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Local Currency Sovereign Risk

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ABSTRACT

We introduce a new measure of emerging market sovereign credit risk: the local currency credit spread, defined as the spread of local currency bonds over the synthetic local currency risk-free rate constructed using cross-currency swaps. We find that local currency credit spreads are positive and sizable. Compared with credit spreads on foreign-currency-denominated debt, local currency credit spreads have lower means, lower cross-country correlations, and lower sensitivity to global risk factors. We discuss several major sources of credit spread differentials, including positively correlated credit and currency risk, selective default, capital controls, and various financial market frictions.

WHEN A SOVEREIGN borrows in its own currency, the spread it pays over the U.S. Treasury risk-free benchmark might contain two major types of risk: currency risk and credit risk. We introduce a new sovereign risk measure, the *local currency (LC) credit spread*, to measure the credit risk component of LC-denominated debt. We find that the LC credit spread is positive and sizable for emerging market sovereigns, despite their ability to print their own currency to repay the debt. Furthermore, we document significant differences between the LC credit spread and the conventional measure of emerging market sovereign

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risk based on foreign currency -denominated external debt, the foreign currency (FC) credit spread. LC credit spreads have lower means, lower cross-country correlations, and lower sensitivity to global risk factors. In addition, investors' expectation of LC depreciation upon sovereign default can lower the LC credit spread relative to the FC credit spread. Selective default, capital controls, and financial market frictions can also contribute to the credit spread differentials.

An understanding of the credit risk on LC sovereign debt is important because LC debt has become the primary form of financing for many emerging market governments, as well as a growing global asset class. While an important literature examines why emerging markets could not borrow in their own currency from foreigners in the past (Eichengreen and Hausmann (2005)), the situation has changed dramatically over the last decade. As we show in Du and Schreger (2015), the mean share of LC debt in total external sovereign debt held by nonresidents increased from around 10% to nearly 60% over the past decade for a sample of 14 emerging markets. According to volume surveys conducted by the Emerging Market Trading Association (EMTA), the share of LC debt in total offshore emerging market debt trading volume has increased from 35% in 2000 to 66% in 2013, reaching $3.5 trillion. The growing importance of LC debt markets stands in stark contrast to the declining role of FC sovereign financing. The popular country-level JP Morgan Emerging Market Bond Index (EMBI), commonly used in academic research to measure sovereign risk, today tracks a dwindling number of outstanding FC eurobonds with declining liquidity and trading volume.[1]

Taking a frictionless financial market as a benchmark, we construct the LC risk-free rate by swapping the dollar cash flows from a default-free U.S. Treasury bond into the LC using a cross-currency swap (CCS) with negligible counterparty risk. We then define the LC credit spread as the difference between the nominal yield on an LC bond and this LC risk-free rate, or the deviation from covered interest parity (CIP) between government bond yields in emerging markets and the United States. In the absence of financial market frictions, the LC credit spread can be positive only if there is explicit default risk associated with the LC debt. Formally speaking, the LC credit spread is exactly equal to the risk-neutral expected default loss of the LC bond under the LC risk-neutral measure.

From a dollar investor's perspective, the LC credit spread is equivalent to the synthetic dollar spread on a swapped LC bond over the U.S. Treasury yield. By swapping all the promised cash flows of LC debt into the U.S. dollar, a dollar investor can lock in the LC credit spread even if the value of the currency plummets—as long as explicit default is avoided. If an LC default does occur, in addition to the default loss measured in dollars, the dollar investor will have overhedged currency risk, as the CCS notional exceeds the realized LC

[1] Furthermore, according to the Credit Derivative Physical Settlement Matrix published by the International Swaps and Derivatives Association, defaults on LC bonds governed under domestic law do not constitute credit events that trigger credit default swap (CDS) contracts in emerging markets. As a result, sovereign CDS spreads cannot directly characterize LC sovereign credit risk.

bond cash flows due to the loss caused by default. The valuation impact of this currency hedging error depends on the covariance between currency risk and default risk, which we refer to as the "quanto adjustment." Formally speaking, under the dollar risk-neutral measure, the LC credit spread is equal to the risk-neutral expected default loss of the LC bond plus the quanto adjustment. In the case of positively correlated credit and currency risk, the quanto adjustment is negative, and thus the LC credit spread will understate the risk-neutral expected default loss under the dollar measure.

Using a new data set of daily zero-coupon LC and FC yield curves and swap rates for 10 major emerging market countries with sizable LC and FC sovereign debt markets from 2005 to 2014, we present the first set of broad stylized facts about LC sovereign risk and its relationship to FC sovereign risk. We find that LC credit spreads are significantly above zero. For five-year zero-coupon bonds, the mean LC credit spread is equal to 145 basis points, which accounts for more than one-quarter of the LC nominal spread over U.S. Treasuries. This LC credit spread is lower than the average credit spread of 201 basis points on FC sovereign debt during the same period.

LC and FC credit spreads are different along three important dimensions. First, LC credit spreads are persistently lower than FC credit spreads in 9 out of 10 sample countries, with the exception of Brazil. The mean LC-over-FC credit spread differential is equal to negative 56 basis points. The gap between LC and FC credit spreads significantly widened during the peak of the crisis following the Lehman Brothers bankruptcy. Second, FC credit spreads are much more correlated across countries than LC credit spreads. The first principal component (PC) can explain 77% of the variation in FC credit spreads, but only 54% of the variation in LC credit spreads, pointing to the relative importance of country-specific factors in driving LC spreads. Third, FC credit spreads are much more correlated with global risk factors than LC credit spreads, in both the ex-ante yield space and the ex-post return space. Despite the common perception that emerging market LC debt is very risky, we find that, after the currency risk is hedged, swapped LC debt has lower loadings on global risk factors than FC debt. After presenting the stylized facts, we discuss three potential sources of the credit spread differentials: (1) covariance between currency and credit risk, or the quanto adjustment, (2) selective default and capital control risk, and (3) several important financial market frictions.

First, the covariance between currency and default risk can create a wedge between LC and FC credit spreads. Our simple calibration suggests that a 39% expected LC depreciation upon default relative to the counterfactual nondefault state would imply an equal expected default loss on the LC and FC debt under the dollar risk-neutral measure. Our risk-neutral calibration of depreciation upon default based on CDS spreads denominated in different currencies gives an estimate of about 36%. In addition, we perform a historical calibration of depreciation upon default using ex-post realized exchange rates over a five-year horizon and historical default classifications by Reinhart and Rogoff (2009) and Cruces and Trebesch (2013). We show that the value of the currency in defaulting countries is 27% to 34% lower than that in ex-ante similar countries without a default. Therefore, the magnitude of the covariance adjustment is broadly equal to the observed mean difference in credit spreads, suggesting that LC and FC bonds on average have similar risk-neutral expected default losses under the dollar measure.

Second, selective default and capital controls can also contribute to credit spread differentials. Selective default is the risk that the sovereign may choose to default on one type of debt but not on the others. In our sample countries, the vast majority of LC debt is issued in domestic markets under domestic law, while FC debt is issued in international markets under foreign law. Default outcomes can be quite different for bonds governed under different jurisdictions, as illustrated by the Russian default in 1998 (Duffie, Pedersen, and Singleton (2003)), and the recent Greek default experience (Chamon, Trebesch, and Schumacher (2014)). It is a priori ambiguous whether LC or FC sovereign debt is associated with a higher probability or severity of default, as the recent historical incidence of domestic LC default and FC external default is quite comparable (Moody's (2014), Standard & Poor's (2014)). In addition to outright default, foreign holders of LC debt also face several risks not present in FC debt, including currency convertibility risk as well as the risks of changing taxation and regulation. From an offshore investor's perspective, we consider these additional risks as a general form of credit risk on LC debt even though the government may not explicitly break the bond covenants. We show that capital controls and jurisdiction risks are particularly helpful in explaining the Brazilian exception, where the LC credit spread is higher than the FC credit spread.

Third, various financial market frictions can also affect the relative pricing of swapped LC and FC bonds. We discuss the impacts of differential liquidity risk, market segmentation between domestic and external markets, short-selling constraints, and no-arbitrage violations in the currency markets. In particular, we show that, compared to FC debt, swapped LC debt is more liquid but more difficult to short, and is more likely affected by market segmentation between domestic and external debt markets as well as frictions in the currency markets. We quantify the plausible magnitudes for these frictions. These estimates can be further refined in future work by focusing on specific frictions.

Our paper contributes to several strands of the literature. Our primary contribution is to present a set of new stylized facts about LC sovereign risk, contributing to work by Reinhart and Rogoff (2011) on domestic defaults and earlier work by Burger and Warnock (2007) and Burger, Warnock, and Warnock (2012) on pricing LC debt using bond return indices. By contrasting LC sovereign risk with FC sovereign risk, our work is also closely related to the large empirical literature on FC sovereign risk and currency risk, including Longstaff et al. (2011), Borri and Verdelhan (2012), Lustig and Verdelhan (2007), Lustig, Roussanov, and Verdelhan (2014), and Lettau, Maggiori, and Weber (2014). We further contribute to the literature using currency forwards or swaps to study ex-ante yield differentials across currencies. Popper (1993) and Fletcher and Taylor (1996) document small and less persistent deviations from covered parity between Treasury yields in developed markets. Yield differentials between euro- and dollar-denominated sovereign bonds are examined for three emerging markets by Buraschi, Meguturk, and Sener (2014) and for European sovereigns by Corradin and Rodriguez-Moreno (2014). CCS have also been used to study corporate credit spreads in different currencies and their relationship to corporate issuance decisions (McBrady and Schill (2007)).

In addition, our results shed further light on the joint dynamics between currency and default risk and thus are related to the literature on so-called "cousin risks" (Garcia and Lowenkron (2005)). The role of correlation between foreign exchange (FX) and default risk in affecting currency-specific corporate credit spreads is also studied by Jankowitsch and Stefan (2005). Furthermore, we document various financial market frictions in emerging market currency and fixed income markets. The existing asset pricing literature helps us understand credit spread differentials in the presence of financial market frictions including illiquidity (i.e., Chen, Lesmond, and Wei (2007), Bao, Pan, and Wang (2011)), short-selling constraints (i.e., Miller (1977), Duffie, Garleanu, and Pedersen (2002)), market segmentation (i.e., Gromb and Vayanos (2002), Greenwood and Vayanos (2014)), and slow-moving capital (i.e., Shleifer and Vishny (1997), Duffie (2010)).

The rest of the paper is structured as follows. Section I formally introduces the LC credit spread measure. Section II presents new stylized facts on LC sovereign risk. Section III discusses major sources of credit spread differentials. Section IV concludes.

I. LC and FC Sovereign Credit Spreads

A. Historical Defaults on LC Debt

Although sovereigns have the ability to print the currency in which LC bonds are denominated, they may still choose to default on the debt for economic or political reasons. The government might find it preferable to explicitly default rather than tolerate very high inflation,[2] or it might find that the additional cost of defaulting on LC debt is small if the sovereign has already decided to default on its FC debt. Additionally, LC debt issued in domestic markets and governed under domestic law contains the risk that sovereigns can change the law. The sovereign can also suspend currency convertibility or impose capital controls on the repatriation of foreign funds without explicitly breaking the bond covenants. Our model-free empirical measure, the LC credit spread, captures these credit risks embedded in LC debt.

One famous example of domestic sovereign default is the Russian default in 1998. Prior to the default, Russia had successfully brought down chronically high inflation from three digits to around 10% by early 1998. When the fiscal crisis began, rather than financing the sovereign debt entirely by printing money and exposing the country to very high inflation once again, the government instead chose to selectively default on three-month LC Treasury bills

[2] In Du and Schreger (2015), we present a model in which private FC debt discourages the government from inflating away LC sovereign debt and generates equilibrium default risk.

(GKO) and a dollar-denominated bond under domestic jurisdiction (MINFIN 3) before carrying out more comprehensive debt restructuring. Duffie, Pedersen, and Singleton (2003) provide a detailed discussion of the yield differentials across different Russian sovereign bonds around the default, suggesting that the market expected different default scenarios for different types of bonds issued by the same sovereign. Another example of an LC sovereign default is given by Turkey in 1999, soon after the Asian and Russian crises and the Kocaeli earthquake. While inflation in Turkey was around 70%, the government defaulted by retroactively imposing high withholding taxes on all outstanding LC government securities. Fixed rate LC bonds were taxed at 20%, while FC debt was untouched. Given the uncertainty in LC default and recovery, an empirical measure is needed to assess credit risk on LC debt.

B. Definition of the LC Credit Spread

In defining and interpreting the LC credit spread under a frictionless financial market, we maintain three key assumptions:

ASSUMPTION 1: *The financial market does not allow risk-free arbitrage. In particular, we assume that (1) all bonds have perfect liquidity, (2) all bonds can be accessed by unconstrained arbitrageurs, (3) there are no short-selling constraints, and (4) there is a perfectly elastic supply of long-term capital denominated in both the U.S. dollar and emerging market local currencies.*[3]

ASSUMPTION 2: *FX forward and swap contracts are free from counterparty risk.*

ASSUMPTION 3: *U.S. Treasuries denominated in dollars are default-free.*

Before proceeding to the definition of the LC credit spread, we first explain how to derive the long-term FX forward premium implicit in the zero-coupon fixed-for-fixed CCS. A fixed-for-fixed LC/dollar CCS can be constructed in two steps. The investor first swaps fixed LC cash flows into floating U.S. London Interbank Offer Rate (LIBOR) cash flows,[4] and then swaps floating U.S. LIBOR cash flows into fixed dollar cash flows. We show in the following lemma that the difference between the two swap rates, or the zero-coupon fixed-for-fixed LC/dollar CCS rate, must be equal to the long-term forward premium by no arbitrage.[5] All proofs can be found in the Appendix.

[3] These assumptions for frictionless financial markets follow Buraschi, Meguturk, and Sener (2014).

[4] For Mexico, Hungary, Israel, and Poland in our sample, this step itself combines two interest rate swaps: a plain-vanilla LC fixed for LC floating interest rate swap and a cross-currency LC floating for U.S. LIBOR basis swap. U.S. dollar tenor basis swaps are used when the interest rate swap and CCS are referenced to U.S. LIBOR cash flows at different tenors (e.g., three-month versus six-month U.S. LIBOR).

[5] In the case that long-dated forward contracts are directly traded, such as the euro/dollar pair, the difference between the CCS and long-term forward is indeed very small (Buraschi, Meguturk, and Sener (2014)).

LEMMA 1: *We let $F_{t,t+n} \equiv \exp(f_{t,t+n})$ denote the outright forward exchange rate and $\mathcal{E}_t \equiv \exp(e_t)$ denote the spot exchange rate, measured as LC units per dollar. Given the log zero-coupon swap rate $\tilde{r}_{nt}^{LC}$ from the fixed LC for U.S. LIBOR CCS and $\tilde{r}_{nt}^{\$}$ from the fixed dollar for U.S. LIBOR interest rate swap, the zero-coupon fixed-for-fixed LC/dollar CCS rate ($\rho_{nt} \equiv \tilde{r}_{nt}^{LC} - \tilde{r}_{nt}^{\$}$) is equal to the long-term forward premium:*

$$\rho_{nt} = \frac{1}{n}(f_{t,t+n} - e_t). \tag{1}$$

To measure credit risk on LC debt, we first construct the LC risk-free rate. We demonstrate in the following proposition that we can construct a default-free LC instrument by swapping the U.S. Treasury bond into the LC using the CCS contract. Figure 1 presents a cash flow diagram of this synthetic LC default-free bond.

