UIP Violations and the Cost of Capital: Firm-level Evidence *

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Abstract

This paper establishes cross-currency differences in risk-free interest rates as a key determinant of the cost of capital at the firm level. I introduce a new security-level data set of primary market prices of corporate bond issuance and find that violations of uncovered interest rate parity (UIP) directly pass through to firm borrowing costs. As a result, firms that issue debt in currencies with high risk-free interest rates face higher effective funding costs, and, consistent with this finding, firms in countries with higher interest rates have a higher return on assets (ROA). When local currency risk-free interest rates are relatively high, firms are more likely to issue bonds in foreign currency, and when they do so, they appear to be more insulated from the local interest rate environment. This suggests that firms use foreign currency bonds as a way to alleviate domestic financial constraints. In contrast to the role of UIP violations, differences in sovereign risk and violations of covered interest rate parity (CIP) do not exhibit a statistically significant relationship with firm borrowing costs.

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1 Introduction

Over the last three decades, private-sector firms have rapidly increased their dependence on cross-border financing. From 1990 to 2019, the total outstanding amount of international corporate debt securities grew from $ 1.1 trillion to $ 22 trillion, a ten-fold increase in real terms.[1] In light of this dramatic increase, a growing body of literature has studied corporate cross-border financing decisions, with an emphasis on the volume of capital flows.[2] However, less is known about the prices at which international financial markets allocate capital across firms and countries.

This paper introduces a novel, security-level data set of borrowing costs on $25 trillion in corporate bond issuance to demonstrate that firms' cost of capital varies substantially and systematically with currency denomination. In particular, I establish a direct link between (i) cross-currency differences in risk-free interest rates and violations of uncovered interest rate parity (UIP), and (ii) corporate bond borrowing costs and firms' return on assets (ROA). Violations of UIP and the existence of the currency carry trade are major stylized facts in international finance. A large literature documents that a simple strategy of lending in high-interest rate currencies and simultaneously borrowing in low-interest rate ones is highly profitable.[3] I show that this phenomenon, which has almost exclusively been studied in currency derivative markets, extends to corporate bond markets and is strongly related to real outcomes at the firm level.

As a result, this paper shows that UIP violations are of first-order importance for our understanding of firms and the allocation of capital across countries. Risk-free interest rate differentials, commonly measured in currency derivative markets as forward premia, pass through almost one-for-one to corporate bond yields. For example, I find that corporate bonds denominated in Japanese yen have substantially lower yields than bonds denominated in Australian dollars, in line with large differences in risk-free interest rates between the two currencies. Importantly, these differences are not due to firm credit risk, as they also extend to bonds issued in different currencies by the same firm. As nominal exchange rates of low-interest rate currencies do not appreciate enough to offset differences in firm borrowing costs, UIP violations extend to corporate bond markets and effective corporate borrowing costs differ substantially by currency. In contrast, I do not find statistical evidence for similar effects due to sovereign risk or violations of covered interest rate parity (CIP). Moving from individual bonds to the underlying firms, I find that differences in risk-free rates are also closely related to variation in firm capital stocks. Firms in a country with high local currency forward premia have higher output to assets ratios than observationally identical firms in a country with low risk-free interest rates, as measured by firm-level ROA. This is consistenet with the view that higher cost of borrowing

[1] BIS debt securities statistics
[2] Gozzi et al. (2015), Avdjiev et al. (2017), Celik et al. (2019), Maggiori et al. (2019)
[3] Fama (1984), Lewis (1995), Engel (1996, 2014)

translates into higher cost of capital for the whole firm. Lastly, I provide a detailed look at firm issuance behavior in global corporate bond markets. Firms in countries with high local currency risk-free rates are more likely to issue foreign currency bonds, and I find that firms that do so appear to be more insulated from their domestic interest rate environment. Even among firms with similar characteristics, foreign-currency issuers have ROAs that are less closely aligned with local risk-free rates than firms that only issue bonds in domestic currency.

At the heart of this research effort is the introduction of a novel data set of corporate debt securities. Previous studies of cross-border firm financing have focused on volumes but have paid much less attention to pricing. My dataset, based on the proprietary Bloomberg Back Office universe, provides detailed primary market pricing information and bond characteristics for $ 25 trillion of corporate bond issuance. The data covers all bonds issued by non-financial corporations from 1995 to 2019, as captured in Bloomberg. While Bloomberg is a standard data provider for financial markets research, this particular data set is new to the literature because it originates from the system's underlying infrastructure, Bloomberg Back Office, which requires a separate subscription, at considerable cost, and is commonly only used by large financial institutions.

This paper makes three main contributions. First, I document a strong empirical relationship between differences in risk-free rates and corporate bond yields. The standard textbook approach defines the yield of a corporate bond security as the combination of two components: a risk-free rate, and a residual, commonly referred to as the credit spread. When risk-free rates differ across currencies, one may expect that corporate bond yields reflect this difference, which would mean that UIP violations directly pass through to the firm. To document that this relationship holds in the data, I regress the corporate bond yield differential (i.e., the difference between the corporate bond yield, denominated in a foreign currency, and the duration-matched US risk-free interest rate) on the forward premium, which measures differences in risk-free rates between the bond's currency of denomination and the US dollar. These regressions consistently estimate a coefficient that is close to one and robust to controls for industry effects and bond maturity structure. In additional regressions, I control for a broad set of firm variables to ensure that the difference in bond yields can truly be attributed to variation in the risk-free rate component of corporate bond yields rather than to other firm characteristics. To exclude selection effects, I make use of a special feature of international bond markets and examine the yields of bonds issued by multi-currency issuers, i.e. firms that issue bonds in multiple currencies simultaneously.

Even within the same firm at the same time, bond yields vary substantially with risk-free interest rate differentials between the underlying issuance currencies. To show this empirically, I add a firm-year fixed effect to the original regression. This absorbs all variation at the firm level, and as a result, the pass-through coefficient is solely estimated based on variation in bond yields within an individual firm. The underlying identifying assumption is that at a given point in time, all bonds issued by a firm carry the same default risk. This assumption is reasonable since corporate bond contracts commonly include cross-default or "pari passu" clauses.[4] This new, tightly identified regression produces a pass-through coefficient for risk-free rate differentials that is still very close to one. This indicates that selection on unobservables is not driving the earlier results.[5]

In contrast to the importance of cross-currency risk-free rate differentials for firm financing, other prominent features of international financial markets, namely sovereign risk and violations of covered interest rate parity (CIP), do not appear to be statistically related to firm borrowing costs in primary bond markets. A growing literature argues that sovereign default risk has large effects on firm borrowing costs (Bocola, 2016). However, once forward premia are accounted for, the effect of sovereign risk, measured by credit default swap contracts (CDS), on corporate bond yields is statistically indistinguishable from zero. A similar observation follows from the inclusion of CIP violations in the bond-level regressions. CIP violations describe arbitrage opportunities where interbank interest rate differentials between two currencies diverge from forward premia in derivative markets (Du et al. 2018). In primary markets, and after controlling for forward premia, the relationship between corporate bond borrowing costs and CIP violations is also statistically insignificant.

Because of the pass-through of risk-free interest rate differentials to corporate bond yields, firms face very different funding costs depending on the currency denomination of their debts. Differences in bond yields persist even after taking into account changes in the nominal exchange rate of the issuance currency. As a result, bonds issued in currencies with higher risk-free interest rates also have higher dollar cash flows, which means that they are more costly for the issuer. This finding provides direct evidence that violations of UIP extend to corporate bond markets, and that currency denomination is a key determinant of firm borrowing costs.

Secondly,I show that the same risk-free interest rate differentials are strongly related to variations in firm ROA. While there are strong effects of risk-free rate differentials on firm borrowing costs, corporate bonds make up only a fraction of total firm financing. Hence, I separately establish a relationship between UIP violations and firm-level cost of capital that takes into account a broader set of funding sources. A simple model of firm capital choice predicts that firms in countries with a higher risk-free interest rate will have higher required rates of return, resulting in higher output-capital ratios. I proxy for this ratio with firm-level return on assets (ROA), calculated as an average over the five years after a firm borrows in corporate bond

[4] Li et al. (2015), Liao (2019)

[5] The results are unchanged when I use firm-month fixed effects, which forces the regression to identify pass-through using only bonds issued by the same firm in a very narrow time window. In additional robustness checks, I find that other bond characteristics, such as the market of issuance or bond seniority, also do not affect my results.

markets. Then I regress firm ROA on the firm's local currency forward premium. Even with a broad set of firm- and industry-level controls, I find a strongly positive relationship between local currency risk-free rates and firm ROA, which predicts that a firm in an economy with high currency returns like Australia will have a higher output-capital ratio, i.e. a lower capital stock for a given amount of output, than a similar firm in a country with low currency returns like Japan.

Since differences in risk-free interest rates between countries are large and persistent,[6] this result uncovers systematic variation in firm ROA, and hence firm capital stocks. Heterogeneity in the distribution of capital across countries has been a major topic of research in international macro, also referred to as the allocation puzzle. Beyond the previously proposed factors, such as variation in property rights (Hall and Jones, 1997), taxation rates (Jorgenson, 1996) or the capital share of output (Karabarbounis and Neiman, 2014), my findings point to differences in risk-free interest rates between currencies as an important potential driver, even among developed economies. A simple example highlights the economic significance of this relationship. Over the last 20 years, risk-free interest rates have been 4.4 percent higher in Australia than in Japan. The estimated relationship suggests that the ROA of an Australian firm will on average be close to two percentage points higher, measured in common units, than the ROA of an observationally identical Japanese firm. This difference accounts for about a third of the long-run difference in average firm ROA between Japan (9 percent) and Australia (15 percent).

Lastly, this paper provides new, detailed evidence on how firms issue bonds in multi-currency bond markets. These findings are important complements to those on investor portfolio holdings in Maggiori, Neiman and Schreger (2019), and provide a new dimension to earlier results based on quantities by adding data on borrowing costs. In the aggregate, non-financial firms almost exclusively issue bonds in local currency or in US dollars and I observe substantial heterogeneity in the currency composition of bond issuance at the country-level. At the firm level, size and real hedging demands from foreign sales exposure are important but not the only correlates of funding currency choice. Even after controlling for these factors, I find that firms rely more on foreign currency debt when local risk-free interest rates are high relative to the rest of the world - in particular relative to the US. This observation suggests that firms issue foreign currency bonds to access lower financing costs available abroad, even when real hedging motives do not play a role.

Consistent with this perspective, I find some evidence that foreign-currency issuer firms are more insulated from their domestic interest rate environment than firms that only issue bonds in local currency. Given the documented relationship between local currency interest rate differentials and firm cost of capital, lower funding rates on foreign currency bonds may be related to a lower required rate of return for the firm. I again regress firm ROA on the local currency forward premium and test if foreign-currency issuer

[6] Lustig, Roussanov and Verdelhan (2011); Hassan and Mano (2019)

firms have a different coefficient on forward premia than local currency issuers. Accounting for the same set of stringent controls at the firm- and industry-level, I find that the alignments of firm ROA and local interest rate differentials are substantially reduced for foreign-currency issuer firms. As a result, among this subset of companies, there is less systematic dispersion in capital allocation across countries. Because a firm's ability to access foreign currency bond markets is unlikely to be exogenous, this relation is primarily a correlation and not necessarily causal. But this finding, which persists even among firms with similar size and observable real hedging motives, is consistent with the interpretation that foreign-currency issuer firms face a required rate of return that is less dependent on the local interest rate environment relative to the global one. Consistent with the interpretation that this can serve to loosen domestic financial constraints, within-firm evidence shows that becoming a foreign currency issuer is related to lower levels of firm ROA going forward.

The findings in this paper connect to several strands in the literature in international finance. Most immediately, it documents the relevance of UIP violations and the carry trade for corporate credit markets and firm real outcomes. While a number of papers show that macroeconomic factors are represented in the cross-section of currency returns (Lustig and Verdelhan, 2007; Della Corte et al. 2016; Colacito et al. 2019; Lustig and Richmond, 2019), this paper is the first to connect risk-free rate differentials and UIP violations to outcomes at the corporate bond and firm level.

In relation to the large literature on UIP violations, my findings are also relevant to a growing list of papers that study fundamental risk-based explanations of UIP violations.[7] In these papers, differences in the stochastic properties of exchange rates can generate cross-country variation in risk-free interest rates and currency returns. Countries with a more pro-cyclical exchange rate are a worse hedge from the perspective of a global investor and hence need to have higher interest rates and pay higher currency returns, on average. The underlying mechanism, shared among the different papers in this literature, has immediate implications for capital accumulation (Hassan, Mertens and Zhang; 2016). Countries with counter-cyclical exchange rates and low interest rates accumulate more capital because of the implicit hedge value of local assets.[8] My findings on the connection between firm ROA and currency risk-free rate differentials provide direct, micro-level evidence consistent with the predictions of this set of models.

The results in this paper also point to a connection to the literature on global capital allocation and development. Starting with Lucas (1990) and expanded by Gourinchas and Jeanne (2006, 2013), this line of research documents that global capital flows are at odds with the predictions of the standard neoclassical growth model. In the baseline model, low capital stocks in one country imply high returns, which should

[7]The list of papers include Hassan, (2013), Farhi and Gabaix (2015), Ready, Roussanov and Ward (2015), Maggiori (2019), and Richmond (2019).

[8]In these models, this is limited to firms in the non-traded sector.

attract capital inflows from abroad. In the data, however, we observe very little flow of capital from countries with high capital stocks to those with low capital stocks, if not the opposite. This paper also documents systematic dispersion in firm ROA at the country-level, even among firms that have access to corporate bond markets, and shows that this dispersion is aligned with long-lasting differences in risk-free interest rates. This points to a connection between firm capital stocks and different levels of required rates of return that are not matched in models with a single global risk-free interest rate.[9]

A growing literature studies the role of international financial markets and foreign currency-denominated debt for corporate borrowers (Bräuning and Ivashina, 2019; Eren and Malamud, 2019). These papers are based on the assumption that foreign currency debt provides cheaper funding rates for firms, motivating them to take on exchange rate exposure. Hence, they implicitly assume that risk-free interest rate differentials pass through to individual firms (Bruno and Shin, 2017; Gopinath and Stein, 2018; Salomao and Varela, 2019). This paper is the first to provide explicit evidence for this assumption and and to estimate a pass-through coefficient in international bond markets.

In this context, the finding that foreign-currency issuer firms exhibit lower sensitivity to local risk-free rates is particularly important for, consistent with, recent work that studies real effects of foreign currency corporate debt. Salomao and Varela (2019) develop a model of firm funding currency choice and show that in an emerging economy, firms with access to foreign currency funding increase capital stocks more rapidly than others. The results in this paper, predominantly based on firms in advanced economies with deep financial markets, are consistent with an application of their model to a broader set of firms.[10] My findings on foreign-currency issuer firms also points to a connection between my paper and Maggiori, Neiman and Schreger (2019), who show that investors have a strong bias towards holding assets denominated in their home currency or the US dollar. My findings are consistent with the idea that investor segmentation along currency denomination may have real effects on the international allocation of capital. In thematically related work, Liao (2019) studies the interaction of CIP violations and corporate credit spreads in secondary market pricing, while I consider the role of UIP violations in overall firm funding costs in primary markets.

The paper is structured as follows. Section 2 discusses the data set and its construction. Section 3 studies the connection between currency interest rate differentials and firm bond borrowing rates, while section 4 documents that UIP violations are also closely related to firm-level variation in ROA. Section 5 discusses variation in the currency composition of corporate bond issuance and the distinct relationship between firm real outcomes and domestic currency risk-free rate differentials for foreign-currency issuers. Section 6 concludes.

[9] In this way, this paper also connects to the literature on capital misallocation at the firm level (Restuccia and Rogerson, 2008; Hsieh and Klenow, 2009)

[10] 90 % of the firm-level observations in my sample are related to firms in developed economies.

2 Data

This paper is based on a newly compiled data set that combines three separate databases of corporate bond securities, firm fundamentals, and currency market instruments. I discuss each in turn below.

2.1 Corporate Bonds

The main empirical innovation of this paper is the introduction of a novel data set of primary corporate bond issuance. What sets this data set apart from the existing literature on international corporate financing is the availability of primary market prices, which represent the actual cost that firms pay to raise funds in corporate bond markets.[11] My data set consists of 105,000 individual corporate debt securities, issued by 17,000 firm entities and covers $25 trillion of gross bond issuance from 1995 to 2019. These observations represent all corporate bond securities issued by non-financial, private-sector firms, as far as they are captured in the Bloomberg data universe. While Bloomberg is a standard source for research on financial markets, this particular data set is new to the literature as it requires a separate, costly subscription to the metadata underlying the Bloomberg system (Bloomberg Back Office). Bloomberg Back Office is generally only accessed by financial firms, where, among other uses, it is often a key input in security master lists that are important for portfolio monitoring and risk modeling. I gain access to this data through a large financial institution.

