0.020)	(0.009)	(0.020)	(0.007)
D.CDS (US) × Bond spread	-0.118***	-0.163***	-0.118***	-0.164***
	(0.014)	(0.015)	(0.011)	(0.017)
Traded share	0.115***	0.158***	0.138***	0.103***
	(0.015)	(0.019)	(0.014)	(0.022)
Observations	55186	52645	74840	32991
R-squared	0.48	0.33	0.48	0.22

Table 7: **Effect of the Level of the Home Yield on Risk-taking in U.S. Bonds**
The table shows the estimated coefficients for equation (1) in the text. The dependent variable is the change in holdings by country j of bond i at time t scaled by the outstanding amount of the bond i at time t. Sample period: 2003-2016 in columns (1) and (4); we exclude the crises years 2008-2012 in columns (2), (3), (5), and (6). The euro area is included as one country. Countries' sovereign rates are the year-end 1-year sovereign yields; the yield for the euro area is the weighted (by GDP) average of the sovereign yields of the euro area countries. Weighted regressions with bonds' outstanding amounts as weights. All regressions include country*time fixed effects and we allow the country fixed effects to differ for newly-issued and seasoned bonds. For brevity the coefficients for fixed effects and the constant are not reported. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Heteroscedasticity-consistent standard errors are reported in parentheses.

	Bond yield			Spread and duration		
	(1)	(2)	(3)	(4)	(5)	(6)
Bond yield	0.071***	0.039***	0.038***			
	(0.005)	(0.007)	(0.009)			
Sov1y × Bond yield	-0.006*	-0.042***	-0.054***			
	(0.003)	(0.004)	(0.005)			
D.CDS (US) × Bond yield	-0.033***	-0.079***	-0.091***			
	(0.002)	(0.006)	(0.008)			
Traded share			0.164***			0.161***
			(0.012)			(0.012)
Bond spread				0.088***	0.056***	0.059***
				(0.006)	(0.008)	(0.010)
Duration				0.002	-0.007**	-0.009**
				(0.002)	(0.003)	(0.004)
Sov1y × Bond spread				0.005	-0.041***	-0.052***
				(0.003)	(0.005)	(0.006)
Sov1y × Duration				-0.018***	-0.012***	-0.016***
				(0.001)	(0.002)	(0.002)
D.CDS (US) × Bond spread				-0.040***	-0.114***	-0.135***
				(0.002)	(0.008)	(0.010)
Observations	215313	134754	107862	215313	134754	107862
R-squared	0.34	0.37	0.40	0.34	0.37	0.40
Sample	2003-2016	Ex. 08-12	Ex. 08-12	2003-2016	Ex. 08-12	Ex. 08-12

Table 8: **Robustness: Alternative Explanations**
For robustness checks, the estimation includes interation terms of our risk variables (bond spread and duration) with the CDS of countries' banking sector (column 1), with the expected earnings growth of countries' corporate sector. (column 2), and with a U.S. dollar equivalent of home yields (column 3). Country sovereign rates are the year-end 1-year sovereign yields; the yield for the euro area is the weighted (by GDP) average of the sovereign yields of the euro area countries. The CDS of the banking sector and the expected earnings growth for the euro area are also the weighted (by GDP) average of the euro area countries. Sample period excludes the crises years 2008-2012. All regressions include country*time fixed effects and we allow the country fixed effects to differ for newly-issued and seasoned bonds. For brevity the coefficients for fixed effects and the constant are not reported. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Heteroscedasticity-consistent standard errors are reported in parentheses. Weighted regressions with bonds' outstanding amounts as weights.

	Bank CDS	Exp. earnings growth	Synthetic dollar home yield
	(1)	(2)	(3)
Bond spread	-0.039**	0.036***	0.002
	(0.020)	(0.011)	(0.012)
Duration	-0.010	-0.002	-0.025***
	(0.008)	(0.005)	(0.004)
D.Sov1y × Bond spread	-0.366***	-0.351***	-0.325***
	(0.028)	(0.026)	(0.027)
D.Sov1y × Duration	-0.018**	0.001	-0.009
	(0.009)	(0.009)	(0.008)
Bank CDS × Bond spread	0.031		
	(0.027)		
Bank CDS × Duration	-0.030***		
	(0.011)		
Exp. Earnings growth × Bond spread		-0.443***	
		(0.108)	
Exp. Earnings growth × Duration		-0.177***	
		(0.045)	
D.Synth rate × Bond spread			-0.037**
			(0.016)
D.Synth rate × Duration			0.020***
			(0.006)
D.CDS (US) × Bond spread	-0.136***	-0.144***	-0.120***
	(0.011)	(0.011)	(0.010)
Traded share	0.163***	0.156***	0.156***
	(0.013)	(0.012)	(0.012)
Observations	99537	107831	107829
R-squared	0.41	0.40	0.40

Table 9: **Robustness: Country Samples**
The table shows the estimated coefficients for equation (1) in the text. The dependent variable is the change in holdings by country j of bond i at time t scaled by the outstanding amount of the bond i at time t. Sample period excludes the crises period 2008-2012. In columns 1-3 the euro area is included as one country. The sample excludes emerging market economies. Countries' sovereign rates are the year-end 1-year sovereign yields; the yield for the euro area is the weighted (by GDP) average of the sovereign yields of the euro area countries. In columns 4-6 euro area countries are included as individual countries. The sovereign rate for Belgium, Ireland, and Luxembourg is the average of the sovereign rates of the Netherlands, France, Italy, and Spain. Weighted regressions with bonds' outstanding amounts as weights. All regressions include country*time fixed effects and we allow the country fixed effects to differ for newly-issued and seasoned bonds. For brevity the coefficients for fixed effects and the constant are not reported. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Heteroscedasticity-consistent standard errors are reported in parentheses.

	Exclude Emerging Markets			Individual Euro Area Countries		
	(1)	(2)	(3)	(4)	(5)	(6)
Bond yield	-0.015**	-0.028***		0.001	-0.000	
	(0.007)	(0.008)		(0.004)	(0.005)	
D.Sov1y × Bond yield	-0.240***	-0.284***		-0.084***	-0.113***	
	(0.019)	(0.023)		(0.008)	(0.009)	
D.CDS (US) × Bond yield	-0.079***	-0.090***		-0.055***	-0.058***	
	(0.007)	(0.008)		(0.004)	(0.004)	
Traded share		0.164***	0.157***		0.034***	0.031***
		(0.012)	(0.012)		(0.007)	(0.007)
Bond spread			-0.014			0.002
			(0.009)			(0.005)
Duration			-0.022***			-0.005***
			(0.003)			(0.002)
D.Sov1y × Bond spread			-0.377***			-0.147***
			(0.027)			(0.011)
D.Sov1y × Duration			0.002			0.002
			(0.010)			(0.004)
D.CDS (US) × Bond spread			-0.135***			-0.077***
			(0.010)			(0.005)
Observations	131353	105000	105000	192262	159593	159593
R-sq	0.37	0.40	0.40	0.26	0.29	0.29