PROPOSITION 1: *Let $y_{nt}^{*\$}$ denote the log zero-coupon yield on the n-year U.S. Treasury bond, and ρ_{nt} denote the n-year fixed-for-fixed log zero-coupon CCS rate from the U.S. dollar to the LC. We can obtain the following log LC risk-free rate:*

$$y_{nt}^{*LC} = y_{nt}^{*\$} + \rho_{nt}. \tag{2}$$

Once we have the LC risk-free rate, we can define the LC credit spread as follows.

DEFINITION 1: *The LC credit spread, s_{nt}^{LCCS}, is defined as the difference between the LC nominal yield, y_{nt}^{LC}, and the LC risk-free rate, y_{nt}^{*LC},*

$$s_{nt}^{LCCS} \equiv y_{nt}^{LC} - y_{nt}^{*LC} = y_{nt}^{LC} - \left(y_{nt}^{*\$} + \rho_{nt}\right), \tag{3}$$

or the deviation in CIP between government bond yields in emerging markets and the United States.

We provide a formal interpretation of the LC credit spread under the LC and dollar risk-neutral measure, respectively, in Proposition 2. For simplicity, we consider a one-period defaultable LC bond. Intuitively, the LC credit spread gives the expected default loss as a fraction of the face value of the debt in LC, regardless of the exchange rate dynamics. However, the dollar numeraire-based LC credit risk measures the expected default loss as a fraction of the face value of the LC debt in dollars, which would be higher than the LC credit spread if the LC is expected to be less valuable in the default state than in the repayment state.

PROPOSITION 2: *Let $\mathbb{Q}_t^{LC}$ and $\mathbb{Q}_t^{\$}$ denote the risk-neutral measures for the LC and U.S. dollar, respectively, at time t, and L_{t+1}^{LC} denote the default loss on the LC bond at time $t+1$ measured as a fraction of the face value in the LC. Then, the LC credit spread at time t is given by*

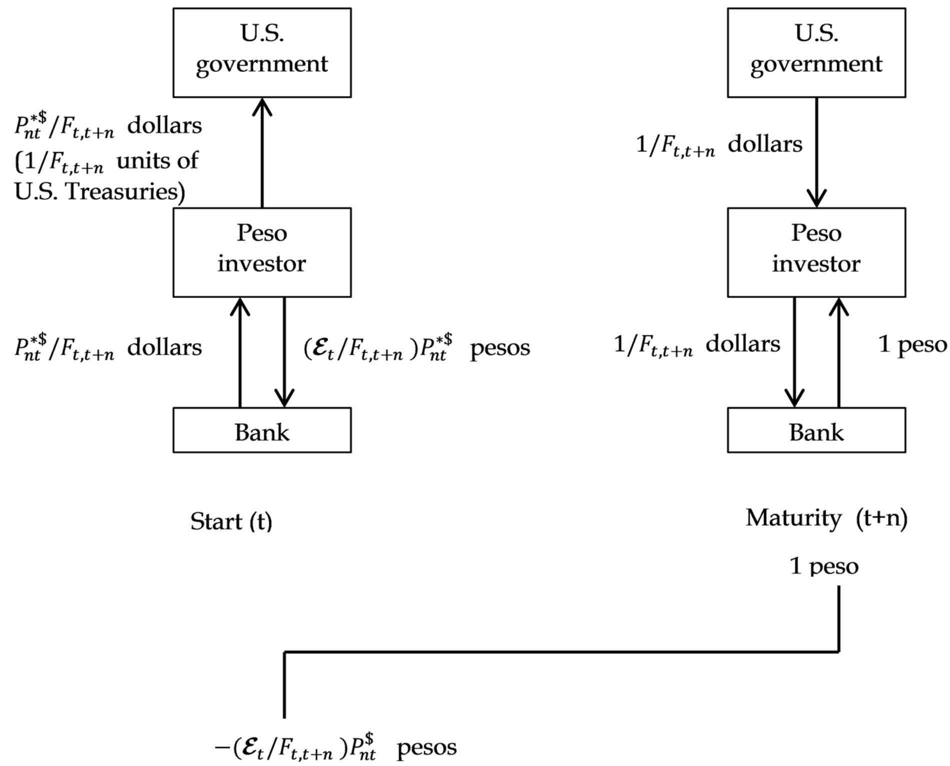


Figure 1. Cash flow diagram for a synthetic LC risk-free bond. This diagram shows cash flows for a synthetic LC risk-free bond by swapping the U.S. Treasury bond into pesos using an outright FX forward contract. At time t, a peso investor exchanges $(\mathcal{E}_t/F_{t,t+n})P^{*\$}_{nt}$ pesos for $P^{*\$}_{nt}/F_{t,t+n}$ dollars with a bank at the spot exchange rate $\mathcal{E}_t$, where $P^{*\$}_{nt}$ is the price of the Treasury at time t and $F_{t,t+n}$ is the outright forward rate. She then invests all the dollar proceeds into zero-coupon U.S. Treasuries with face value $1/F_{t,t+n}$. Meanwhile, at time t, she enters into an outright forward contract to sell $1/F_{t,t+n}$ dollars forward for one peso at time $t+n$. At time $t+n$, the U.S. government repays full principal, $1/F_{t,t+n}$ dollars. The peso investor gives the dollar payment to the bank to fulfill the outright forward contract and receives one peso. The net cash flows of this synthetic risk-free peso bond is that the peso investor invests in $(\mathcal{E}_t/F_{t,t+n})P^{*\$}_{nt}$ pesos at time t and receives one peso with certainty at time $t+n$. Therefore, the synthetic peso risk-free rate is given by $y^{*LC}_{nt} = -\frac{1}{n}\log[(\mathcal{E}_t/F_{t,t+n})P^{*\$}_{nt}] = y^{*\$}_{nt} + \rho_{nt}$.

$$s^{LCCS}_t \approx \mathbb{E}^{\mathbb{Q}^{LC}}_t L^{LC}_{t+1} \qquad \textit{under } \mathbb{Q}^{LC} \tag{4}$$

$$\approx \mathbb{E}^{\mathbb{Q}^{\$}}_t L^{LC}_{t+1} - q_t \quad \textit{under } \mathbb{Q}^{\$}, \tag{5}$$

where $q_t = \frac{Cov^{\mathbb{Q}^{\$}}_t(1-L^{LC}_{t+1}, \mathcal{E}_t/\mathcal{E}_{t+1})}{\mathbb{E}^{\mathbb{Q}^{\$}}_t(1-L^{LC}_{t+1})\mathbb{E}^{\mathbb{Q}^{\$}}_t(\mathcal{E}_t/\mathcal{E}_{t+1})}$ *measures the covariance between currency and credit risk under* $\mathbb{Q}^{\$}$*, referred to as the quanto adjustment.*

Throughout the paper, we refer to $\mathbb{E}_t^{\mathbb{Q}^{LC}} L_{t+1}^{LC}$ as the credit risk of the LC debt measured using the LC numeraire and $\mathbb{E}_t^{\mathbb{Q}^{\$}} L_{t+1}^{LC}$ as the credit risk of the LC debt measured using the dollar numeraire. For simplicity of exposition, we assume two future states: a repayment state in which $L_{t+1}^{LC} = 0$ and a default state in which $L_{t+1}^{LC} = \delta_{t+1}$.

Depending on the choice of numeraire, the LC credit spread can be interpreted in the following two ways. First, equation (4) shows that the LC credit spread captures the risk-neutral expected default loss of the LC debt measured in terms of the LC risk-free bond. At time t, by going long one unit of the LC sovereign bond at $y_t^{LC} = y_t^{*LC} + s_t^{LCCS}$ and going short one unit of the LC risk-free bond at y_t^{*LC}, the LC investor receives the LC credit spread, s_t^{LCCS}, in units of LC. At time $t+1$, the investor receives zero net cash flows if the sovereign repays and loses δ_{t+1} units of LC if the sovereign defaults.[6] By no arbitrage, at time t, the risk-neutral expected default loss of the LC debt at $t+1$ must be equal to s_t^{LCCS} percent of one unit of the risk-free LC. This LC measure-based perspective captures the credit component of the LC debt, independent of the joint dynamics between currency and default risk.

Second, equation (5) shows that the LC credit spread also captures the risk-neutral expected default loss of LC debt measured in terms of risk-free dollar bonds, plus an adjustment for the covariance between currency risk and default risk. To see this, in Figure 2, we consider a dollar investor who uses the CCS to hedge the promised cash flows of the LC bond. We refer to the LC bond and CCS package as a swapped LC bond with promised yield equal to $y_t^{SLC} = y_t^{LC} - \rho_t$. The LC credit spread is also equal to the dollar spread on the swapped LC bond, $s_t^{LCCS} = (y_t^{LC} - \rho_t) - y_t^{*\$} = s_t^{SLC} - y_t^{*\$}$. To collect the LC credit spread from the dollar investor's perspective, we consider the strategy going long one unit of the swapped LC bond at y_t^{SLC} and shorting one unit of the U.S. Treasury bond at $y_t^{*\$}$.[7] The dollar investor receives the LC credit spread, s_t^{LCCS}, in dollars at time t. If the sovereign repays, the strategy yields zero net cash flows at time $t+1$. The dollar investor can lock in s_t^{LCCS} dollars even if the LC depreciates, provided that explicit default is avoided. However, if the sovereign defaults, the currency hedging becomes imperfect, and the dollar investor loses δ_{t+1} dollars and still needs to unwind the swap position with unmatched LC cash flows. In the case of positively correlated credit and currency risk, the LC depreciates more upon default relative to the nondefault state. The dollar investor holding the swapped LC bond has a net long position in dollars in the event of an LC default, which corresponds to additional currency gains.[8] These profits would be passed into an ex-ante negative spread adjustment. As shown in Section I

[6] We illustrate the net cash flows of going long in the LC sovereign and short in the LC risk-free bond in Figure IA.1, Panel A, in the Internet Appendix, which is available in the online version of the article on the *Journal of Finance* website.

[7] We illustrate the net cash flows of this strategy in Figure IA.1, Panel B, in the Internet Appendix.

[8] To see this, we note that, in Figure 2, the hedging error upon default is given by $\delta_{t+1}(1 - F_{t,t+1}/\mathcal{E}_{t+1})$, where δ_{t+1} is the loss given default. If currency depreciates upon default relative

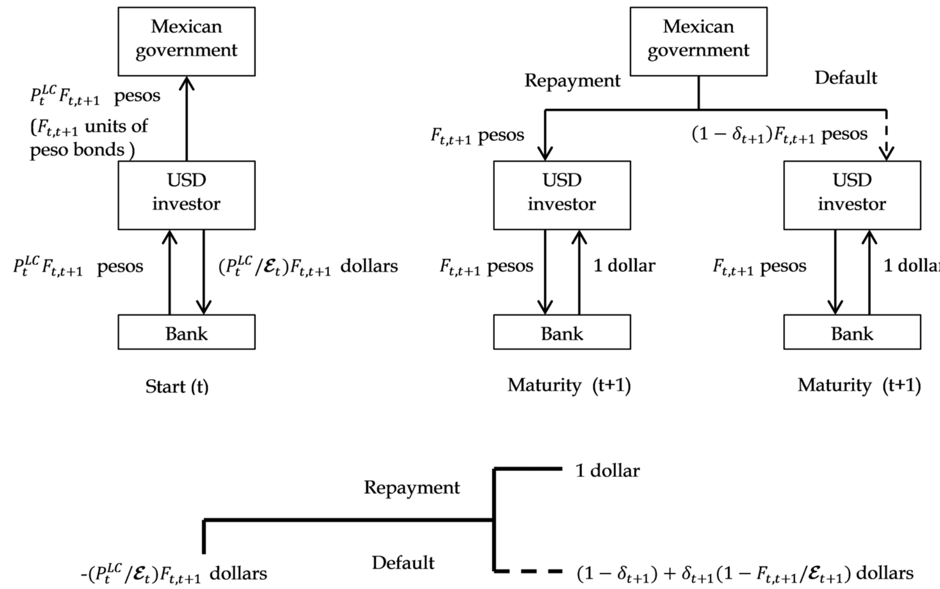


Figure 2. Cash flow diagram for a swapped LC sovereign bond. This diagram shows cash flows for a synthetic dollar bond by swapping a peso bond into U.S. dollars using an outright FX forward contract. At time t, the dollar investor exchanges $(P_t^{LC}/\mathcal{E}_t)F_{t,t+1}$ dollars for $P_t^{LC}F_{t,t+1}$ pesos with a bank at the spot exchange rate $\mathcal{E}_t$, where P_t^{LC} is the price of a zero-coupon Mexican Treasury in pesos and $F_{t,t+1}$ is the outright forward rate at time t. She then invests all the peso proceeds into Mexican Treasuries with face value $F_{t,t+1}$. Meanwhile, at time t, she enters into an outright forward contract to sell $F_{t,t+1}$ pesos forward for one dollar at time $t+1$. At time $t+1$, if the Mexican government repays full principal, $F_{t,t+1}$, the dollar investor gives all the peso payments to the bank to fulfill the outright forward contract and receives one dollar. However, if the Mexican government defaults, the peso payment to the dollar investor becomes $(1-\delta_{t+1})F_{t,t+1}$, where δ_{t+1} denotes the loss given default. However, the dollar investor still has to fulfill the outright forward, so the total cash flow from the bond and swap package is equal to $[(1-\delta_{t+1})+\delta_{t+1}(1-F_{t,t+1}/\mathcal{E}_{t+1})]$ upon default, where the last term $\delta_{t+1}(1-F_{t,t+1}/\mathcal{E}_{t+1})$ denotes the FX hedging error. As the swapped LC bond pays off one dollar in the nondefault state, the synthetic dollar yield on the swapped LC bond is equal to $y_t^{SLC} = -[(P_t^{LC}/\mathcal{E}_t)F_{t,t+1}] = y_t^{LC} - \rho_t$.

of the Internet Appendix, the valuation impact of this hedging error is exactly equal to the quanto adjustment, q_t.

Therefore, in a frictionless financial market, the LC credit spread is always equal to expected default losses under the LC risk-neutral measure. If the covariance between currency and credit risk is zero ($q_t = 0$), then the LC credit spread will also equal the expected default losses under the dollar risk-neutral measure. However, if credit and currency risks are positively correlated ($q_t > 0$), then the LC credit spread will understate expected default losses under the

to the nondefault state, we have $\mathcal{E}_{t+1} > F_{t,t+1}$, and thus $\delta_{t+1}(1-F_{t,t+1}/\mathcal{E}_{t+1}) > 0$, which implies positive profits.

dollar measure.[9] After presenting the stylized facts on LC credit spreads, we return to a theoretical and empirical calibration of the magnitude of q_t in Section III.A.

Finally, as additional evidence for the validity of the LC risk-free rate and the presence of credit risk on emerging market LC debt, we examine the yields paid by AAA-rated supranationals in various emerging market currencies. While the U.S. Treasury does not issue debt in emerging market local currencies, some supranationals, such as the World Bank and the European Investment Bank (EIB), have issued debt denominated in emerging market local currencies. We can define an alternative LC credit spread measure as the difference between LC emerging market sovereign yields and AAA-rated supranational yields in the same currency. We present the results for Brazil and Turkey using this alternative construction, which does not rely on U.S. Treasuries or CCS rates, in Section II.D. Due to the limited availability of supranational bond issuance in most emerging market currencies, this method cannot be generalized for all sample countries.

C. LC and FC Credit Spread Benchmark Comparison

In this subsection, we perform a theoretical comparison between LC and FC credit spreads in a frictionless financial market. We start with the conventional definition of the FC credit spread.