While Bloomberg Back Office contains more than 500,000 individual securities that are widely defined as corporate bonds, I focus on the subset of corporate bonds issued by private sector non-financial firms. I exclude any bonds whose sector description indicates the financial industry or the government sector. To this end, I consider both the immediate issuers' designation as well as that of the ultimate parent companies, which is also identified by Bloomberg. Also, I exclude commercial paper and other short-term instruments with a time to maturity below one year but include private placements.

For each bond, I have a detailed set of attributes available, such as total amount issued, currency denomination, maturity date, coupon size, type and frequency, embedded options, bond seniority, and the market of issuance. I also observe the name, ticker, and country of origin for each issuer firm and, if applicable, any parent firms thereof, as identified by Bloomberg. This is an important piece of information since firms frequently use subsidiaries domiciled in different countries to issue securities (BIS, 2016; Copola et al. 2019).[12]

[11] Most firms issue bonds infrequently and the process is connected with long lead-up times, all of which may lead to secondary market prices being an inexact measure of actual firm financing costs. The issuance process generally includes a pre-launch stage, which consists of legal preparation and negotiations with advising investment banks and a separate launch or "road show" period, during which the firm and the representing banks drum up investor interest. The advising investment banks ("book runners") commonly allocate shares of the issuance to specific investors rather than releasing all of it into open markets.

[12] For example, the automaker BMW issues bonds in different currencies through different direct subsidiaries that are located in the respective countries: BMW Finance N.V. issues euro-denominated bonds and is domiciled in the Netherlands, while BMW US Capital LLC issues US dollar-denominated debt, and is domiciled in the US.

Most relevant for my purposes, the available information on the bond coupon structure and the issuance price allow me to calculate the yield-to-maturity on all fixed-coupon and zero-coupon bonds in my sample. I also convert each bond's issuance amount to US dollars using the spot exchange rate of the issuance currency at the time of issuance.[13]

For external validity, I compare the total volume of gross bond issuance in my data set against volume calculations by the OECD (Celik et al. 2019), which also looks explicitly at non-financial firm issuers. Gross issuance in my data set is at least as large as what they document, based on SDC Platinum data, on a year-by-year basis. The Bloomberg data set also provides additional historical data back to the pre-2000 period (see Figure 8 in the appendix). As a result, my data set appears to provide a comprehensive picture of global corporate bond issuance by non-financial firms, which extends beyond the data universe traditionally used in the literature.

In the following, I use the data set of individual corporate bonds in two ways. In the bond-level analysis in section 3, I study the explicit borrowing costs associated with each security and its connection to currency market instruments. As a result, this analysis is based on all corporate bonds with no missing pricing information and a fixed- or zero-coupon cash flow structure that is required to calculate the yield to maturity. Also, I drop all bonds with special features, such as convertible bonds, bonds with dual currency payout structure, or with inflation indexation (popular in Latin American markets). This results in a data set of 53,000 individual bond securities for which the appropriate currency market data is available, as described below. Panel A in Table 1 shows the summary statistics of the bond data set. The median bond has a yield-to-maturity of 4.8 percent, a time-to-maturity of seven years, and a duration of 5.7 years. The median bond raises $130 million, converted at spot exchange rates, though the distribution of bond sizes is widely dispersed and with a large right tail. In sections 4 and 5, I aggregate up all available bonds to calculate total bond issuance volume and the underlying currency composition at the firm level, as desribed in the next section.

2.2 Firm fundamentals

For the study of firm behavior, I trace back the individual bonds to the underlying issuers. Using the Factset data universe, I match each bond ISINs to the commensurate Factset identifier, which connects to the underlying firm. This way, I can match two-thirds of the total dollar gross issuance volume at the bond level ($17.4 trillion). This results in 20,500 firm-year observations where I observe both firm fundamentals and primary bond issuance activity.[14]

[13] I use the closing exchange and forward rates at month end.

[14] Factset directly links bonds to the underlying firm if issuance takes place through a wholly-owned subsidiary, as in the example of BMW's different subsidiaries used for bond issuance. To be conservative, I do not aggregate up beyond this

The Factset data set provides extensive information on corporate balance sheets for public and private firms globally. Since outside of the US quarterly reports are often not required, even for public firms, I use balance sheet data as collected from annual reports. The variables of interest include firm total assets, sales, earnings, net income, debt, and cash holdings. I present most variables as ratios to firm assets or sales, otherwise I convert figures using the annual average exchange rate of the currency of documentation to the US dollar. I also trim the resulting variables at the one-percent level to deal with extreme outliers that are most likely due to data error. All results are robust to the inclusion of outliers. Of particular interest are data on firm international exposure, which I measure as the ratio of international sales to total sales, and international assets to total assets, where all assets and sales outside of the firm's country of origin are taken into account.

For consistency, I ascribe to each firm the ultimate parent company's country designation from Bloomberg, as previously used at the bond level. I confirm that my results are robust to using the immediate firm's country of origin as identified by Factset. The data set is quite diverse in regional exposure, with around a third of all matched firm-year issuance observations coming from the US (accounting for $8.2 trillion of total issuance). Panel B in Table 1 displays the summary statistics for the firm-level data set. Across all firms identified from the bond-level data, the median amount of total issuance (the sum of all bonds issued in a given year) is $430 million, again with a large right tail of very high issuance amounts.[15] Converted at spot exchange rates, the median firm has close to $9 billion worth of assets and a return on assets (ROA) of 10.5%. Median firm leverage is 34% and cash holdings are 24%. Around a quarter of all sales are sourced internationally for the median firm.[16]

2.3 Currency markets

Lastly, I collect spot and forward exchange rate data on 26 currencies, including all major developed market currencies and the main actively and freely traded emerging market currencies, for which the necessary currency market instruments are available in Bloomberg.[17] All exchange rate measures, spot and forward, are measured against the US dollar.

I follow the literature on UIP violations and calculate the forward premium in currency markets (Engel, 1996) to measure differences in risk-free interest rates. Under the assumption of covered interest rate parity

immediate match from Factset.

[15] Large bond issues are often used to fund M&A transactions. The largest individual bond in my sample is a Verizon 30-year security with an issue amount of $15 billion, which is part of a $49 billion raise in 2013 to fund the acquisition of Vodafone's minority share in Verizon Wireless.

[16] The duration and maturity profile of bond issuance, averaged by firm, is similar to the distribution at the bond level.

[17] Since access to local capital markets is highly restricted and currency markets are actively managed, this means that I do not include China in my analysis. Chinese corporate bond markets have grown dramatically in recent years, but the lack of currency convertibility for both firms and investors make cross-currency comparisons of borrowing cost not immediately comparable.

(CIP), the spread between the forward and the spot exchange rate is equal to the difference in risk-free interest rates between the two currencies.[18] In the following, I define the differential between risk-free interest rate r in currency j and the US dollar as

$$r_t^j - r_t^{\$} = f_t^j - s_t^j,$$

where s^j and f^j denote the log of the current level of spot and forward exchange rates of currency j to the dollar. The forward premium represents differences in *risk-free* rates, as forward contracts are free of sovereign default risk since they are struck with international broker-dealers or banks instead of national institutions. Contracts are standardly collateralized, and any counterparty risk would affect all contracts instead of varying systematically across currencies.

International investors can directly operate in currency forward markets, which are deep and highly liquid.[19] As a result, the literature on UIP violations, starting with Fama (1984), has almost exclusively studied this set of instruments. Across currencies, the forward premium provides a standardized measure of interest rate differentials, which is of particular importance for emerging market currencies, where interbank markets may be less accessible or contaminated with default risk. Since currency forwards are less liquid for longer time horizons, I rely on cross-currency swaps from interbank markets to calculate the forward premium for risk-free differentials with maturities of longer than a year (Du and Schreger, 2016).[20] I obtain all relevant currency instruments from Bloomberg.

In line with the data on forward points and currency swaps, I measure the US risk-free interest rate with US dollar interbank interest rate swaps (IRS) at the same maturity points.[21] In the data, the interbank swap rate is generally close to the interest rate on a comparable government bond. I also add data on violations of CIP, measured using the cross-currency basis.

Lastly, I also add data on sovereign default swaps (CDS) from Bloomberg. These measure the cost of insurance against default on the US dollar-denominated sovereign bond of a given country. To make sovereign spreads directly comparable to differentials in risk-free interest rates between currencies and the US dollar, I compute a similar differential between each country's sovereign CDS and the CDS on US government bonds.

[18] While CIP has historically held across frequencies and maturities in currency markets, Du et al. (2018) document sizeable deviations during the financial crisis and smaller ones in the time since. I control for these deviations in the bond-level analysis and find that they do not appear to have a significant effect on firm borrowing costs.

[19] The latest BIS Triennial Central Bank Survey puts total daily turnover in currency markets at \$6 trillion US dollars in 2019. Currency forwards and swaps make up more than 65% of daily turnover. While most of the volume is concentrated in maturities of one year or less, currency swaps and forwards with maturities of over one year had an average daily turnover of \$ 48 billion in 2016, the last available data point. For reference, the World Bank puts the total value of all stocks traded globally at \$ 77 trillion for the same year, which comes out to \$ 300 billion of daily turnover, assuming 252 trading days.

[20] I calculate risk-free interest rate differentials using forward and cross-currency swap contracts at the 1, 2, 3, 5, 7, and 10-year maturity points and linearly interpolate for the intermittent years, as in Liao (2019).

[21] I use the interest rate on the fixed leg of a fixed-for-floating interest rate swap, in which market participants agree to swap floating interest payments at the current LIBOR rate against fixed-rate payments for the duration of the contract.

3 Risk-free interest rate differentials and corporate bond yields

In this section, I show that differences in risk-free interest rates across currencies pass through to corporate borrowing costs in bond markets. Recent work has documented that cross-country differences in risk-free rates are large and persistent and that nominal exchange rates do not move enough to erase these differences, leading to violations of UIP (Hassan and Mano, 2019). Hence, if risk-free interest rate differentials pass through to corporate bond yields, then corporate bonds will also be affected by UIP violations. As a result, firms face different financing costs based on the denomination of their bonds, a new observation since UIP violations have historically only been documented in government bond and currency derivatives markets.

3.1 Linking risk-free interest rates to corporate bond yields

How do risk-free rates relate to corporate bond yields? In standard asset pricing form, we can write the price of a one-period risky (corporate) bond, issued by firm i in currency j as

$$P^j_{i,t} = \mathbb{E}\left(M^j_{t+1}(1 - D_{i,t+1})\right), \tag{1}$$

where M^j denotes the pricing kernel in currency j (Backus, Foresi and Telmer, 2001), and D_i describes the loss on default. Assuming risk neutrality for parsimony, and using the standard property of the pricing kernel that

$$\mathbb{E}\left(M^j_{t+1}\right) R^j_t = 1, \tag{2}$$

where R^j denotes the risk-free interest rate in currency j, we can re-write this expression in logs. Approximately, this gives

$$y^j_{i,t} = r^j_{t+1} + d_{i,t+1}, \tag{3}$$

where y^j_i denotes the yield on the bond issued by firm i in currency j, and d_i is defined to represent the residual or the expected loss from default, which under risk-neutrality, is equivalent to the credit spread. [22] As a result, we observe that the yield on a corporate bond represents the combination of a credit spread (or residual) and a risk-free rate, which depends on the currency of bond denomination. Hence, if risk-free interest rates differ across currencies, bond yields will vary accordingly. Subtracting the US dollar risk-free rate on both sides, we can uncover a relationship between corporate bond yields and the risk-free interest

[22] Under the assumption that credit risk for a given firm is independent of bond currency denomination, d only depends on i, not j. As I discuss below, this assumption is based on the observation that corporate bond contracts commonly include cross-default clauses, under which default is indiscriminate. Without risk neutrality, d_i would also include potential covariance terms between the pricing kernel and firm default, which may differ by by currency denomination. I discuss this special case in appendix A2.

rate differential between the dollar and the currency of bond denomination:

$$y_{i,t}^{j} - r_t^{\$} = (r_t^{j} - r_t^{\$}) + d_{i,t+1}. \tag{4}$$

This equation shows that differences in risk-free interest rates, which can be approximated with forward premia in currency markets, should directly pass through to corporate bond yields. In this section, I test if this relationship is reflected in the data while controlling for variation in the credit spread residual. Because of the large literature that documents violations of uncovered interest rate parity in risk-free interest rates, if these differentials pass through to corporate bond yields, this implies that firms will differ in their cost of financing based on the currency denomination of their bonds.

Before moving to the regression analysis, I inspect the data visually. As a particularly prominent example, Figure 1 shows a boxplot of the yield-to-maturity on all corporate bonds issued in Japanese yen (JPY) on the left-hand side and of those issued in Australian dollar (AUD) on the right-hand side. For each year covered in my sample, the graph shows the interquartile range (IQR) of yields with boxes, while the whiskers capture the minimum and maximum values observed. The graph shows some variation in corporate bond yields within currency denomination but differences in bond yields across denominations are substantially larger. While corporate bond yields can vary for a whole range of reasons, in particular, as they pertain to differences in credit risk across firms, the most obvious explanation for the cross-currency variation in bond yields is the difference in risk-free rates between the yen and the Australian dollar. The thick line in each graph shows the 5-year risk-free rate in each currency.[23] Since risk-free rates are substantially higher in Australia than in Japan, corporate bond yields in Australian dollars are systematically and meaningfully higher. As a result, the graph crystalizes the first key observation of this paper, which I document more rigorously in a regression setting below.

A less immediate but important observation in the graph is that, at least on some rare occasions, we observe corporate bond yields that are below the 5-year risk-free rate. This, however, does not indicate that firms can borrow at rates that are lower than the respective issuance currency's risk-free rate. Instead, it reflects that firms issue bonds with a wide range of maturities. While the 5-year risk-free interest rate is an appropriate point of comparison for the median bond in the sample, which has a duration of 5.7 years, it is likely to be a less accurate match for securities that have noticeably shorter or longer maturities. Furthermore, corporate bonds also exhibit substantial heterogeneity in their payout structure. While a small set of bonds only repays the bond's face value at the time of maturity (zero-coupon bonds), most bonds have regular coupon payments scheduled over the life of the bond. The cash flow properties of most corporate

[23] Consistent with the construction of forward premia, I measure the risk-free rate from the fixed-rate leg of a fixed-to-floating interbank interest rate swap. In the data, these rates closely follow the respective government bond benchmark rate.

bonds hence stand in contrast to those of the standard measures of risk-free interest rates and forward premia, which are generally zero-coupon instruments.

To jointly account for these differences in the regression analysis below, and in order to make corporate bonds comparable across characteristics and currencies, I match each security to the respective risk-free rate measures based on each bond's duration. The duration of a bond represents the average time to repayment, based on the timing of all cash flows. As a result, a corporate bond with a high coupon will have a shorter duration than maturity.[24] Since duration is equal to the time to maturity for a zero-coupon asset, a corporate bond with a five-year duration will be matched to the five-year forward premium, for example.[25]

3.2 Regression analysis

Building on this foundation, I can now test for the link between risk-free interest rate differentials and corporate bond yields, while controlling for alternative explanatory factors. The standard regression is specified as

$$y_{i,t}^{j,d} - r_t^{\$,d} = \beta(r_t^{j,d} - r_t^{\$,d}) + X'_{i,t}\gamma_t + \theta_t^{industry} + \omega_{l,t}^{maturity} + \epsilon_{i,t}, \tag{5}$$

where $y_{i,t}^{j,d}$ denotes the yield on a corporate bond denominated in currency j and with duration d. $r^{j,d}$ refers to the risk-free rate in currency j with the matching duration d. X denotes the vector of controls at the firm level, θ captures the industry-year fixed effect, and ω denotes the maturity bucket-year fixed effects.

I use the corporate bond yield in currency j minus the duration-matched US risk-free rate as the left-hand side variable. This ensures that all bonds are compared to a common baseline, similar to the perspective of a US investor. On the right-hand side, I include the forward premium, i.e. the risk-free rate differential between the bond's currency of denomination j and the US dollar. As described above, all interest rate variables, including the forward premium, are matched to the underlying corporate bond's duration d to adjust for differences in interest rate risk. In order to account for possible systematic variation of credit risk of issuer firms with bond currency denomination, I include a broad set of controls of firm characteristics and industry-year fixed effects. Lastly, in addition to duration-matching, I also account for variation in bond maturity directly in a non-parametric way by including bond maturity buckets, interacted with year-fixed effects. This controls for the possibility that there are systematic differences in bond maturity by issuance

[24] A 7-year bond with annual coupon payments at an annualized rate of 10 percent, issued at par and with a yield-to-maturity of 10 percent, will roughly have a 5-year duration. The formula for Macaulay Duration M is $M = \frac{\sum_{t=1}^{n}\left(\frac{t \cdot C}{(1+y)^t}\right) + \frac{n \cdot V}{(1+y)^n}}{P}$, where P represents the current bond price, n denotes the total number of years (or coupon payment periods), and y is the periodic yield. C denotes the coupon payments and V the bond's maturity value.

