Do Dollar-Denominated Emerging Market Corporate Bonds Insure Foreign Exchange Risk?*

Stefanos Delikouras†
Robert F. Dittmar‡
Haitao Li§

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†Department of Finance, University of Miami

‡Department of Finance, Stephen Ross School of Business, University of Michigan

§Cheung Kong Graduate School of Business

Abstract

We examine the sensitivity of dollar-denominated emerging market corporate bond prices to currency risk. Investors in international markets overwhelmingly demand that emerging market corporate issuers float debt in major currencies; over 85% of emerging market debt is denominated in developed market currencies. Investors cite insurance against foreign exchange risk as the rationale for demanding developed market currency debt. However, in doing so, these investors may overlook the influence of foreign exchange risk on the probability that emerging market corporations will default on their debt due to a currency mismatch between revenues and liability payments. We find in our sample that on average 35% of hazard rate variability can be attributed to changes in exchange rate volatility. We propose a model incorporating currency risk in spreads and find significant impacts on spread sensitivity to foreign exchange risk and material impacts on prices of default risk. Our results suggest that investors in dollar-denominated emerging market bonds are substituting currency risk for default risk.

1 Introduction

Dollar-denominated emerging market bonds are marketed to investors as a vehicle for gaining exposure to emerging fixed income markets while avoiding exposure to currency risk. For example, in an article from Reuters Money, the author suggests that dollar-denominated emerging market bonds are immune from currency exposure:

> Those interested in emerging market bonds can choose from a growing roster of mutual funds that mine this space in different ways. Some skirt currency risk by investing exclusively in U.S. dollar-denominated bonds, while others seek to profit from a weakening dollar through bonds denominated in local currencies.[1]

A similar sentiment is echoed in this research memorandum from Morgan Stanley Smith Barney:

> For U.S. based investors, the key difference is foreign currency risk where local currency debt (if unhedged) exposes investors to currency fluctuations.[2]

Taking these quotes at face value, an investor would draw the conclusion that an investment in dollar-denominated emerging market bonds was free of currency risk.

In this paper we ask whether this conclusion is warranted by examining whether the yield spreads of bonds issued by emerging market corporations denominated in U.S. dollars exhibit sensitivity to risks in currency exchange rates. Our question is motivated by a large literature on development and finance suggesting that issuing dollar debt exposes emerging market firms to increased risk of financial distress. Dollarization potentially generates distress when the local currency is devalued, increasing the local currency value of the dollar debt and the debt burden of the issuer.[3] Krugman (1999) suggests that these balance sheet effects can be exacerbated by a reduction in domestic currency revenue and increase in interest rates during a currency crisis. These ideas are summarized in Caballero and Krishnamurthy (2003),

> Although observers still debate the causes underlying recent emerging markets' crises, one factor they agree on is that domestic firms' contracting of external debt in dollars as opposed to domestic currency creates balance sheet mismatches that lead to bankruptcies and dislocations.

[1] "Investors warm up to emerging market bonds," *Reuters Money Online*, July 14, 2011

[2] 'Emerging Markets Debt: An Evolving Opportunity Set," by Steve Lee, CFA, Morgan Stanley Smith Barney Consulting Group Investment Advisor Research.

[3] A related idea is the increased default risk caused by deflation for nominally-denominated corporate bonds. Fisher (1933) suggests that deflation led to defaults and thus prolonged the Great Depression. In more recent work, Kang and Pflueger (2011) explore the extent to which fears about deflation are reflected in corporate bond prices.

That is, dollar debt can contribute to the default risk of emerging market firms. If currency risk generates default risk, which impacts dollar-denominated bond yields, it is difficult to argue that these bonds are immune from currency risk.

We examine a set of dollar bonds issued by large firms in five emerging markets: Brazil, Chile, Mexico, Russia, and South Korea. Most of the firms issuing these bonds hedge currency risk, and many have operational hedges, such as sales in U.S. dollars, that should ameliorate the effects of issuing debt in U.S. dollars. Nonetheless, nearly two-thirds of the bonds in our sample have yield spreads that are significantly and positively exposed to innovations in the local currency per dollar exchange rate and over one-third have yield spreads significantly exposed to innovations in the volatility of exchange rates. These effects are broadly distributed across bonds from all countries in the sample, excepting Russia in which no bonds have positive and statistically significant coefficients. Our initial conclusion from these results is that despite dollarization, these bonds are exposed to risks in innovations in both the level and volatility of exchange rates.

While our initial results suggest that investors in dollar-denominated corporate bonds are exposed to currency risk, currency risk is related to, and potentially difficult to disentangle from sovereign default risk. Carr and Wu (2007) document sensitivity of Brazilian and Mexican sovereign CDS spreads to the implied volatility of currency options, similar to our finding that innovations in exchange rate volatility impact corporate yield spreads. Longstaff, Pan, Pedersen, and Singleton (2011) find that the sovereign CDS spreads of Brazil, Chile, South Korea, and Mexico are positively affected by exchange rate innovations. We re-examine the exposure of dollar-denominated bonds to currency risk controlling for sovereign risk in the form of sovereign CDS spreads, as well other covariates examined in Longstaff, Pan, Pedersen, and Singleton (2011). We find that while most of the explanatory power of exchange rate innovations is absorbed by sovereign CDS and other covariates, the significance of innovations in exchange rate volatility is not impacted. Thus, controlling for a number of other potential sources of common risk, we find that a significant fraction of dollar-denominated corporate bonds in emerging markets remain exposed to exchange rate risk through exposure to exchange rate volatility.

The regression evidence suggests that a significant fraction of variation in dollar-denominated corporate bond yield spreads in emerging markets is accounted for by aggregate sources of risk. Put differently, a significant amount of the default intensity implied by a reduced-form model of risky bond yields can be traced to systematic, rather than firm-specific sources of risk. We model corporate bonds with a reduced-form framework in which spreads exhibit sensitivity to default-free term structure factors, sovereign spreads, and exchange rate volatility. We compare this model to a setting in which spreads are sensitive only to term structure factors, as in Duffie and Singleton (1999).

Our work complements the literature on excessive dollar borrowing by emerging market corporations, which focuses on the reasons that emerging market corporations borrow in dollars. The phenomenon that this literature seeks to explain is the fact that these corporations borrow more in dollars than would otherwise seem optimal relative to the risk that dollar debt can exacerbate a currency crisis. For example, Caballero and Krishnamurthy (2003) and Korinek (2011) examine the equilibrium composition of a company's domestic and foreign currency debt given the fact that investors demand dollar-denominated debt. That is, these authors take demand for dollar-denominated debt as given and derive optimal supply of this debt. Our investigation differs from this literature in that it takes the supply of debt as given, and asks empirically whether investors price foreign exchange risks that may be generated by the default risk externality modeled in these papers. Our results suggest that investors do, and that taking these risks into account improves upon pricing of dollar-denominated emerging market corporate bonds.

The remainder of this paper is organized as follows. In Section 2, we discuss the data used in the paper and empirically examine the sensitivity of dollar-denominated emerging market bonds to risks in currency exchange rates. We derive a reduced-form model of dollar-denominated corporate bond pricing and estimate model parameters in Section 3. Concluding remarks and some directions for future research are discussed in Section 4.

2 Foreign Exchange Sensitivity of Bond Yields

2.1 Data

We obtain data for yields on emerging market corporate bonds from Datastream. Our starting sample includes all bond issues denominated in U.S. dollars by corporations domiciled in the set of MSCI emerging markets over the period January, 2000 through September, 2010. We eliminate all bonds that are not standard semiannual fixed coupon debentures, since these bonds have contractual features that are not captured well in standard models of bond pricing as in Merton (1974) or Duffie and Singleton (1999). Since we are interested in the impact of exchange rate on the pricing of corporate obligations, we eliminate the obligations of quasi-sovereign agencies, including subsidiaries of sovereign wealth funds, airport and port authorities, and toll roads. Finally, we delete obligations of companies in countries where exchange rates are pegged or quasi-pegged to the dollar, as there is little variation in exchange rates to generate the effects discussed above. Given the previous screens, this means eliminating obligations from companies domiciled in Hong Kong.

Liquidity is a significant issue in corporate bond markets, and liquidity problems are even more salient in bond issues by emerging market firms. Many of the bonds in our sample trade infrequently and we have price, but not volume or trade information. We use the liquidity measure proposed in Lesmond, Ogden, and Trzcinka (1999), the fraction of non-zero price change days, to screen bonds for liquidity. In order to balance between liquidity and the number of bonds in the sample, we somewhat arbitrarily choose bonds with at least 75% of days with non-zero price changes. Observations with prices that imply negative yields are also eliminated. Our data screening process results in a sample of 61 obligations from 22 companies in five countries; Brazil, Chile, Mexico, the Russian Federation, and South Korea.

Because of the nature of our selection criteria, our sample is not truly random, and selection biases are a very real possibility. The firms in our sample are all large, multinational corporations, coming from a set of five countries, who are able to issue bonds that trade on international markets. In principle, we would like to measure the sensitivity of all dollar obligations from all emerging markets to exchange rate risk. Unfortunately, we are unable to observe market prices of non-publicly-traded debt, which constitutes much of the dollar obligations of emerging market firms. We are instead relying on market price reactions in publicly traded debentures to innovations in exchange rate risk. Although this limitation means that we examine price sensitivity of only a fraction of emerging market debt to foreign exchange risk, our screens are meant to ensure that we capture the population of Datastream-covered public bonds for which econometric inference is reliable. We acknowledge, however, that this is a necessary limitation of this study.

Descriptive information for these issues is presented in Table 1. There are 11 bonds issued by six companies in Brazil, 11 bonds issued by four companies in Chile, 11 bonds issued by three companies in Mexico, 10 bonds issued by four companies in Russia, and 18 bonds issued by five companies in South Korea. Thus, in terms of number of companies and number of bonds, each of the five countries is relatively well represented, with a slight skew in number of issues toward South Korea. Median coupon rates are relatively high in Brazil and Russia, and lower in Mexico and South Korea. The maximum coupon in our sample is a 10.50% coupon for a Brazilian issue, and the lowest is 4.25% for a South Korean issue. In all countries except Chile, the minimum initial maturity is five years; in Chile the minimum initial maturity is 9.5 years. Median and maximum initial maturities are also similar across countries except for Russia, where the median and maximum life at issue are substantially shorter, at 6 and 10 years, respectively. The first bond issued in our sample was issued in December, 2000, and our sample extends through September, 2010.

In Figure 1, we depict the time series of yield spreads averaged within each country across bonds in our sample. Spreads are calculated relative to the constant maturity yield on a Treasury security with maturity closest to the maturity of the bond in question, obtained from the FRED database at the Federal Reserve. To facilitate comparison, we plot the averaged spreads on a common time and spread scale. The exception to our spread scaling is the Russian Federation, where average bond yields approach 30% during the global financial crisis, which is approximately twice as large as the next maximum average yield spread observed over our sample period. As shown in the plots, spreads exhibit a pronounced and sustained increase associated with the global financial crisis of 2007-2009. This increase is less pronounced in Chile and Mexico, with spreads increasing to approximately 6% during the height of the crisis in these countries, similar to the spread on Moody's Baa bonds in excess of 10-year Treasury constant maturity bonds during this time period.[4] The spreads of bonds in the remaining countries suggest a greater sensitivity of these bond prices to the global financial crisis than those of speculative grade issues. Brazilian corporate spreads exhibit approximately twice as large of an increase, and Russian spreads four times as large of an increase, as U.S. speculative grade issues.