DEFINITION 2: *Let y_{nt}^{FC} denote the n-year zero-coupon yield on a U.S. dollar denominated debt and $y_{nt}^{*\$}$ denote the zero-coupon yield on an n-year U.S. Treasury bond. We define the FC credit spread as*

$$s_{nt}^{FCCS} \equiv y_{nt}^{FC} - y_{nt}^{*\$}. \tag{6}$$

As a corollary to Proposition 2, the difference between LC and FC credit spreads is given as follows.

COROLLARY 1: *Let $\mathbb{Q}_t^{LC}$ and $\mathbb{Q}_t^{\$}$ denote the risk-neutral measure for the LC and U.S. dollar, respectively, at time t, and let L_{t+1}^{LC} and L_{t+1}^{FC} denote the default losses on the LC and FC bonds, respectively, at time $t+1$, measured in terms of the fraction of the face value in the respective currency. Then, the LC-over-FC credit spread differential, $s_t^{LC/FCCS} \equiv s_t^{LCCS} - s_t^{FCCS}$, is given as follows:*

$$s_t^{LC/FCCS} = \mathbb{E}_t^{\mathbb{Q}^{LC}} L_{t+1}^{LC} - \mathbb{E}_t^{\mathbb{Q}^{\$}} L_{t+1}^{FC} \tag{7}$$

$$= \mathbb{E}_t^{Q^{\$}} \left(L_{t+1}^{LC} - L_{t+1}^{FC}\right) - q_t, \tag{8}$$

[9] Similarly, if the currency depreciates upon the implementation of capital control measures targeting capital outflows, the hedge also becomes imperfect and the covariance adjustment needs to be made. We thank an anonymous referee for raising this point.

where $q_t \equiv \frac{Cov_t^{\mathbb{Q}^\$}(1-L_{t+1}^{LC}, \mathcal{E}_t/\mathcal{E}_{t+1})}{\mathbb{E}_t^{\mathbb{Q}^\$}(1-L_{t+1}^{LC})\mathbb{E}_t^{\mathbb{Q}^\$}(\mathcal{E}_t/\mathcal{E}_{t+1})}$.

Therefore, the LC-over-FC credit spread differential reflects the difference in expected default losses measured using the LC and dollar risk-free bond as the numeraire (equation (7)). Furthermore, if we also value LC credit risk using the dollar risk-free bond as the numeraire, we need to add a quanto adjustment due to the covariance between currency risk and default risk (equation (8)). We present evidence in Section III.A that the positive covariance between currency risk and default risk makes the LC credit risk measured under the LC numeraire significantly lower than that measured under the dollar numeraire.

D. Potential Financial Market Frictions

Having presented interpretations of the LC credit spread under the frictionless benchmark, we now examine how financial frictions could affect the measure. We first discuss how counterparty risk and nondeliverability of CCS contracts affects the interpretation of our LC credit spread. We then provide a brief overview of potential financial market frictions that may have differential impacts on LC and FC credit spreads. After presenting the stylized facts about LC and FC credit spreads, in Section III.C, we discuss how these frictions may lead our actual measures of the LC risk-free rate and LC credit spread to depart from their frictionless interpretation as given by Propositions 1 and 2.

One potential concern in using CCS to construct the LC risk-free rate is that the CCS rate may reflect the risk of a counterparty default (Assumption 2). However, the impact of counterparty risk on the pricing of CCS is negligible due to a high degree of collateralization. Following the International Swaps and Derivatives Association Credit Support Annex, the common market practice among dealers is to post variation margins in cash with the amount equal to the mark-to-market value of the swap. The counterparty seizes collateral in the event of a default, so that counterparty risk exposure is hedged to the first order. Consistent with high collateralization, Arora, Gandhi, and Longstaff (2011) offer direct evidence on counterparty risk in the CDS market. They find that a 645 basis point increase in the seller's CDS spreads translates only to a one basis point reduction in the quoted CDS premium.[10]

Aside from counterparty risk, one distinct feature of emerging market CCS is that many countries do not allow the LC to be delivered offshore for FX derivative transactions. The CCS swap involving nondeliverable currencies is referred to as the nondeliverable swap (NDS).[11] The U.S. dollar is used to

[10] Even under the assumption that there is no collateralization, the magnitude of the bilateral counterparty risk adjustment for CCS is quite small. As shown in the calibration by Duffie and Huang (1996), for a five-year fixed-for-fixed currency swap and 100 basis point asymmetry in the counterparty' s credit risk, the bilateral credit value adjustment is about 8.6 basis points for 15% FX volatility.

[11] Among our 10 sample countries, Hungary, Mexico, and Poland have deliverable CCS, while the rest of our sample countries have nondeliverable CCS.

cash settle the NDS position, without exchanging the LC. The LC bond hedged with the NDS cannot protect the investor from capital control and currency convertibility risks. Therefore, in addition to outright default risk, the LC credit spread based on the NDS also includes these additional risks.

Furthermore, several financial market frictions could potentially affect the valuation of LC and FC credit spreads, which we abstracted from under Assumption 1. First, swapped LC and FC debt might have different liquidity risk, so the credit spread differential partly reflects differential liquidity premia. In particular, we show that the swapped LC bond can earn a liquidity premium because it goes long in the more liquid bond and short in the more illiquid swap. Second, LC and FC debt pricing can be affected by slow-moving capital and market segmentation in domestic and external debt markets. LC debt is largely held by local institutional investors and FC debt is largely held by global investors, and thus arbitrage between the two markets can be incomplete due to arbitrageurs' limited capital and risk aversion. Third, we show that it is easy to short the swap rate but more difficult to short LC bonds than FC bonds. The swapped LC bond can also be traded at a premium over FC bonds due to more binding short-selling constraints. Fourth, no-arbitrage violations in the currency markets can also affect the LC credit spread but not directly affect the FC credit spread. A severe dollar shortage during the financial crisis can make synthetic dollar borrowing more costly than direct dollar borrowing.

II. New Stylized Facts on LC Sovereign Risk

A. Data Sources

The core of our data are daily zero-coupon swap curves and yield curves for LC and FC sovereign bonds issued by 10 emerging market governments from January 2005 to December 2014. We use a benchmark tenor of five years. The choice of countries is mainly constrained by the lack of sufficient numbers of outstanding FC bonds. Furthermore, all 10 sample countries belong to the J.P. Morgan EM-GBI index, an investable index for emerging market LC bonds. The length of the sample period is constrained by the availability of long-term currency swap data. Details on the yield curve construction and specific Bloomberg tickers used in our analysis are given in Section II of the Internet Appendix.

B. Summary Statistics of LC and FC Credit Spreads

In Figure 3, we plot LC nominal yields, swap rates, and LC and FC credit spreads for our sample emerging markets. To summarize these figures, in column (1) of Table I, we present summary statistics for five-year LC spreads from 2005 to 2014 at a daily frequency. LC credit spreads, s^{LCCS}, have a cross-country mean of 145 basis points, calculated using the midrates on the swaps. Brazil records the highest mean LC spread at 339 basis points, while Israel,

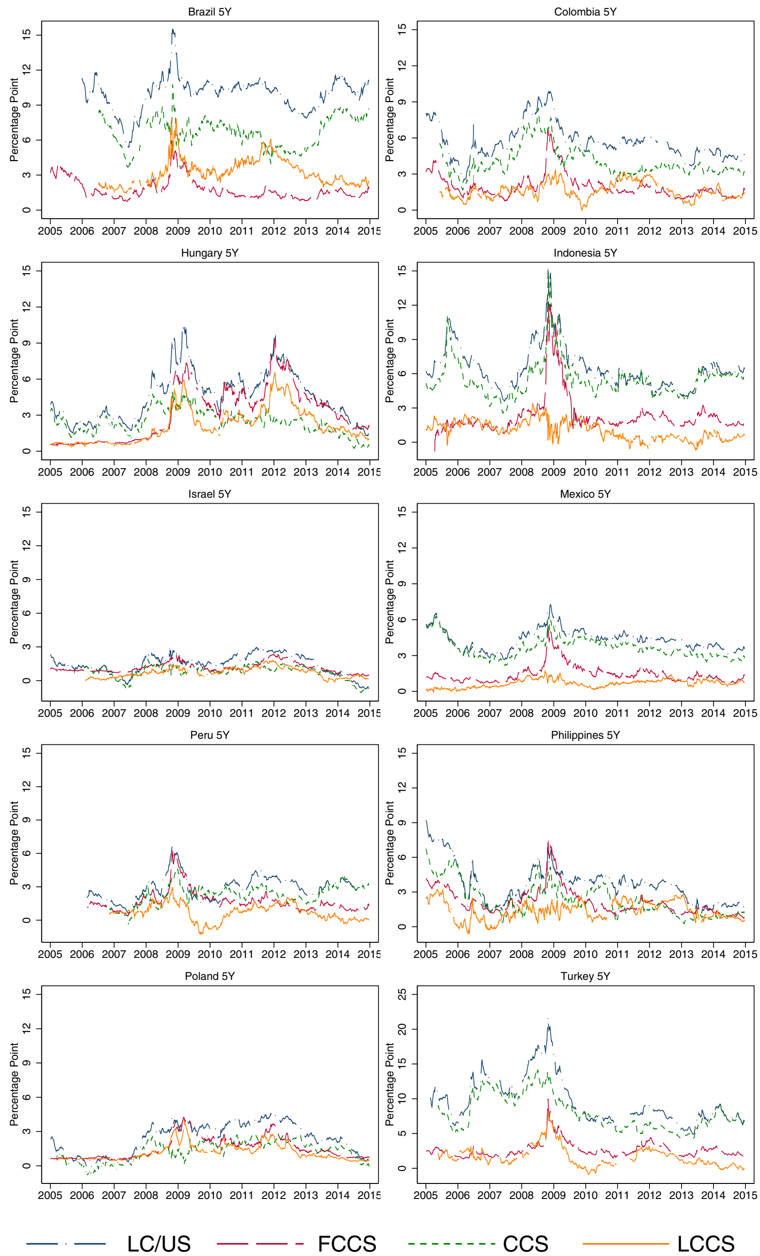


Figure 3. Five-year nominal spreads, CCS, and credit spreads (percentage points). Each figure plots 10-day moving averages of zero-coupon LC and FC spreads over the U.S. Treasury at five years. LC/US denotes the LC nominal yield over the five-year U.S. Treasury bond. FCCS denotes the FC credit spread. CCS denotes the fixed-for-fixed LC/dollar cross-currency swap rate. LCCS denotes the LC credit spread.

Table I

Mean LC and FC Credit Spread Comparison (Percentage Points), 2005 to 2014

This table reports the starting date, mean, and standard deviation of five-year log yield spreads at a daily frequency. The variables are (1) s^{LCCS}, LC credit spread; (2) s^{FCCS}, FC credit spread; (3) $s^{LC/FCCS}$, LC over FC credit spread, or column (1/2) minus column (1); and (4) $ba^{CCS}/2$, half of the bid-ask spread of cross-currency swaps. In column (5), we report the correlation between daily credit spreads. Standard deviations of the variables are reported in parentheses.

Country	Sample Start	(1) s^{LCCS}	(2) s^{FCCS}	(3) $s^{LC/FCCS}$	(4) $ba^{CCS}/2$	(5) *Corr(LCCS,FCCS)*
Brazil	July 2006	3.39	1.67	1.71	0.36	0.48
		(1.16)	(0.84)	(1.06)	(0.14)	
Colombia	June 2005	1.59	1.93	−0.34	0.15	0.42
		(0.70)	(0.95)	(0.91)	(0.08)	
Hungary	January 2005	2.34	3.46	−1.12	0.17	0.94
		(1.41)	(2.11)	(0.92)	(0.08)	
Indonesia	April 2005	1.02	2.25	−1.23	0.40	0.11
		(0.81)	(1.64)	(1.75)	(0.34)	
Israel	February 2006	0.68	1.13	−0.44	0.12	0.82
		(0.43)	(0.46)	(0.26)	(0.03)	
Mexico	January 2005	0.67	1.44	−0.77	0.06	0.42
		(0.33)	(0.74)	(0.67)	(0.04)	
Peru	July 2006	0.72	1.74	−1.02	0.18	0.36
		(0.77)	(1.00)	(1.02)	(0.07)	
Philippines	March 2005	1.42	2.11	−0.69	0.29	0.28
		(0.80)	(1.08)	(1.15)	(0.12)	
Poland	March 2005	1.28	1.71	−0.43	0.11	0.93
		(0.69)	(0.86)	(0.33)	(0.05)	
Turkey	May 2005	1.62	2.77	−1.15	0.10	0.75
		(1.56)	(1.19)	(1.02)	(0.06)	
Total	January 2005	1.45	2.01	−0.56	0.19	0.55
		(1.23)	(1.31)	(1.30)	(0.18)	
Observations		17,809	17,809	17,809	17,809	

Mexico, and Peru have the lowest means at about 70 basis points.[12] Column (4) provides summary statistics for the liquidity of the CCS, $ba^{CCS/2}$, defined as half of the bid-ask spread of CCS rates, with the sample average equal to 19 basis points. The LC credit spread remains significantly positive for every country after subtracting one-half of the bid-ask spread on the CCS in order to incorporate the transaction costs.

To compare the sovereign's dollar borrowing costs using FC debt with the synthetic dollar borrowing costs using LC debt, we perform an ex-ante credit spread comparison. FC credit spreads, s^{FCCS}, reported in column (2) in Table I have a mean of 201 basis points, which is 56 basis points higher than LC

[12] All mean LC credit spreads are positive and statistically significantly different from zero using Newey-West standard errors allowing for heteroskedasticity and serial correlation. Following Datta and Du (2012), missing data are treated as nonserially correlated for Newey-West implementations throughout the paper.

credit spreads based on the mid-rates for CCS. In column (3), we compute the difference between LC and FC credit spreads by country. The LC-over-FC credit spread differential, $s^{LC/FCCS}$, is significantly negative for all of our sample countries except Brazil. We discuss the Brazilian exception in detail in Section III.B. Although all of our sample countries have LC bond markets open to foreign investors, foreigners may still need to incur transaction costs to buy into LC markets. In addition to taxes on capital inflows, LC bonds are often subject to local taxation, whereas FC international bonds are exempt from interest withholding taxes. For 9 out of 10 countries with negative LC-over-FC credit spread differentials, the promised dollar spread on LC bonds is unambiguously lower than that on FC bonds, since swapped LC-over-FC spreads would become more negative after taking into account positive taxes on LC bonds.

Despite the mean difference in credit spreads, one might expect LC and FC credit risk to be correlated within countries, as, in a downturn, a country might find it more tempting to explicitly default on both types of debt. Column (5) confirms this conjecture. The within-country correlation between LC and FC credit spreads is positive for every country with a mean of 55%. However, there is significant cross-country heterogeneity. The correlation is highest for Hungary at 94% and lowest for Indonesia at 11%.

Figure 4 plots the difference in LC and FC credit spreads, $s^{LC/FCCS}$, across 10 countries over the sample period. While LC-over-FC credit spread differentials largely remain in negative territory (with the exception of Brazil), the spreads significantly widened during the peak of the crisis following the Lehman bankruptcy. The largest difference between LC and FC credit spreads for any country during the crisis was Indonesia's negative 10 percentage points. The divergent behavior of these credit spreads during the crisis peak highlights significant differences between LC and FC bonds and offers a key stylized fact to be examined later.