[25] This approach follows Gilchrist and Mojon (2018), who show that this procedure delivers a close approximation of the exact cash-flow matching in Gilchrist and Zakrajsek (2012). In the appendix, I document that my empirical findings are robust to the alternative matching process, based on bond maturity (Table A4).

currency [26] In addition, I separately consider the role of sovereign risk and CIP violations in section 6.

The regression results are reported in Table 2. Throughout this paper, unless otherwise noted, I report standard errors that are clustered at the country-level.[27] The first row presents the estimates of the coefficient on the risk-free interest rate differential, $\hat{\beta}$, which can be interpreted as a pass-through coefficient. Throughout the different specifications, the coefficient is consistently estimated to be almost exactly equal to one, with a high degree of statistical significance and a low standard error, ranging between 0.05 and 0.1. This indicates that observed differences in risk-free interest rates across currencies pass through directly to corporate bond yields.

Since the yield on a corporate bond contains both risk-free interest rates as well as compensation for credit risk, it is possible that selection between currency forward premia and firm characteristics drives the estimated coefficient. This could overstate the effect of forward premia if riskier firms are more likely to issue in high-interest rate currencies. In order to account for this possibility, I consider a range of additional controls that are likely correlated with credit risk.

Column 1 shows the pass-through coefficient based on the baseline regression without industry-year fixed effects and without firm characteristics. Column 2 adds industry-time fixed effects, and column 3 adds firm-level characteristics. These variables appear to be statistically related to the corporate credit risk residual: firm size, measured as the log of total firm assets in US dollars, is strongly negatively related to corporate bond yields, consistent with the observation that larger firms tend to be less risky. Firm leverage, on the other hand, is positively related to bond yields, in line with intuition.[28] Even after controlling for a range of variables that are conceptually closely related to the credit spread residual in corporate bonds, the estimated coefficient on the currency forward premium is stable and persistently close to one.

I further document that these differences in bond yields directly translate into differences in effective borrowing costs at the firm level, after taking into account changes in the nominal exchange rate. Under the assumption of UIP, current differences in risk-free interest rates are offset by future shifts in the nominal exchange rate, so that ex post, total returns in common currency are equalized. I test for the failure of UIP at the firm level by calculating the effective borrowing cost of a given corporate bond. If UIP held over the life of a bond, then we would expect that the currency in which the borrowing firm makes coupon and principal payments appreciates if the respective risk-free rate is low. The currency appreciation would hence

[26] I use separate buckets for bonds with a maturity of one to three years, three to seven years, and for maturities greater than seven.

[27] The appendix provides a broad range of alternative standard error calculations that document the robustness of my empirical results. Countries in the euro area are treated as separate clusters, but my findings are robust to treating them as one.

[28] Corporate cash holdings are positively related to bond yields, although this finding is not robust in additional specifications discussed below. Also, I do not find evidence that, after controlling for variables discussed above as well as currency forward premia, firms with more international exposure have higher borrowing costs. Table A2 in the appendix further shows that the results persist in subsamples of bonds with explicitly similar duration.

increase the effective (US dollar) repayment costs for the firm. Next, I test if differences in risk-free rates between currencies are related to differences in realized borrowing costs.

To approximate the effective borrowing costs in different currencies, I add the annualized rate of appreciation in the nominal exchange rate of the bond's currency of denomination to the US dollar over the life of the bond, so that the regression's left-hand side variable is now defined as:

$$y_{i,t}^{j,d} - r_{i,t}^{\$,d} + \Delta s_{i,t+d}^{j,d}, \tag{6}$$

where $\Delta s^{j,d}$ denotes the annualized change in the nominal exchange rate of currency j versus the US dollar from time t to $t+d$, and a positive number indicates appreciation of the local currency. Because of the frequent coupon payments of many corporate bonds, which means that firms already pay out a substantial amount of borrowing costs way before the maturity date, I calculate the change in the nominal exchange rate from the time of issuance t to the point in time in the future that represents the average weighted time of all cash flows $t+d$. I then repeat the baseline regression with this new variable on the left-hand side. If risk-free interest rate differentials were perfectly offset by nominal exchange rate shifts over the life of a bond, then the effective borrowing cost in US dollars, i.e. the corporate bond yield plus currency appreciation, should show no relation to risk-free interest rate differentials. Instead, the effective borrowing cost should be the same for all bonds, irrespective of their currency denomination.

The data strongly rejects this hypothesis. While the coefficient on the forward premium is slightly smaller, the pass-through is still very high at 0.7, with a standard error between 0.13 and 0.19. Using the same regression specifications as before, I find that higher risk-free interest rate differentials are also strongly related to higher effective financing costs. The slight decrease in coefficient size may represent the tendency of high-interest rate currencies to depreciate somewhat more than low-interest rate currencies, but nowhere near what would be required by UIP. In addition, the larger standard errors also suggest that the increased volatility from including the exchange rate term may bias the estimated pass-through coefficient towards zero. In conclusion, there is ample evidence that differences in risk-free interest rates across currencies are directly related to corporate borrowing costs, both ex ante and ex post.

3.3 Within-firm evidence

Even though I control for a number of different axes of differentiation across firms, I cannot fully exclude the possibility that there are selection effects between the issuer firm and bond currency denomination. I approach this concern in two ways. First, Oster (2019) proposes a formalized test for the robustness of a coefficient to bias from selection on unobservables. I show in the appendix (section A1) that the pass-through coefficient passes the established critical values, which indicates robustness. A second approach, based on particular features of international corporate bond markets, provides a more direct test, which also allows for a more precise estimate of the size of the pass-through coefficient.

In my data set, I observe that a subset of firms issue bonds in multiple currencies and often does so in close succession. As a concrete example, I observe that BMW issued a US dollar-denominated bond on August 14, 2018, and subsequently issued a euro-denominated bond two weeks later. Even though the bonds are similar in maturity structure and size, the yield-to-maturity is dramatically lower on the euro-denominated bond, in line with the risk-free interest rate differential between the two currencies at the time. Since it is relatively unlikely that BMW's credit risk had changed drastically over the course of two weeks, I use within-firm variation in borrowing costs to identify the pass-through of risk-free rate differentials to corporate bond yields.

Multi-currency issuer firms are not a rare aberration in bond markets. While firm-year observations with multi-currency issuance make up less than ten percent of the total number of observations in the sample, they account for close to a fourth of total gross issuance ($ 6.8 trillion). More generally, multi-currency issuers are responsible for three times as many bonds and four times as much dollar volume in a given year as the average firm.[29]

In order to take advantage of this feature in the data, I return to the regression setting from above and add a firm-year fixed effect. As a result, the pass-through coefficient is no longer estimated across firms but instead only within firms. Since the firm-time fixed effect absorbs the average bond yield for the firm at a given time, we can directly attribute differences in bond yields to variation in currency denomination.[30]

The key identifying assumption for this regression is that for the same firm, at the same time, bond currency denomination is uncorrelated with other drivers of bond yields, and credit risk in particular. This assumption would not be valid for sovereign bonds, where selective defaults and restructurings are common and credit spreads reflect this distinction (Du and Schreger, 2016). However, it is generally appropriate for corporate bonds, since the underlying bond agreements commonly contain cross-default clauses.[31] These clauses effectively make selective default highly costly for corporate borrowers, since default on a single bond allows all lenders (including bondholders) to sue the issuer company for bankruptcy and to accelerate any outstanding debt payments.[32]

[29] Details on the relative figures are provided in the appendix in Table A1.

[30] The duration-matched US risk-free rate on the left-hand side and the maturity bucket-year fixed effects take into account differences in yields that arise from differences in bond maturities. Table A3 in the appendix shows that the coefficient is stable in regressions based on subsamples of bonds with similar duration.

[31] Li et al. (2015), Liao (2019)

[32] In additional robustness checks in Table A5, I further demonstrate that my results are not affected by differences in bond issuance markets, or by bond seniority, which are additional reasons why credit risk may vary across bonds issued by the same firm.

Since the firm-year fixed effect subsumes any variation at the cross-firm level, I can drop firm- and industry-level controls.[33] The regression now takes the following form:

$$y_{i,t}^{j,d} - r_t^{\$,d} = \kappa_{i,t} + \beta\,(r_t^{j,d} - r_t^{\$,d}) + \omega_{m,t} + \epsilon_{i,t}, \tag{7}$$

where κ denotes the firm-time fixed effect and all other terms are as described above.The resulting pass-through coefficient, which is now cleanly identified and not exposed to potential selection between issuer firms and issuance currency, is presented in Table 3. Even with this stringent set of controls, the pass-through coefficient is still estimated to be very close to one, at 0.85 and with a standard error of 0.07. This documents that even within a single firm at the same time, bond yields can differ substantially and do so in alignment with the differences in risk-free interest rates of the underlying issuance currencies. Furthermore, the stability of the regression coefficient, which is only slightly smaller in the within-firm estimate relative to the across-firm estimate, suggests that selection effects between firms and bond denomination are not driving the overall results.

While the firm-time fixed effect absorbs all firm-level characteristics that may be related to corporate bond yields, it can most immediately be interpreted as absorbing credit risk. Since firms issue only a handful of bonds (2.2 per year, on average) and do so intermittently, holding the fixed effect constant for all bonds issued by a firm in a given year allows me to compare a broad set of bonds from a larger set of issuers. However, this comes at the expense of the assumption that changes in credit risk at the firm level over the course of a year are uncorrelated with bond currency denomination. To document that this assumption is not crucial for my results, I replace firm-year with firm-month fixed effects. In turn, I lose a number of observations but gain additional precision because I only compare bonds that are issued in close proximity or even at the same time as different tranches of the same offering. Column 2 shows that this results in a more tightly estimated pass-through coefficient of 0.92, with a standard error of 0.025, which further supports the previous findings.

In addition, columns 3 and 4 show that differences in bond yields within individual firms lead to substantially different ex post borrowing costs. Here again, I add the change in the nominal exchange rate of the issuance currency relative to the US dollar over the duration of the underlying bond in order to approximate the effective borrowing cost. The coefficient is somewhat smaller than one and less precisely estimated, with point estimates of 0.44 with a standard error of 0.25 for the regression with firm-year fixed effects and 0.62 with a standard error of 0.23 with firm-month fixed effects. Still, as a result I observe violations of UIP even within individual firms.

[33] This allows me to broaden my sample, since I can also include bonds for which I do not find a match in Factset, and hence do not have underlying firm data or industry classification. These sample additions do not change the estimated results.

3.4 Sovereign risk and CIP violations

Given the important role of UIP violations on firm borrowing costs documented above, I next study if there is evidence that other prominent features of international financial markets, sovereign risk and violations of covered interest rate parity have similar effects.

First, a growing literature points to the role of sovereign risk in driving corporate borrowing costs. Bocola (2016) models how sovereign risk tightens financial conditions for local firms. More immediately related to the study of corporate bond markets, Almeida et al. (2016) show that sovereign downgrades can have a direct effect on firm outcomes through the sovereign ceiling effect, i.e. the policy followed by rating agencies that no private entity in a particular country can have a higher credit rating than the underlying sovereign. In my data set, I can test for the effects of sovereign risk on corporate bond borrowing costs directly. I measure sovereign risk using credit default swaps, which represent the cost of insuring a five-year sovereign bond against a default event. In order to give sovereign risk the same interpretation as currency forward premia, I calculate CDS differentials relative to the CDS on US Treasuries.

There are two different approaches to relate sovereign risk to corporate bonds. First, sovereign risk may affect the firm as a whole, for example, through the sovereign ceiling on ratings. To test this assumption, I run a cross-firm regression with the CDS differential but without firm-year fixed effects, since those would absorb any firm-level variation that may be related to sovereign risk.[34] The regression results are reported in columns 1 and 2 in Table 4. After accounting for risk-free interest rate differentials, the coefficient on the sovereign CDS is small and becomes statistically indistinguishable from zero when I include a set of firm-level characteristics as controls (size, leverage, cash holdings, and international sales share). This suggests that for firms with bond market access, cross-country variation in sovereign credit risk is difficult to disentangle from firm-level developments. Second, I also test if sovereign risk has an effect at the bond-level rather than the firm-level and match the sovereign CDS differential to each bond based on currency denomination.[35] The results in columns 3 and 4, which include firm-time fixed effects, again show no statistically significant results.

Given the extensive literature on the topic, it is perhaps surprising that the empirical findings are not more clear cut. Here, it is useful to consider the characteristics of firms that have bond market access. Firms in my sample tend to be large and are likely to be less dependent on bank financing. Therefore, the limited effect of sovereign risk on corporate borrowing costs is consistent with the argument in the literature that sovereign risk predominantly affects firm financial conditions through the banking sector (Perez, 2015). Firms with a higher dependence on bank financing, for example, firms without bond market access, may

[34] As before, I identify each firm's country of origin based on the firm's ultimate parent company.

[35] Euro-denominated bonds are matched to the German CDS differential.

hence be more severely affected than firms with alternative financing sources (Arellano, Bai, and Bocola, 2019).[36]

Second, I study the role of violations of covered interest rate parity (CIP) for corporate borrowing costs. As described in detail above, I rely on forward premia to calculate cross-currency differentials in risk-free interest rates. Under the assumption of CIP, forward premia exactly capture differences in the respective interbank rates. Up until the financial crisis, this assumption was generally uncontroversial, since CIP deviations were minuscule if present at all (Du, Tepper, and Verdelhan, 2018). However, in recent years, and especially in periods of financial market stress, there has been more evidence that interbank interest rate differentials and forward premia do not always align.

Since CIP violations describe a "pure" risk-free arbitrage opportunity, this observation has generated much interest, and a recent paper documents that CIP deviations align with cross-currency variation in credit spreads in secondary markets (Liao, 2019). To explore the implications that these deviations may have for firm borrowing costs in primary markets, I next test for a connection between CIP violations and corporate bond yields at issuance and add the duration-matched cross-currency basis, i.e. the arbitrageable difference between forward premia and the interest rate swap differential, to the baseline regression.[37] Since the cross-currency basis applies at the currency level, I can estimate the relationship using the tightly identified within-firm regression, consistent with Liao (2019). The results are reported in column 5, with the standard firm-year fixed effect, and in column 6 with the more narrow firm-month fixed effect. As is observable from the estimated coefficients, the inclusion of CIP violations does not change the pass-through coefficient on the forward premium, which remains close to one. Further, CIP violations do not appear to have a significant effect on corporate borrowing costs in primary markets, at least once I account for the forward premium.

These results show that differences in risk-free rates and UIP violations appear to have a particularly important status when it comes to firm financing costs in international bond markets. This importance does not appear to be matched by other factors, which may be considered "close cousins," and which have received relatively more attention with respect to firm funding costs so far. In particular in light of much active research on the connection between sovereign risk and its effects on firms, this points to substantial room for further theoretical and empirical work to explore the role of UIP violations on firm behavior and outcomes.

[36] An important caveat here is that I only observe issuance yields. While I control for firm observables, it is technically possible that the unobservable risk profile of the issuer pool shifts in ways to offset increased sovereign risk.

[37] Following Du et al. (2018), the cross-currency basis is defined as $basis_t^{j,d} = (irs_t^{\$,d} - irs_t^{j,d}) - (f_t^{j,d} - s_t^{j,d})$, where $irs^{j,d}$ denotes the interbank swap rate with duration d in currency j.

4 UIP violations and firm cost of capital

This paper documents that firms that issue predominantly in currencies with low forward premia are likely to have a lower cost of funds raised in bond markets, all else equal. However, corporate bonds only account for a portion of firm financing, while internal funds, equity issuance, and bank loans may account for the rest. As a result, it is unclear how meaningful the variation of bond borrowing costs with risk-free interest rate differentials is for the cost of capital at the firm level. I now explore to what extent risk-free interest rate differentials are related to variation in firm real outcomes.

Abstracting from default risk, in a standard model of a firm with a CRS production function and competitive markets, the firm's profit maximization problem yields the following first-order condition with respect to capital:

$$\mathbb{E}\left(\frac{Y_i}{K_i}\right) = \frac{\mathbb{E}\left(r^j\right) + \delta}{\alpha}, \tag{8}$$

where the $\mathbb{E}\left(\frac{Y_i}{K_i}\right)$ denotes firm i's expected ratio of output to capital, α denotes the capital share of output, and δ describes the depreciation rate. In turn, $\mathbb{E}\left(r^j\right)$ captures the required net rate of return on capital. As documented above, variation in risk-free interest rates across currencies pass through to the risk-free component of corporate borrowing rates in bond markets, and as a result, this suggests that the required rate of return varies with currency j, even in absence of default risk.