2.2 Emerging Market Corporate Bond Spreads and Exchange Rate Risk

We speculate that foreign exchange dynamics may affect the magnitude of dollar-denominated corporate bond spreads in two ways. First, as alluded to in the introduction, unhedged level variation in exchange rates may affect default risk and, hence, dollar-denominated corporate bond spreads. Specifically, a depreciation in local currency results in an increase in dollar-denominated debt service from the perspective of a firm with local currency revenues. Moreover, since depreciations tend to occur in states of the world in which local currency revenues are depressed, a depreciation may have an accelerated impact on default risk. The second mechanism is volatility of foreign exchange rates. An increase in exchange rate volatility implies increased volatility in cash flows from a U.S. Dollar perspective. Since the value of a firm's assets depends on the value of its cash flows, increased volatility in dollar cash flows results in increased volatility of dollar asset value. In the context of Merton (1974), this increased asset volatility increases the probability of default and, as a consequence, the corporate bond spread.

In order to investigate the impact of these two sources of risk on corporate yield spreads, we conduct a simple regression analysis. Specifically, we estimate the parameters of the following regression,

$$\Delta S_{i,k,t} = a_i + b_{fx,i,k}\Delta FX_{k,t} + b_{v,i,k}\Delta FXV_{k,t} + \epsilon_{i,t}, \tag{1}$$

where $\Delta S_{i,k,t}$ is the first difference in the spread on bond i in country k at time t, the difference in the yield on bond i and a comparable Treasury, $\Delta FX_{k,t}$ is the change in the log level of exchange rate between the home currency of the issuer of bond and the U.S. Dollar, and ΔFXV_{ikt} is the change in the volatility of the first difference in the log exchange rate between the home currency of the issuer of bond and the U.S. Dollar. The comparable Treasury security yield used in computing

[4] Based on data obtained from the FRED database at the Federal Reserve.

the spread on bond i is the constant maturity Treasury yield on a Treasury security with time to maturity closest to that of bond i. Treasury yields for 1-, 2-, 3-, 5-, 7-, 10-, 20-, and 30-year maturities are obtained from the FRED database at the Federal reserve. The regression is estimated at the monthly frequency; we sample the data at the daily frequency but use the last observation of the calendar month to calculate first differences.

Regression (1) is not meant as a causal statement of the effects of innovation of exchange rates on innovations in spreads. That is, we cannot say that, for instance, a positive coefficient $b_{fx,i,k}$ means that a positive innovation in exchange rates *causes* an increase in spreads, due to, for example, an increase in default risk. Rather, we are merely attempting to establish a sensitivity through correlation that suggests that a shock to exchange rates or their volatility is accompanied by a shock to the spread on the dollar-denominated debt. The point of this exercise is rather to address the prevailing wisdom discussed in the introduction, that prices of dollar-denominated bonds are immune from exchange rate risk.

Data on exchange rates are taken from Datastream. We sample exchange rates in terms of foreign currency per U.S. Dollar at the daily frequency over the period January 3, 1994 through September 28, 2010. We use these data to construct the time series of foreign exchange volatility, $v_{k,t}$, by filtering from an MA(1)-EGARCH(1,1) model. While the state of the art in modeling realized volatility is arguably using intraday data to measure the volatility, we do not have access to intraday data. Andersen and Bollerslev (1998) and Baillie and Bollerslev (1989) argue that the simple MA(1)-GARCH(1,1) model adequately captures foreign exchange dynamics. Since the principal contribution of our work is not in modeling foreign exchange volatility, we adopt their advice, but use an EGARCH(1,1) specification for volatility as this specification appears to yield more stable parameter estimates. Results of this estimation are not reported for brevity, but are available from the authors upon request.

We depict the volatility of foreign exchange innovations in Figure 2. As shown in the Figure, currencies of each country depict episodes of high volatility, followed by low volatility, with a high degree of persistence. Common to the volatility plots of all countries are a sharp spike associated with the bankruptcy of Lehman Brothers in 2008, with continued pronounced volatility through the rest of the sample. In most countries, there are no other uniquely pronounced spikes in volatility; the exception is in Brazil. Volatility of the Brazilian Real experienced a spike similar to that during the global financial crisis in August, 2002, leading up to the country's presidential election and the aftermath of the Argentine default.

Since currency is expressed in terms of local currency per U.S. dollar, we hypothesize that $b_{fx,i,k} > 0$; that is, when the home currency depreciates relative to the dollar, debt service will become more expensive, and bond spreads will rise. Similarly, we hypothesize that $b_{v,i,k} > 0$;

when foreign exchange innovations are more volatile, cash flows, default risk, and thus spreads, will increase.

Results of the estimation of equation (1) are presented in Table 2. We present medians of parameter estimates, heteroskedasticity-adjusted t-statistics, and adjusted R^2, where medians are calculated over all bonds and bonds within each of the five countries in our sample. In addition to the median statistics, we present the fraction of point estimates for which the null hypotheses $b_{fx,i,k} > 0$ and $b_{v,i,k} > 0$ hold at the 10% critical level. As shown in the table, at the median for all bonds, innovations in both foreign exchange levels and volatility have positive effects on innovations in yield spreads. The median point estimate for innovations in the level of exchange rates, $b_{fx,i,k}$ is statistically significantly greater than zero at the 10% critical level based on a one-sided test; the median point estimate of $b_{v,i,k}$ is positive but not statistically significantly greater than zero. However, these median estimates belie a substantial amount of variation across bonds. Of the 61 bonds in our sample, 39 (64%) exhibit statistically significantly positive exposures to foreign exchange innovations, and 23 (38%) exhibit statistically significantly positive exposures to volatility innovations. Moreover, at the median, 26% of time series variation in yield spread innovations can be traced to innovations in foreign exchange level and volatility innovations.

In addition to the substantial variation across bonds in the sample, the table suggests considerable variation across countries in the relation between spread innovations and foreign exchange risks. At one extreme, none of the Russian Federation companies' bonds exhibit significantly positive exposure to foreign exchange risks, either from level innovations or volatility innovations. In contrast, all of the Brazilian bonds in our sample have positive and significant exposure to innovations in exchange rates and 7 of 11 have positive and significant exposure to innovations in exchange rate volatility. Results for Korean firms are similar; 12 of 18 bonds have positive and significant exposures to innovations in foreign exchange rates and 13 of 18 bonds have positive and significant exposures to innovations in volatility. In both countries, over 40% of the variation in changes in monthly spreads for the median bond can be attributed to variation in foreign exchange risk innovations. Finally, in Mexico, 9 of 11 bonds are positively and significantly exposed to innovations in exchange rates, but no bonds are positively and significantly exposed to innovations in exchange rate volatility.

We suggest that these results indicate that the assumption that dollar-denominated bonds are free from exchange rate risks is potentially mistaken. Even though these bonds' cash flows are hedged from the investors' perspective in the sense of being payable in U.S. dollars, many of the bonds' prices respond to innovations in exchange rates and/or exchange rate volatility. While not every bond is exposed to these risks, the results suggest that a sufficiently significant fraction are exposed to challenge the conventional wisdom in the opening paragraph that an investor seeking exposure to emerging markets while avoiding exchange rate risk can do so by purchasing dollar-denominated bonds.

While the evidence presented in this section supports the idea that dollar-denominated bonds are exposed to exchange rate risks, it does not address the question of *why* these bonds are exposed. One possibility is the explanation advocated by Krugman (1999), that dollarization generates distress risk, leading to increased default intensity for emerging market firms. Alternatively, the sensitivity of yield spreads to exchange rate risks may reflect exposure to systematic risks that are correlated with exchange rate risks. In the next section, we examine additional variables that may contribute to variation in emerging market corporate bond yield spreads and assess the degree to which exchange rate and exchange rate volatility innovations remain a driver of emerging bond risks.

2.3 Systematic Determinants of Dollar-Denominated Yield Spreads

The results presented in the previous section suggest that dollar-denominated bond yield spreads are influenced by fluctuations in the level and volatility of local currencies. However, it is unclear whether this influence is directly due to exchange rate movements or due to an indirect effect of other aggregate covariates. Carr and Wu (2007) demonstrate that Brazilian and Mexican sovereign CDS spreads are correlated with the implied volatility of currency options. Longstaff, Pan, Pedersen, and Singleton (2011) find positive exposures of Brazilian, Chilean, Mexican, and Korean sovereign CDS spreads to innovations in exchange rates. This evidence suggests that innovations in exchange rate levels and volatility are correlated with sovereign default risk. In this section, we ask whether it is this sovereign risk alone that is driving variation in dollar-denominated corporate bond yield spreads, or whether exchange rate risk has an additional impact on the pricing of these bonds.

In addition to sovereign default risk, the theoretical and empirical literature suggest that a number of covariates in addition to sovereign risk may impact yield spreads of the corporate bonds in our sample. Structural models of default risk, such as Merton (1974), suggest that the default free term structure affects the probability of default, and thus the yield spread on corporate bonds. Similarly, reduced form models such as Duffie and Singleton (1999) incorporate sensitivity to default-free term structure factors in the expression for the yield spread. Confirming evidence of these effects is shown in Duffee (1999) and Collin-Dufresne, Goldstein, and Martin (2001). In addition to term structure effects, the latter authors show that a number of equity market variables have significant influence on corporate bond yield spreads. Since the bonds in our sample are corporate debentures subject to default risk, it is likely that variables impacting yield spreads on corporate bonds in the U.S., or their counterparts in the firms' home countries, will also impact yield spreads on corporate bonds in emerging markets.

We utilize a set of covariates examined in Longstaff, Pan, Pedersen, and Singleton (2011) as a guide to the regression analysis of this section. These covariates overlap substantially with those examined in Collin-Dufresne, Goldstein, and Martin (2001) in their study of corporate bond yield spreads. In our analysis, we regress first differences in yield spreads on the following variables, grouped by category of covariation that the variables are meant to capture:

Local Variables

Longstaff, Pan, Pedersen, and Singleton (2011) note that among the many variables that may determine the credit spread of a sovereign entity, perhaps the most important is the state of the local economy. We speculate that this observation holds for corporate issuers as well, and that the effects may be above and beyond those of the impact on sovereign debt. With these considerations in mind, we control for the following variables:

- Return on the local stock market ($R_{m,local,t}$), measured as the return on the local country stock market index obtained from Datastream. The return on the local stock market index captures the overall health of the corporate sector of the country's economy.
- Sovereign CDS spread (ΔCDS_t), the first difference in the 5-year CDS spread on sovereign bonds issued by the country in which the corporate issue is headquartered. Data are obtained from Bloomberg. This measure captures the fiscal health of the country in which the company resides. Further, controlling for this variable allows us to isolate impacts of foreign exchange variables above and beyond the impacts of these variables on sovereign yields.
- Percentage changes in the country's holdings of foreign reserves (ΔRES_t). We obtain data on foreign reserve holdings from the International Monetary Fund.
- Percentage change in local currency per dollar exchange rates (ΔFX_t). Longstaff, Pan, Pedersen, and Singleton (2011) include the percentage change in the exchange rates as a measure of local economic health. In our analysis, we are interested in whether dollarization of debt insulates investors from variation in local economic health that is specific to exchange rates.
- Change in volatility of foreign exchange (ΔFXV_t). As before, this variable is intended to capture an additional source of risk in foreign exchange that may increase the volatility of cash flows from the perspective of a U.S. dollar investor.

Global Variables

Globalization and liberalization of financial markets suggest that global factors influence the prices and returns on emerging market securities in addition to local factors. As in Longstaff, Pan, Pedersen, and Singleton (2011), we include measures from the U.S. equity and fixed income markets to capture global indicators of the state of the economy.