C. Correlation with Global Risk Factors

C.1. Credit Spreads

In Table II, we conduct PC analysis to determine the extent to which fluctuations in LC and FC credit spreads are driven by common components or by idiosyncratic country shocks. In the first column, we see that the first PC explains less than 54% of the variation in LC credit spreads across countries. By contrast, the first PC explains over 77% of total variation in FC credit spreads (column (2)). The first three PCs explain slightly less than 78% of the total variation for LC credit spreads, whereas, for FC credit spreads, they explain about 96%. In addition, we find that the average pairwise correlation of LC credit spreads between countries is only 43%, in contrast to 73% for FC credit spreads. These findings suggest that country-specific idiosyncratic components are important drivers of LC credit spreads, whereas, in the FC market, global factors are far more important. The finding that an overwhelming amount

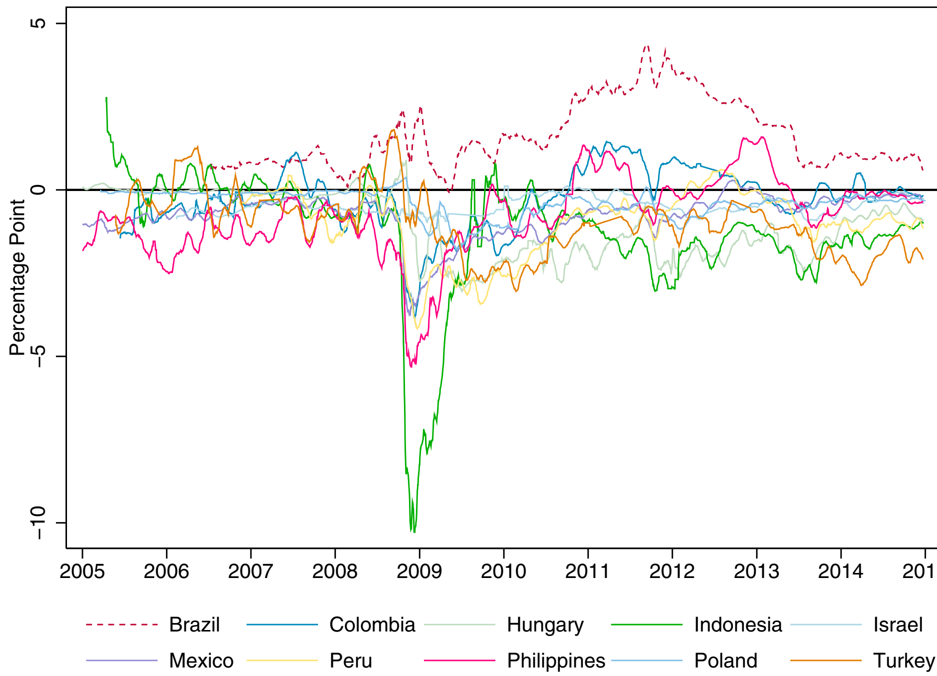


Figure 4. LC-over-FC credit spreads (percentage points). This figure plots 30-day moving averages of the five-year zero-coupon LC over FC credit spread differential for all 10 sample countries. Data sources and details on yield curve construction are given in Internet Appendix Table IA.V.

Table II

Cross-Country Correlation of Credit Spreads, 2005 to 2014

This table reports summary statistics of the principal component analysis and the cross-country correlation matrices of monthly five-year LC and FC credit spreads and sovereign credit default swap spreads. The variables are (1) s^{LCCS}, LC credit spreads; (2) s^{FCCS}, FC credit spreads; and (3) *5Y CDS*, five-year sovereign CDS spreads. "First," "Second," and "Third" report percentage and cumulative percentage of the total variation explained by the first, second, and third principal components, respectively. "Pairwise Corr." reports the mean of all bilateral correlations for all country pairs. All variables are end-of-month observations.

Components	(1) s^{LCCS}		(2) s^{FCCS}		(3) *5Y CDS*	
Principal	Percentage	Total	Percentage	Total	Percentage	Total
First	54.28	54.28	77.35	77.35	74.57	74.57
Second	14.69	68.96	15.21	92.56	18.10	92.67
Third	9.37	78.33	3.32	95.88	2.70	97.37
Pairwise Corr.	0.43		0.73		0.71	

Table III
Correlation among Credit Spreads and Global Risk Factors, 2005 to 2014

This table reports correlations among credit spreads and global risk factors. Panel A reports correlations between the first principal component of credit spreads and global risk factors. Panel B reports average correlations between raw credit spreads of the 10 sample countries and global risk factors. The three credit spreads are (1) s^{LCCS}, the five-year LC credit spread; (2) s^{FCCS}, the five-year FC credit spread; and (3) *CDS*, the five-year sovereign credit default swap spread. The three global risk factors are (1) *BBB/T*, Merrill Lynch BBB over 10-year Treasury spread; (2) −*CFNAI*, minus the real-time Chicago Fed National Activity Index, or the first principal component of 85 monthly economic indicators (positive *CFNAI* indicates improvement in macroeconomic fundamentals); and (3) *VIX*, implied volatility on the S&P index options. All variables use end-of-month observations.

	Panel A: First PC of Spreads			Panel B: Raw Spreads		
	s^{LCCS}	s^{FCCS}	*CDS*	s^{LCCS}	s^{FCCS}	*CDS*
s^{LCCS}	1.00			1.00		
s^{FCCS}	0.75	1.00		0.50	1.00	
5Y CDS	0.72	0.94	1.00	0.49	0.91	1.00
BBB/T	0.68	0.93	0.93	0.35	0.63	0.58
−*CFNAI*	0.52	0.76	0.75	0.28	0.50	0.45
VIX	0.69	0.92	0.85	0.34	0.61	0.53

of the variation in FC credit spreads is explained by the first PC echoes the findings of Longstaff et al. (2011) on CDS spreads.

Having identified an important global component in both LC and FC credit spreads, we now try to understand what exactly this first PC is capturing. In Table III, we begin by examining the correlation of the first PCs of credit spreads with each other and with global risk factors. The global risk factors include the Merrill Lynch U.S. BBB corporate bond spread over Treasuries, *BBB/T*, the implied volatility on S&P options, *VIX*, and the Chicago Fed National Activity Index, *CFNAI*, which is the first PC of 85 monthly real economic indicators. Panel A indicates that the first PC of FC credit spreads has very high correlations with these three global risk factors: 93% with *VIX*, 92% with *BBB/T*, and 76% with global macrofundamentals (or, more precisely, U.S. fundamentals) as proxied by the CFNAI index. The correlations between the first PC of LC credit spreads and the global risk factors are lower, but still substantial, at 68% with *VIX*, 69% with *BBB/T*, and 52% with *CFNAI*. In terms of the correlations between raw spreads and global factors, Panel B shows that *VIX* has a mean correlation of 61% with FC credit spreads but only 34% with LC credit spreads. This leads us to conclude that the observed global factors are more important in driving spreads on FC debt than on swapped LC debt. Unsurprisingly, the correlations between the global factors and the CDS spread are very similar to the correlations between these factors and the FC spread.

C.2. Excess Returns

Having examined the ex-ante promised yields in Tables II and III, we next turn to ex-post realized returns. The natural measures to study are the excess returns of LC and FC bonds over U.S. Treasury bonds. In particular, we run a series of contemporaneous beta regressions to examine how LC and FC excess returns vary with global and local equity markets. Since all yield spreads are for zero-coupon benchmarks, we can quickly compute various excess returns for the holding period Δt.[13] The FC-over-U.S. Treasury excess holding-period return for an n-year FC bond is equal to

$$rx^{FC/US}_{n,t+\Delta t} = ns^{FCCS}_{nt} - (n - \Delta t)s^{FCCS}_{n-\Delta t,t+\Delta t}, \tag{9}$$

which represents the change in the log price of the FC bond over a U.S. Treasury bond of the same maturity.

Similarly, the currency-specific return differential of an LC bond over a U.S. Treasury bond is given by

$$rx^{LC/US}_{n,t+\Delta t} = ns^{LC/US}_{nt} - (n - \Delta t)s^{LC/US}_{n-\Delta t,t+\Delta t}. \tag{10}$$

Depending on the specific FX hedging strategies, we can translate $rx^{LC/US}_{n,t+\Delta t}$ into three types of dollar excess returns on LC bonds. The unhedged LC-over-U.S. excess return, $uhrx^{LC/US}_{n,t+\Delta t}$, is equal to the currency-specific return differential minus the ex-post LC depreciation:

$$uhrx^{LC/US}_{n,t+\Delta t} = rx^{LC/US}_{n,t+\Delta t} - (e_{t+\Delta t} - e_t). \tag{11}$$

If the dollar investor would like to hedge LC risk, we consider two types of hedging strategies. First, the dollar investor only hedges currency risk of the holding period by rolling over three-month forward contracts. The holding-period hedged LC-over-U.S. excess return, $hrx^{LC/US}_{n,t+\Delta t}$, is approximately equal to the currency-specific return differential minus the ex-ante holding-period forward premium:

$$hrx^{LC/US}_{n,t+\Delta t} \approx rx^{LC/US}_{n,t+\Delta t} - (f_{t,t+\Delta t} - e_t). \tag{12}$$

Second, the dollar investor hedges the currency risk of the entire duration of the bond with CCS. The swapped LC-over-U.S. excess return, $srx^{LC/US}_{n,t+\Delta t}$, is approximately equal to the currency-specific return differential minus the return on the currency swap:[14]

$$srx^{LC/US}_{n,t+\Delta t} \approx rx^{LC/US}_{n,t+\Delta t} - [n\rho_{nt} - (n - \Delta t)\rho_{n-\Delta t,t+\Delta t}]. \tag{13}$$

[13] For quarterly returns, Δt is a quarter and we approximate $s_{n-\Delta t,t+\Delta t}$ with $s_{n,t+\Delta t}$.

[14] For both types of hedging, the forward/swap hedging notional is equal to the initial market value of the LC bond at the beginning of the quarter and is dynamically rebalanced every quarter. As the market value of the LC bond at time $t + \Delta t$ may be under- or overhedging the notional, equations (11) and (12) only provide a first-order approximation of actual hedged and swapped returns and thus do not hold exactly. We obtain very similar regression results with or without currency hedging errors.

Table IV

Regressions of Bond Excess Returns on Equity Returns, 2005 to 2014

This table reports contemporaneous betas of bond quarterly excess returns on global and local equity excess returns. The dependent variables are (1) and (4) $rx^{FC/US}$, FC-over-U.S. Treasury bond excess returns; (2) $hrx^{LC/US}$, hedged LC-over-U.S. Treasury bond excess returns using three-month forward contracts; (3) and (6) $uhrx^{LC/US}$, unhedged LC-over-U.S. Treasury bond excess returns; and (5) $srx^{LC/US}$, swapped LC-over-U.S. Treasury bond excess returns. All excess returns are computed based on the quarterly holding-period returns on the five-year zero-coupon benchmark (annualized). The independent variables are: *S&P $rx*, the quarterly return on the S&P 500 index over three-month U.S. T-bills; *LC equity hedged $rx*, the quarterly return on the local MSCI index hedged using three-month FX forward over three-month U.S. T-bills; and *LC equity swapped $rx*, the quarterly return on the local MSCI index combined with a five-year CCS over three-month U.S. T-bills. All regressions are run at the monthly frequency with country fixed effects using Newey-West standard errors with 24-month lags and clustering by month following Driscoll and Kraay (1998). Standard errors are shown in parentheses. Significance levels are denoted by $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.1$.

	(1) $rx^{FC/US}$	(2) $hrx^{LC/US}$	(3) $uhrx^{LC/US}$	(4) $rx^{FC/US}$	(5) $srx^{LC/US}$	(6) $uhrx^{LC/US}$
S&P $rx	0.139***	−0.0335	0.212***	0.227***	−0.00396	0.422***
	(0.0471)	(0.0631)	(0.0583)	(0.0518)	(0.0287)	(0.106)
LC equity hedged $rx	0.140***	0.232***	0.405***			
	(0.0455)	(0.0369)	(0.0471)			
LC equity swapped $rx				0.0463*	0.108***	0.192**
				(0.0254)	(0.0220)	(0.0782)
Observations	1,032	1,032	1,032	1,034	1,034	1,034
R^2	0.357	0.273	0.433	0.273	0.127	0.300

Table IV presents panel regression results for excess bond returns over local and global equity excess returns. Global equity excess returns are defined as the quarterly return on the S&P 500 index over three-month U.S. Treasury bills. We define two measures of LC equity excess returns (holding-period hedged and long-term swapped) so that a foreign investor hedging her currency risk in the local equity market has the same degree of hedging on her bond position. We find that FC excess returns have significantly positive betas on both global and hedged LC equity returns, with the loading on S&P being greater. Hedged and swapped LC excess returns do not load on the S&P, but they do have a significantly positive beta on local equity returns. In contrast, FX unhedged LC excess returns have positive betas on both the S&P and local equity returns. We therefore conclude that, for foreign investors, the main systematic risk of LC bonds is that emerging market currencies depreciate when returns on global equities are low, as the global risk factor affects currency excess returns. Once currency risk is hedged, LC debt appears to be much less risky than FC debt in the sense that it has significantly lower loadings on global equity returns than FC debt.

D. Alternative LC Credit Spread Measure

In this section, we present results for an alternative LC credit spread measure based on supranational bond yields denominated in emerging market local currencies. AAA-rated supranational organizations, such as the World Bank, EIB, and Kreditanstalt für Wiederaufbau (KfW), a German government-owned development bank, have issued debt in emerging market local currencies at yields lower than those on emerging market sovereign debt. Instead of measuring the LC risk-free rate as the sum of the U.S. Treasury yield and the CCS rate, we can instead use the AAA-rated supranational yield. We define an alternative LC credit spread as the difference between the emerging market sovereign yield and the supranational yield denominated in the same currency. We find a significantly positive LC credit spread using this alternative measure, which does not rely on U.S. Treasury bonds or CCS rates. However, the limitation of this approach is that we need a large and liquid bond market for supranational issuance in each emerging market currency.

In our sample countries, using primary market issuance data in Thomson One, the Turkish lira and Brazilian real are the two most frequently chosen emerging market currencies among supranational debt issuers. Between December 2004 and July 2014, 15 supranational organizations issued 1,429 bonds in our 10 sample emerging market currencies, with a total gross notional equal to \$66.3 billion, of which 575 bonds were denominated in the Turkish lira with total notional equal to \$38.4 billion, and 474 bonds were denominated in the Brazilian real with total notional of \$21.1 billion. For the most frequent single-name issuers, the EIB issued 271 bonds in the Turkish lira and the KfW issued 122 bonds in the Brazilian real. We can construct a zero-coupon Turkish lira-denominated yield curve for bonds issued by the EIB and a Brazilian real-denominated yield curve for bonds issued by the KfW.