In consequence, the simple firm model predicts a link between differences in risk-free interest rates and firm-level outcomes. Firms that face lower risk-free interest rates, and hence lower required rates of returns, will have lower output-capital ratios. This indicates that all else equal, firms that fund themselves in currencies with higher risk-free rates will have relatively fewer assets.

To test this prediction empirically, I move the analysis from the bond level to the firm level. As described in the data section, I trace individual bond issues to the underlying issuer firms and retrieve the underlying balance sheet data. I explicitly consider firm outcomes around bond issuance events, though my results persist in panels where I include non-issuance years for the same set of firms.

At the firm balance sheet-level, I approximate the output-capital ratio, and hence the level of the firm's required rate of return, by the firm's return on assets (ROA).[38] I define firm ROA as

[38] In doing so, I follow the empirical literature on investment, which uses the average return on capital to approximate marginal returns (Abel and Blanchard, 1986). This approximation is appropriate as long as the underlying production function has constant returns to scale. Further, as discussed in Gilchrist and Himmelberg (1999), using ROA to calculate the marginal product of capital requires the assumptions of no fixed costs and perfect competition. In the investment literature, which is primarily concerned with dynamics, these assumptions may be too strong at the firm-level. For the present purposes, where I focus on long-run differences in the return to capital across different countries, consistent with persistent differences in risk-free rates, these assumptions appear less onerous.

$$\overline{ROA}_{i,t+5} = \frac{1}{5}\sum_{n=1}^{5}\frac{EBITDA_{i,t+n}}{Assets_{i,t+n}}, \tag{9}$$

where EBITDA denotes total firm earnings before interest, taxes, depreciation, and amortization. Assets represent total firm assets. Since both figures come from the same annual reports, the contemporaneous ratio of the two is directly comparable across currencies. I calculate ROA as the average of firms' earnings to assets ratio over the five years following bond issuance. This diminishes the effect that short-term fluctuations at the firm level have on my estimate of the firm's required rate of return. It also mirrors the median duration of corporate bond funding in my sample (5.7 years).

In my calculations, I measure firm return using EBITDA instead of the commonly used net income figure, in order to capture firm output in its broadest form after accounting for inputs, such as labor costs. As a result, this already accounts for potentially different labor shares across countries. Importantly, EBITDA measures output before subtracting firm interest expenses. This is key for my analysis since we know from the bond-level results that interest payments will vary directly with currency forward premia. Second, I look to abstract as cleanly as possible from differences in accounting treatments for depreciation or amortization, which may vary across countries and time periods.[39] However, as I discuss below, my findings are robust to alternative measures of firm output, which take into account potentially confounding factors that have previously been associated with differences in capital stocks across countries, such as differnces in depreciation rates or taxation (Table A7).

In the regression analysis for firm ROA, I match each firm with the one-year forward premium of its local currency.[40] The regression is specified as

$$\overline{ROA}_{i,t+5} = \beta(r_t^j - r_t^\$) + X'_{i,t}\gamma_t + \theta_{k,t} + \epsilon_{i,t}, \tag{10}$$

where I control for industry-year fixed effects, indicated by θ, to account for cross-industry and cross-time variation in firm ROA. In addition, I include the same set of firm-level characteristics $X_{i,t}$, previously used in the bond-level regressions as additional controls.

Table 5 presents the results, with the coefficient of interest, $\hat{\beta}$, given in the first row. Consistent with the findings at the bond level, firm ROA shows strong positive alignment with the underlying domestic currency's forward premium. The estimated coefficient is large and strongly statistically significant, at 0.42

[39] This choice is further supported by recent evidence that, at least for US firms, the vast majority of firm borrowing is based on cash flows, measured with EBITDA (Lian and Ma, 2019).

[40] As before, I consider the firm's ultimate parent company's country of risk exposure, as determined by Bloomberg. In additional robustness checks, I document that the results persist when I match firms to their local currency based on the primary issuer firm's country designation in Factset.

and with a standard error of 0.15.[41]

As the other columns in the regression table show, the estimated coefficient is robust to the inclusion of additional controls. Industry-time fixed effects control for the possibility that systematic differences in firm ROA across industries drive my results, which they do not (column 2). In column 3, I add firm characteristics as in the bond-level regression and find that the coefficient on forward premia retains its size and significance. Some of these firm-level controls are possibly endogenous "bad controls" (Angrist and Pischker, 2009), because they may also be driven in part by the firm's required rate of return. For example, if firms face lower required rates of return, one may expect firms to be able to sustain higher leverage. However, firm leverage may also differ systematically across firms in different countries due to differences in other, unrelated matters, such as the relative taxation of debt and equity. To account for the possibility of cross-country variation in corporate structure, which may lead to unobservable variable bias, I include these additional regressors as a robustness check. However, even after controlling for these potentially endogenous firm characteristics, I continue to find a strong relationship between currency forward premia and firm ROA.

Lastly, I control for the possibility that forward premia only show a connection to firm ROA because forward premia may proxy for risk. First, I include sovereign risk, measured as the local sovereign CDS spread relative to the US CDS and find that the coefficient on the forward premium is broadly unaffected.[42] Apart from sovereign risk, forward premia may also be correlated with the average market beta of firms in a given country. In the spirit of a classic CAPM model, firms whose returns have a higher beta to the aggregate market should deliver higher returns, even if all firms face the same risk-free interest rate. I control for the possibility that aggregate stock market exposure drives my result with an additional variable. Here, I calculate the covariance of the local MSCI stock market index with the global stock market (MSCI Global) using monthly returns measured in US dollars and a rolling five-year window. While this measure does not capture firm-specific betas, which are not directly available since a number of firms in my sample are privately held, it adequately controls for unobserved variable bias at the country-level since all firms in a given country also share the same forward premium.[43]

While this part of the analysis does not allow for a detailed within-firm test in order to definitely

[41] Based on the simple firm model discussed above, one may expect a coefficient of one. The estimated coefficient is biased downward in the full sample because it is estimated across all firms, even when some of these firms fund in foreign currency, where risk-free interest rates may differ from the local rate (see section 5.2). The coefficient also increases towards one when risk-free interest rate differentials are measured at longer maturities, which align more closely with the maturity structure of firm funding.

[42] The estimated coefficient on the sovereign CDS is large but counter-intuitively negative, indicating that firms in countries with high sovereign risk have low ROA. Since the limited availability of CDS spreads restricts the sample to only more recent years and because of the large variation in sovereign spreads during the financial and the European debt crisis, it may be more difficult to interpret this finding in the same structural sense as the results on forward premia. However, it is instructive that the inclusion of sovereign CDS renders all firm-level characteristics insignificant, while the coefficient on risk-free interest rate differentials persists.

[43] Since violations of covered interest rate parity have been substantially smaller than risk-free rate differentials and sovereign risk spreads and have only very rarely exceeded a few tenths of a percent over the course of the sample (Du et al. 2019), they are conceptually unlikely to have a meaningful effect on longer-run capital allocation.

rule out selection effects, the target coefficient's broad level of robustness to the inclusion of alternative explanatory variables gives support to the view that, as demonstrated at the bond-level in a cleanly identified setting, selection does not drive the observed relationship between currency forward premia and firm ROA. Furthermore, I find support for this claim in the standardized test for selection on unobservables based on Oster (2019), where the regression coefficient generates a test statistic $\delta = 2.22$, which convincingly clears the standard critical value of one (appendix A1).

As before, I provide a range of additional robustness checks in the appendix. First, I document that my results do not depend on the long-term time window used to construct ROA. The coefficient is essentially the same when ROA is measured either contemporaneously to or over the year following a firm's bond issue (Table A8). The results are also not sensitive to alternative inputs into the ROA calculation. Alternative measures of firm output deliver similar results. This includes using EBIT, which measures total earnings but subtracts depreciation and amortization and therefore takes into account potential differences in depreciation rates. I also include pre- and post-tax net income, which further removes interest expenses. I also replace firm assets with firm PPE (property, plants, and equipment), which measures physical rather than total assets, and I find that the relationship retains statistical significance (Table A7). Lastly, I find that my findings are robust to both country and firm fixed effects, which forces the regression to estimate the coefficient of interest purely from cross-time variation in forward premia and firm ROA. I also broaden the sample to include non-issuance years and find that the relationship between firm ROA and forward premia persists (Table A9).

Importantly, the ROA result also persists when I use contemporaneous UIP violations, i.e. the ex-post realizations of currency returns, taking into account both differences in risk-free rates and changes in the nominal exchange rate (Table A11). In addition, I test if different measures of risk-free rate differentials lead to different results. Firm ROA remains strongly connected to forward premia, even if they are calculated based on longer-dated instruments (Table A10). In fact, using longer-term forward premia increases the size of the estimated coefficient towards unity, which is more closely aligned with the magnitude one may expect based on the simple model or the bond-level results.

Not only is the relationship between firm ROA and risk-free interest rate differentials statistically significant and highly robust, but it is also of high economic significance. Figure 2 shows that differentiation in currency forward premia is connected to meaningful variation in firm ROA at the country level. In this graph, I average firm ROA and forward premia by country over all years in my sample. The x-axis shows that forward premia, or risk-free interest rate differentials of the local currency to the US dollar, show substantial differences between countries. Since 1995, risk-free rates have been low in Japan (JP) whereas they have been high in Australia (AU). At the same time, average firm ROA has also been substantially higher in

Australia, where the average rate has been close to 15 percent, relative to 9 percent in Japan. While the difference between Australia and Japan is most striking, differences in ROA between countries appear to generally align with variation in the long-run relative levels of risk-free rates.[44] A rough calculation using the baseline regression coefficient in column 1 of Table 5 suggests that almost a third of the difference in firm ROA between Australian and Japanese firms, or 2 percentage points of ROA, can be related to differences in risk-free interest rates, which are equal to 4.4 percent on average over the sample period.

As a result, this analysis documents large, economically meaningful variation in firm ROA across firms and countries, aligned with differences in risk-free interest rates. In consequence, forward premia appear to be connected to the allocation of capital across firms. This is a new empirical observation and emphasizes the importance of risk-free interest rate differentials (and UIP violations) for macroeconomic outcomes.

In the literature on international capital allocation, it is an open question to what extent cross-country differences can be attributed to frictions that impede or limit the free flow of capital across borders (Caselli and Feyrer, 2007). In this context, it is important to highlight that recent literature on the fundamental causes of UIP violations demonstrates how differences in capital stocks, aligned with differences in risk-free rates, can occur even with frictionless capital markets.

In these models, the key innovation relative to earlier generations of international general equilibrium models is to allow for asymmetry in countries' exposure to global risk. For some countries, local output shocks are more correlated with global consumption risk, for example due to differences in countries' relative importance for global output (Hassan, 2013) or due to different positions in global trade networks (Richmond, 2019). While the underlying drivers of country asymmetry may differ, the resulting dynamics are similar when added to an otherwise standard international real business cycle model with traded and non-traded goods. Complete financial markets allow for perfect risk-sharing between households in different countries. As a result, when local output suffers a negative shock, local households pull in more traded goods from abroad to make up for a shortfall in the domestic non-traded good. Since this makes the local non-traded good relatively scarce, it becomes more expensive in terms of the traded good and the local currency's real exchange rate appreciates.

When local output shocks are correlated with global output, local risk becomes harder to diversify and the domestic currency will exhibit counter-cyclical properties (i.e. it will tend to appreciate when global output is low). As a result, the currency has attractive hedging properties from the perspective of a global investor: while a risk-free bond denominated in the local currency still only delivers a fixed number of units of the domestic consumption bundle, the bundle's value in terms of traded goods will fluctuate with global

[44] Some emerging economies, such as Turkey (TR) or Brazil (BR) appear to deviate from this relationship in the graph. This may well represent data quality issues, since emerging market issuers overall only account for 10 percent of the firm sample, so country-average ROA figures are more likely to be distorted by idiosyncratic firm developments in these countries.

output. In particular, it promises to be more valuable to the global investor when global consumption is low. Because of these hedging properties, real interest rates and expected currency returns of a "safe-haven" country will be low, and assets denominated in the local currency will similarly inherit the stochastic properties of the real exchange rate.

This process can directly explain differences in corporate bond yields and borrowing costs by currency. From the perspective of a global investor, holding credit risk constant, a corporate bond in a "safe" currency promises a higher hedge value than a corporate bond denominated in a currency with a more pro-cyclical exchange rate.[45] Commensurately, the bond will have a lower required rate of return, which means a lower borrowing cost from the perspective of the firm. However, this also means that firms that issue in low-interest rate currencies provide a hedge to global investors in exchange for lower funding costs (Eren and Malamud, 2019), and some firms may be able to do so more efficiently than others.

This insight connects the stochastic properties of the exchange rate to firm-level capital accumulation. At least in the non-traded sector, firms in countries with counter-cyclical exchange rates will have higher capital stocks because they provide a natural hedge to global consumption. More capital accumulation in the non-traded sector firms of "safe-haven" countries increases the mean level of output of non-traded goods. Because this raises the amount of non-traded goods in safe countries in all states, this serves to cushion the effects of negative shocks, which are more likely to coincide with "bad" global conditions. From the perspective of households globally, increasing total output of non-traded goods in countries that are expensive to insure (i.e. "safe-havens") in all periods reduces the transfers to these countries in times when they are most costly.[46]

As a result, the two main findings in this paper provide micro-level evidence that is consistent with risk-based theories of UIP violations and currency risk, in particular as it pertains to the cost of capital and capital accumulation as predicted in Hassan, Mertens and Zhang (2016).

5 Foreign currency corporate bonds

So far, this paper has outlined two key findings that are new to the literature: first, cross-currency differentials in risk-free interest rates, and hence well-documented violations of UIP, directly pass through to corporate bond borrowing cost, and, second, risk-free rate differentials also appear to be closely related to cross-country variation in firm ROA, which is indicative of differences in capital allocation. The documented connection between firm ROA and local currency forward premia is consistent with the observation that most firms

[45] Appendix A2 discusses covariance between default risk and exchange rates.

[46] Because of global risk-sharing, there is no such benefit to firms in the traded sector in these models. In the data, the distinction is not as sharp, and I do not observe a statistically significant difference in the relationship between local currency forward premia and firm ROA for firms with high and those with low foreign sales; for example (Table A6).

issue bonds denominated in their local currency. However, as part of the bond-level analysis in Table 3, I find that differences in risk-free interest rates are directly accessible to firms when they issue in different currencies.

Motivated by these observations, I explore how firms operate in international bond markets, and in particular, if foreign currency bond issuance is related to real outcomes at the firm level. If firms can access risk-free interest rates in other currencies, this may make firms less susceptible to the local interest rate environment, particularly if it substantially diverges from financial conditions elsewhere as indicated by large forward premia. After aggregating individual bonds to the issuer firm, my data set provides me with a comprehensive picture of the currency composition of bond issuance at the firm-level, which I explore in the following section.

5.1 Currency composition of corporate bond issuance

On aggregate, and in alignment with the findings on the investor side in Maggiori et al. (2019), I find that non-financial firms generally issue bonds either in local currency or in US dollars. Figure 3 shows a scatterplot based on total gross issuance volume by country, with the share of total issuance denominated in the local currency on the y-axis and the issuance share of dollar-denominated bonds on the x-axis.

The first observation is that most countries are closely clustered along the diagonal, which marks the possibility frontier if firms split up bond issuance exclusively between the two currencies. Only a selected few countries are away from the line and closer to the origin. These economies (in particular, Denmark and Sweden) are adjacent to the euro area, and euro-denominated bonds account for almost all foreign currency issuance in these countries. The US is in the top right corner since US dollar and local currency issuance are synonymous. Reflecting the central role of the US dollar in corporate bond markets, US firms issue the smallest share of total volume in foreign currency among all countries in the sample.

Secondly, we observe that the relative use of foreign currency debt, and hence of US dollar-denominated bonds, varies substantially across countries. While firms in Europe and East Asia appear to issue mostly in local currency, firms in Latin America and major developed Anglo-Saxon economies, such as Canada, Australia, and the UK, rely more heavily on US dollar-denominated debt.

What factors may explain the substantial cross-country dispersion in currency composition, and may the dispersion be related to differences in risk-free interest rates? Based on having matched individual debt issues to the underlying issuers, I can observe the currency composition of bond issuance at the firm level. Simple graphical analysis presented as binscatters in Figures 4 and 5 shows that large firms and firms with high international sales issue a substantially lower share of their bonds in domestic currency, on average. These findings are intuitive. Firms with higher foreign sales exposure may want to hedge foreign currency-denominated earnings with debt denominated in the same currency. At the same time, the relationship between firm size and local currency issuance shares is consistent with the interpretation that firms may have to pay a fixed cost to access different currency markets because this may require firms to build relationships with a new investor base (Maggiori et al. 2019). This emphasizes that the currency composition of bond issuance at the firm level may depend on several different factors, which requires a more thorough empirical analysis.