- Return on the U.S. equity market ($R_{m,US,t}$), the return on the CRSP value-weighted index. This variable is intended to capture the state of the economy for the global corporate sector.

- First difference of the yield on 10-year constant maturity Treasury Notes ($\Delta Y_{10,5}$). The level of the term structure has important influences on the yield on default-sensitive bonds, as documented in Longstaff and Schwartz (1995) and Duffee (1999). Additionally, the variable captures the state of the global risk-free sovereign market. Data are obtained from the Federal Reserve report H.15.

- First difference of the term spread on U.S. Treasuries (ΔTS_t). Litterman and Scheinkmann (1991) document the presence of three latent variables in the term structure of interest rates. Of these variables, two, linked to the level and the slope of the term structure, dominate variation in Treasury yields. Again following Collin-Dufresne, Goldstein, and Martin (2001), we include a measure of the first difference in the term spread, measured as the difference in yields on 10-year and 2-year constant maturity Treasury bonds from the Federal Reserve report H.15.

- The first difference in the spread between Moody's Baa-rated and Moody's Aaa-rated bonds (ΔDS_t. This variable is frequently referred to as the "default spread," and captures the premium required in the U.S. market for borderline investment-grade bonds over the most creditworthy corporate issues.

Global Risk Premia

As discussed above, at least some of the variation in foreign exchange rates, and foreign exchange volatility in particular, can be linked to measures of aggregate risk premia. Further, variation in credit spreads may be due to changes in the premium required for holding risky assets rather than variation in default probability *per se*. Following Longstaff, Pan, Pedersen, and Singleton (2011), we include several variables meant to capture these risk premia.

- Change in U.S. market price-earnings ratio (ΔPE_t). Longstaff, Pan, Pedersen, and Singleton (2011) suggest using the earnings-to-price ratio on a U.S. index as a coarse measure of the aggregate risk premium. We utilize the price-to-earnings ratio on the S&P 500 as a measure of the risk premium with data obtained from Robert Shiller's website.[5]

- Variance Risk Premium (ΔVRP_t). The variance risk premium, calculated as the difference in the implied and realized volatility on the S&P 100 index, is a measure of the premium required for bearing volatility risk. The realized volatility is calculated using the open-high-low-close estimator of Garman and Klass (1980) using a 20-day rolling window of prices on

[5]Data are obtained from `http://http://www.econ.yale.edu/~shiller/`.

the S&P 100 index. Both the implied volatility series and the relevant prices are obtained from Yahoo! Finance. The premium is included in first differences in the estimation.

Empirical Results

Results of regressions of changes in yield spreads on percentage change in the foreign exchange rate and the volatility of foreign exchange, controlling for covariates discussed above, are presented in Table 3. As in our simple regressions, the table presents the median point estimate, median t-statistic, and median adjusted R^2 for the set of all bonds, as well as bonds segregated by country. The t-statistics are computed using Newey-West standard errors. Below each t-statistic, we present the fraction of coefficients that are statistically different from zero at the 10% critical level. In the case of innovations in the exchange rate and the volatility of the exchange rate, the critical values are for one-sided tests of the hypothesis that the coefficient is greater than zero. In the case of the remaining variables, critical values are based on two-sided tests of the hypothesis that the coefficient is different than zero.

The results reported in the table suggest that the importance of innovations in foreign exchange volatility in explaining variation in innovations in yield spreads is virtually unaffected by including additional covariates. Across all countries, the median point estimate is similar ($b_v = 0.818$) to earlier results without covariates ($b_v = 0.762$), and the proportion of these coefficients that are statistically greater than zero, 0.371, indicates that there is a net loss of only a single bond with statistically positively significant exposure to foreign exchange volatility. The number and fraction of bonds with statistically significant exposures across countries also exhibits little impact from the inclusion of covariates. An additional bond each in Brazil and Mexico exhibit positive and significant exposure, and two bonds in Chile no longer have statistically significantly positive exposures. As before, no bonds in Russia and 13 bonds in Korea exhibit coefficients that are statistically significantly greater than zero. These results suggest that the impact of foreign exchange volatility on yield spreads of dollar-denominated bonds is largely independent of other local factors, global factors, and global risk premia.

A second noteworthy result from the table is that while volatility risk exposure appears to be largely independent from local factors, global factors, and global risk premia, exchange rate level risk exposure is not. When covariates are not accounted for, approximately 64%, or 39 bonds, exhibited exposures of yield spread innovations to exchange rate innovations that were statistically greater than zero. When covariates are included, this percentage drops to 18%, or 11 bonds. The median point estimate in the earlier results is positive ($b_{fx} = 5.796$), but is negative when covariates are included ($b_{fx} = -0.470$). When covariates are omitted, foreign exchange level exposures were statistically positive in over 60% of the bonds within each country, except Russia, in our sample. Proportions fall from 100% to 0% in Brazil, 82% to 9% in Mexico, and 67% to 17% in Korea. Only

Chile retains the same fraction of bonds with statistically positive exposures to foreign exchange level innovations, with 64% or 7 of 11 bonds exhibiting statistically positive coefficients.

The factor that is likely dominant in absorbing this statistical significance is sovereign risk, captured in the innovation in the sovereign CDS spread. Across all countries, 61% of bonds exhibit coefficients that are statistically different than zero, with a positive median point estimate of 0.669. Not surprisingly, an increase in sovereign risk has a positive impact on the spreads of emerging market corporate bonds. In Russia, 100% of the bonds have statistically significant exposures to innovations in the Russian CDS spread, and few of the other variables, with the exception of the variance risk premium, have a large number of bonds with statistically significant exposures. Sovereign risk exposure appears less important in Mexico, with only 18% of bonds having statistically significant exposures, and Chile, where 46% of bonds exhibit statistically significant exposure to sovereign risk.

The remaining covariates also have some marginal influence on explaining innovations in yield spreads on dollar-denominated emerging market corporate bonds. Approximately one-third of the bonds in our sample have statistically significant exposures to the variance risk premium and the 10-year Treasury yield. Exposure to the risk-free term structure is, as discussed above, empirically documented and theoretically motivated in the finance literature. Longstaff, Pan, Pedersen, and Singleton (2011) also document a strong empirical relation between sovereign CDS spreads and global risk premium variables, in particular the variance risk premium. As in their study, the median sign of the risk premium exposure is negative. Equity market returns exhibit median negative influences on innovations in yield spreads, with approximately one-quarter of bonds exhibiting exposure to local and U.S. stock market returns. The remaining variables, change in the price-earnings ratio, default spread, and reserves, are less frequently statistically significant, suggesting that other covariates absorb most of these variables' explanatory power.

In untabulated results, we analyze regressions that include only the U.S. term structure variables, the sovereign CDS spread, the innovation in the exchange rate, and the innovation in the foreign exchange level. Longstaff, Pan, Pedersen, and Singleton (2011) conclude that the majority of sovereign CDS innovations relate to global, rather than local, factors. In these regressions we are essentially assuming that the sovereign CDS spread is a sufficient statistic for these factors. We also include the U.S. term structure factors, however, since models of bond yield spreads depend on the risk-free term structure. We find that median point estimates, fraction of firms with statistically significant exposures to the variables in the regression, and magnitudes of point estimates are materially unchanged. We use this evidence to proceed in modeling dollar-denominated emerging market corporate bond yields as functions of the risk-free term structure, sovereign CDS spreads, foreign exchange volatility, and firm-specific default intensity in the next section.

Robustness to the Global Financial Crisis

During the global financial crisis of 2007-2009, spreads on corporate bonds widened dramatically relative to pre-crisis levels. The financial crisis is clearly visible in Figure 1 as a period during which these spreads were persistently, albeit temporarily high. As shown in Figure 2, the financial crisis also corresponds to a period during which exchange rate volatility experiences a large increase. One potential concern is that our results suggesting that dollar-denominated bonds are exposed to foreign exchange volatility risk is an artifact of the crisis. To address this concern, we repeat the preceding analysis, regressing innovations in yield spreads on the set of local, global, and risk premium-related factors plus the innovations in the level and volatility of the exchange rate, restricting attention only to periods other than the global financial crisis. We define the crisis as beginning in August, 2007 with the suspension of fund redemptions by BNP Paribas, and ending in June, 2009 with NBER's dating of the end of recession in the United States.

Results of these regressions are presented in Table 4. As shown in the first row of the table, in the period outside of the crisis, the sensitivity of yield spreads to innovations in exchange rate volatility is materially lower at the median, falling from 0.818 to 0.265. However, a similar fraction of bonds remains significant, with 27.9% or 17 bonds continuing to exhibit coefficients that are statistically significantly greater than zero. The proportion of significant coefficients is more evenly distributed across countries in contrast to earlier results. Most surprisingly, 8 of the 10 bonds in Russia exhibit positively significant coefficients in the non-crisis period, whereas no Russian bonds had bonds with coefficients statistically significantly greater than zero in the full sample. Further, whereas all bonds were statistically significantly exposed to sovereign risk in Russia over the full sample, only 3 bonds have statistically significant exposure to sovereign risk in the form of CDS for the non-crisis sample.

We conclude from this analysis that the inferences we draw from the full sample seem to be representative of conditions outside of the global financial crisis, and not merely reflecting crisis dynamics. Even outside the crisis, a material number of dollar-denominated bonds in emerging markets display positive exposure to exchange rate risk embodied in foreign exchange volatility. Hence, despite dollarization, investors in these bonds are not immune to exchange rate risk. We next ask whether there are specific firm characteristics that are likely to drive these exchange rate sensitivities in the cross-section.

2.4 Cross-Sectional Determinants of Foreign Exchange Sensitivity

Our working hypothesis is that exchange rate risk affects the pricing of dollar-denominated bonds because dollarization impacts default risk. Thus far, we have established a link between the volatility of exchange rates and yield spreads on dollar-denominated bonds for a sizable portion of the bonds in our sample. This link is surprising not only because dollar denomination is intended to hedge foreign exchange risk, but also because it is likely that many of the firms in our sample will have financial or operational hedges against foreign exchange risk. These hedges may be the reason that there are relatively few bonds in our sample with significant exposures to innovations in exchange rates. However, linear hedges may insulate these companies' cash flows less effectively against innovations in the volatility of exchange rates.

A large literature has examined the sensitivity of firms' equity returns to foreign exchange risks, although many empirical studies document weak to no relation between exchange rates and equity returns.[6] Bartram, Brown, and Minton (2010) suggest that the weakness of this relation may be due to cross-sectional variation in the availability of operational and financial hedges to firms with exposure to exchange rate risk. The authors expand on the model of exchange rate exposure in Bodnar, Dumas, and Marston (2002) to construct a measure of foreign exchange exposure. In empirical tests, the authors find that the most important variables determining exchange rate exposure are foreign sales, foreign debt, and, to a lesser extent, financial derivative use. We examine the degree to which these operational and financial hedges influence the sensitivity of bonds' yield spreads to innovations in foreign exchange volatility.

We collect financial statement data for the firms in our sample from three different sources. If available, we utilize 20-F filings on the EDGAR database at the SEC, and search the notes to the financial statements for the information needed to construct our variables. If we are unable to find the filings on EDGAR, we collect financial statements from the company's investor relations website. Finally, for two of the stocks in our sample, AK Transneft and Evraz Group, we were unable to locate financial statements on the company websites. For these firms we utilized financial statements found on the website `http://www.rustocks.com`. From these sources, we construct the following variables in the spirit of Bartram, Brown, and Minton (2010):

1. *Percent of sales in U.S. Dollars.* This variable, $sales_j$, is the fraction of total revenues denominated in U.S. dollars. When U.S. Dollar sales were not explicitly stated, we assumed that North American sales were U.S. dollar sales. For companies producing commodities that are sold in U.S. dollars, we assumed that 100% of sales were in U.S. dollars. Finally, if neither U.S. nor North American sales numbers were available, we utilized all non-domestic sales. We expect that, all other considerations constant, firms with more U.S. dollar sales will be less vulnerable to foreign exchange risks, as these firms' dollar revenues will offset risks induced by lower cash flows due to exchange rate fluctuations.