Figure 5, Panel A, plots EIB Turkish lira yield spreads over U.S. Treasuries, Turkish LC sovereign bond yield spreads over U.S. Treasuries, and lira/dollar CCS rates. All yield spreads and CCS rates are zero-coupon rates for the five-year maturity. We can see that Turkish sovereign yield spreads are generally higher than EIB yield spreads. EIB yield spreads track CCS rates very closely, suggesting very low levels of perceived default risk for the EIB. The only exception is that, during the peak of the European debt crisis, the EIB spread was significantly above the CCS rate, but was still consistently below the Turkish sovereign spread. Figure 5, Panel B, plots Turkish sovereign LC credit spreads over U.S. Treasuries and the CCS rate, as defined in equation (3), and our alternative LC credit spread as the difference between Turkish sovereign bond yields and the EIB yields. LC credit spreads over U.S. Treasuries and the CCS rate are generally higher than LC credit spreads over the EIB, potentially reflecting better liquidity, credit quality, and convenience associated with U.S. Treasuries. However, the two credit spreads are highly correlated and significantly above zero. Panels C and D of Figure 5 display similar patterns for the Brazilian real. The KfW issues bonds at slightly higher yields than the sum of

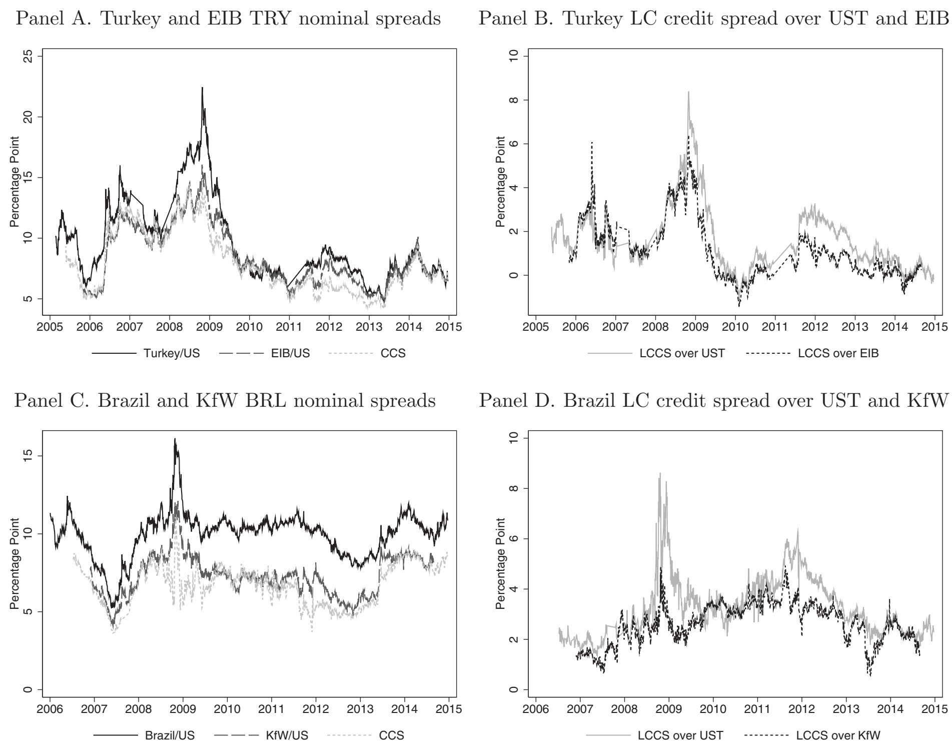


Figure 5. Emerging market sovereign and supranational yield spreads (percentage points). All yield spreads in the figures are zero-coupon rates for the five-year maturity. In Panel A, the solid line (Turkey/US) plots the Turkish Treasury yield spread over U.S. Treasury yield spread. The dashed line (EIB/US) plots the yield spread of Turkish lira-denominated bonds issued by the EIB. The dotted line (CCS) plots the fixed-for-fixed lira/dollar CCS rate. In Panel B, the solid line (LCCS over UST) plots the LC credit spread of the Turkish sovereign over the U.S. Treasury yield (Turkey/US minus CCS), and the dotted line (LCCS over EIB) plots the LC credit spread over EIB, which is defined as the difference between the Turkish sovereign bond yield and the EIB yield in the Turkish lira. In Panel C, the solid line (Brazil/US) plots the Brazilian Treasury yield spread over U.S. Treasury yield spread. The dashed line (KfW/US) plots the yield spread of Brazilian real denominated bonds issued by KfW. The dotted line (CCS) plots the fixed-for-fixed real/dollar CCS rate. In Panel D, the solid line (LCCS over UST) plots the LC credit spread of the Brazilian sovereign over the U.S. Treasury yield (Brazil/US minus CCS), and the dotted line (LCCS over KfW) plots the LC credit spread over KfW, which is defined as the difference between the Brazilian sovereign bond yield and the KfW yield in the Brazilian real. Zero-coupon bond yields for EIB and KfW are estimated using the Nelson-Siegel methodology based on coupon bond yields available in Bloomberg.

the U.S. Treasury and real/dollar NDS rates, but at significantly lower yields than those on Brazilian LC sovereign bonds. LC credit spreads over KfW yields are also significantly above zero and highly correlated with LC credit spreads over U.S. Treasuries.

III. Sources of Credit Spread Differentials

In this section, we examine three main sources of credit spread differentials. First, we discuss the impact of the covariance between currency and credit risk on the credit spread differentials. Second, we consider how selective defaults, capital controls, and domestic jurisdiction risks impact the LC and FC credit spreads. These latter two are particularly helpful in explaining the Brazilian anomaly. Third, we examine the impact of various financial market frictions on the credit spread differential, including liquidity, short-selling constraints, slow-moving capital, and market segmentation in the debt and currency markets.

A. Covariance between Currency and Credit Risk

In this subsection, we calibrate the quanto adjustment term in Proposition 2 and Corollary 1, which allows us to change the LC credit spread from a credit risk measure under the LC numeraire to a credit risk measure under the dollar measure. We show that once we take into account the positive covariance between currency and default risk, the mean credit risk across LC and FC debt is roughly equal under the common dollar risk-neutral measure. Although the covariance adjustment can explain the persistent level difference between the LC and FC credit spreads, it cannot explain all of the time variation in credit differentials.

A.1. A Simple Theoretical Calibration

We give a simple theoretical calibration of the size of the covariance between currency and default risk, or the quanto adjustment given in equation (5), for a one-period bond. Under the dollar risk-neutral measure, we let π_t denote the risk-neutral probability of default and δ denote the loss given default as a fraction of the face value in the LC. We let $\mathcal{E}_{t+1}^{ND}$ and $\mathcal{E}_{t+1}^{D}$ denote the spot exchange rate in the nondefault and default states. To capture depreciation upon default, we assume that the LC depreciate by a fraction $\alpha \in [0, 1]$ in the default state relative to the nondefault state, or, $\frac{1}{\mathcal{E}_{t+1}^{D}} = (1-\alpha)\frac{1}{\mathcal{E}_{t+1}^{ND}}$. Following Khuong-Huu (1999), we assume that α is nonstochastic for simplicity. It can be shown that the values of the exchange rates in the two states are given by[15]

$$\frac{1}{\mathcal{E}_{t+1}^{ND}} = \left(\frac{1}{1-\alpha\pi_t}\right)\frac{1}{F_{t,t+1}}, \quad \text{and} \quad \frac{1}{\mathcal{E}_{t+1}^{D}} = \left(\frac{1-\alpha}{1-\alpha\pi_t}\right)\frac{1}{F_{t,t+1}}.$$

[15] Under these expressions, the outright forward exchange is equal to the risk-neutral expected spot rate: $1/F_{t,t+1} = (1-\pi_t)/\mathcal{E}_{t+1}^{D} + \pi_t/\mathcal{E}_{t+1}^{ND} = \mathbb{E}_t^{\mathbb{Q}^\$}(1/\mathcal{E}_{t+1})$.

It then follows that the quanto adjustment in equations (5) and (8) is given by[16]

$$q_t = \frac{Cov_t^{\mathbb{Q}^\$}\left(1 - L_{t+1}^{LC}, \mathcal{E}_t/\mathcal{E}_{t+1}\right)}{\mathbb{E}_t^{\mathbb{Q}^\$}\left(1 - L_{t+1}^{LC}\right)\mathbb{E}_t^{\mathbb{Q}^\$}\left(\mathcal{E}_t/\mathcal{E}_{t+1}\right)} \approx \alpha\pi_t\delta = \alpha\mathbb{E}_t^{\mathbb{Q}^\$} L_{t+1}^{LC}. \tag{14}$$

Therefore, under this simple calibration, we have

$$s_t^{LCCS} = \mathbb{E}_t^{\mathbb{Q}^{LC}} L_{t+1}^{LC} = (1-\alpha)\mathbb{E}_t^{\mathbb{Q}^\$} L_{t+1}^{LC}. \tag{15}$$

The LC credit spread is lower than the expected loss of the LC bond under the dollar risk-neutral measure by a fraction α. We can use equation (15) to convert the LC credit risk measure based on the LC risk-neutral measure to one based on the dollar risk-neutral measure,

$$s_t^{QLCCS} \equiv \mathbb{E}_t^{\mathbb{Q}^\$} L_{t+1}^{LC} = \frac{1}{1-\alpha}\mathbb{E}_t^{\mathbb{Q}^{LC}} L_{t+1}^{LC} = \frac{1}{1-\alpha} s_t^{LCCS}, \tag{16}$$

where we define the dollar-measure-based LC credit spread as the "quanto LC credit spread," s_t^{QLLCS}.[17]

Before formally calibrating α to data in the next subsection, we perform a thought experiment to see how large α would need to be for the mean credit spreads we observe to correspond to equal credit risk between LC and FC debt under the dollar risk-neutral measure. Under the assumption that $\mathbb{E}_t^{\mathbb{Q}^\$} L_{t+1}^{LC} = \mathbb{E}_t^{\mathbb{Q}^\$} L_{t+1}^{FC}$, or $s_t^{QLCCS} = s_t^{FCCS}$, by equation (16), we have that

$$\alpha = \left(s_t^{FCCS} - s_t^{LCCS}\right)/s_t^{FCCS}.$$

In our sample countries excluding Brazil, the mean LC-over-FC credit spread differential is equal to negative 81 basis points and the mean FC credit spread is 205 basis points. Assuming equal credit risk across the two instruments under the common dollar risk-neutral measure, our data would imply 39% (0.81/2.05) expected depreciation upon default.

A.2. Empirical Evidence on Depreciation upon Default

We can calibrate the magnitude of depreciation upon default using two approaches. First, following Mano (2013), we use CDS traded in different currencies on FC sovereign debt to obtain an estimate of the ex-ante risk-neutral

[16] To derive equation (14), we note that $q_t = \frac{\mathbb{E}_t^{\mathbb{Q}^\$}[(1-L_{t+1}^{LC})/\mathcal{E}_{t+1}]}{\mathbb{E}_t^{\mathbb{Q}^\$}(1-L_{t+1}^{LC})\mathbb{E}_t^{\mathbb{Q}^\$}(1/\mathcal{E}_{t+1})} - 1 = \frac{(1-\pi_t)(\frac{1}{1-\alpha\pi_t})+\pi_t(1-\delta)(\frac{1-\alpha}{1-\alpha\pi_t})}{(1-\pi_t)+\pi_t(1-\delta)} - 1 = \frac{1-\pi\delta-\alpha\pi+\alpha\pi\delta}{(1-\pi\delta)(1-\alpha\pi)} - 1 \approx \alpha\pi\delta$ for small π.

[17] In practice, a direct model-free empirical measure of s_t^{QLCCS} would require (1) a liquid market for the so-called "quanto currency swap," for which the LC notional is always equal to the recovery value of specific LC bonds, or (2) CDS contracts denominated in dollars, but linked to the LC debt instrument. However, to our knowledge, both contracts are rarely traded in the current market.

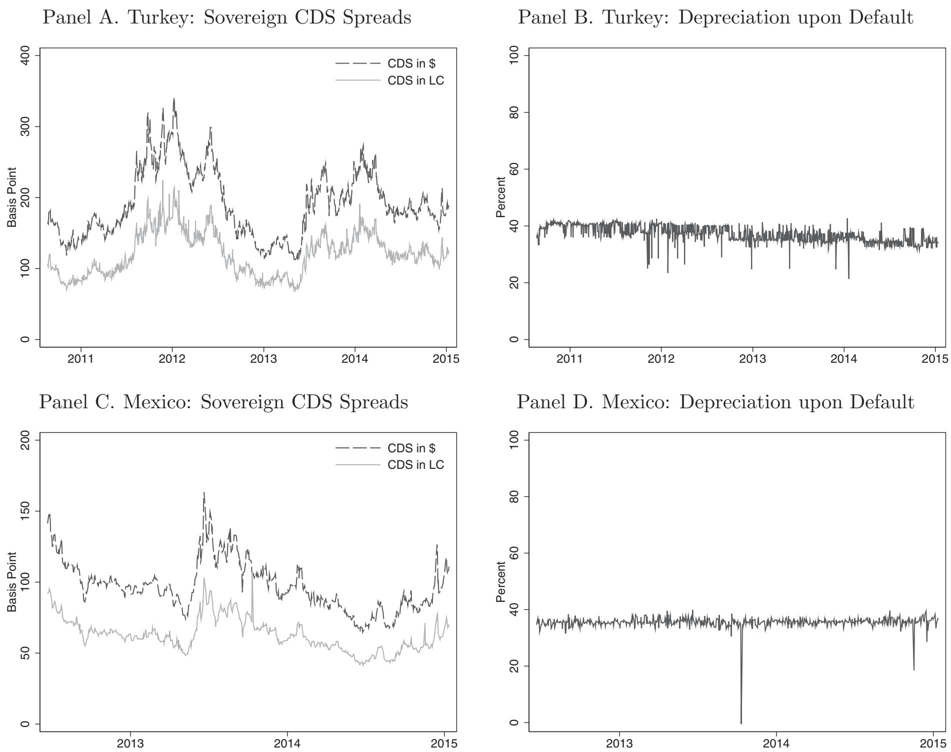


Figure 6. Sovereign CDS spreads denominated in LC and the U.S. dollar. Panels A and C plot the CDS spreads in basis points for contracts denominated in U.S. dollars (dashed line) and contracts denominated in Turkish lira or Mexican pesos (solid line). Panels B and D plot risk-neutral expected percentage depreciation upon default calculated as $\frac{CDS(\$)-CDS(LC)}{CDS(\$)} \times 100$. The CDS data are from Markit.

expectation of depreciation upon default. We find that, on average, this estimate is approximately 36%. This comparison is relevant for us if we assume that the depreciation rate is the same following LC and FC defaults or that the two types of debt default simultaneously. Second, we perform a historical calibration for realized currency depreciation upon default using the long history of default dates identified by Reinhart and Rogoff (2009) and Cruces and Trebesch (2013). We obtain historical depreciation upon default of about 27% to 34% relative to the counterfactual nondefault state.

First, CDS contracts linked to the same debt instrument but denominated in different currencies can offer a clean measure of the risk-neutral implied depreciation upon default perceived by market participants. However, the liquidity of LC-denominated quanto CDS contracts is generally very thin. For this reason, we limit ourselves to studying Mexico and Turkey using the most recent three or four years of data. Figure 6 plots CDS spreads for Mexico and Turkey denominated in the U.S. dollar and local currencies (Mexican peso and

Turkish lira, respectively). LC CDS spreads are consistently below dollar CDS spreads. Despite the level difference, the two CDS spreads have a correlation of 99%. Given the observed mean difference between LC and dollar CDS spreads, we can compute α as

$$\alpha_t = \left(cds_t^{\$} - cds_t^{LC}\right)/cds_t^{\$}, \tag{17}$$

where $cds_t^{\$}$ denotes the spread on the dollar CDS and cds_t^{LC} denotes the spread on the quanto LC CDS. The implied depreciation upon default is fairly stable over the entire sample, with a mean of 36% and a standard deviation of 1.9% for Mexico and a mean of 37% and a standard deviation of 2.9% for Turkey. The low volatility of depreciation upon default implied by the Turkish and Mexican CDS lends support to our simplifying assumption that α is time-invariant.