I explore the relationship between foreign currency bond issuance and firm and country characteristics in a regression setting. Across all firms with observed bond issuance, I regress the share of total issuance that is denominated in local currency on a range of potentially relevant characteristics at the firm level. The list of variables includes firm size, international sales exposure, and the local currency's forward premium. I again account for cross-industry variation with industry-year fixed effects.

To be clear, this test highlights correlations between characteristics and the currency composition of bond issuance, which are not necessarily causal. Still, the regression results in Table 6 show that on average, firms have a lower share of local-currency denominated bond issuance when the risk-free interest rate differential of the domestic currency to the US dollar is large. The coefficient on the risk-free interest rate differential is estimated to be -4.2, with a standard error of 1.01, which indicates that the share of bond issuance denominated in the local currency decreases by 4 percentage points in association with a one percent increase in the local currency's interest rate differential to the US dollar, on average. This is quantitatively important since a 10 percentage point increase in the international sales share is only related to a 3.5 percentage decrease in the local currency issuance share. Moreover, the estimated regression coefficient implies that an Australian firm will on average have a *foreign* currency issuance share that is 18.5 percentage points above that of a similar Japanese firm, all else equal, given the regression coefficient and the average risk-free interest rate differential of 4.4 of percent over the course of my sample between the yen and the Australian dollar. The coefficient on the risk-free rate differential is robust to the inclusion of firm characteristics, in particular foreign sales exposure and firm size, which are both strongly related to the currency composition of bond issuance, as expected. Sovereign risk and violations of uncovered interest rate parity do not appear related to bond currency composition at the firm level in a statistically significant way.[47] In addition, once differences in risk-free interest rates are accounted for, firms in emerging markets do not appear to rely more on foreign currency bond markets than firms in developed markets. Firms in developed and in emerging markets have the same mean currency composition between local and foreign

[47] This is a subtly different finding relative to Liao (2019), who argues that firms may arbitrage differences in the net deviation of credit spreads across currencies, which may align with CIP violations.

currency, as a dummy variable for emerging market firms is statistically insignificant in the regression.

Lastly, I consider the special status of US firms. For firms with foreign sales, foreign currency liabilities can serve as a natural (operational) hedge against changes in the nominal exchange rate, at least if both income streams and debts are denominated in the same currency. As a large literature on currency invoicing shows, a large amount of cross-border trade is commonly denominated in US dollars (Gopinath, 2015). The dominant position of the dollar on trade mirrors the unique role the US currency plays in corporate bond markets, since bonds issued in foreign currency are largely dollar-denominated, as shown in Figure 3. These observations fit together intuitively, since, under dollar invoicing, firms have a real hedging motive to issue dollar-denominated bonds, even when they sell to a third country.

At the same time, US firms are in a unique position since an increase in foreign sales should not increase the need for operational hedges. The data support this intuition: Figure 6 shows that US firms with a large share of international to total sales do not have substantially lower foreign currency issuance shares. Instead, even for firms that source almost all of their sales from abroad, the local currency issuance share is very close to 100 percent.[48]

More generally, US firms are an outlier relative to firms anywhere else when it comes to the currency composition of debt issuance. On average, as shown in column 6 of Table 6, a firm in the US will have a local currency issuance share that is 20 percent higher than that of an identical firm in any other country. While the role of the dollar as the dominant trade currency likely plays an important part, another intuitive consideration is the depth of financial markets. In contrast even to other developed markets, the US is unique in terms of its long history of corporate credit markets, even for non-financial firms. Even for firms at the very top end of the size distribution, US firms do not increase their foreign currency issuance share very much, while very large firms in other countries do so quite rapidly (Figure 7).

5.2 Foreign currency issuance and firm ROA

At the firm-level, I find strong evidence that high interest rates in the local currency are correlated with higher shares of foreign currency bond issuance. This is consistent with the interpretation that firms may issue in foreign currency to access more accommodative funding conditions and lower risk-free rates abroad. To test if we observe a related difference in real outcomes between firms with and without foreign currency bond issuance, I return to the firm-level ROA regression from the previous section. If foreign currency bond issuers are less exposed to the domestic interest rate environment, then these firms should exhibit a weaker link between domestic risk-free rate differentials and firm ROA. I test this prediction in a regression of the

[48] Based on text analysis of conference calls of S&P 500 companies, Liao (2019) also provides suggestive evidence that for the small share of foreign currency-denominated bonds issued by US companies, firms may hedge the exchange rate exposure to some extent.

following form:

$$\overline{ROA}_{i,t+5} = \left(\beta + \psi \mathbb{I}_{i,t}^{FC}\right)\left(r_t^j - r_t^\$\right) + X_{i,t}'\gamma_t + \theta_{k,t} + \epsilon_{i,t}. \tag{11}$$

Relative to equation (10), this regression adds an indicator term $\mathbb{I}_{i,t}^{FC}$, which is equal to one if I observe that firm i issues a bond in foreign currency in a given year, and zero otherwise. I interact this indicator with the domestic currency forward premium. As a result, the coefficient on this term measures the extent to which the link between firm ROA and the local risk-free rate differential is different among firms with and without foreign currency bond market access.

Table 7 presents the results of this regression. The coefficient on the standard forward premium, $\hat{\beta}$, is now larger at 0.57 with a standard error of 0.1, relative to 0.42 in the baseline regression in Table 5, because it is now only estimated over firms without foreign currency bond issuance, versus all firms in the sample previously. The new coefficient of interest, $\hat{\psi}$, is reported in the second row. It is quantitatively large at -0.34 and statistically significant with a standard error of 0.17. In combination, the coefficients indicate that the required rate of return of domestic currency issuers increases by 57 basis points, as approximated by ROA, for every percentage point of risk-free interest rate differential of the local currency to the US dollar. However, for firms that issue in foreign currency bond markets, the required rate of return only appears to increase by 23 basis points. As a result, the regressions suggest that foreign-currency issuers are substantially more insulated from the domestic interest rate environment since the local currency interest rate differential appears to be less directly related to firm ROA (and hence firm capital stocks).[49] This is likely because foreign currency issuance is mostly US dollar-denominated, and dollar risk-free rates tend to be low, which then may translate into lower required rates of return for the firm.

Since the results in the previous section show that foreign currency issuance is related to other underlying firm characteristics, these findings should be interpreted with caution. I take a three-pronged approach to deal with concerns about possible selection effects. First, I account for differences in firm observables, which may be related to foreign currency borrowing access and sensitivity to local currency forward premia simultaneously. Column 2 in the regression table includes the standard set of firm characteristics from the previous regressions. This includes firm size and foreign sales exposure, which are strongly related to foreign currency issuance but the estimated difference in the relationship between ROA and local currency forward premia for foreign and domestic currency bond issuers retains its size and significance. As a result, observable differences between firms with and without foreign currency issuance cannot explain the different levels of sensitivity to risk-free rate differentials in the local currency.

[49] Table A12 shows that this result is not related to how the firm's local currency is identified. The result is identical if the local currency is based on the underlying firm's immediate country of domicile instead of the firm's ultimate parent company's country of exposure.

Furthermore, I test if the result is due to systematic differences in mean ROA between the two groups of firms, but the indicator variable without interaction with the local forward premium is statistically insignificant in column 3 of the regression table. This shows that differences in firm ROA between domestic and foreign currency bond issuers only occur when local risk-free rates deviate from the global (US) interest rate environment, which is consistent with foreign currency bonds providing insulation from the local interest rate environment for the issuing firm.

Secondly, I test explicitly if the difference in sensitivity to local interest rates persists within subsamples of firms with similar ability or motives to issue foreign currency bonds. Table 8 repeats the regression, based only on firms that are above the median firm size, measured as total assets in US dollars. Since small firms are substantially less likely to issue in foreign currency, potentially because of the presence of fixed costs, the regression result above may simply represent different sensitivities to local interest rates among small and large firms. However, as the results in column 1 show, the difference between firms with and without foreign currency bonds is even larger and more statistically significant, at -0.41 and with a standard error of 0.15 when I only compare firms with total assets above the sample median. Similarly, my finding may be driven by selection along the axis of foreign exposure. In column 2, I re-estimate the regression based only on firms with below-median foreign sales exposure. Even among firms that are predominantly domestic in nature, the difference in sensitivity is large and strongly significant. Consistently, in the intersection of the two samples, i.e. firms that are likely to be able to access foreign currency markets because of their size but do not have a strong observable operational hedging motive to issue foreign currency bonds, the difference in sensitivities is large and statistically significant. In fact, the implied relationship between firm ROA and the local currency forward premium for foreign currency issuers with these characteristics is so weak that a one percentage point difference in local risk-free interest rates relative to the US is related to only a six basis point higher ROA at the firm level. Meanwhile, it is almost ten times larger for similar firms in this subsample that issue only in domestic currency. This finding shows that differentiation along firm observables is unlikely to explain the different relationships between ROA and local risk-free rates between the two groups of firms.

Lastly, I perform an additional test in the time series to account for potential differences in unobservables between foreign currency issuers and firms that only issue in domestic currency. Here, I rely on the panel structure of the data. Given that for individual firms, I observe issuance behavior over time, I can construct a dummy variable that is equal to one if I observe a given firm issuing a bond in foreign currency, or having done so in the past. I then run a simple regression of firm ROA on the new dummy variable, the standard set of firm characteristics, and firm-fixed effects. To account for common variation in ROA across time and industries, I again include industry sector-year fixed effects. The regression coefficient on the variable that captures foreign currency bond market entry measures whether ROA changes systematically for a given firm after it becomes a foreign currency issuer. The coefficient estimate is equal to -0.6 and is statistically significant with a standard error of 0.2. The coefficient, which is robust to the inclusion of firm-level controls, suggests that after a firm becomes a foreign currency issuer, firm ROA, measured over the following 5 years, falls by 60 basis points on average. As the median firm's ROA in the sample is equal to 10.5, this is an economically meaningful finding, especially given the inclusion of firm-fixed effects.

In sum, the evidence is consistent with the interpretation that foreign currency-denominated bond issuance allows firms to access different, and often lower, risk-free interest rates abroad, which may in part shield them from the local interest rate environment, where higher risk-free rates may lead to higher required rates of return.

This insight establishes a connection to other work that has documented real effects of foreign currency borrowing by firms. Salomao and Varela (2019) show that foreign currency issuers accumulate more capital in emerging markets and develop a model of endogenous funding currency choice. In turn, my findings are consistent with the interpretation that their results are relevant for firms globally since only 10 percent of my sample is made up of emerging market firms.[50] Furthermore, the observation that foreign currency issuance insulates firms from the domestic interest rate environment is relevant to recent research on the behavior of investors. In portfolio-level data, Maggiori, Neiman and Schreger (2019) document that investors almost exclusively hold assets denominated in their local currency or in US dollars. As a result, they find that firms can only raise funds from foreign investors if they issue dollar-denominated bonds. My findings are consistent with the interpretation that investor segmentation along currency denomination may have real consequences for borrowing costs and the allocation of capital across firms and countries.

5.3 Firm heterogeneity in the pass-through of risk-free rate differentials

We observe heterogeneity in the sensitivity of individual firms to their local interest rate environment in alignment with the currency composition of their bonds because foreign currency bonds may provide access to different, i.e. lower funding costs in foreign currency. In addition to heterogeneity between firms with and without foreign currency bond issuance, I now explore if there is additional heterogeneity in the ability of firms to capture differences in risk-free interest rates among multi-currency issuers.

Based on the underlying information at the firm level, I perform an additional set of tests, which estimate the extent to which the pass-through of risk-free interest rate differentials may differ along firm characteristics. To do so, I re-run the within-firm regression specification from section 3 and include an additional term that allows for different pass-through coefficients based on firm characteristics. The regression

[50] Emerging market firms make up 15 percent of all foreign-currency issuer firms.

specification is then

$$y_{i,t}^{j,d} - r_t^{\$,d} = \kappa_{i,t} + \left(\beta + \psi \mathbb{I}_{i,t}^M\right) \ (r_t^{j,d} - r_t^{\$,d}) + \omega_{m,t} + \epsilon_{i,t}, \tag{12}$$

where the ψ coefficient measures the difference between the pass-through coefficient for firms that are above the sample median of a given characteristic, and those that are not. For example, the indicator is equal to one for firms with total assets above the sample median, and zero for those with total assets lower than the median. In Table 10, the second row shows the estimate for the ψ coefficient. The coefficient on the indicator, based on firm size in column 1 and firm leverage in column 2, interacted with the local currency forward premium, is not statistically distinguishable from zero. This show that, conditional on a firm issuing in multiple currencies in the first place, the ability to capture risk-free interest rate differentials does not appear to be different between large and small firms, or between firms with high or low leverage. Interestingly, a firm's foreign exposure, measured as the international share of total sales, also does not appear related to the pass-through coefficient, which indicates that domestic and international firms all appear to have the same ability to access foreign financing conditions. Because we only observe this result for firms that actively issue in multiple currencies, the data are potentially censored. One could imagine that firms without the ability to capture the full risk-free rate differential may issue only in a single currency.

At least for a particular group of firms that are commonly faced with high local currency risk-free rates relative to the dollar, this does not appear to be the case. As shown in column 4, there appears to be a significant difference in the pass-through coefficient for firms that are located in developed markets (where the pass-through coefficient is tightly estimated at 0.94 with a standard error of 0.01) compared to firms in emerging markets. For the latter group of firms, the pass-through coefficient is estimated to be smaller by 0.38, with a standard error of 0.07, which implies that only a little over half of the difference in risk-free interest rates is passed through to corporate bond yields of these firms. This means that a firm in a developing economy with high local currency forward premia is not able to capture the full risk-free rate differential between its local currency and the US dollar by issuing a dollar-denominated bond.

The lower pass-through coefficient for firms in emerging markets is an interesting insight from an asset pricing perspective since it is consistent with the interpretation that there is a connection between firm default and exchange rate ("quanto") risk (Kremens and Martin, 2019). The fact that the coefficient is substantially below unity implies that for a US dollar-based investor, buying a bond denominated in the firm's local (high risk-free rate) currency and hedging it back into US dollars using currency forwards, delivers a lower yield than buying the firm's dollar-denominated bond, even in absence of transaction costs. Transaction costs may be substantial, however,which would lower the expected return on the hedged bond even further from the investor's perspective, worsening the puzzle. As I discuss the underlying mechanics formally in the appendix (section A2), correlation between default risk and the firm's local currency's exchange rate may explain this observation, as the currency forward may provide some hedge value in the case of default.[51] This finding on the limited ability of EM firms to capture differences in risk-free interest rates is relevant for work that studies the role of foreign currency corporate borrowing (Bruno and Shin, 2017; Gopinath and Stein, 2018; Salomao and Varela, 2019). These papers make the implicit assumption that differences in risk-free rates between the firm's local currency and foreign currency, often the US dollar, are directly accessible to the firm. The data from corporate bond markets show that this may only be true to a limited extent.

6 Conclusion

In this paper, I document that UIP violations and differences in risk-free rates have first-order effects on firms in the non-financial sector, in particular on their borrowing costs in bond markets and the firm-level cost of capital. Based on a large, novel data set on security-level corporate bond issuance, I document that risk-free interest rate differentials directly pass through to corporate borrowing rates, at the rate of almost one-for-one. As violations of UIP extend to corporate bond markets, firms face substantially different borrowing costs depending on the currency denomination of their bonds.

Furthermore, this connection between firm borrowing costs and forward premia appears to be reflected in real outcomes, as firm-level ROA varies strongly with risk-free rate differentials. Since ROA may be thought of as representative of a firm's required rate of return on capital, this is consistent with the interpretation that risk-free interest rate differentials have a meaningful effect on the allocation of capital across firms. This effect is economically large as I observe large, persistent differences in ROA and risk-free interest rates across countries. Lastly, I find evidence suggestive of a firm response. When local risk-free interest rates are high, firms appear to issue more bonds in foreign currency. Furthermore, and consistent with this perspective, I find that foreign-currency issuer firms appear to be more insulated from their domestic interest rate environment, as they exhibit a significantly weaker link between local interest rates and firm ROA.

In conclusion, this paper provides strong evidence that risk-free interest rate differentials and UIP violations between currencies are directly connected to the variation in firm borrowing costs and the allocation of capital. At the same time, I show that firm heterogeneity in access to international financing markets appears to be connected to real effects. This finding provides motivation and economic relevance for future

[51] While credit risk in both bonds should generally be the same given cross-default clauses, there may be other potential reasons for the resulting differences, such as government intervention or legal enforcement, though it is unclear in which direction these factors should drive relative risk in two bonds by the same emerging market company. For example, if dollar-denominated bonds fall under US jurisdiction and hence provide better creditor protection, then one would expect the yield on the dollar bond to be below that of the hedged local currency bond, which is the opposite of what I find in the data.

research on the determinants of firm funding currency choice and the effects of heterogeneity in firm access to international financing.