2. *Percent of U.S. dollar bond debt.* The percent of U.S. dollar debt, $debt_j$ reflects the importance

[6] An inexhaustive list of these studies include Jorion (1990), Amihud (1993), Bodnar and Gentry (1993), Bartov and Bodnar (1994), Bartov, Bodnar, and Kaul (1996), Choi and Prasad (1995), He and Ng (1998), Chow, Lee, and Solt (1997), Griffin and Stulz (2001), and Dominguez and Tesar (2006).

of these bonds in the overall debt structure of the firm. The variable is calculated as the reported local currency value of U.S. dollar corporate debentures to total local currency debt. If the firm's balance sheet is reported in U.S. dollars, the U.S. dollar corporate debentures are the face value of the U.S. dollar debt. We expect that for firms for which the U.S. dollar bonds are a more important fraction of their overall capital structure, that sensitivities to foreign exchange risk will be higher.

3. *Foreign currency derivative usage.* The variable $deriv_j$ takes the value 1 if the company reports the use of forwards or swaps to manage foreign currency risk exposure. Since this management will reduce the exposure of cash flows to currency risks, we expect a negative coefficient.

We collect these data over fiscal years ending in calendar years 2006-2009.

Means of these variables are presented in Panel A of Table 5. As shown in the table, most of the firms in our sample avail themselves of currency hedges. All Mexican and South Korean firms indicate use of financial hedges, 83% of Brazilian, and 75% of Chilean firms also hedge using financial instruments. None of the Russian firms in our sample hedge. There is considerable variation across countries in the proportion of U.S. or U.S. dollar sales. Three of the four Chilean firms in our sample are mining concerns and report sales entirely in U.S. dollars. At the other end of the spectrum are Mexican and South Korean firms, who report only 6% and 7% U.S. sales, respectively. Finally, the table indicates that the bonds in our sample represent a fairly sizable fraction of these companies' long-term debt. For Mexican firms, the bonds are, on average, nearly half of the long term debt obligations of the firm. The lowest average fraction is in South Korea, where the bonds constitute 17% of long term debt on average.

To analyze the relation between these measures in the cross-section and sensitivity to exchange rate volatility, we regress point estimates from the previous section on the hedging dummy, the percentage of U.S. sales, and the percentage of debt denominated in U.S. dollars. We also control for bond maturity and coupon to try to capture bond-specific effects that may influence exchange rate volatility sensitivity. Results are reported on the basis of pooled regressions; including time fixed effects yielded little change on the interpretation or significance of the coefficients.

Results of these regressions are presented in Panel B of Table 5. As shown in the table, all three variables of interest, the hedging dummy, the percentage of U.S. sales, and the proportion of dollar debt are all statistically distinguishable from zero at the 10% critical value. The coefficient on the proportion of debt is positive and significantly different than zero at the 1% level, suggesting that when the firm has a greater fraction of its debt in U.S. dollars, the yield spread is more sensitive to innovations in foreign exchange volatility. This result is consistent with the idea that firms with more dollar borrowing have bond yield spreads (and potentially default risk) that are more sensitive to foreign exchange risk. The proportion of U.S. sales is negative and statistically different than zero at the 10% level, consistent with U.S. sales acting as a cash flow hedge to the risks involved in issuing dollar debt. One puzzling result is the fact that hedging is positively associated with exchange rate volatility exposure. One possible reason for this result may be the fact that there is relatively little variation in this variable, and there are no Russian firms that indicate hedging or have bonds with statistically significant positive exposures to foreign exchange rate volatility.

The results in this section do not definitively point to increased default risk as the reason that firms' bond prices are exposed to risks in the volatility of exchange rates. However, the evidence is suggestive of the idea that the degree to which firms are exposed is linked to operational hedges which, in turn, may contribute to reduced default risk. Smith and Stulz (1985) develop a model in which firms have incentive to hedge as it reduces variation in their cash flows, reducing costs of financial distress. Exchange rate volatility may induce volatility in cash flows that is difficult to hedge; our evidence is consistent with this conclusion. Firms with more exposure to exchange rate risk through lower dollar borrowing and U.S. sales have bond prices that are more sensitive to movements in exchange rate volatility.

3 Pricing Dollar-Denominated Corporate Bonds

The evidence in the preceding section suggests that spreads on dollar-denominated corporate bonds are sensitive to innovations in sovereign CDS spreads and exchange rate volatility. In this section, we present and estimate parameters of a formal model of bond prices in the spirit of reduced-form risky bond models of Duffie and Singleton (1997, 1999).

3.1 Modeling Bond Prices

We assume that the price of a zero-coupon bond with default risk is given by

$$P_i\left(t,T\right) = E_t^Q\left[e^{-\int_t^T R_{i,s} ds}\right], \tag{2}$$

with $R_{i,s}$ representing the instantaneous default-adjusted discount rate,

$$R_{i,t} = r_t + \left(1-\delta_i\right)\lambda_{i,t}. \tag{3}$$

In this expression, r_t is the instantaneously risk free spot rate, and $\left(1-\delta_i\right)\lambda_{i,t}$ is the spread over the risk-free rate on bond i in country k at time t. The parameter δ_i is the rate of recovery on the bond, which is assumed constant.

The risk free term structure is determined by two-factors as in Duffee (1999). Risk-free bond prices are exponentially affine in the two factors as in Duffie and Kan (1996). In this class of models, the risk free rate can be expressed as an affine function of the two state variables,

$$r_t = a_f + x_{1,t} + x_{2,t}, \tag{4}$$

where we assume that the state variables $x_{1,t}$ and $x_{2,t}$ follow square root dynamic processes under the risk-neutral probability measure Q as in Cox, Ingersoll, and Ross (1985),

$$dx_{1,t} = (\kappa_1\theta_1 - (\kappa_1 + \eta_1)\, x_{1,t})\, dt + \sigma_1\sqrt{x_{1,t}} dw_{1,t}^Q \tag{5}$$

$$dx_{2,t} = (\kappa_2\theta_2 - (\kappa_2 + \eta_2)\, x_{2,t})\, dt + \sigma_2\sqrt{x_{2,t}} dw_{2,t}^Q. \tag{6}$$

The parameters η_1 and η_2 represent prices of risk and $dw_{1,t}^Q$ and $dw_{2,t}^Q$ are independent Brownian motions under the risk neutral probability measure Q.

The credit spread for bond i in country k, $(1-\delta_i)\lambda_{i,t}$, is modeled using a variant of the special case of Duffie and Singleton (1999) employed in Duffee (1999). The spread is assumed to be a function of the risk-free term structure state variables and a default risk latent variable $(h_{i,t})$,

$$(1-\delta_i)\,\lambda_{i,t} = a_i + \boldsymbol{\beta}_{i,x}' (\mathbf{x}_t - \bar{\mathbf{x}}) + h_{i,t}. \tag{7}$$

The parameter vector $\boldsymbol{\beta}_i$ allows for correlation between the default-free term structure and the spread on the bond above the risk free rate; as referenced above, Longstaff and Schwartz (1995) argue that structural models in the line of Merton (1974) result in a negative relation between the credit spread and the risk-free rate.

The default risk factor, $h_{i,t}$, is referred to as the hazard rate and follows a stochastic process under the risk-neutral probability measure Q defined as

$$dh_{i,t} = (\kappa_i\theta_i - (\kappa_i + \eta_i)\, h_{i,t})\, dt + \sigma_i\sqrt{h_{i,t}} dW_{i,t}^Q. \tag{8}$$

We assume that the Brownian motion driving the evolution of the hazard rate is independent of the Brownian motions governing the riskless rate, the exchange rate volatility, and the CDS spread.[7] Duffie and Singleton (1999) note that one can view the hazard rate as the arrival intensity of a

[7] An alternative approach is to use a three-factor model in which the correlation among the state variables is explicit. Dai and Singleton (2000) provide conditions for which affine term structure models are identified. The principal cost of doing so, as the authors note, is that the correlation structure and the stochastic volatility in the hazard rate process are constrained. In order to allow negative correlation between the hazard rate process and the risk-free term structure, one would have to model the hazard process as a Gaussian state variable. This would allow the spread to potentially take on negative values, which is undesirable in the context of a positive premium for default risk.

jump that first occurs as default. Thus, although default is a discrete event, the intensity follows a diffusion.

Given the dynamics of the risk free term structure and hazard rates, log zero-coupon bond prices are affine in the state variables and hazard rates,

$$\ln P_{i,t}(\tau) = A_i(\tau) + \mathbf{B}_{i,x}(\tau)'\mathbf{x}^*_{i,t} + B_i(\tau)h_{i,t},$$

where $x^*_{i,j,t} = (1+\beta_{i,x,j})x_{j,t}$ for $j = 1, 2$, and the coefficients $A_i(\tau)$, $\mathbf{B}_{i,x}(\tau)$, and $B_i(\tau)$ are solutions to ordinary differential equations as in Duffie and Singleton (1999) and Cox, Ingersoll, and Ross (1985). The precise form of the coefficients are provided in the Appendix. These solutions are for zero-coupon bond prices, whereas the bonds in our sample are coupon bonds. We treat these coupon bonds as a portfolio of zero coupon bonds with face value c plus a zero coupon bond with face value of 1. Mathematically, the price of the coupon bond with maturity T is given by

$$P_{i,t}(\tau, c) = E^Q_t\left[c\sum_{m=1}^{T-t} e^{-\int_t^{t+m} R_{i,s}ds} + e^{-\int_t^{T} R_{i,s}ds}\right], \tag{9}$$

where m indexes the periodic coupon payments.

Incorporating Sovereign and Foreign Exchange Risk

We augment the basic reduced form model to incorporate sensitivity foreign exchange volatility and sovereign default risk, embodied in the spread on sovereign CDS. Specifically, we assume that these two variables also follow square root dynamics under the risk neutral measure Q,

$$dv_{k,t} = \left[\kappa_{v_k}\theta_{v_k} - (\kappa_{v_k} + \eta_{v_k})\, v_{k,t}\right] dt + \sigma_{v_k}\sqrt{v_{k,t}}dW^Q_{v_k,t} \tag{10}$$

$$ds_{k,t} = \left[\kappa_{s_k}\theta_{s_k} - (\kappa_{s_k} + \eta_{s_k})\, s_{k,t}\right] dt + \sigma_{s_k}\sqrt{s_{k,t}}dW^Q_{s_k,t}. \tag{11}$$

where $v_{k,t}$ is the foreign exchange volatility in country k estimated in the EGARCH(1,1) model above and $s_{k,t}$ is the 5-year CDS spread for country k's sovereign debt.

The presence of sovereign and exchange rate risk leads to an alternative specification of the default-adjusted discount rate,

$$R_{i,t} - r_t = a_i + h_{i,t} + \boldsymbol{\beta}'_{i,x}(\mathbf{x}_t - \bar{\mathbf{x}}) + \beta_{i,v_k}v_{k,t} + \beta_{i,s_k}s_{k,t}. \tag{12}$$

The credit spread depends on foreign exchange volatility and sovereign CDS spreads in a manner similar to that of the risk-free term structure state variables. That is, β_{i,v_k} allows correlation in the credit spread and the volatility of exchange rates while β_{i,s_k} allows correlation in the credit spread and the CDS spread. However, the hazard rate, $h_{i,t}$ is assumed independent of this volatility, similar to the independence of the hazard rate and the risk-free term structure variables. Thus, in this context, hazard rates can be interpreted as the default risk independent of default risk induced by risk-free term structure, foreign exchange volatility, or CDS spreads.