Second, we perform a historical calibration for depreciation upon default using realized exchange rates. The difficulty is that, while we observe ex-post depreciation in the default state, we do not observe LC depreciation in the nondefault counterfactual state for the same country at the same time. The empirical strategy we use is to compare depreciation in defaulting countries with contemporaneous depreciation in ex-ante similar countries that do not default. The regression specification is as follows:

$$Dep_{t-\Delta t,t} = a_{Group(i),t} + \beta Def_{i,t} + \epsilon_{i,t},$$

where $Dep_{t-\Delta t,t} = 1 - \mathcal{E}_{t-\Delta t}/\mathcal{E}_t$ measures five-year backward-looking LC depreciation and $Def_{i,t}$ is an indicator variable denoting whether a sovereign default occurs in country i at time t. The fixed effects, $a_{Group(i),t}$, are time fixed effects that interact with country groups based on ex-ante characteristics, such as per capita income, debt to GDP ratios, and credit ratings. The coefficient β identifies the difference between depreciation in the default state and our constructed counterfactual nondefault state. Therefore, the implied depreciation upon default relative to the nondefault state is given by $\hat{\alpha} = 1 - (1 - \bar{a} - \hat{\beta})/(1 - \bar{a})$, where $\bar{a}$ denotes the average of the fixed effects $a_{Group(i),t}$.[18]

Table V displays our estimation results. Results in columns (1) to (4) are based on the annual default time obtained from Reinhart and Rogoff (2009) for the post-Bretton Woods period, 1971 to 2010. In column (1), we only include year fixed effects and find that defaulting countries, on average, depreciate 31% more than nondefaulting countries, which implies an α equal to 34%. In column (2), we include year fixed effects interacting with three income group fixed effects. The income groups are determined by the 33$^{\text{rd}}$ and 67$^{\text{th}}$ percentiles of per capita income at time $t - 5$. The implied α decreases to 29%. In column (3), we include more fixed effects for three debt levels, as determined by the 33$^{\text{rd}}$ and 67$^{\text{th}}$ percentiles of government debt to GDP ratios at time $t - 5$, and obtain an α estimate of 27%. In column (4), we restrict ourselves to domestic default

[18] The average fixed effect $\bar{a}$ in the regression measures the mean depreciation in the nondefault countries, and $\bar{a} + \hat{\beta}$ captures the mean depreciation in the default countries. Given that $\alpha = 1 - \mathcal{E}_{t+1}^{ND}/\mathcal{E}_{t+1}^{D}$, we obtain the estimate $\hat{\alpha} = 1 - (1 - \bar{a} - \hat{\beta})/(1 - \bar{a})$.

Table V

Historical Estimates of Depreciation upon Default

This table reports empirical estimates for the regression $Dep_{t-\Delta t,t} = a_{Group(i),t} + \beta Def_{i,t} + \epsilon_{i,t}$. In columns (1) to (4), we use annual default time from Reinhart and Rogoff (2009), denoted by "RR," for the post-Bretton Woods era (1971 to 2010). In columns (5) and (6), we use monthly default time from Cruces and Trebesch (2013), denoted by "CT," for 1980 to 2014. Different fixed effects are used for each column. The dependent variable in all regressions is backward-looking five-year exchange rate depreciation. The independent variable $Def_{i,t}$ is a binary variable indicating whether a sovereign default/restructuring occurs in country i at time t, and $Def_{i,t}^{domestic}$ indicates whether a domestic default or restructuring occurs. The constant reports the average fixed effect. The fixed effect "Income" refers to one of three income groups: the top 33%, middle 34%, and bottom 33% based on per capita income at $t-5$ obtained from the Total Economy Database. The fixed effect "Debt" refers to one of the three debt levels: the top 33%, middle 34%, and bottom 33% based on government debt to GDP at $t-5$ obtained from Reinhart and Rogoff (2009). The fixed effect S&P rating refers to a coarse measure of credit rating given by S&P (1=AAA; 2=AA+/AA/AA-; 3=A+/A/A-; 4=BBB-/BBB/BBB+; 5=BB-/BB/BB+; 6=B-/B/B+; 7=all C ratings; 8=D/SD; 9=unrated). Only the first year(month) of each default episode is used in the estimation. The row "implied α" reports LC depreciation in the default state relative to the counterfactual nondefault state: $\alpha = 1-(1-\bar{a}-\hat{\beta})/(1-\bar{a})$, where $\bar{a}$ denotes the average fixed effect estimate (the constant). The standard errors are clustered at the country level and shown in the parestheses. Significance levels are denoted by $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.1$.

	(1) RR Benchmark (1971 to 2010)	(2) RR Income (1971 to 2010)	(3) RR Income/Debt (1971 to 2010)	(4) RR Income/Debt (1971 to 2010)	(5) CT Benchmark (1980 to 2014)	(6) CT S&P Rating (1980 to 2014)
$Def_{i,t}$	0.31^{***}	0.26^{***}	0.24^{***}		0.33^{***}	0.28^{***}
	(0.055)	(0.056)	(0.060)		(0.049)	(0.052)
$Def_{i,t}^{Domestic}$				0.27^{***}		
				(0.089)		
Constant	0.088^{***}	0.094^{***}	0.100^{***}	0.096^{***}	0.17^{***}	0.17^{***}
	(0.023)	(0.020)	(0.020)	(0.019)	(0.018)	(0.015)
Observations	1,951	1,792	1,599	1,566	43,315	43,315
FE	Year	Year × Income × Debt	Year × Income × Debt	Year × Income	Month	Month × Rating
Implied α	0.34	0.29	0.27	0.30	0.40	0.34

episodes and obtain similar results of 30%. In columns (5) and (6), we use monthly default dates between 1980 and 2014 given by Cruces and Trebesch (2013). The estimate for α is 40% with only monthly fixed effects in column (6), and it decreases to 34% after including S&P country credit ratings at time $t-5$.[19] Our preferred specifications are presented in columns (3), (4), and (6), where more controls for ex-ante characteristics of the countries are included.

Based on the above, we estimate 36% to 37% risk-neutral depreciation upon default using quanto CDS spreads and 27% to 34% depreciation based on historical calibration. These empirical estimates are broadly in line with the 39% depreciation over default that would equalize expected default losses for LC and FC debt under the dollar risk-neutral measure. Therefore, the positive covariance between currency and default risk offers a quantitatively plausible explanation for the negative mean LC-over-FC credit spread differentials, even if credit risk on LC and FC debt is the same under the dollar risk-neutral measure.

In addition to explaining the average difference in credit spreads, the quanto adjustment can also help explain some of the time variation in credit spread differentials. Using our simple model that assumes a constant α, the quanto adjustment is proportional to the LC credit spread ($q_t = \frac{\alpha}{1-\alpha} s_t^{LCCS}$). During the peak of the Global Financial Crisis and the European sovereign debt crisis, the mean quanto adjustment accounted for 150 to 200 basis points of the credit spread differentials, under the assumption of 36% depreciation upon default. During the "normal" times when LC credit spreads were low, the mean quanto adjustment was below 100 basis points. We plot the time series of average credit spreads and quanto adjustment in Figure IA.2 in the Internet Appendix.

A.3. Can the Quanto Adjustment Explain All of the Observed Variation?

While the quanto adjustment can explain the large persistent level differences between LC and FC credit spreads, by itself it cannot explain all of the variation in the credit spread differentials. If we were to assume that the credit risk on LC and FC debt were always the same under the dollar risk-neutral measure and that the LC debt and that on FC credit spreads only differed because of the quanto adjustment, then the expected depreciation upon default α would need to be implausibly volatile. Table IA.I in the Internet Appendix summarizes the implied depreciation upon default under our thought experiment of equal default probabilities and recovery rates under the dollar measure ($s_t^{QLCCS} = s_t^{FCCS}$) by country. The standard deviation of the expected depreciation upon default over the full sample period (excluding Brazil) needs to be as high as 46%, compared with the 2% to 3% standard deviation implied from the Turkish and Mexican quanto CDS data.

In addition, given the low volatility of implied depreciation upon default, the quanto adjustment alone cannot explain the low correlation between LC and

[19] Our earliest S&P sovereign credit ratings start in 1975 for select countries. Countries without S&P ratings belong to the unrated category.

FC credit spreads in countries such as Indonesia, Peru, and the Philippines. It also cannot explain why the LC credit spreads are less correlated across countries and are less sensitive to global risk factors than FC credit spreads. The near perfect (99%) correlation between CDS spreads denominated in different currencies suggests that the quanto LC credit spread under the dollar measure, s_t^{QLCCS}, and the LC credit spread under the LC measure, s_t^{LCCS}, would also be highly correlated under perfect capital markets, if s_t^{QLCCS} were directly observed.[20] Moreover, although the quanto adjustment can explain the lower sensitivity of excess returns on swapped LC bonds to global risk factors, it cannot explain why these excess returns have close to zero loadings on the global equity excess returns but significant positive loadings on the local equity excess returns. In summary, the covariance between currency and credit risk is a very important source of credit spread differentials, but it cannot be the only source.

B. Selective Default, Capital Control, and Jurisdiction Risks

In addition to the covariance between currency and default risk, selective default, capital controls, and differential jurisdiction risks can also have differential impacts on LC and FC credit spreads. Looking back at sovereign defaults in recent history, it is ambiguous, a priori, whether we should expect higher default probabilities or haircuts on domestic LC or FC external debt. Moody's (2014) and Standard & Poor's (2014) document that, among countries not in currency unions, 21 sovereigns have defaulted since 1997, of which five have selectively defaulted on LC debt, eight have selectively defaulted on FC debt, and eight have defaulted simultaneously on LC and FC debt.[21] Among all the FC defaults, Nicaragua (in 2003 and 2008) and Jamaica (in 2010 and 2013) defaulted only on FC debt issued under domestic jurisdiction but exempted FC external debt under foreign laws. Therefore, the incidence of domestic LC defaults is comparable with the incidence of external FC defaults in the recent sample. In terms of the severity of default, taking the joint Argentine defaults in 2001 as an example, Moody's (2014) gives a mean recovery of face value equal to 28.5% for the U.S. dollar debt and 17.5% for the peso debt.

In addition to outright defaults, as LC debt is governed under the domestic jurisdiction, our LC credit spreads encompass a broader view of "credit" risk because there are more ways for a government to avoid payments to foreign creditors, such as imposing taxes on capital outflows or suspending currency convertibility. While a systematic analysis of time variations in capital controls

[20] Using our simple model, in which $s_t^{QLLCS} = \frac{1}{1-\alpha} s_t^{LCCS}$ and α is time-invariant, we have a perfect correlation between s_t^{QLCCS} and s_t^{LCCS}. In addition, s_t^{QLCCS} and s_t^{LCCS} have the same correlation with any other factor x_t, $\mathrm{Corrs}_t^{LCCS}, x_t) = \mathrm{Corrs}_t^{LCCS}, x_t)$.

[21] Selective LC defaults: Mongolia (1997), Venezuela (1998), Suriname (1999), Turkey (1999), and Dominica (1999). Selective FC defaults: Indonesia (1999 to 2002), Pakistan (1999), Peru (2000), Moldova (2002), Nicaragua* (2003, 2008), Dominican Republic (2005), Belize (2006, 2012), and Seychelles (2008). LC and FC joint defaults: Russia (1998 to 1999), Ukraine (1998 to 2000), Ecuador (1999), Argentina (2001), Uruguay (2003), Paraguay (2004), Grenada (2004, 2013), and Jamaica* (2010, 2013). An asterisk indicates that the defaulted FC debt is under domestic jurisdiction.

and jurisdiction risks for all sample countries is important, it is beyond the scope of the paper. Instead, we focus on Brazil as a specific case to illustrate how these risks may affect the LC credit spread.

As a country offering one of the highest nominal interest rates in the world, Brazil has implemented several macroprudential and exchange rate policy measures to curb portfolio investment flows and cross-border derivative trading. The Imposto sobre Operações Financieras (IOF), or tax on financial transactions, was introduced in October 2009 and abandoned in the face of large capital outflows in June 2013. The IOF varied between 2% and 6% on foreign investment in fixed income instruments while it was in effect.

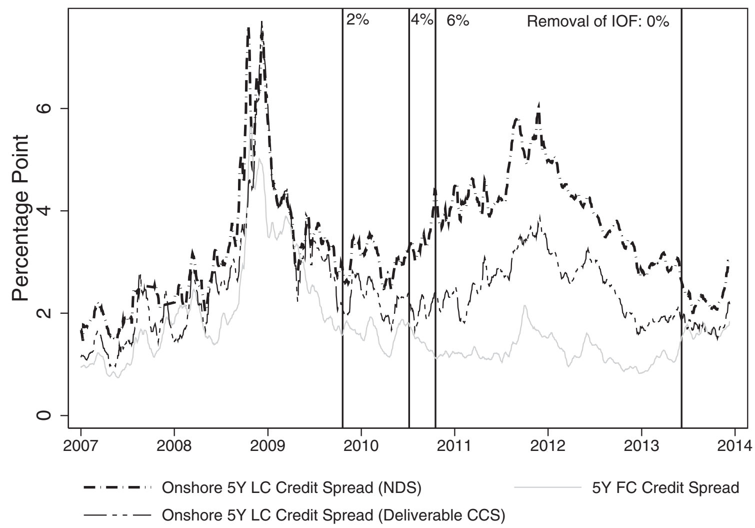
The difference between the onshore deliverable CCS and the offshore NDS rates captures currency convertibility and capital control risks. We construct the Brazilian onshore fixed-for-fixed deliverable CCS by subtracting the onshore Cupom Cambial futures (which is the fixed U.S. dollar against the floating Brazilian interbank deposit rate DI) from the onshore plain-vanilla interest rate swap PRE/DI (which is the fixed Brazilian real against the DI), with both legs settled in Brazilian reais.[22] The onshore deliverable CCS is higher than the offshore NDS because it is subject to cross-border taxation, capital control, and convertibility risks. These risks are also faced by holders of domestic LC sovereign bonds. Therefore, the LC credit spread based on the deliverable CCS provides the investor with a first-order hedge of the capital control risk and thus should be lower than the LC credit spread based on the NDS.

Panel A in Figure 7 plots the five-year LC credit spreads based on the NDS and deliverable CCS compared to the FC credit spread. The four changes in the IOF tax rate are indicated by the vertical lines. The LC credit spread based on onshore deliverable CCS is lower than our conventional LC credit spread based on the NDS. The two LC credit spread measures diverged significantly during the period when the IOF was in effect, with a mean spread differential of 1.3%, which accounts for about one-third of the LC credit spread based on the NDS and about one-half of the differential between the NDS-based LC credit spread and the FC credit spread. After the IOF was removed in June 2013, the two LC credit spread measures and the FC credit spread converged significantly, with the LC credit spread based on deliverable CCS approximately equal to the FC credit spread.

Furthermore, we note that, even if convertibility and capital control risks are hedged to the first order by the onshore deliverable CCS, the LC credit spread measure based on the deliverable CCS is still higher than the FC credit spread. We attribute this difference to the additional credit risk from lending under domestic law. To see this, we examine Brazil's four large offshore issuances of LC-denominated eurobonds, which are governed under international laws, settled in U.S. dollars, and free of capital control and convertibility risks. Figure 7, Panel B, shows the NDS-based offshore LC credit spread on a eurobond—

[22] As the Cupom Cambial is traded on a futures exchange subject to margin calls and the PRE/DI does not involve the exchange of the principal, the counterparty risk in the deliverable CCS is even more negligible compared to the NDS.