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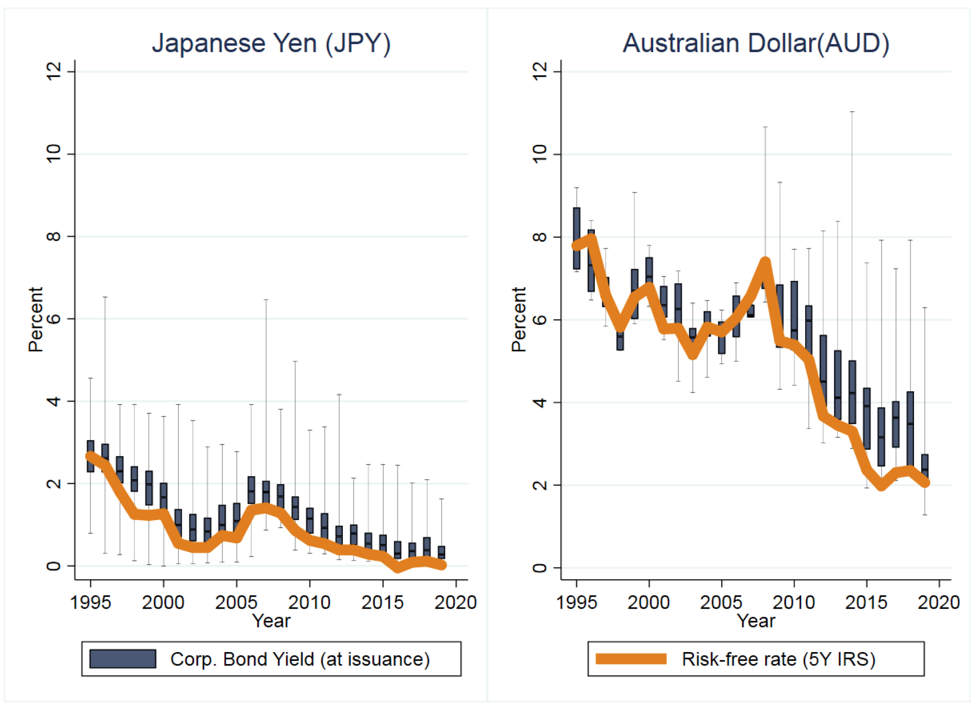
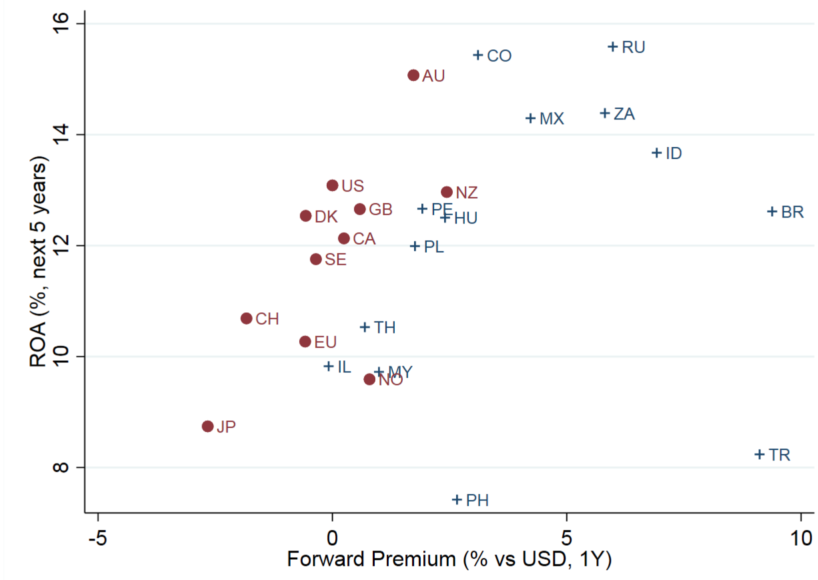
Figure 1: Yields of corporate bonds denominated in Japanese Yen (JPY) and Australian Dollar (AUD) over time



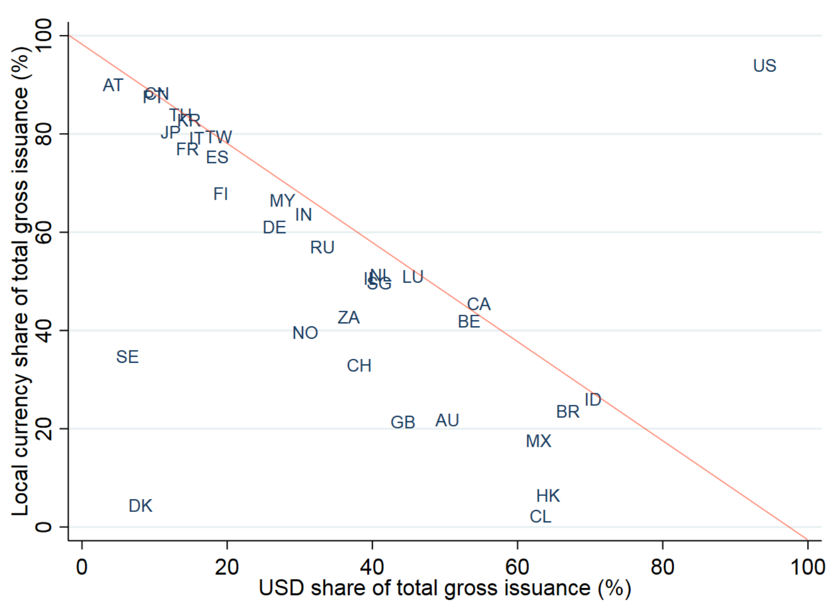
Notes: Each box plot captures the distribution of all corporate bonds issued in Japanese Yen or Australian Dollar, respectively, issued in the given year. Boxes describe the interquartile range (25th-75th percentile) while whiskers capture minimum and maximum values. Yields are measured at issuance, representing the actual financing cost to the firm. The line represents the 5-year risk-free interest rate, measured using each currency's interbank interest rate swap. Data is annual from 1995 to 2019.

Figure 2: Firm cost of capital and local currency interest rate differential



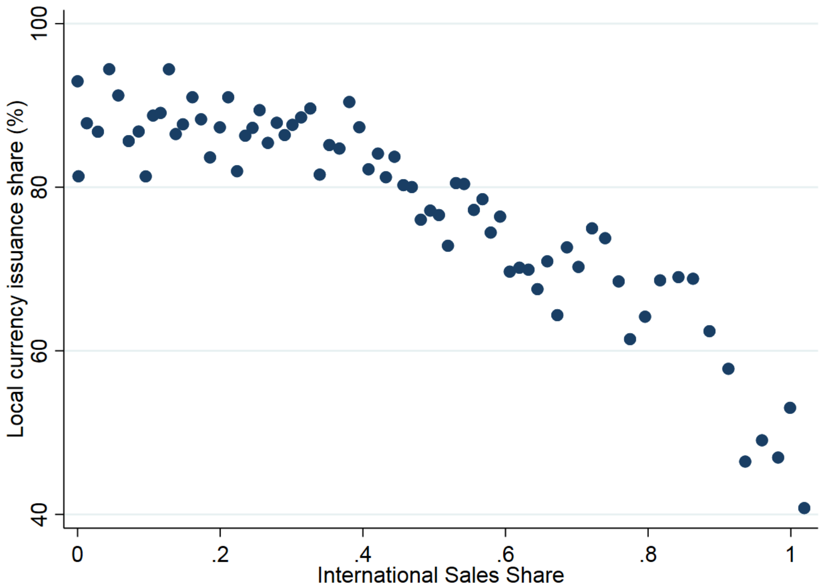
Notes: Average firm ROA of all issuers in a given country, versus the country's forward premium. The forward premium captures the 1-year interest rate differential priced into currency forwards, and each firm is assigned the local currency of its ultimate parent company's country of risk (consistent with BIS methodology). The earnings to assets ratio is calculated as the ratio of EBITDA to total firm assets, averaged over the next five years, and measures firm cost of capital, or firm output-to-capital ratio. Data is averaged over 1995 to 2019. Blue color + denote emerging markets.

Figure 3: Currency composition of bond issuance



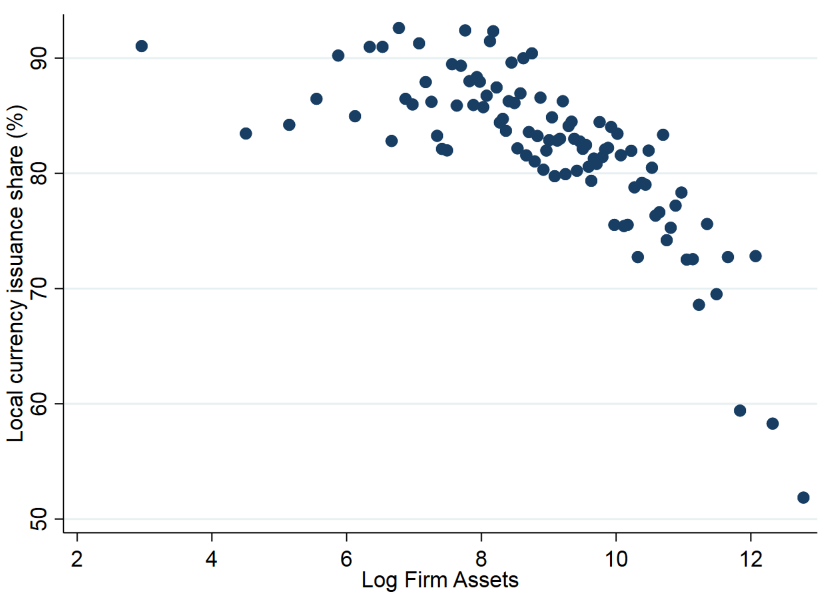
Notes: Issuance share denotes the percentage of total gross bond issuance by non-financial corporations in each country, either in local currency or in US Dollars. Data runs from 1995 to 2019.

Figure 4: Local currency issuance share and firm international sales exposure



Notes: Binscatter. Each dot accounts for around 200 firm-year observations. Local currency issuance share denotes the percentage of total gross bond issuance denominated in local currency. Firm international sales exposure measures the ratio of international to total firm sales. Data runs from 1995 to 2019.

Figure 5: Local currency issuance share and firm size

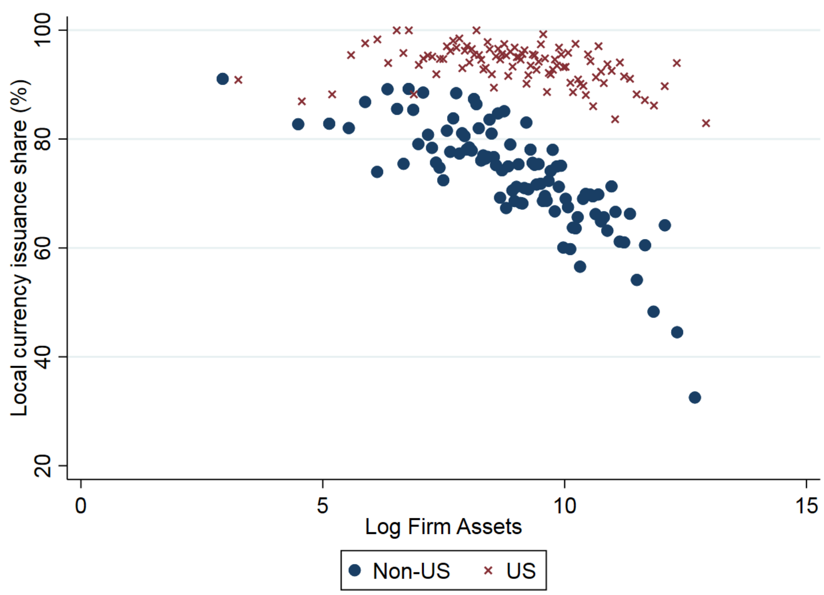


Notes: Binscatter. Each dot accounts for around 200 firm-year observations. Local currency issuance share denotes the percentage of total gross bond issuance denominated in local currency. Firm size is measured as the log of total firm assets, measured in current US Dollars, converted at yearly average spot exchange rates. Data runs from 1995 to 2019.

Figure 6: Local currency issuance share vs firm international exposure, US vs RoW

Notes: Binscatter. Local currency issuance share denotes the percentage of total gross bond issuance denominated in local currency. International Sales share is measured as foreign sales divided by total sales. Data runs from 1995 to 2019.

Figure 7: Local currency issuance share vs firm size, US vs RoW



Notes: Binscatter. Local currency issuance share denotes the percentage of total gross bond issuance denominated in local currency. Firm size is measured as the log of total firm assets, measured in current US Dollars, and converted at year-average spot exchange rates. Data runs from 1995 to 2019.

Table 1: Summary statistics for corporate bond and issuer firm data sets

	N	Mean	Median	St. Dev	P10	P90
Panel A: Corporate Bonds						
Yield-to-maturity(%)	52,909	4.85	4.83	2.64	1.41	8.08
US risk-free rate(%)	52,909	3.48	2.89	1.99	1.22	6.39
Forward premium (%)	52,909	-0.36	0.00	1.61	-2.47	0.72
CIP Violation (%)	44,565	-0.12	0.00	0.36	-0.45	0.00
CDS differential (%)	25,029	0.25	0.00	0.75	-0.02	0.84
Amount Issued (USD bn)	52,909	0.31	0.13	0.46	0.01	0.8
Maturity (years)	52,909	9.12	7.04	8.31	3.02	20.05
Duration	52,139	6.51	5.68	3.75	2.76	11.64
Panel B: Firms						
Issuance Volume (USD bn, year)	14,250	1.05	0.43	2.13	0.01	2.40
Size (USD bn)	13,306	25.53	8.65	52.37	0.92	60.32
Size (log)	13,306	8.96	9.06	1.60	6.87	10.92
$\overline{ROA}_{i,t}$	12,131	11.30	10.50	6.06	4.81	19.21
$\overline{ROA}_{i,t+5}$	8,736	11.35	10.59	5.37	5.36	18.45
Leverage(%)	13,301	35.28	33.55	17.39	15.76	56.22
Cash holdings (%)	13,171	28.29	23.47	21.00	5.46	59.18
International Sales Share	12,473	0.32	0.26	0.31	0.00	0.8

Notes: This table describes the bond- and firm-level data sets constructed in this paper. An observation in the corporate bond database is a single bond, identified by a unique ISIN. Yield to maturity and all other variables are as of initial issuance. The US risk free interest rate is calculated using interest rate swaps, and are matched to the duration of each underlying corporate bond. Duration matching also applies to forward premia, capturing the interest rate differentials between the bond's currency denomination and the US Dollar, and the cross-currency basis for the same currency pair. Bond size denotes the total amount issued in US Dollars, converted at the spot exchange rate at issuance. Bond maturity and duration are calculated relative to the original issuance date. All bonds in this sample have either a fixed or a zero coupon to allow for cross-comparison. The firm data set consists of the firms to which individual bonds can be matched, by year. Each observation is at the firm-year level. There are 4800 individual firms in the data set. Issuance volume represents the total amount raised with corporate bonds, converted at spot exchange rates. Firm size is defined as total firm assets, and is presented in Dollars and in logs. Return on assets (ROA) is calculated as the Data runs from 1995 to 2019.

Table 2: Pass-through of risk-free interest rate differentials to corporate bond yields

	$y_{i,t}^{j,d} - r_t^{\$,d}$			$y_{i,t}^{j,d} - r_t^{\$,d} + \Delta s_{t+d}^{j,d}$		
	(1)	(2)	(3)	(4)	(5)	(6)
$r_t^{j,d} - r_t^{\$,d}$	1.099***	1.064***	1.070***	0.691***	0.698***	0.690***
	(0.061)	(0.046)	(0.061)	(0.139)	(0.163)	(0.191)
Firm Size			-0.332***			-0.424***
			(0.043)			(0.046)
Firm Leverage			0.016***			0.019***
			(0.003)			(0.004)
Firm Cash/Assets			0.005***			0.005**
			(0.002)			(0.002)
Firm Int'l Sales Exposure			0.283			0.308
			(0.188)			(0.334)
N	52731	33861	30072	43103	27236	23999
R^2	0.47	0.65	0.73	0.07	0.27	0.31
Maturity-Year FE	Y	Y	Y	Y	Y	Y
Sector-Year FE		Y	Y		Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: The dependent variable in columns 1 through 3 is the difference between the corporate bond yield to the duration-matched US risk-free rate (IRS). In order to approximate realized effective borrowing cost in common currency, columns 4 through 6 add the realized appreciation in the nominal exchange rate of the bond's currency of denomination to the USD, annualized, over the duration of the bond. Risk-free interest rate differentials are measured using currency forward premia and currency swaps (Du and Schreger, 2016), and match the underlying corporate bond's duration. Firm size is measured as the log of firm total assets, all other firm characteristics are calculated as ratios to firm assets or sales. All firm information is contemporaneous to bond issuance. Sovereign CDS is measured as the CDS spread of the respective underlying sovereign's USD-denominated debt, relative to the contemporaneous US government CDS. Data runs from 1995 to 2019.