Defining $v^*_{i,k,t} = \beta_{i,v_k} v_{k,t}$ and $s^*_{i,k,t} = \beta_{i,s_k} s_{k,t}$, we incorporate two additional terms in the log risky bond price,

$$\ln P_{i,t}(\tau) = A_i(\tau) + \mathbf{B}_{i,x}(\tau)'\mathbf{x}^*_{i,t} + B_i(\tau) h_{i,t} + B_{i,v_k}(\tau) v^*_{i,k,t} + B_{i,s_k}(\tau) s^*_{i,k,t}, \tag{13}$$

where expressions for for the additional coefficients are again provided in the appendix. Coupon bond prices are constructed as portfolios of zero coupon bonds as in equation (9).

3.2 Estimation Procedure

The state variables of the default-free term structure, x_1 and x_2, as well as the hazard rate h_i, are unobservable. We estimate model parameters and identify the variables using the extended Kalman filter. Our Kalman filtering process first estimates parameters of the risk-free term structure using the measurement equation

$$\mathbf{Y}_t(\boldsymbol{\tau}) = a_f \boldsymbol{\iota} - \frac{1}{\tau}\left(\mathbf{A}(\boldsymbol{\tau}) + \mathbf{B}(\boldsymbol{\tau})'\mathbf{x}_t\right) + \mathbf{u}_t \tag{14}$$

where $\mathbf{Y}_t(\tau)$ is a vector of risk-free zero coupon bond yields observed at time t with maturities $\boldsymbol{\tau}$, $\mathbf{A}(\boldsymbol{\tau})$ is a vector of coefficients as in equation (8), and $\mathbf{B}(\boldsymbol{\tau})$ is a matrix of coefficients as in equation (7). The vector of pricing errors $\mathbf{u}_t$ is assumed to by i.i.d. $\mathcal{N}(\mathbf{0}, \boldsymbol{\Sigma}_u)$, where $\boldsymbol{\Sigma}_u$ is a diagonal covariance matrix.

Transition equations for the state variables are given by:

$$\begin{pmatrix} x_{1,t} \\ x_{2,t} \end{pmatrix} = \begin{pmatrix} \theta_1(1-e^{-\kappa_1}) \\ \theta_2(1-e^{-\kappa_2}) \end{pmatrix} + \begin{pmatrix} e^{-\kappa_1} & 0 \\ 0 & e^{-\kappa_2} \end{pmatrix} \begin{pmatrix} x_{1,t-1} \\ x_{2,t-1} \end{pmatrix} + \begin{pmatrix} w_{1,t} \\ w_{2,t} \end{pmatrix}, \tag{15}$$

where

$$\mathbf{w}_t \sim \mathcal{N}\left(\mathbf{0}, \begin{pmatrix} Q_{1,t} & 0 \\ 0 & Q_{2,t} \end{pmatrix}\right) \tag{16}$$

$$Q_{k,t} = x_{k,t}\frac{\sigma_k^2}{\kappa_k}\left(e^{-\kappa_k} - e^{-2\kappa_k}\right) + \theta_k \frac{\sigma_k^2}{2\kappa_k}\left(1 - e^{-\kappa_k}\right)^2, \quad k = 1, 2. \tag{17}$$

These transition dynamics represent the conditional means and volatilities of the state variables of square root processes as shown in Cox, Ingersoll, and Ross (1985), where the innovation terms are assumed Gaussian. We use the measurement and transition errors to find parameter estimates and filter state variables by maximizing the log likelihood function of the measurement errors.

Given the estimates of the risk-free term structure parameters and the state variables, we estimate the parameters of the risky term structure and filter hazard rates. Our measurement equation is a discretized version of the risky coupon bond price equation (9), measured with error:

$$P_{i,t}(\tau, c) = c \sum_{m=1}^{\tau} P_i(m) + P_i(\tau) + u_{i,t}, \tag{18}$$

Since we take the latent risk-free variables as given from the estimation of the risk-free term structure, our transition equation applies to the hazard rate:

$$h_{i,t} = \frac{\theta_i \kappa_i}{\kappa_i + \eta_i}\left(1 - e^{-\kappa_i}\right) + e^{-\kappa_i} h_{i,t-1} + w_{i,t}, \tag{19}$$

where

$$w_{i,t} \sim \mathcal{N}(0, Q_{i,t}), \tag{20}$$

$$Q_{i,t} = h_{i,t-1}\frac{\sigma_i^2}{\kappa_i}\left(e^{-\kappa_i} - e^{-2\kappa_i}\right) + \theta_i \frac{\sigma_i^2}{2\kappa_i}\left(1 - e^{-\kappa_i}\right)^2. \tag{21}$$

As with the risk-free estimation, we estimate parameters and filter hazard rates by maximizing the log likelihood function of the measurement errors for each bond in our sample.

The standard errors of parameter estimates are constructed according to the quasi-maximum likelihood error approach. The approach uses both the Hessian of the log likelihood function and the outer product estimate for the information matrix. The conditional normality assumption for the log likelihood function is an approximation to the true data generating process which, under the assumption of a square-root process for the state variables, is a non-central χ^2 distribution. In tabulating our results, we do not report the standard errors for the point estimates of the hazard rate process; instead, we report quantiles of the estimates.

Our estimation approach mirrors Duffee (1999). As in his investigation, we estimate parameters of the risk free term structure separately from estimation for individual bonds. Doing so ensures that that common risk free term structure factors and parameters are common to all bonds. In principle, it would be desirable to jointly estimate the parameters of the risky and risk free term structures. However, the technical complications of a joint estimation over a large cross-section of assets renders joint estimation infeasible.

3.3 Model Performance

Performance without Sovereign and Currency Risk

We present medians of parameter estimates across all countries and within countries for the model without sovereign and currency risk in Table 6. The median point estimate of the mean reversion parameter, κ_i, is greater than two, suggesting strong mean reversion in default intensity, and the median long-run mean, θ_i is somewhat higher than than that reported for U.S. Baa-rated bonds in Duffee (1999). The median price of default risk, $\eta_i = -0.134$, is actually smaller in magnitude than the median estimate in Duffee (1999), but of a similar order of magnitude. There is considerable variation in this parameter across countries, with the median point estimate in Chile as the highest at 0.170 and that in Brazil as the lowest at -0.417. The median point estimate of the price of risk is also positive in Russia, and approximately one-third (22) of the bonds in the sample have positive prices of default risk. This positive estimate is puzzling, as it implies a discount, rather than a premium for default risk.

The median sensitivities of the default intensity to the default-free term structure factors are negative as in Duffee (1999), with median estimates of $\beta_{x,1}$ and $\beta_{x,2}$ of -0.64 and -0.42, respectively. These estimates indicate a somewhat stronger reaction of default intensities to the level and slope of the term structure in emerging markets, such that an increase in the overall level and slope of yields translates into reduced default intensity. Longstaff and Schwartz (1995) suggest negative sensitivity of risky bond prices to interest rates since an increase in interest rates reduces the risk neutral drift of the firm's asset value, leading in turn to a lower probability of default.

In Panel B, we present pricing errors for the overall sample and by country. For each set of bonds, we report interquartile ranges and medians (25th, 50th, and 75th percentiles) of the root mean squared error (RMSE) of bond yields. Median estimates of root mean square errors are larger than those in studies of U.S. bonds, such as Duffee (1999). The median RMSE is 13.52 basis points, with a 25th percentile of 10.67 basis points and a 75th percentile of 22.17 basis points. In contrast, Duffee (1999) reports a median estimate of approximately 10 basis points, a 25th percentile of 7 basis points, and a 75th percentile of 11 basis points. Thus, in our estimates, while pricing errors are comparable (although slightly larger) at the median, they exhibit greater variation across bonds. The table also shows that pricing difficulties are particularly severe in the Russian Federation, compared to the remaining countries. The median pricing error in Russia is 28.25 basis points, with an interquartile range of 22.66 to 50.69 basis points. The model also has somewhat more difficulty in pricing Brazilian bonds with an interquartile range of 9.66 to 31.77 basis points. In contrast, the remaining countries are better represented by the overall estimates.

Incorporating Sovereign and Currency Risk

In Table 7, we introduce the free parameter β_s and allow the bond spread relative to the risk-free yield to depend on the sovereign CDS spread. This model shifts some of the spread dynamics attributable to default intensity to time variation in sovereign CDS spreads. The median point estimate of $\beta_s = 0.064$ is positive across all countries, and positive within each country with the exception of Chile. However, the interquartile range incorporates negative values ($\beta_s = -0.025$) suggesting that sovereign risk does not unambiguously increase risky bond spreads. Across all countries, 40 point estimates, or roughly two-thirds are positive, suggesting that in general these bonds' prices are positively exposed to sovereign risk. The impact varies across countries, however. In Russia, all 10 bonds have positive exposures and in Brazil 9 of 11 bonds have positive exposures. However, only 4 of 11 bonds in Chile have spreads that are positively exposed to sovereign risk. These numbers of sensitivities are similar to the proportions reported in reduced-form regressions in Table 3.

All parameters are free in Table 8, where we report estimates of the model incorporating currency risk through sensitivity to exchange rate volatility. The median point estimate across all countries of $\beta_v = 0.022$ is positive but, like the sovereign risk exposure parameter β_s, the interquartile range incorporates negative exposures. Median estimates are positive in Brazil, Russia, and South Korea, but negative in Chile and Mexico. Of the 61 bonds in our sample, 37 have positive exposure of spreads to exchange rate volatility, a somewhat higher proportion than reported in the reduced-form regressions. Again, sensitivity varies across countries; 9 of 11 Brazilian bonds and 13 of 18 Korean bonds are positively exposed to exchange rate volatility, while only 4 of 11 Chilean and 5 of 11 Mexican bonds exhibit positive exposures.

The results also suggest that exchange rate volatility and sovereign risk interact to some extent, as the median and interquartile range of parameter estimates for β_s seem to be affected by the inclusion of exchange rate volatility. At the median across all countries, the sovereign exposure, $\beta_s = 0.190$ is approximately three times larger than when foreign exchange volatility is not included in the model. The interquartile range shifts slightly to the right, with a 25^{th} percentile estimate of -0.009 (compared to -0.025 previously), and narrows slightly, with a 75^{th} percentile estimate of 0.312 (compared to 0.578 without currency volatility).

We depict the impact of incorporating sovereign CDS and currency volatility in estimates of risky bond spreads in Figure 3. Each panel of the figure depicts the average filtered hazard rate across bonds within each country under the three model specifications. The plots suggest that incorporating sovereign and currency risks in the estimation of default intensities has a material impact on the magnitude of the default intensity estimate. The effect is more dramatic in some countries than others. In Chile, for example, including sovereign risk shifts default intensity down prior to the Lehman Brothers bankruptcy in September 2009, and shifts intensity sharply upward after the bankruptcy. Incorporating exchange rate volatility yields a shift upward; prior to the financial crisis, average default intensities with and without sovereign and currency risk are similar. However, starting in mid-2007, the default intensity with sovereign and currency risk deviates sharply upward from the estimates without these risks. Average default intensity estimated over the post-Lehman period in Chile is 41% higher when incorporating exchange rate volatility and sovereign spreads than in the simple reduced-form model.