Panel A. Onshore LC Credit Spreads Based on the NDS and Deliverable CCS



Panel B. Onshore and Offshore LC Credit Spreads

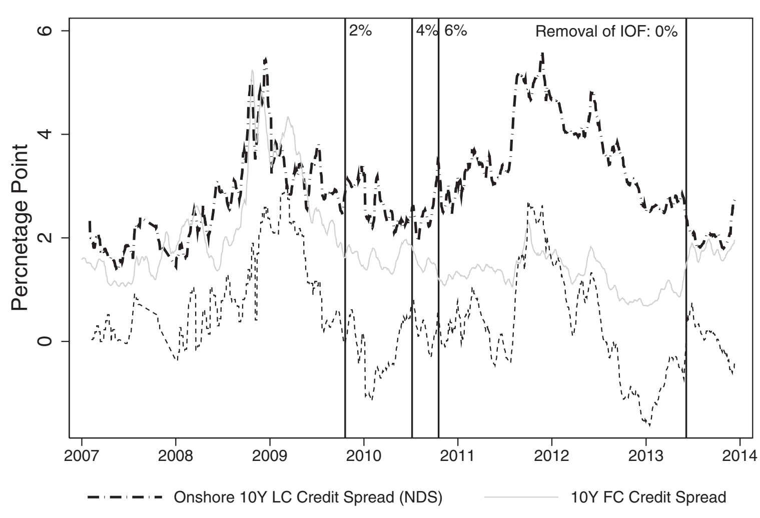


Figure 7. Brazil onshore and offshore credit spread comparison. In the top figure, the long-dashed line plots the Brazilian five-year LC credit spread of the domestic LC bond using the NDS. The short-dashed line plots the five-year LC credit spread of the domestic LC bond using the deliverable CCS implied by the Cupom Cambial future and the pre-DI swap. The solid lines plot the five-year FC credit spread. In the bottom figure, the long-dashed line plots the Brazilian 10-year LC credit spread of the domestic LC bond using the NDS. The short-dashed line plots the yield spread on a eurobond issued by the Brazilian sovereign (denominated in BRL traded offshore and maturing in 2022) minus the 10-year NDS. The solid lines plot the 10-year FC credit spread. One-week moving averages are plotted for all series. The eurobond yield is obtained from the Luxembourg Stock Exchange and Bloomberg.

denominated in reais and maturing in 2022—is much lower than the LC credit spread on an onshore bond based on the same NDS rate. The offshore LC credit spread is also generally lower than the FC credit spread. Therefore, the general pattern that the LC credit spread is lower than the FC credit spread also holds for Brazil once we remove capital control and domestic jurisdiction risks.[23]

C. Financial Market Frictions

While the benchmark of perfect capital markets provides a useful starting point, a number of important frictions affect the pricing of the assets we use to measure credit risk. The comparison between LC and FC credit spreads highlights not only the differential credit risk between the two types of debt, but also various financial market frictions that have differential impacts on LC and FC credit spreads. We now discuss the impacts of the four types of frictions that we initially abstracted from under Assumption 1: (1) differential liquidity risk, (2) market segmentation between domestic and external debt markets, (3) short-selling constraints, and (4) no-arbitrage violations in the currency markets. We discuss how each of these frictions causes our measures of the LC risk-free rate and LC credit spread to differ from their frictionless interpretations offered by Propositions 1 and 2.

C.1. Liquidity Risk

In addition to differential credit risk, differential liquidity risk between swapped LC and FC debt can also create a wedge between the two credit spreads. We assess the liquidity of swapped LC debt and FC debt by comparing the bid-ask spread, market size, and trading volume of the two types of debt. A summary of liquidity and trading volume at the country level can be found in Internet Appendix Table IA.II. We obtain bid-ask spreads on LC and FC bonds by averaging yield bid-ask spreads across all sovereign bonds with remaining maturities between 2 and 10 years in Bloomberg for each sample country. The sample mean bid-ask spread is equal to 11.1 basis points for LC debt and 14.5 basis points for FC debt. The mean bid-ask spread on the five-year currency swaps is equal to 38.2 basis points, greater than the bid-ask spread on the LC and FC bonds. In terms of market size and trading volume, we obtain data from the quarterly Debt Trading Volume Survey compiled by EMTA. The survey participants consist of around 60 offshore large financial institutions, including most of the well-known investment banks and a few hedge funds. The mean reported quarterly trading volume reported in the EMTA surveys is

[23] In addition to Brazil, Colombia has also issued several LC eurobonds payable in dollars and traded offshore. The offshore LC credit spread in Colombia is also lower than the FC credit spread. Furthermore, Chamon, Schumacher, and Trebesch (2014) also document significantly lower spreads on foreign bonds than those on domestic bonds in Greece and Portugal during the peak of the European debt crisis, and in Russia (2000 to 2006) and Argentina (2005 to 2012).

equal to \$49 billion for LC bonds and \$25 billion for FC bonds.[24] We aggregate total CCS notional exchanged from the Depository Trust & Clearing Corporation (DTCC) available on the Bloomberg Swap Depositary Reporting platform for 2013. The mean quarterly trading volume for CCS in our sample is about \$9 billion, lower than the trading volume of LC and FC bonds.

It follows from above that investors in the synthetic swapped LC bonds have long positions in the more liquid cash market and short positions in the less liquid swap market, and hence have better overall liquidity than if they held FC bonds. The potential liquidity premium would be translated into lower spreads for swapped LC bonds. To analyze the effect of the time-varying liquidity risk on the spread differential, we perform a contemporaneous regression of changes in LC and FC credit spreads and LC-over-FC credit spread differentials on changes in bid-ask spreads on bonds and swaps in Table VI. Conditional on VIX and our host of macroeconomic controls, we find that a one basis point increase in the bid-ask spread of the FC bond and the currency swap significantly reduces the LC-over-FC credit spread differential by 1.5 and 2 basis points, respectively. The impact of the LC bond bid-ask spread on the credit spread differential is also positive, although statistically insignificant.

Furthermore, in Table VII, we show that liquidity factors significantly forecast bond excess returns. The bid-ask spreads on FC bonds and offshore currency swaps predict positive excess returns on the FC bonds. Although currency swaps are not used in constructing FC excess returns, the liquidity of currency swaps is indicative of the overall offshore liquidity condition. We show that illiquidity of LC bonds positively forecasts excess returns, while illiquidity of FC bonds and currency swaps negatively forecasts excess returns. Finally, the same set of liquidity factors are powerful predictors of the FC-over-swapped LC excess returns, which suggests time-varying differential liquidity risk premia between swapped LC and FC debt.

C.2. Market Segmentation and Slow-Moving Capital

In addition to differential cash flow, liquidity risks, and short-selling constraints, the strong correlation between FC credit spreads and VIX and the lack of a strong correlation between LC credit spreads and VIX motivate us to consider potential market segmentation between domestic and external debt markets. In particular, the marginal investors for LC and FC debt might be different in the presence of slow-moving capital and limits to arbitrage. For emerging market debt, FC bonds are issued offshore, mainly targeting global investors. Although there has been increasing foreign ownership in LC debt markets, the bulk of the LC debt is still held by local investors, such as local

[24] Since the size of the LC bond market is about five times as large as the FC bond market, the turnover ratio (defined as the trading volume decided by total outstanding debt) of offshore participants is lower for LC debt (28%) than for FC bonds (74%). However, since foreign holdings represent, on average, 15% of outstanding LC debt in the sample, a back-of-the-envelope calculation suggests that if local investors traded 28% as frequently as foreigners, the total turnover ratios for LC and FC debt would be the same.

Table VI

Regressions of Quarterly Changes in Yield Spreads, 2005 to 2014

This table reports fixed effect panel regression results for quarterly changes in yield spreads. The dependent variables are: (1) Δs^{LCCS}, change in the LC credit spread; (2) Δs^{FCCS}, change in the FC credit spread; (3) $\Delta s^{LC/FCCS}$, change in the LC- over- FC credit spread; (4) $\Delta s^{LC/US}$, change in the LC nominal spread; and (5) ΔCCS, change in the cross-currency swap rate. The independent variables are: Δba^{LC}, Δba^{FC}, and Δba^{CCS}, changes in the mean bid-ask spreads on all LC and FC bonds between 2 and 10 years in Bloomberg and on five-year par CCS in basis points, respectively; ΔVIX, change in the monthly standard deviation of implied volatility on S&P index options (conventional quote/$\sqrt{12}$); $\Delta CFNAI$, change in the Chicago Fed National Activity Index; Δ*FC(LC) Debt*/*GDP*, change in the FC (LC) debt to GDP ratio from the BIS debt securities statistics; $\Delta Reserve$, log change in FX reserves; ΔIP, percentage change in the year-over-year (y.o.y.) industrial production index; $\Delta\pi$, percentage change in y.o.y. inflation; $\Delta\sigma_\pi$, change in the 12-month rolling standard deviation of y.o.y. inflation; ΔToT, log change in terms of trade; $\Delta\sigma_{ToT}$, change in the 12-month rolling standard deviation of ΔToT; and $\Delta\sigma_{MSCI}$, change in the 30-day rolling standard deviation of daily local MSCI equity returns. All regressions are run at the quarterly frequency with country fixed effects using Newey-West standard errors with eight-quarter lags clustered by quarter following Driscoll and Kraay (1998). Standard errors are shown in the parentheses. Significance levels are denoted by $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.1$.

	(1) Δs^{LCCS}	(2) Δs^{FCCS}	(3) $\Delta s^{LC/FCCS}$	(4) $\Delta s^{LC/US}$	(5) Δccs
Δba^{LC}	0.0062	0.0053**	0.00090	0.0030	−0.0032
	(0.0062)	(0.0022)	(0.0056)	(0.0071)	(0.0041)
Δba^{FC}	0.0085	0.023**	−0.015**	0.022**	0.014
	(0.0085)	(0.011)	(0.0074)	(0.010)	(0.011)
Δba^{CCS}	−0.0052**	0.0042**	−0.0094***	−0.0022	0.0030
	(0.0025)	(0.0020)	(0.0034)	(0.0032)	(0.0031)
ΔVIX	0.020	0.099***	−0.079**	0.0035	−0.017
	(0.033)	(0.013)	(0.034)	(0.034)	(0.027)
$\Delta CFNAI$	−0.18**	−0.14*	-0.046	−0.17	0.010
	(0.093)	(0.071)	(0.059)	(0.16)	(0.20)
Other Controls					
Δ*FC Debt*/*GDP*	0.18**	0.25**	−0.071	0.18*	0.0042
Δ*LC Debt*/*GDP*	−0.053**	−0.018	−0.035	−0.039*	0.014
$\Delta Reserve$	0.0043	0.0015	0.0029	−0.0047	−0.0090
ΔIP	−0.0063	−0.014**	0.0079**	−0.0058	0.00058
$\Delta\pi$	0.070**	0.052***	0.018	0.24***	0.17**
$\Delta\sigma_\pi$	0.056	0.057	−0.00060	−0.063	−0.12
ΔToT	−0.0035	0.0016	−0.0051	−0.0015	0.0020
$\Delta\sigma_{ToT}$	0.0039	0.029***	−0.025**	−0.0032	−0.0071
$\Delta\sigma_{MSCI}$	0.14**	0.18***	−0.046	0.39***	0.25***
Observations	347	347	347	347	347
Within R^2					
Full model	0.168	0.577	0.258	0.222	0.116
Without VIX or Liquidity	0.143	0.393	0.083	0.211	0.091
With VIX and Liquidity Only	0.077	0.450	0.228	0.086	0.048

Table VII

Forecasting Quarterly Holding-Period Excess Returns, 2005 to 2014

This table reports annualized quarterly return forecasting results for $rx_{t+3}^{FC/US}$, FC-over-US excess returns, $srx_{t+3}^{LC/US}$, swapped LC over-U.S. excess returns, and $srx_{t+3}^{FC/LC}$, FC-over-swapped LC excess returns. The "local" controls refer to all other local macroeconomic controls used in Table VI, expressed in levels. Mark-to-market accounting is used to calculate returns for swapped LC bonds to take into account second-order currency hedging errors due to the covariance between credit risk and currency risk. The LC swap and bond positions are rebalanced at the daily frequency so that the two positions have the same market value. All regressions are run at a monthly frequency with country fixed effects using Newey-West standard errors with 24-month lags clustered by month, following Driscoll and Kraay (1998). Standand errors are shown in the parentheses. Significance levels are denoted by $^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.1$.

		ba^{LC}	ba^{FC}	ba^{CCS}	VIX	Other Controls	R^2
$rx_{t+3}^{FC/US}$	(1)	0.0220	0.24***	0.15***	1.59*	*CFNAI*	0.205
		(0.042)	(0.091)	(0.034)	(0.83)		
	(2)	0.0470	0.17**	0.17***	1.62*	*CFNAI, local*	0.275
		(0.067)	(0.084)	(0.032)	(0.89)		
$srx_{t+3}^{LC/US}$	(3)	0.25***	−0.0240	−0.085**	0.620	CFNAI	0.0320
		(0.068)	(0.10)	(0.034)	(0.58)		
	(4)	0.25***	−0.140	−0.069**	0.850	*CFNAI, local*	0.0900
		(0.084)	(0.13)	(0.034)	(0.65)		
$srx_{t+3}^{FC/LC}$	(5)	−0.23***	0.260	0.24***	0.97***	*CFNAI*	0.187
		(0.083)	(0.16)	(0.044)	(0.33)		
	(6)	−0.20***	0.30*	0.23***	0.77**	*CFNAI, local*	0.221
		(0.070)	(0.17)	(0.037)	(0.35)		

pension funds, insurance companies, commercial banks, and other government agencies. These domestic entities gives rise to a distinct local clientele demand that is absent from the external debt market.[25]

To provide an example of the lack of distinct local clientele demand (e.g., Italy) and the presence of an extreme form of local clientele demand (e.g., Russia), Figure 8 shows LC and FC credit spreads for Italy and Russia, respectively. In the case of Italy, euro-denominated and dollar-denominated sovereign debt markets are both easily accessible to global investors. Prior to 2008, the two Italian credit spreads were indistinguishable. The two credit spreads diverged slightly beginning in 2008, but are highly correlated with the sample correlation equal to 90%. On the other hand, Russia displays extreme local clientele demand for LC bonds during the 2008 to 2009 crisis, as the LC credit spread reached negative 10 percentage points during the crisis and the CDS spread on FC debt was above positive 10 percentage points. While the nominal yield on ruble debt was 10 percentage points above U.S. Treasuries, the ruble/dollar NDS rate increased to 20 percentage points as offshore investors were concerned that Russia would abandon the euro/dollar peg and devalue. The share

[25] Kumara and Pfau (2011) document stringent caps faced by emerging market pension funds in investing in local equities and overseas assets.