Table 3: Pass-through of risk-free interest rate differentials to corporate bond yields within firms

	$y_{i,t}^{j,d} - r_t^{\$,d}$		$y_{i,t}^{j,d} - r_t^{\$,d} + \Delta s_{t+d}^{j,d}$	
	(1)	(2)	(3)	(4)
$r_t^{j,d} - r_t^{\$,d}$	0.849***	0.924***	0.439*	0.621***
	(0.068)	(0.025)	(0.248)	(0.230)
N	39766	28548	32136	22742
R^2	0.90	0.91	0.77	0.85
Firm-Year FE	Y		Y	
Firm-Month FE		Y		Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: The dependent variable in columns 1 and 2 is the difference between the corporate bond yield to the duration-matched US risk-free rate (IRS). In order to approximate realized effective borrowing cost in common currency, columns 3 and 4 add the realized appreciation in the nominal exchange rate of the bond's currency of denomination to the USD, annualized, over the duration of the bond. Risk-free interest rate differentials and CIP violations are measured using currency swaps and interbank interest rate swaps (Du and Schreger, 2016). Data runs from 1995 to 2019.

Table 4: Pass-through of risk-free interest rate differentials, sovereign CDS and CIP violations to corporate bond yields

	$y_{i,t}^{j,d} - r_t^{\$,d}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$r_t^{j,d} - r_t^{\$,d}$	1.101***	1.091***	0.927***	0.917***	0.955***	0.918***
	(0.084)	(0.102)	(0.0129)	(0.017)	(0.016)	(0.015)
CDS Differential (firm-matched)	0.276***	0.125				
	(0.0839)	(0.130)				
CDS Differential (bond-matched)			0.091	0.105		
			(0.146)	(0.180)		
CIP violation					-0.213	0.036
					(0.147)	(0.056)
N	18417	16918	18246	13728	33150	24455
R^2	0.58	0.66	0.89	0.89	0.86	0.88
Maturity-Year FE	Y	Y	Y	Y	Y	Y
Sector-Year FE	Y	Y	Y	Y	Y	Y
Controls: Firm Characteristics		Y				
Firm-Year FE			Y		Y	
Firm-Month FE				Y		Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Risk-free interest rate differentials are measured using currency forward premia and currency swaps (Du and Schreger, 2016), and match the underlying corporate bond's duration. Sovereign CDS is measured as the CDS spread of the respective underlying sovereign's USD-denominated debt, relative to the contemporaneous US government CDS. In columns 1 and 2, I match each bond to the respective sovereign CDS of the firm's ultimate parent company's country of origin. In column 3 and 4, I match each bond to the CDS based on the currency denomination of the bond (Euro-denominated bonds are matched to the German government CDS. CIP violations are measured as the cross-currency basis of the bond's currency of denomination, relative to the US Dollar, and is matched to the duration of the underlying bond. Column 2 includes unreported controls for firm characteristics as used in Table 2, which include firm size, firm leverage, firm cash holdings relative to total assets, and the firm's international sales share. Data runs from 1995 to 2019.

Table 5: Pass-through of risk-free interest rate differentials to firm-level cost of capital

	$\overline{ROA}_{i,t+5}$			
	(1)	(2)	(3)	(4)
$r_t^j - r_t^\$$	0.424***	0.387***	0.541***	0.446***
	(0.145)	(0.123)	(0.198)	(0.108)
Firm Size		0.157	0.265	0.149
		(0.137)	(0.185)	(0.136)
Firm Leverage		-0.018**	-0.015	-0.018**
		(0.007)	(0.013)	(0.007)
Firm Cash/Assets		-0.017*	-0.006	-0.017
		(0.009)	(0.007)	(0.009)
Firm Int'l Sales Exposure		1.293*	1.106	-1.578***
		(0.714)	(0.666)	(0.577)
Sovereign CDS (5y vs US)			-1.458**	
			(0.608)	
Equity Covariance				571.6
				(444.6)
N	8740	7910	4443	7910
R^2	0.24	0.26	0.22	0.27
Sector-Year FE	Y	Y	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets over the next five years. Risk-free interest rate differentials are measured using currency forward premia at the 1-year maturity point. Firm size is measured as the log of firm total assets in USD, all other firm characteristics are calculated as ratios to firm assets or sales. All firm information is contemporaneous to bond issuance. Sovereign CDS is measured as the CDS spread of the respective underlying sovereign's USD-denominated debt, and calculated relative to the US government CDS. Equity covariance measures the covariance between the local economy's MSCI equity index with the MSCI global stock index (both in USD), based on monthly returns over a five-year rolling window. Data runs from 1995 to 2019.

Table 6: Firm-level currency composition in bond issuance

	Local Currency Share of Total Bond Issuance (%)					
	(1)	(2)	(3)	(4)	(5)	(6)
$r_t^j - r_t^\$$	-4.187***	-4.471***	-4.896***	-3.365***	-3.851***	-5.155***
	(1.087)	(1.009)	(1.632)	(1.455)	(1.363)	(0.879)
Firm Size		-1.942***	-2.169***	-1.289*	-2.161***	-2.686***
		(0.891)	(0.839)	(0.652)	(0.800)	(0.947)
Firm Leverage		-0.037	-0.042	-0.008	-0.036	-0.050*
		(0.030)	(0.024)	(0.025)	(0.026)	(0.0276)
Firm Cash/Assets		-0.087	-0.046	-0.028	-0.079	-0.079
		(0.055)	(0.059)	(0.036)	(0.054)	(0.049)
Firm Int'l Sales Exposure		-35.02***	-35.21***	-29.71***	-35.27***	-27.31***
		(6.720)	(5.866)	(5.445)	(6.558)	(6.667)
Sovereign CDS (5y vs US)			0.0356			
			(6.117)			
CIP Violation				10.77		
				(11.93)		
Emerging Markets					-8.383	
					(10.97)	
US						19.46***
						(4.205)
N	14250	12103	8386	11160	12103	12103
R^2	0.07	0.23	0.22	0.18	0.23	0.29
Sector-Year FE		Y	Y	Y	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: The local currency issuance share is equal to the percentage of total bond issuance volume in a given year that is denominated in the firm's local currency. Risk-free interest rate differentials are measured using currency forward premia at the 1-year maturity point. Firm size is measured as the log of firm total assets in USD, all other firm characteristics are calculated as ratios to firm assets or sales. All firm information is contemporaneous to bond issuance. Sovereign CDS is measured as the CDS spread of the respective underlying sovereign's USD-denominated debt, relative to the US government CDS. The cross-currency basis measures violations of covered interest rate parity, i.e. the difference between the interest rate differential implied by interest rate swaps and cross-currency swaps, respectively. Emerging markets describes a dummy variable that is equal to one for all firms located in countries that are designated emerging market economies by the IMF WEO publication. US describes a dummy variable that is equal to one for all firms in the US. Data runs from 1995 to 2019.

Table 7: Pass-through of risk-free interest rate differentials to firm-level cost of capital for foreign- and domestic-currency bond issuers

	$\overline{ROA}_{i,t+5}$		
	(1)	(2)	(3)
$r_t^j - r_t^\$$	0.570***	0.520***	0.527***
	(0.100)	(0.073)	(0.085)
$(r_t^j - r_t^\$) \cdot \mathbb{I}_{i,t}^{FC}$	-0.343*	-0.310*	-0.305*
	(0.173)	(0.163)	(0.155)
Firm Size		0.166	0.173
		(0.140)	(0.149)
Firm Leverage		-0.016**	-0.016**
		(0.007)	(0.007)
Firm Cash/Assets		-0.016*	-0.016*
		(0.008)	(0.008)
Firm Int'l Sales Exposure		1.190*	1.254*
		(0.678)	(0.700)
$\mathbb{I}_{i,t}^{FC}$			-0.16
			(0.377)
N	8740	7910	7910
R^2	0.24	0.27	0.27
Sector-Year FE	Y	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets over the next five years. Risk-free interest rate differentials are measured using currency forward premia at the 1-year maturity point, and firms are assigned the forward premium of their domestic currency, based on the ultimate parent company's country of risk designation in Bloomberg. The second row denotes the forward premium a second time, interacted with a dummy variable that equals one if the firm issues a foreign currency bond in a given year. Firm size is measured as the log of firm total assets in USD, all other firm characteristics are calculated as ratios to firm assets or sales. All firm information is contemporaneous to bond issuance. The last row denotes a foreign currency dummy variable, without the interaction with the local currency forward premium. Data runs from 1995 to 2019.

Table 8: Pass-through of risk-free interest rate differentials to firm-level cost of capital for foreign- and domestic-currency bond issuers: firm subsamples

	$\overline{ROA}_{i,t+5}$		
	Large Firms	Domestic Firms	Large & Domestic
	(1)	(2)	(3)
$r_t^j - r_t^\$$	0.588***	0.599***	0.526***
	(0.091)	(0.076)	(0.072)
$\left(r_t^j - r_t^\$\right) \mathbb{I}_{i,t}^{FC}$	-0.414**	-0.460**	-0.462***
	(0.153)	(0.125)	(0.146)
N	5622	4564	2723
R^2	0.34	0.32	0.42
Sector-Year FE	Y	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets over the next five years. Risk-free interest rate differentials are measured using currency forward premia at the 1-year maturity point, and firms are assigned the forward premium of their domestic currency, based on the ultimate parent company's country of risk designation in Bloomberg. The second row denotes the forward premium a second time, interacted with a dummy variable that equals one if the firm issues a foreign currency bond in a given year. Column 1 is based on a subsample of firms with firm size above the sample median. Column 2 is based on a subsample of firms with an international sales share below the sample median, and column 3 uses a sample with only those firms that are both above the median size, and below the median international sales share. Data runs from 1995 to 2019.

Table 9: Effects of foreign currency bond market access: within-firm

	$\overline{ROA}_{i,t+5}$	
	(1)	(2)
Entry in FC bond market	-0.566**	-0.596***
	(0.210)	(0.277)
Firm Size		-1.215***
		(0.205)
Firm Leverage		0.006***
		(0.004)
Firm Cash/Assets		-0.011**
		(0.004)
Firm Int'l Sales Share		0.247
		(0.712)
N	9937	8889
R^2	0.86	0.87
Sector-Year FE	Y	Y
Firm FE	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets, on average over the next five years. The first row, "entry into FC bond market" equal to 1 if the firm issues bonds in foreign currency in a given year, or has done so in the past. The sample includes non-issuance years. Data runs from 1995 to 2019.

Table 10: Pass-through of risk-free interest rate differentials to corporate bond yields by firm characteristics

	$y_{i,t}^{j,d} - r_t^{\$,d}$			
	Large Firms	High Leverage	High Int'l Sales Share	Emerging Markets
	(1)	(2)	(3)	(4)
$r_t^{j,d} - r_t^{\$,d}$	0.725***	0.898***	0.873***	0.942***
	(0.156)	(0.058)	(0.082)	(0.008)
$(r_t^{j,d} - r_t^{\$,d}) \cdot \mathbb{I}_{i,t}^{group}$	0.184	-0.000	-0.033	-0.375***
	(0.139)	(0.035)	(0.067)	(0.071)
N	24544	24598	23541	39510
R^2	0.90	0.90	0.92	0.90
Sector-Year FE	Y	Y	Y	Y
Firm-Year FE	Y	Y	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Risk-free interest rate differentials are measured using currency forward premia (or currency swaps, Du and Schreger, 2016). The second row captures the coefficient on the forward premium added a second time, interacted with a dummy variable that is equal to one if the underlying firm is above the sample median for firm size, leverage, or international sales exposure. The last column proceeds similarly, with the interaction being equal to one if the firm's underlying country of risk exposure is considered an emerging market by the IMF. Data runs from 1995 to 2019.

A0 Appendix

A1 Selection on Unobservables

In the preceding analysis, at the bond- and at the firm-level, a fundamental concern has been possible selection effects. If firms that borrow in currencies with higher risk-free rates were to have fundamentally higher credit risk (or other features that are positively correlated with the residual), then the estimates from the pass-through regression would be systematically biased. Similar concerns about selection on unobservables at the firm-level apply.

While I discuss my preferred identification scheme in the main body of the paper, a growing literature has recently made use of a formalized test to establish robustness to omitted variable bias. Historically, researchers have often interpreted the stability of the coefficient of interest to the inclusion of additional controls as a sign that selection bias is unlikely to drive an empirical relationship. Oster (2019) proposes an explicit test of this intuition, which takes the following form:

$$\beta^* = \tilde{\beta} - \delta \left[\dot{\beta} - \tilde{\beta} \right] \frac{R_{max} - \tilde{R}}{\tilde{R} - \dot{R},} \tag{13}$$

where β^* and R_{max} denote the true coefficient of interest and R^2, while $\tilde{\beta}$ $\tilde{R}$ denote the same for the regression *with*, and $\dot{\beta}$ $\dot{R}$ do so for the regression *without* observable controls. The parameter δ captures how strongly the unobserved variable must be correlated with the variable of interest, relative to the observable controls, in order to confound the estimated relationship (i.e., $\beta^* = 0$). In practice, Oster (2019) argues that $\delta = 1$ is a useful critical value, since it implies that the chosen observable control variables are at least as important as the unobservables. Furthermore, it is standard to calculate $R_max = min(1.3\tilde{R}, 1)$ in order to allow for measurement errors and similar concerns.

Under this test specification, I find that my regressions at the bond-level (without firm-time fixed effects, as presented in table 2) pass the test for selection on unobservables, with $\delta = 1.22$. So the underlying unobservables would need to be at least as important as all the previously controlled-for firm characteristics, such as size and leverage, in order for unobserved variable bias to explain all of the estimated relationship between risk-free interest rate differentials and corporate bond yields. Similarly, the coefficient on the forward premium in the firm-level ROA regressions passes this test, with $\delta = 2.22$. As a result, there is formalized statistical evidence that my results are not driven by unobserved variable bias.

A2 Limited pass-through and quanto risk

In the bond-level regressions documeting the pass-through of risk-free interest rate differentials to corporate bond yields only one group of firms appears to have a susbtantially lower pass-through coefficient than one. Firms in emerging markets appear to borrow in corporate bond markets with bond yields that differ by less than what risk-free interest rate differentials between the issuance currencies would suggest. In practice, this means that an emerging market firm in a high-risk-free interest rate country will face yields on US Dollar-denominated bonds that are higher than what is implied by the local currency-denominated corporate bond and the risk-free interest rate differential between the local currency and the dollar. Since risk-free interest rate differentials are measured with the forward premium, which approximates the cost of hedging out the nominal exchange rate risk, this means that in practice, the yield on a US Dollar-denominated bond is higher than the yield on a local currency bond, after it is hedged back into US Dollars, at least for firms in emerging markets.

This is a strinking observation since transaction costs, often a concern in derivative markets, would make the local currency bond yield even lower from the perspective of a US Dollar-based investor (relative to the Dollar-denominated bond where no currency hedging would be necessary). This is puzzling because the inherent credit risk in the two bonds, given cross-default clauses is assumed to be the same.

There are a number of possible explanations, rooted in market segmentation or access limitations. However, we can also make sense of this pattern in the data by considering the quanto risk inherent in the two instruments. As I show below, the correlation of default risk and the value of the local currency, which may well be more substantial for firms in emerging markets rather than those in developed markets, can lead to differences in bond prices, and hence yields, between two assets that may at first glance look interchangeable. While cash flows of the two instruments (in the presented simplified form) are identical in the case of repayment, if the firm defaults, the investor in the local currency bond still owns the currency forward contract. Intuitively, since the investor is now overhedged, due to the reduction or complete loss of bond redemptions, the currency forward provides additional value. Since the forward contract allows the purchase of a fixed amount of US Dollars for a pre-determined amount of the local currency, if the local currency tends to depreciate concurrently with firm default, the forward contract provides a hedge. As a result, the two instruments may have different prices, even under the assumption of frictionless markets and no-arbitrage.