4 Conclusion

Dollar denominated emerging market bonds are marketed to investors as free of exchange rate risk. In this paper, we present evidence to suggest that in the case of a sample of corporate bonds that this claim is not strictly true. When we simply ask whether innovations in bond yields are positively sensitive to innovations in exchange rates and exchange rate volatility, we find that a substantial fraction of the bonds in our sample are exposed to these innovations. Approximately 57% of the bonds in our sample have positive and significant exposures to foreign exchange rate innovations, and 38% have positive and significant exposure to exchange rate volatility innovations. These risks account for a median 25% of the variation in bond yield innovations in our sample, and over 42% of the median variation in yield innovations in Brazil and South Korea.

When we control for other aggregate determinants of bond yields, including the U.S. term structure, sovereign risk, and other global factors, we obtain a more nuanced picture of the sensitivity of dollar-denominated yields to exchange rate risks. The proportion of bonds with positive exposure to exchange rate levels drops substantially, to 16%. However, exposure to exchange rate volatility remains fairly stead, with approximately 33% of bonds exhibiting positive and significant exposure to exchange rate volatility. Most of the difference in these and earlier results is due to sovereign risk; we find that 59% of the bonds in our sample have significant exposures to innovations in their country's CDS spread. At the median, this regression model suggests that 72% of the variation in dollar-denominated emerging market corporate bond yields is captured by these systematic factors, reminiscent of findings in Longstaff, Pan, Pedersen, and Singleton (2011).

We formalize our regression findings in a model of reduced-form defaultable bond pricing as in Duffie and Singleton (1997, 1999), augmented to allow for sensitivity of bond yields to sovereign credit risk and exchange rate volatility. We find that the majority of bonds exhibit positive exposures to sovereign risk, whereas the exposure to exchange rate volatility is more disperse. However, a substantial number of the bonds in our sample do exhibit positive exposure to exchange rate volatility. Our model has pricing errors that are similar at the median to those presented in Duffee

(1999), but with greater cross-sectional dispersion. These results suggest that a richer model of pricing of emerging market defaultable securities might improve on our understanding of how yields on these securities are determined.

A large literature in economic development suggests that issuance of dollar-denominated corporate debt represents an externality to emerging market firms. The externality arises due to the increased risk of default induced by requirement to pay interest in dollars rather than the home currency. Our evidence suggests that, to some extent, the bonds in our sample hedge these risks operationally or through financial hedges. However, the hedge is incomplete, and yields remain exposed to volatility. An open question is whether these securities are optimal given the tradeoff that an investor bears between exchange rate and default risk. It is possible that a better contract would have investors hedging exchange rate risk using derivative instruments. Our view is that this is an intriguing question for future research.

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A Appendix

In this appendix, we present the explicit form of bond pricing coefficients for the models estimated in the paper. In our fully specified model with default, CDS, and foreign exchange risk, a system of four variables follows risk neutral dynamics[8]

$$
\begin{pmatrix} dx_{1,t} \\ dx_{2,t} \\ dv_t \\ ds_t \\ dh_{i,t} \end{pmatrix} =
$$

$$
\left[\begin{pmatrix} \kappa_1 & 0 & 0 & 0 & 0 \\ 0 & \kappa_2 & 0 & 0 & 0 \\ 0 & 0 & \kappa_v & 0 & 0 \\ 0 & 0 & 0 & \kappa_s & 0 \\ 0 & 0 & 0 & 0 & \kappa_i \end{pmatrix} \begin{pmatrix} \theta_1 \\ \theta_2 \\ \theta_v \\ \theta_s \\ \theta_i \end{pmatrix} - \begin{pmatrix} \kappa_1+\eta_1 & 0 & 0 & 0 & 0 \\ 0 & \kappa_2+\eta_2 & 0 & 0 & 0 \\ 0 & 0 & \kappa_v+\eta_v & 0 & 0 \\ 0 & 0 & 0 & \kappa_s+\eta_s & 0 \\ 0 & 0 & 0 & 0 & \kappa_i+\eta_i \end{pmatrix} \begin{pmatrix} x_{1,t} \\ x_{2,t} \\ v_t \\ s_t \\ h_{i,t} \end{pmatrix} \right] dt
$$

$$
+ \begin{pmatrix} \sigma_1 & 0 & 0 & 0 & 0 \\ 0 & \sigma_2 & 0 & 0 & 0 \\ 0 & 0 & \sigma_v & 0 & 0 \\ 0 & 0 & 0 & \sigma_s & 0 \\ 0 & 0 & 0 & 0 & \sigma_i \end{pmatrix} \begin{pmatrix} \sqrt{x_{1,t}} & 0 & 0 & 0 & 0 \\ 0 & \sqrt{x_{2,t}} & 0 & 0 & 0 \\ 0 & 0 & \sqrt{v_t} & 0 & 0 \\ 0 & 0 & 0 & \sqrt{s_t} & 0 \\ 0 & 0 & 0 & 0 & \sqrt{h_{i,t}} \end{pmatrix} \begin{pmatrix} dW_{1,t}^Q \\ dW_{2,t}^Q \\ dW_{v,t}^Q \\ dW_{s,t}^Q \\ dW_{i,t}^Q \end{pmatrix}, \qquad \text{(A.1)}
$$

where $x_{1,t}$ and $x_{2,t}$ are state variables governing the default-free term structure, v_t is the foreign exchange variance, s_t is the CDS spread, and $h_{i,t}$ is the default intensity for bond i. The instantaneous risk free rate is a linear function of the state variables,

$$
r_t = a_f + x_{1,t} + x_{2,t},
$$

and the credit spread as

$$
R_{i,t} - r_f = (1-\delta_i)\,\lambda_{i,t} = a_i + \beta_{i,x,1}\,(x_{1,t} - \bar{x}_1) + \beta_{i,x,2}\,(x_{2,t} - \bar{x}_2) + \beta_{i,v} v_t + \beta_{i,s} s_t + h_{i,t},
$$

where $R_{i,t}$ is the instantaneous zero-coupon yield on a risky bond.

Log risky zero coupon bond prices are affine in the state variables in the form

$$
\ln P_{i,t}(\tau) = A_i(\tau) + B_{i,x,1}(\tau) x^*_{i,1,t} + B_{i,x,2}(\tau) x^*_{i,2,t} + B_{i,v}(\tau) v^*_{i,t} + B_{i,s}(\tau) s^*_{i,t} + B_i(\tau) h_{i,t},
$$

[8]We suppress the country subscript for ease of notation.

where τ is the time to maturity in years till the expiration of the zero coupon bond, $x^*_{i,1,t} = (1+\beta_{i,x,1})\, x_{1,t}$, $x^*_{i,2,t} = (1+\beta_{i,x,2})\, x_{2,t}$, $v^*_{i,t} = \beta_{i,v} v_t$, and $s^*_{i,t} = \beta_{i,s} s_t$. Collecting the variables into a five-dimensional vector $\mathbf{y}_t = \{x^*_{i,1,t}, x^*_{i,2,t}, v^*_{i,t}, s^*_{i,t}, h_{i,t}\}$,

$$B_{i,j}(\tau) = -\frac{2\left(e^{\gamma_j \tau} - 1\right)}{2\gamma_j + \left(\kappa_j + \eta_j + \gamma_g\right)\left(e^{\gamma_j \tau} - 1\right)} \tag{A.2}$$

$$A_i(\tau) = \sum_{j=1}^{4} \frac{2\kappa_j \theta_j}{\sigma_j^2} \ln\left[\frac{2\gamma_j e^{\frac{1}{2}(\kappa_j + \eta_j + \gamma_j)\tau}}{2\gamma_j + \left(\kappa_j + \eta_j + \gamma_j\right)\left(e^{\gamma_j \tau} - 1\right)}\right], \tag{A.3}$$

where $\gamma_j = \sqrt{\left(\kappa_j + \eta_j\right)^2 + 2\sigma_j^2}$, and j indexes the parameters associated with the j^{th} element of $\mathbf{y}_t$.

Table 1: Summary Statistics for Emerging Market Dollar-Denominated Bonds

Table 1 presents summary statistics for emerging market dollar-denominated bonds in our sample. Bonds are sampled from Datastream and represent fixed coupon semi-annual debentures issued by corporations with no call provisions and fixed maturity. All bonds have payments denominated in U.S. Dollars and are issued by companies in countries considered emerging markets as of January, 2001. Bonds must have at least 250 days of price information and 75% of price changes non-zero. The table presents, by country, median, minimum, and maximum coupon rates and years to maturity of the bonds. The countries in our sample are Brazil (BR), Chile (CL), Mexico (MX), Russia (RS), and South Korea (SK). Additionally, we report the number of bonds, number of companies issuing bonds, and first observation by country. Data are sampled over the period 12/28/2000 through 9/28/2010 at the daily frequency.

Country:	BR	CL	MX	RS	SK
Number of Bonds	11	11	11	10	18
Number of Companies	6	4	3	4	5
Minimum Coupon	6.25	5.13	4.75	5.67	4.25
Median Coupon	8.00	7.38	5.63	8.48	5.88
Maximum Coupon	10.50	8.63	6.63	9.75	8.75
Minimum Life at Issue	5.00	9.50	5.00	5.00	5.00
Median Life at Issue	10.00	10.00	10.00	6.00	8.50
Maximum Life at Issue	30.00	30.00	30.00	10.00	20.00
First Observation Year	2004	2000	2005	2004	2001

Table 2: Sensitivity of Spreads to Foreign Exchange Innovations and Volatility

Table 2 presents results regressing innovations in yield spreads on emerging market dollar-denominated bonds on innovations in foreign exchange rates, ΔFX_t and foreign exchange volatility, ΔFXV_t. The dependent variable is the spread on a bond's yield relative to a comparable maturity Treasury security. ΔFX_t is the first difference in the log rate of exchange of U.S. Dollar for the home currency of the bond i, and ΔFXV_t is the first difference in the volatility of the foreign exchange innovation modeled via an MA(1), EGARCH (1,1) time series specification. Data on emerging market corporate bonds and exchange rates are obtained from Datastream; the bond data represent 61 issues from 22 companies across five countries. Treasury yield data are constant maturity yields obtained from the FRED database at the Federal Reserve. Data are sampled at the monthly frequency over various horizons with the first observation in December, 2000 and the final observation in September, 2010. The table presents the median of point estimates, Newey-West t-statistics, and the proportion of coefficients that are significantly greater than zero at the 10% critical level in parentheses. Results are reported in aggregate and by country.