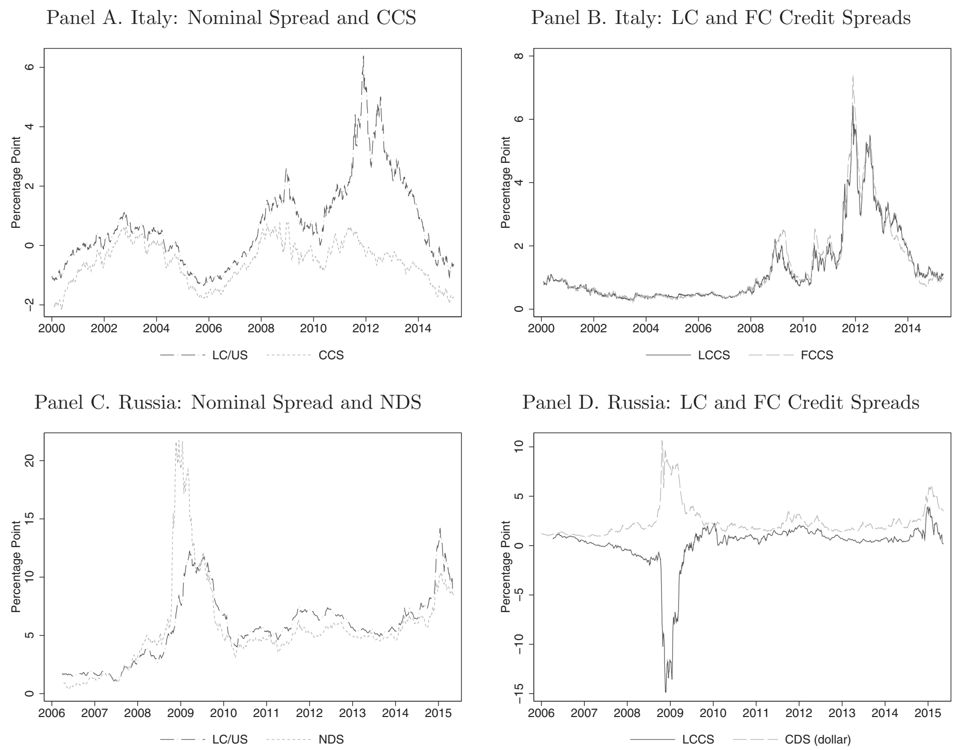


Figure 8. Five-year sovereign credit spreads in Italy and Russia (percentage points). In Panel A, "LC/US" plots five-year nominal yield spreads of euro-denominated Italian sovereign bonds over U.S. Treasury bonds, and "CCS" plots five-year fixed-for-fixed euro/dollar CCS rates. In Panel B, "FCCS" plots five-year yield spreads of dollar-denominated Italian sovereign bonds over U.S. Treasury bonds, and "LCCS" plots five-year LC credit spreads for euro-denominated Italian sovereign bonds. In Panel C, "LC/US" plots five-year nominal yield spreads of Russian LC sovereign bonds over U.S. Treasury bonds, and "NDS" plots five-year fixed-for-fixed ruble/dollar NDS rates. In Panel D, "CDS" plots five-year Russian sovereign credit spread swaps spreads denominated in dollars (Russia does not have enough dollar bonds outstanding to construct yield curves), and "LCCS" plots five-year LC credit spreads for the ruble bond. All data are from Bloomberg.

of nonresident holdings of Russian LC debt was close to zero around the time (Du and Schreger (2015)).[26] Local investors, meanwhile, continued to hold LC debt despite extremely unattractive yields. Foreign participation of the ruble bond market increased steadily after the crisis and has surged in recent years after Russian LC bonds became Euroclearable in early 2013. During the recent financial turbulence in Russia starting at the end of 2014, the LC credit spread

[26] We note that, before Russian LC bonds became Euroclearable in 2013, offshore investors were allowed to participate in the LC market in Russia but had to have a broker and custody agreement with a local financial institution in order to obtain market access. Investors were exposed to significant settlement and custody risks, especially during the peak of the crisis.

increased significantly and was strongly correlated with the CDS spread on FC debt.

If LC and FC debt markets are completely integrated, global investors are the marginal investors for both types of debt. If LC and FC markets are completely segmented, global investors price the FC debt and the local clientele price the LC debt. Our sample emerging markets stand in between perfect market integration in Italy and extreme market segmentation in Russia during the peak of the crisis, with the country credit spread correlation ranging from 11% for Indonesia to over 90% for Hungary and Poland. In countries where the LC debt market is imperfectly integrated into the global capital market, local clientele demand can still play a role in the presence of risky arbitrage by global investors. Furthermore, shocks to global risk aversion have perfect pass-through into the FC credit spread, but incomplete pass-through into the LC credit spread, which can be an important source of the credit spread differentials. More discussions can be found in Sections III and IV of the Internet Appendix.

C.3. Short-Selling Constraints

In this subsection, we discuss impacts of short-selling constraints on the valuation of LC and FC credit spreads. We show that it is generally more difficult to borrow LC debt than FC debt from global securities lenders. Markit Securities Finance (formerly known as Data Explorer) provides security-level lending information covering more than 20,000 institutional funds. We use 12 quarter-end reports from Markit Securities Finance between 2012 and 2014 to document differences in inventories for lendable securities, actual lending amounts, and average lending fees across the two types of debt.

We present the country-level summary statistics in Internet Appendix Table IA.IV. The average daily inventory for lendable FC sovereign bonds in our sample countries is equal to $40 billion, which accounts for about 11% of total outstanding FC sovereign debt securities. The total average daily inventory for LC bonds is $23 billion, which accounts for less than 1% of total outstanding LC sovereign debt securities. In addition to lower inventory levels, the actual inventory utilization rates are also significantly lower for LC debt than for FC debt. On average, only 4% of lendable LC bonds are actually lent out, compared with 12% of FC bonds. There is significant cross-country heterogeneity in the size of LC securities lending. We only observe negligible amounts (below $1 million) of securities lending for LC bonds in Indonesia, Israel, Mexico, and Philippines. In contrast, Hungary and Poland have sizable LC bond lending, with the average balance over $300 million, which is comparable with lending of FC bonds. In terms of average lending fees on existing transactions, it costs 21 basis points to short FC bonds and 31 basis points to short LC bonds.[27]

[27] The empirical literature on borrowing and shorting defaultable bonds is quite limited. Recently, Asquith et al. (2013) present some stylized facts for borrowing corporate bonds using a

Following the existing literature, we know that the existence of short-selling constraints can increase securities prices, either because more pessimistic investors are kept away from participating in the market (i.e., Miller (1977)) or because there are search and bargaining frictions associated with shorting securities (i.e., Duffie, Garleanu, and Pedersen (2002)). Therefore, short-selling constraints can potentially lower LC credit spreads, more so than FC credit spreads. To arbitrage the mispricing, an investor needs to pay the borrowing cost to short LC bonds. Therefore, short-selling constraints cannot explain away positive LC credit spreads, but can potentially explain temporarily negative LC credit spreads. Short-selling constraints can also contribute to negative LC-over-FC credit spread differentials.

C.4. No-Arbitrage Violations in the Currency Market

In addition to segmentation between domestic and external debt markets, potential segmentation and slow-moving capital in the FX markets can also affect our LC credit spread measure. Assuming that the FX spot and forward markets are frictionless, the CIP condition should hold between risk-free rates across currencies. However, several papers have documented the failure of the short-term CIP condition between money market rates in developed markets during the financial crisis (Baba (2009), Coffey, Hrung, and Sarkar (2009), and Griffoli and Ranaldo (2011)). The CIP failures during the crisis share a common feature: The synthetic dollar borrowing cost was higher than the direct dollar borrowing cost. The authors attribute the breakdown of the no-arbitrage condition to a severe dollar shortage during the crisis.[28] Ivashina, Scharfstein, and Stein (2015) argue that the dollar shortage facing European banks during the European debt crisis prompted these banks to swap euro funding into dollar funding using FX swaps, which resulted in CIP violations when there was limited capital to take the other side of the trade.[29]

If the dollar shortage affected our sample emerging market currencies, then the LC credit spread based on the synthetic LC risk-free rate constructed from U.S. Treasuries and CCS rates would overstate the credit risk component of the LC sovereign debt. However, the alternative LC credit spread based on supranational yields presented in Section II.D. should not be directly affected, as no swaps are used in the construction. In Section V of the Internet Appendix, we measure no-arbitrage violations in the FX markets for emerging markets using CIP deviations between supranational yields in emerging market

proprietary data set from a major securities lender and show that the cost of borrowing is between 10 and 20 basis points, comparable to the cost of shorting stocks.

[28] We note that, at the peak of the crisis, CIP deviation was much smaller at medium to long tenors than at short tenors. While prior papers find an approximately 300 basis point CIP deviation based on LIBOR for the euro/dollar pair at short tenors of up to one year, the most negative five-year cross-currency basis for the euro/dollar pair was around negative 50 basis points during the peak of the crisis.

[29] More generally, Hau and Rey (2006) and Gabaix and Maggiori (2015) examine the role of capital flows in determining exchange rates in imperfect financial markets.

currencies and the dollar. We argue that, while long-term CIP deviations can be significant during the crisis, they are much smaller in size on average than LC credit spreads.

IV. Conclusion

The last decade has seen a remarkable change in emerging market government finance, as major emerging market sovereigns are increasingly borrowing in their own currency. In this paper, we introduce a new measure of LC sovereign risk, the LC credit spread, defined as the difference between the LC bond yield and the LC risk-free rate implied by the swap market. Using this new measure, we document several key findings. First, emerging market governments pay a significant credit spread when they borrow in their own currency, despite the sovereign's option to inflate the debt away. Second, LC bonds have lower credit spreads than FC bonds issued by the same sovereign. The LC-over-FC credit spread differential became even more negative during the peak of the global financial crisis. Third, while FC credit spreads are very integrated across countries and responsive to global risk factors, LC credit spreads are much less so. After presenting the stylized facts, we discuss several sources of credit spread differentials: (1) covariance between currency and default risk; (2) selective default, jurisdiction, and capital control risks; and (3) financial market frictions, including illiquidity, short-selling constraints, market segmentation, and slow-moving capital.

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Appendix

Proof of Lemma 1: The net cash flows of a fixed-for-fixed LC/dollar CCS are as follows. Party A gives one dollar to Party B and receives $\mathcal{E}_t$ units of LC at the inception of the swap at time t. At the maturity of the swap, Party A pays $\exp(n\tilde{r}_{nt}^{LC})\mathcal{E}_t$ units of LC to Party B and receives $\exp(n\tilde{r}_{nt}^{\$})$ dollars. There are no net exchanges of floating payments, as both parties are paying and receiving the same LIBOR cash flow at each coupon period. At time t, since the LC can be exchanged forward at time $t+n$ at the outright forward rate $F_{t,t+n}$ and both parties must be ex-ante indifferent between receiving $\exp(n\tilde{r}_{nt}^{LC})\mathcal{E}_t$ units of LC and $\exp(n\tilde{r}_{nt}^{\$})$ dollars at time $t+n$, we must have

$$\exp\left(n\tilde{r}_{nt}^{\$}\right) = \exp\left(n\tilde{r}_{nt}^{LC}\right)\mathcal{E}_t/F_{t,t+n},$$

or in logs, $\rho_{nt} \equiv \tilde{r}_{nt}^{LC} - \tilde{r}_{nt}^{\$} = \frac{1}{n}(f_{t,t+n} - e_t)$. □

Proof of Proposition 1: Given the U.S. Treasury yield $y_{nt}^{*\$}$, the price of the U.S. Treasury bond at time t is equal to $P_{nt}^{*\$} = \exp(-ny_{nt}^{*\$})$. Suppose an LC investor has $(\mathcal{E}_t/F_{t,t+n})P_{nt}^{*\$}$ units of the LC at time t. She can lock in a default-free LC return by exchanging the LC in $(P_{nt}^{*\$}/F_{t,t+n})$ in U.S. dollars and investing the dollar proceeds into $1/F_{t,t+n}$ units of U.S. Treasury bonds at time t. Meanwhile, the investor can sell $1/F_{t,t+n}$ dollars forward for one unit of the LC. At time $t+n$, the U.S. Treasury bond pays off $1/F_{t,t+n}$ dollars with certainty. In the absence of counterparty risk in the forward contract, the investor gives $1/F_{t,t+n}$ dollars to the bank, exactly offsetting the U.S. Treasury bond payment, and receives on net one unit of the LC at time $t+n$ with certainty. By Lemma 1, $F_{t,t+n} = \exp(n\rho^*_{nt})\mathcal{E}_t$. Therefore, the annualized log LC risk-free rate is equal to

$$y^{*LC}_{nt} = -\frac{1}{n}\log\left[(\mathcal{E}_t/F_{t,t+n})P^{*\$}_{nt}\right] = y^{*\$}_{nt} + \rho_{nt}.$$

□

Proof of Proposition 2: Under the LC risk-neutral measure, $\mathbb{Q}^{LC}$, we know that the price of an LC bond is equal to the discounted expected value of future LC cash flows, with cash flows discounted at the LC risk-free rate and the expectation taken under the LC risk-neutral measure:

$$P^{LC}_t = \exp(-y^{*LC}_t)\mathbb{E}^{\mathbb{Q}^{LC}}_t(1 - L^{LC}_{t+1}),$$

which gives

$$s^{LCCS}_t = y^{LC}_t - y^{*LC}_t = -\ln\mathbb{E}^{\mathbb{Q}^{LC}}_t(1 - L^{LC}_{t+1}) \approx \mathbb{E}^{\mathbb{Q}^{LC}}_t L^{LC}_{t+1}.$$

Under the dollar risk-neutral measure $\mathbb{Q}^{\$}$, we know that the price of an LC bond in dollars is equal to the expected discounted value of future dollar cash flows, with cash flows discounted at the dollar risk-free rate and the expectation taken under the dollar risk-neutral measure:

$$P^{LC}_t/\mathcal{E}_t = \exp\left(-y^{*,\$}_t\right)\mathbb{E}^{\mathbb{Q}^{\$}}_t\left[(1 - L^{LC}_{t+1})/\mathcal{E}_{t+1}\right].$$

Using the no-arbitrage condition between LC and the dollar,

$$\exp\left(-y^{*,\$}_t\right)\mathbb{E}^{\mathbb{Q}^{\$}}_t(\mathcal{E}_t/\mathcal{E}_{t+1}) = \exp\left(-y^{*LC}_t\right),$$

we can rewrite the pricing equation as

$$P^{LC}_t = \exp\left(-y^{*LC}_t\right)\mathbb{E}^{\mathbb{Q}^{\$}}_t(1 - L^{LC}_{t+1})\left[1 + \frac{Cov^{\mathbb{Q}^{\$}}_t(1 - L^{LC}_{t+1}, \mathcal{E}_t/\mathcal{E}_{t+1})}{\mathbb{E}^{\mathbb{Q}^{\$}}_t(1 - L^{LC}_{t+1})\mathbb{E}^{\mathbb{Q}^{\$}}_t(\mathcal{E}_t/\mathcal{E}_{t+1})}\right].$$

Therefore, we have

$$s^{LCCS}_t = y^{LC}_t - y^{*LC}_t \approx \mathbb{E}^{\mathbb{Q}^{\$}}_t L^{LC}_{t+1} - \frac{Cov^{\mathbb{Q}^{\$}}_t(1 - L^{LC}_{t+1}, \mathcal{E}_t/\mathcal{E}_{t+1})}{\mathbb{E}^{\mathbb{Q}^{\$}}_t(1 - L^{LC}_{t+1})\mathbb{E}^{\mathbb{Q}^{\$}}_t(\mathcal{E}_t/\mathcal{E}_{t+1})} = \mathbb{E}^{\mathbb{Q}^{\$}}_t L^{LC}_{t+1} - q_t,$$

where $q_t \equiv \frac{Cov^{\mathbb{Q}^{\$}}_t(1 - L^{LC}_{t+1}, \mathcal{E}_t/\mathcal{E}_{t+1})}{\mathbb{E}^{\mathbb{Q}^{\$}}_t(1 - L^{LC}_{t+1})\mathbb{E}^{\mathbb{Q}^{\$}}_t(\mathcal{E}_t/\mathcal{E}_{t+1})}$.

Proof of Corollary 1: Under the dollar risk-neutral measure $\mathbb{Q}^*$, we know that

$$P^{FC}_t = \exp\left(-y^{*\$}_t\right)\mathbb{E}^{\mathbb{Q}^*}_t(1 - L^{FC}_{t+1})$$

$$s^{FCCS}_t = y^{FC}_t - y^{*\$}_t = -\ln\mathbb{E}^{\mathbb{Q}^{\$}}_t(1 - L^{FC}_{t+1}) \approx \mathbb{E}^{\mathbb{Q}^{\$}}_t L^{FC}_{t+1}. \quad \text{(A1)}$$

We obtain the corollary by subtracting equation (1) from equations (4) and (5). □

Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix S1: Internet Appendix.