Based on Du and Schreger (2016), I consider the pricing of the two bond instruments from the perspective of a risk-neutral US Dollar-based investor, under the assumption of frictionless capital markets and no-arbitrage. For simplicity, I consider a one-period bond, with a probability of default D, which is the same for both bonds, and zero recovery in default. We can write the price P of the Dollar-denominated bond as

$$P^{\$}_{i,t} = exp(-r^{\$}_t)\mathbb{E}(1 - D_{i,t+1}), \tag{14}$$

where $r^{\$}$ denotes the risk-free rate in US Dollars. Similarly, we can write the price of the bond denominated in currency j as

$$\frac{P^{j}_{i,t}}{S_t} = exp(-r^{\$}_t)\mathbb{E}\left(\frac{1 - D_{i,t+1}}{S_{t+1}}\right), \tag{15}$$

where S denotes the nominal exchange rate between currency j and the Dollar, i.e. the number of units of currency j necessary to purchase a Dollar. Under the assumption that uncovered interest rate parity holds, we can replace the expected change in the exchange rate with the forward premium priced in forward markets, i.e.

$$\frac{F_t}{S_t} = \mathbb{E}\left(\frac{S_{t+1}}{S_t}\right), \tag{16}$$

where F denotes the current forward contract on the exchange rate in the next period. Under covered interest rate parity, we can then uncover the risk-free interest rate in currency j,

$$exp(-r^{\$}_t)\left(\frac{S_t}{F_t}\right) = exp(-r^{j}_t). \tag{17}$$

We can rewrite the price of the local currency bond as

$$P^{j}_{i,t} = exp(-r^{j}_t)\mathbb{E}(1 - L_{i,t+1})\left[1 + \frac{Cov\left(1 - D_{i,t+1}, \frac{S_t}{S_{t+1}}\right)}{\mathbb{E}(1 - D_{i,t+1})\mathbb{E}\left(\frac{S_t}{S_{t+1}}\right)}\right]. \tag{18}$$

Using (15), we can immediately see that the price on the local currency bond, hedged back into US Dollar, will only be equal to the price of the Dollar-denominated bond if the covariance of corporate default and the exchange rate is zero, i.e.

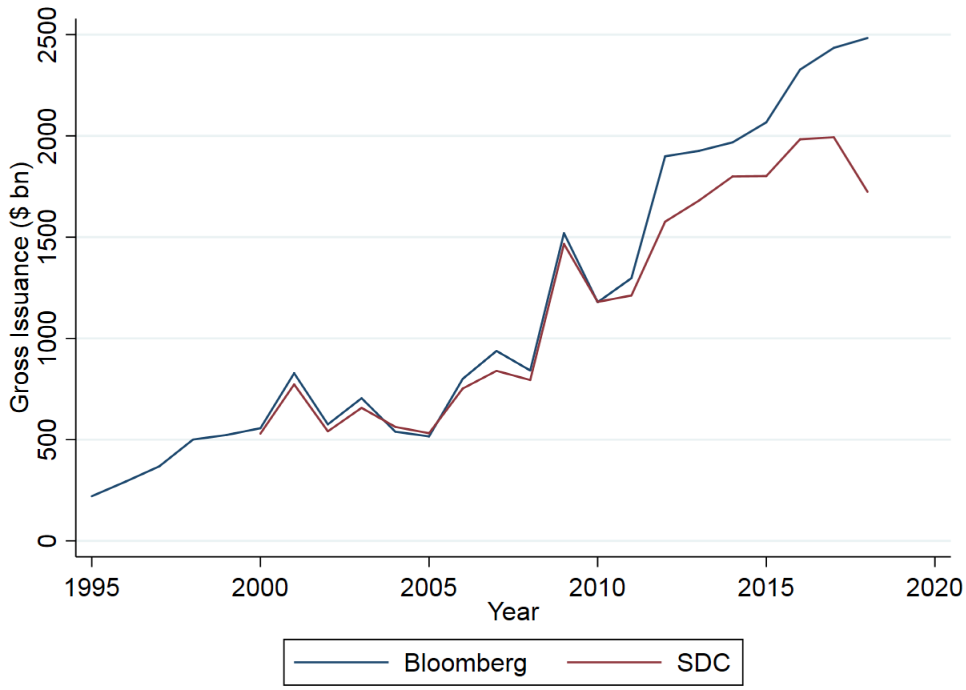
$$P^{\$}_{i,t} = \frac{F_t}{S_t}P^{j}_{i,t} \qquad if \quad Cov\left(1 - D_{i,t+1}, \frac{S_t}{S_{t+1}}\right) = 0. \tag{19}$$

In turn, if the covariance between the local currency and corporate default is positive, i.e. the local currency depreciates (the units necessary to purchase a dollar increases $S + t + 1 \uparrow$) at the same time as the firm defaults, then, the price on the currency-hedged local currency bond will be higher than the price of the Dollar-denominated bond:

$$P_{i,t}^{\$} < \frac{F_t}{S_t} P_{i,t}^{j} \qquad if \quad Cov\left(1 - D_{i,t+1}, \frac{S_t}{S_{t+1}}\right) > 0. \tag{20}$$

Since a higher bond price implies a lower yield, this replicates the observation in the data.

Figure 8: Total gross issuance volume coverage in Bloomberg Back Office



Notes: This chart shows the total annual gross issuance of non-financial private sector companies captured in the data set underlying this paper (Bloomberg), and the figures from a similar data set constructed based on the data from the SDC Platinum database in Celik et al. (2019). The data set from Celik et al. (2019) starts in 2000.

Table A1: Firm characteristics of single- and multi-currency issuers

	All Issuers	Multi-currency Issuers
Firm-Year observation	39,681	3,050
# of bonds issued (mean)	2.24	6.44
# of currencies issued in (mean)	1.12	2.51
Total issuance (mean, $ bn)	0.59	2.29

Table A2: Pass-through of risk-free interest rate differentials to corporate bond yields by duration

	$y_{i,t}^{j,d} - r_t^{\$,d}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$r_t^{j,d} - r_t^{\$,d}$	0.992***	0.997***	1.101***	1.123***	1.113***	0.848***
	(0.039)	(0.075)	(0.124)	(0.041)	(0.045)	(0.140)
N	10200	12699	10130	11930	4740	3032
R^2	0.71	0.67	0.71	0.79	0.82	0.59
Maturity-Year FE	Y	Y	Y	Y	Y	Y
Sector-Year FE	Y	Y	Y	Y	Y	Y
Duration	≤3	(3,5]	(5,7]	(7,10]	(10-15]	>15

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Risk-free interest rate differentials are measured using currency forward premia and currency swaps (Du and Schreger, 2016), and match the underlying corporate bond's duration. Each column shows different subsamples by bond duration. Data runs from 1995 to 2019.

Table A3: Pass-through of risk-free interest rate differentials to corporate bond yields by duration with firm-year fixed effects

	$y_{i,t}^{j,d} - r_t^{\$,d}$					
	(1)	(2)	(3)	(4)	(5)	(6)
$r_t^{j,d} - r_t^{\$,d}$	0.836***	0.894***	0.926***	0.984***	1.099***	0.766***
	(0.063)	(0.032)	(0.079)	(0.031)	(0.069)	(0.241)
N	1811	1990	1075	1671	712	311
R^2	0.94	0.96	0.96	0.95	0.90	0.70
Maturity-Year FE	Y	Y	Y	Y	Y	Y
Firm-Year FE	Y	Y	Y	Y	Y	Y
Duration	≤3	(3,5]	(5,7]	(7,10]	(10-15]	>15

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Risk-free interest rate differentials are measured using currency forward premia and currency swaps (Du and Schreger, 2016), and match the underlying corporate bond's duration. Each column shows different subsamples by bond duration. Data runs from 1995 to 2019.

Table A4: Pass-through of risk-free interest rate differentials to corporate bond yields, matched on bond maturity

	$y_{i,t}^{j,d} - r_t^{\$,d}$		
	(1)	(2)	(3)
$r_t^{j,d} - r_t^{\$,d}$	1.049***	0.889***	0.792***
	(0.059)	(0.053)	(0.101)
N	31897	31757	39552
R^2	0.69	0.74	0.90
Maturity-Year FE	Y	Y	Y
Sector-Year FE	Y		
Country-Year FE		Y	
Firm-Year FE			Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Risk-free interest rate differentials are measured using currency forward premia and currency swaps (Du and Schreger, 2016), and match the underlying corporate bond's time to maturity. Data runs from 1995 to 2019.

Table A5: Pass-through of risk-free interest rate differentials to corporate bond yields by bond type

	$y_{i,t}^{j,d} - r_t^{\$,d}$			
	(1)	(2)	(3)	(4)
$r_t^{j,d} - r_t^{\$,d}$	0.840***	0.725***	1.022***	0.935***
	(0.069)	(0.152)	(0.015)	(0.010)
N	29320	18273	7925	13494
R^2	0.94	0.95	0.91	0.91
Maturity-Year FE	Y	Y	Y	Y
Firm-Year FE	Y	Y	Y	Y
Bond Sample	Non-callable	Senior Unsecured	IG rated	Non-Domestic

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Risk-free interest rate differentials are measured using currency forward premia and currency swaps (Du and Schreger, 2016), and match the underlying corporate bond's duration. Each column shows different subsamples by bond characteristic. The first column includes only bonds that are not callable. The second column includes only bond instruments of "senior unsecured" status. Column 3 uses only bonds rated "Investment Grade" (IG), i.e. BBB- or above by Standard & Poor's, or at least Baa3 By Moody's at the time of issuance. Column 4 only uses bonds whose market of issuance is Non-Domestic, i.e. "Eurobonds" or "Global" bond issues. Data runs from 1995 to 2019.

Table A6: Pass-through of risk-free interest rate differentials to firm-level cost of capital by characteristics

	$\overline{ROA}_{i,t+5}$			
	Large Firms	High Leverage	High Int'l Sales	Emerging Markets
	(1)	(2)	(3)	(4)
$r_t^j - r_t^\$$	0.390***	0.383***	0.448***	0.605***
	(0.100)	(0.073)	(0.085)	(0.111)
$(r_t^j - r_t^\$) \cdot \mathbb{I}_{i,t}^{group}$	0.092	-0.089	-0.099	-0.416*
	(0.113)	(0.073)	(0.155)	(0.241)
N	8702	8702	8185	8703
R^2	0.24	0.24	0.25	0.24
Sector-Year FE	Y	Y	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets over the next five years. Risk-free interest rate differentials are measured using currency forward premia at the 1-year maturity point. Firm size is measured as the log of firm total assets in USD, all other firm characteristics are calculated as ratios to firm assets or sales. All firm information is contemporaneous to bond issuance. The second row captures the coefficient on the forward premium added a second time, interacted with a dummy variable that is equal to one if the underlying firm is above the sample median for firm size, leverage, or international sales exposure. The last column proceeds similarly, with the interaction being equal to one if the firm's underlying country of risk exposure is considered an emerging market by the IMF. Data runs from 1995 to 2019.

Table A7: Pass-through of risk-free interest rate differentials to firm-level return on assets (ROA): alternative measures

	$\frac{Net\ Income}{Total\ Assets}$	$\frac{Net\ Income\ (pre\ tax)}{Total\ Assets}$	$\frac{EBIT}{Total\ Assets}$	$\frac{EBITDA}{PPE}$
	(1)	(2)	(3)	(4)
$r_t^j - r_t^\$$	0.332***	0.373***	0.471***	2.016***
	(0.099)	(0.128)	(0.142)	(0.672)
N	8748	8712	8769	8241
R^2	0.18	0.19	0.22	0.31
Sector-Year FE	Y	Y	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings to total assets over the next five years, with each column using an alternative means of construction. All measures are computed using contemporaneous values for numerator and denominator, and as the average over the next five years. PPE denotes the total value of firm physical assets, measured as property, plants and equipment. Risk-free interest rate differentials are measured using currency forward premia at the 1-year maturity point, and firms are assigned the forward premium of their domestic currency, based on the ultimate parent company's country of risk designation in Bloomberg. Data runs from 1995 to 2019.

Table A8: Pass-through of risk-free interest rate differentials to firm-level return on assets (ROA): alternative time frames

	$ROA_{i,t}$ (1)	$ROA_{i,t+1}$ (2)
$r_t^j - r_t^\$$	0.395***	0.414***
	(0.145)	(0.157)
N	12142	12119
R^2	0.12	0.19
Sector-Year FE	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets. Column 1 computes the ratio based on contemporaneous data, while column 2 uses data for the following year (both for denominator and numerator). Risk-free interest rate differentials are measured using currency forward premia at the 1-year maturity point, and firms are assigned the forward premium of their domestic currency, based on the ultimate parent company's country of risk designation in Bloomberg. Data runs from 1995 to 2019.

Table A9: Pass-through of risk-free interest rate differentials to firm-level return on assets (ROA): firm fixed effects and non-issuance years

	$\overline{ROA}_{i,t+5}$			
	(1)	(2)	(3)	(4)
$r_t^j - r_t^\$$	0.179***	0.145***	0.295*	0.174***
	(0.061)	(0.032)	(0.148)	(0.043)
N	8735	7344	32940	32645
R^2	0.30	0.87	0.08	0.67
Sector-Year FE	Y	Y	Y	Y
Country FE	Y			
Incl. non-issuance years			Y	Y
Firm FE		Y		Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets, on average over the next five years. Column 1 adds a country fixed effect to the standard regression. Column 2 and 4 include firm-level fixed effects, while columns 3 and 4 expands the sample to include data from non-issuance years for all firms in the bond market data set. Risk-free interest rate differentials are measured using currency forward premia at the 1-year maturity point, and firms are assigned the forward premium of their domestic currency, based on the ultimate parent company's country of risk designation in Bloomberg. Data runs from 1995 to 2019.

Table A10: Pass-through of risk-free interest rate differentials to firm-level return on assets (ROA): alternative interest rate maturities

	$\overline{ROA}_{i,t+5}$		
	3Y Fwd Prem	5Y Fwd Prem	10Y Fwd Prem
	(1)	(2)	(3)
$r_t^{j,d} - r_t^{\$,d}$	0.498***	0.531***	0.586***
	(0.133)	(0.133)	(0.137)
N	8745	8758	8714
R^2	0.24	0.24	0.25
Sector-Year FE	Y	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets, on average over the next five years. Risk-free interest rate differentials are measured using currency forward premia at the 3-, 5-, and 10-year maturity point, respectively in each column, and firms are assigned the forward premium of their domestic currency, based on the ultimate parent company's country of risk designation in Bloomberg. Data runs from 1995 to 2019.

Table A11: Pass-through of realized UIP violations to firm-level return on assets (ROA)

	$\overline{ROA}_{i,t+5}$
	(1)
$(r_t^{j,5} - r_t^{\$,5}) + (s_{t+5}^j - s_t^j)^{\frac{1}{5}}$	0.215**
	(0.093)
N	8462
R^2	0.22
Sector-Year FE	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets, on average over the next five years. Realized UIP violations are calculated as the 5-year forward premium of the firm's local currency to the US Dollar, plus the annualized change in the nominal exchange rate over the following 5 years, contemporaneous the time window used to compute ROA. Data runs from 1995 to 2019.

Table A12: Pass-through of risk-free interest rate differentials to firm-level return on assets (ROA): original country designation

	$\overline{ROA}_{i,t+5}$	
	(1)	(2)
$r_t^j - r_t^\$$	0.392**	0.536***
	(0.087)	(0.089)
$\left(r_t^j - r_t^\$\right) \mathbb{I}_{i,t}^{FC}$		-0.355**
		(0.145)
N	8503	8503
R^2	0.23	0.23
Sector-Year FE	Y	Y

SEs in parantheses, clustered by country. *p<0.1, **p<0.05, ***p<0.01

Notes: Firm ROA is measured as the ratio of firm earnings (EBITDA) to total assets, on average over the next five years. Risk-free interest rate differentials are measured using currency forward premia at the 1-year maturity point, and firms are assigned the forward premium of their domestic currency, based on the underlying firm's primary country of domicile, not the country of the ultimate parent company. The second row interacts the forward premium with a dummy variable, equal to 1 if the firm issues bonds in foreign currency in a given year. Data runs from 1995 to 2019.

Table A13: Alternative standard errors

	Bond yield	$\overline{ROA}$
Panel A: Analytical		
Robust	0.006	0.031
Cluster by year	0.026	0.060
Cluster by country*	0.068	0.153
Cluster by country and year	0.069	0.151
Cluster by industry	0.018	0.087
Cluster by industry and year	0.029	0.096
Panel B: Bootstrap		
Robust	0.006	0.028
Cluster by year	0.105	0.202
Cluster by country	0.026	0.060
Cluster by country and year	0.006	0.029

Notes: This table shows the various standard errors on the Forward Premium variable $r_{i,t}^{j,d} - r_{i,t}^{\$,d}$ in the standard specification for the bond yield regression (column 1 in table 3), and the firm ROA regression (column 1 in table 5). The bootstrapped standard errors in Panel B are obtained using 1,000 draws with replacement. * denotes the standard specification.