Country	ΔFX_t	ΔFXV_t	R^2
All Countries	5.796	0.762	25.289
t-stat	1.635	0.588	
Proportion Significant	(0.639)	(0.377)	
Brazil	5.913	2.412	42.957
t-stat	2.360	2.241	
Proportion Significant	(1.000)	(0.636)	
Chile	3.828	−0.018	12.379
t-stat	1.635	−0.021	
Proportion Significant	(0.636)	(0.273)	
Mexico	7.793	0.514	22.827
t-stat	1.625	0.320	
Proportion Significant	(0.818)	(0.000)	
Russia	14.626	−8.276	3.964
t-stat	0.667	−1.052	
Proportion Significant	(0.000)	(0.000)	
South Korea	4.159	3.992	42.496
t-stat	1.649	2.366	
Proportion Significant	(0.667)	(0.722)	

Table 3: Systematic Determinants of Emerging Market Bond Spreads

Table 3 presents regressions of changes in the spread on 61 emerging market dollar-denominated corporate bonds, relative to a U.S. Treasury constant maturity security of closest matching maturity, on local and global determinants of bond spreads. The covariates are VRP_t, the variance risk premium measured as the difference in the VIX index and a measure of realized volatility, Y_t, the yield on a 10-year constant maturity Treasury Bond, TS_t, the difference in the yield on a 10-year and 2-year constant maturity Treasury Bond, $R_{local,t}$, the return on a local stock market index, $R_{US,t}$, the return on the CRSP value-weighted index, PE_t, the price-to-earnings ratio on the S&P 500, DS_t, the difference in the yield on Moody's Aaa and Baa-rated bonds, RES_t, the level of foreign currency reserves of the country of the issuer of the bond, CDS_t, the spread on the 5-year CDS of the country of the bond issuer, FX_t, the rate of exchange of local currency per U.S. dollar, and FXV_t, the volatility of the currency as modeled by a MA(1), EGARCH (1,1) model of volatility. Data on the VIX and CRSP value-weighted index are taken from CRSP, data on U.S. Treasuries, Aaa- and Baa-rated bonds are obtained from the FRED database at the Federal Reserve, data on CDS are obtained from Bloomberg, data on reserves are obtained from the IMF, data on price-earnings ratios are obtained from Robert Shiller's website, and data on emerging market corporate bond yields, local equity market returns, and currency returns are obtained from Datastream. Data are sampled at the monthly frequency over various horizons, starting in December, 2000 through September, 2010. The table reports median point estimates, t-statistics, and regression R^2. The proportion of variables that are statistically significant in parentheses; for covariates other than foreign exchange variables, the proportion represents the proportion of coefficients that are statistically significantly different than zero at the 10% critical level. For the foreign exchange variables, the proportion represents the proportion of coefficients that are statistically significantly greater than zero at the 10% critical level. All t-statistics are computed using Newey-West standard errors.

Country	ΔVRP_t	$\Delta Y_{10,t}$	ΔTS_t	$R_{local,t}$	$R_{US,t}$	ΔPE_t	ΔDS_t	ΔRES_t	ΔCDS_t	ΔFX_t	ΔFXV_t	R^2
All Countries	−1.557	−0.291	−0.054	−1.371	−0.394	−0.119	3.933	−0.634	0.669	−0.470	0.818	72.435
t-stat	−1.084	−1.177	−0.593	−0.905	−0.177	−0.289	0.169	−0.484	1.891	−0.286	0.553	
Prop. Significant	(0.361)	(0.361)	(0.115)	(0.230)	(0.262)	(0.098)	(0.066)	(0.131)	(0.607)	(0.180)	(0.371)	
Brazil	−2.429	−0.472	−0.085	−0.722	−1.260	−0.577	−3.229	−1.459	0.483	−0.997	3.158	81.523
t-stat	−2.139	−2.898	−1.130	−0.194	−0.687	−1.256	−0.253	−0.614	2.495	−0.537	2.108	
Prop. Significant	(0.545)	(0.818)	(0.273)	(0.364)	(0.455)	(0.182)	(0.091)	(0.091)	(0.818)	(0.000)	(0.727)	
Chile	−1.186	−0.260	0.005	−1.065	−0.189	0.254	−2.676	0.924	0.425	2.48	0.099	42.818
t-stat	−1.021	−2.164	0.113	−1.163	−0.111	−0.621	−0.209	1.149	1.387	1.410	0.133	
Prop. Significant	(0.273)	(0.636)	(0.000)	(0.273)	(0.091)	(0.091)	(0.000)	(0.091)	(0.455)	(0.636)	(0.091)	
Mexico	−3.149	−0.203	−0.053	−1.371	−0.740	−0.341	0.179	−3.526	0.191	0.320	−0.027	70.150
t-stat	−1.796	−1.075	−0.854	−1.348	−0.351	−0.673	0.012	−1.380	0.652	0.137	−0.026	
Prop. Significant	(0.636)	(0.091)	(0.091)	(0.364)	(0.182)	(0.000)	(0.182)	(0.364)	(0.182)	(0.091)	(0.091)	
Russia	−5.864	−0.072	−0.417	−3.869	−4.750	−1.625	13.882	−10.807	1.449	−15.904	−0.436	85.720
t-stat	−1.955	−0.083	−0.924	−0.991	−0.863	−0.968	0.189	−1.014	2.898	−1.480	−0.127	
Prop. Significant	(0.500)	(0.000)	(0.200)	(0.100)	(0.200)	(0.200)	(0.000)	(0.200)	(1.000)	(0.000)	(0.000)	
S. Korea	0.907	−0.312	−0.048	−0.845	2.666	0.245	15.680	−0.366	1.110	−2.113	2.289	69.067
t-stat	0.579	−1.051	−0.577	−0.802	1.180	0.211	0.675	−0.305	2.157	−0.596	1.721	
Prop. Significant	(0.056)	(0.278)	(0.056)	(0.111)	(0.333)	(0.056)	(0.056)	(0.000)	(0.611)	(0.167)	(0.722)	

Table 4: Determinants of Emerging Market Bond Spreads: Non-Crisis Subsample

Table 4 presents regressions of changes in the spread on 61 emerging market dollar-denominated corporate bonds, relative to a U.S. Treasury constant maturity security of closest matching maturity, on local and global determinants of bond spreads, excluding months of the global financial crisis. The covariates are VRP_t, the variance risk premium measured as the difference in the VIX index and a measure of realized volatility, Y_t, the yield on a 10-year constant maturity Treasury Bond, TS_t, the difference in the yield on a 10-year and 2-year constant maturity Treasury Bond, $R_{local,t}$, the return on a local stock market index, $R_{US,t}$, the return on the CRSP value-weighted index, PE_t, the price-to-earnings ratio on the S&P 500, DS_t, the difference in the yield on Moody's Aaa and Baa-rated bonds, RES_t, the level of foreign currency reserves of the country of the issuer of the bond, CDS_t, the spread on the 5-year CDS of the country of the bond issuer, FX_t, the rate of exchange of local currency per U.S. dollar, and FXV_t, the volatility of the currency as modeled by a MA(1), EGARCH (1,1) model of volatility. Data on the VIX and CRSP value-weighted index are taken from CRSP, data on U.S. Treasuries, Aaa- and Baa-rated bonds are obtained from the FRED database at the Federal Reserve, data on CDS are obtained from Bloomberg, data on reserves are obtained from the IMF, data on price-earnings ratios are obtained from Robert Shiller's website, and data on emerging market corporate bond yields, local equity market returns, and currency returns are obtained from Datastream. Data are sampled at the monthly frequency over various horizons, starting in December, 2000 through September, 2010, omitting the period August, 2007 through June, 2009. The table reports median point estimates, t-statistics, and regression R^2. The proportion of variables that are statistically significant in parentheses; for covariates other than foreign exchange variables, the proportion represents the proportion of coefficients that are statistically significantly different than zero at the 10% critical level. For the foreign exchange variables, the proportion represents the proportion of coefficients that are statistically significantly greater than zero at the 10% critical level. Standard errors are corrected for heteroskedasticity.

Country	ΔVRP_t	$\Delta Y_{10,t}$	ΔTS_t	$R_{local,t}$	$R_{US,t}$	ΔPE_t	ΔDS_t	ΔRES_t	ΔCDS_t	ΔFX_t	ΔFXV_t	R^2
All Countries	−1.413	−0.147	−0.045	−0.863	−0.910	0.101	−13.643	0.536	0.336	1.403	0.265	70.756
t-stat	−0.991	−0.745	−0.740	−0.587	−0.598	0.377	−0.476	0.496	0.675	0.316	0.380	
Prop. Significant	(0.361)	(0.328)	(0.164)	(0.164)	(0.148)	(0.180)	(0.230)	(0.213)	(0.344)	(0.213)	(0.279)	
Brazil	−1.931	−0.600	−0.052	−1.399	−0.462	−0.180	2.481	2.095	0.490	0.652	1.132	78.739
t-stat	−1.381	−1.701	−0.842	−0.682	−0.142	−0.654	0.120	0.510	1.215	0.201	0.497	
Prop. Significant	(0.455)	(0.545)	(0.000)	(0.091)	(0.182)	(0.182)	(0.273)	(0.273)	(0.636)	(0.091	(0.182)	
Chile	−0.729	−0.266	−0.011	−0.790	−0.479	0.145	−0.183	0.561	0.372	0.988	0.265	45.000
t-stat	−0.803	−1.835	−0.452	−0.916	−0.328	0.449	−0.007	0.946	1.031	0.418	0.408	
Prop. Significant	(0.364)	(0.545)	(0.000)	(0.000)	(0.091)	(0.091)	(0.182)	(0.182)	(0.273)	(0.273)	(0.273)	
Mexico	−0.916	−0.068	−0.059	−0.763	−2.053	0.171	−13.643	−2.173	0.185	0.187	−1.843	66.316
t-stat	−1.163	00.605	−0.838	−0.698	−0.619	0.652	−0.565	−0.895	0.533	0.111	−1.114	
Prop. Significant	(0.455)	(0.182)	(0.636)	(0.364)	(0.182)	(0.364)	(0.545)	(0.182)	(0.455)	(0.182)	(0.182)	
Russia	−1.658	−0.148	−0.219	−1.990	−4.014	0.289	−55.759	−0.276	0.731	2.044	4.332	89.851
t-stat	−0.964	−0.284	−0.480	−0.845	−1.056	0.468	−0.636	−0.075	0.924	0.319	2.340	
Prop. Significant	(0.200)	(0.300)	(0.100)	(0.100)	(0.200)	(0.100)	(0.200)	(0.400)	(0.300)	(0.200)	(0.800)	
S. Korea	−1.233	0.035	−0.059	−0.221	−0.913	0.153	−8.538	0.540	−0.087	2.326	−0.689	62.650
t-stat	−0.896	0.229	−0.834	−0.242	−0.47370−565476		0.776	−0.170	0.858	−0.888		
Prop. Significant	(0.333)	(0.167)	(0.111)	(0.222)	(0.111)	(0.167)	(0.056)	(0.111)	(0.167)	(0.278)	(0.111)	

Table 5: Cross-Sectional Determinants of Foreign Exchange Sensitivity

In Table 5, we present estimates of coefficients in the regressions

$$\hat{b}_{v,i} = d_{02} + d_{12} sales_{j,t} + d_{22} debt_{j,t} + d_{32} deriv_{j,t} + d_{42} coup_i + d_{52} mat_i + u_{2i},$$

where $\hat{b}_{v,i}$ is the point estimate of sensitivity of bond i's credit spread to volatility of exchange rates as reported in Table 3. The variable $sales_{j,t}$ is the proportion of firm j's sales derived from U.S. dollars, $debt_{j,t}$ is the proportion of firm j's total long term debt composed of U.S. dollar debentures, $deriv_{j,t}$ is an indicator variable that takes the value 1 if the firm hedges foreign currency risk and 0 otherwise, $coup_i$ is the coupon rate on the bond, and mat_i is the initial maturity of the bond. The index $t = 2006, 2007, 2008, 2009$ reflects fiscal year ends for which accounting data are available. Data are obtained from 20-F filings with the SEC on the EDGAR database, if available, and directly from company financial statements if not. Summary statistics for the firm-specific variables are presented in Panel A and point estimates and t-statistics, as well as the regression adjusted R^2 are presented in Panel B.

Panel A: Summary Statistics

Country:		Brazil			Chile			Mexico			Russia			S. Korea	
Variable:	*sales*	*debt*	*deriv*	*sales*	*debt*	*deriv*	*sales*	*debt*	*deriv*	*sales*	*debt*	*deriv*	*sales*	*debt*	*deriv*
Mean	0.37	0.23	0.83	0.75	0.33	0.75	0.06	0.49	1.00	0.42	0.27	0.00	0.07	0.17	1.00
Min	0.00	0.06	0.00	0.00	0.12	0.00	0.00	0.31	1.00	0.16	0.18	0.00	0.00	0.11	1.00
Max	0.94	0.41	1.00	1.00	0.74	1.00	0.18	0.70	1.00	0.69	0.44	0.00	0.25	0.26	1.00

Panel B: Regression Results

Dep. Var.	*sales*	*debt*	*deriv*	*coup*	*mat*	$\bar{R}^2$
Estimate	−1.238	4.041	12.687	0.350	−0.024	70.66
t-stat	−1.769	2.769	15.451	−0.625	1.505	

Table 6: Parameter Estimates and Pricing Errors without Sovereign or Currency Risks

Panel A: Parameter Estimates

Country	Pct	κ_i	θ_i	η_i	σ_i	α_i	$\beta_{x,1}$	$\beta_{x,2}$
All	25	1.303	0.499	-0.471	0.122	-0.982	-1.649	-1.037
	50	2.211	0.741	-0.134	0.278	-0.787	-0.638	-0.424
	75	4.062	0.858	0.252	0.612	-0.307	-0.055	-0.144
Brazil	25	1.566	0.705	-0.749	0.151	-1.284	-1.693	-1.436
	50	2.797	0.792	-0.417	0.405	-0.972	-1.455	-0.871
	75	4.815	1.098	-0.087	0.746	-0.720	-0.145	-0.726
Chile	25	0.002	0.388	-0.252	0.093	-0.982	-0.377	-0.396
	50	0.690	0.583	0.170	0.132	-0.460	-0.055	-0.170
	75	1.542	0.802	0.789	0.220	-0.084	0.033	0.020
Mexico	25	0.770	0.268	-0.637	0.205	-1.051	-1.649	-0.721
	50	2.685	0.658	-0.068	0.417	-0.504	-0.541	-0.362
	75	4.616	1.062	0.874	0.767	-0.202	-0.042	-0.143
Russia	25	1.936	0.694	-0.363	0.389	-0.927	-4.291	-2.707
	50	2.745	0.796	0.073	0.588	-0.877	-2.760	-1.864
	75	4.062	0.893	0.570	0.693	-0.459	-1.540	-1.296
S. Korea	25	1.344	0.402	-0.572	0.082	-0.961	-1.297	-0.602
	50	1.642	0.751	-0.182	0.208	-0.797	-0.511	-0.341
	75	5.902	1.064	0.008	0.460	-0.307	0.000	-0.130

Panel B: Root Mean Square Error

Pct	All	BR	CL	MX	RU	SK
25	10.67	9.66	9.46	8.48	22.66	11.97
50	13.52	13.23	10.90	10.86	28.25	15.11
75	22.17	31.77	15.31	12.74	50.69	19.08

Table 7: Parameter Estimates with Sovereign Risk

Country	Pct	κ_i	θ_i	η_i	σ_i	α_i	$\beta_{x,1}$	$\beta_{x,2}$	β_s
All	25	1.705	0.380	-0.484	0.270	-0.937	-1.257	-0.841	-0.025
	50	3.455	0.664	-0.169	0.469	-0.742	-0.590	-0.367	0.064
	75	5.064	0.825	0.204	0.769	-0.301	-0.010	-0.055	0.578
Brazil	25	2.904	0.544	-0.076	0.252	-1.226	-1.333	-1.119	0.045
	50	4.293	0.870	0.042	0.702	-1.040	-0.669	-0.557	0.536
	75	5.556	1.117	0.727	1.294	-0.597	0.017	-0.252	0.907
Chile	25	1.709	0.180	-0.938	0.278	-0.901	-0.682	-0.376	-0.276
	50	3.637	0.494	-0.268	0.486	-0.244	-0.037	-0.214	-0.029
	75	5.064	0.763	0.530	0.556	-0.099	0.320	0.022	0.188
Mexico	25	1.524	0.336	-0.873	0.270	-0.926	-1.142	-0.395	-0.145
	50	3.600	0.714	-0.143	0.383	-0.604	-0.488	-0.300	0.015
	75	5.024	0.840	0.590	0.553	-0.243	0.140	0.095	0.064
Russia	25	2.631	0.539	-0.177	0.758	-0.937	-2.149	-2.253	0.578
	50	4.519	0.652	-0.054	0.826	-0.759	-1.654	-1.211	0.868
	75	6.473	0.728	0.476	0.964	-0.499	-1.257	-1.092	1.325
S. Korea	25	1.304	0.136	-0.403	0.107	-0.935	-0.981	-0.426	-0.018
	50	1.977	0.659	-0.275	0.314	-0.719	-0.506	-0.274	0.040
	75	4.053	0.764	-0.056	0.524	-0.205	-0.115	-0.049	0.275

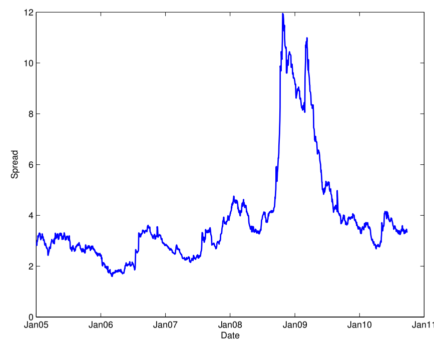
Table 8: Parameter Estimates with Sovereign and Currency Risk

Country	Pct	κ_i	θ_i	η_i	σ_i	α_i	$\beta_{x,1}$	$\beta_{x,2}$	β_s	β_v
All	25	1.387	0.517	-0.370	0.137	-1.119	-1.087	-0.713	-0.009	-0.245
	50	3.539	0.754	-0.111	0.429	-0.830	-0.445	-0.315	0.190	0.022
	75	4.984	0.965	0.106	0.764	-0.591	0.051	0.015	0.391	0.312
Brazil	25	1.372	0.725	-0.260	0.120	-1.525	-1.156	-0.913	0.257	0.000
	50	2.610	1.190	0.049	0.454	-1.346	-0.739	-0.404	0.441	0.001
	75	6.415	1.285	0.211	1.034	-0.667	0.177	-0.206	0.673	0.037
Chile	25	1.122	0.416	-0.443	0.154	-1.024	-1.062	-0.579	-0.148	-3.972
	50	4.455	0.777	-0.179	0.390	-0.894	-0.099	-0.205	0.195	-1.398
	75	6.095	0.836	0.222	0.702	-0.497	0.349	0.094	0.367	1.764
Mexico	25	1.387	0.489	-0.824	0.042	-1.361	-0.921	-0.409	-0.061	-3.287
	50	4.153	0.750	-0.296	0.464	-0.808	-0.269	-0.128	-0.009	-0.206
	75	5.152	1.224	-0.075	0.752	-0.596	0.213	0.018	0.021	2.094
Russia	25	1.602	0.518	-0.370	0.104	-0.856	-2.496	-1.708	0.215	-0.054
	50	3.433	0.626	-0.277	0.504	-0.749	-1.244	-1.124	0.368	0.042
	75	3.715	0.814	-0.009	0.827	-0.669	-0.445	-0.777	0.404	0.107
S. Korea	25	1.346	0.517	-0.216	0.137	-1.112	-0.989	-0.551	-0.049	-0.002
	50	3.406	0.699	-0.014	0.348	-0.696	-0.340	-0.238	0.057	0.171
	75	5.000	0.870	0.432	0.769	-0.562	0.278	0.149	0.211	1.090

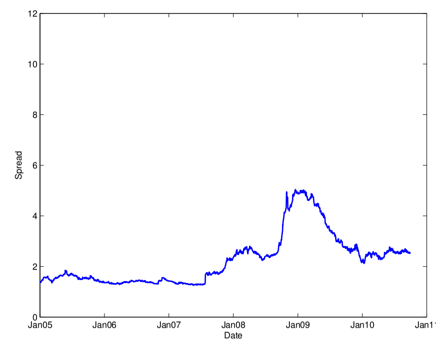
Figure 1: Time Series of Average Bond Yield Spreads

Figure 1 presents the time series of average yield spreads of emerging market corporate bonds plotted for each country in our sample. Yield spreads for individual bonds are calculated as the difference in the yield to maturity on the issue and the yield on a Treasury security with the closest maturity. Yield spreads are then averaged across the bonds within each country on each date to produce a single time series observation for each country. Data on individual bond yields are obtained from DataStream and Treasury yields are constant maturity yields from the Federal Reserve Board of Governors (FRED). Data plotted cover the period January, 2005 through September, 2010, and are sampled at the daily frequency. Panel a) depicts average spreads for Brazilian bonds, b) for Chilean bonds, c) for Mexican bonds, d) for Russian bonds, and e) for South Korean bonds. Panels are depicted on a common y-axis scale with the exception of Russia.

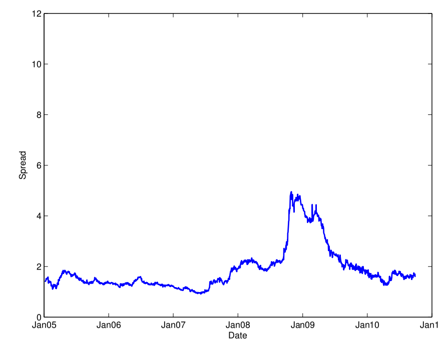
(a) Brazil



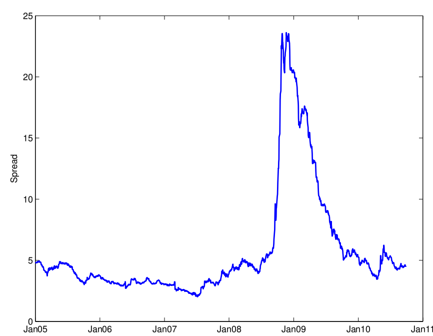
(b) Chile



(c) Mexico



(d) Russia



(e) South Korea

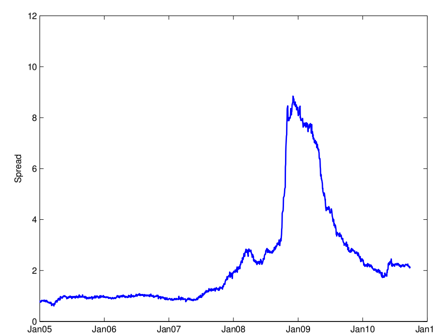
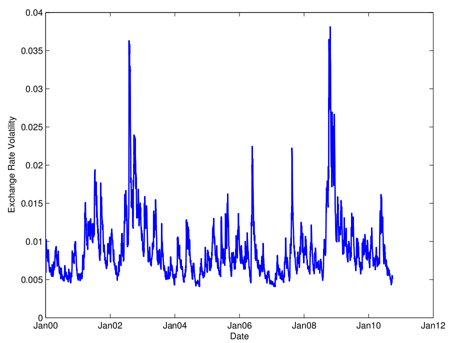


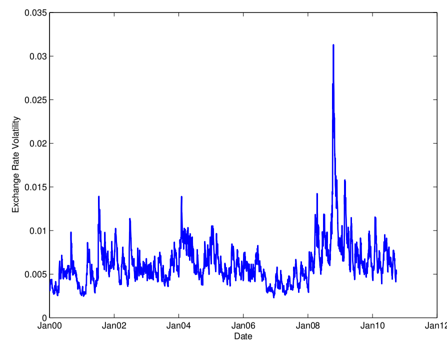
Figure 2: Time Series of Exchange Rate Volatility

Figure 2 presents the time series of estimated volatility of foreign exchange innovations. Volatilities are computed by fitting an MA (0,1), EGARCH (1,1) model to daily exchange rate innovations over various periods from 1994 through 2010. Data are obtained from Datastream. Figure (a) presents plots for Brazil, (b) for Chile, (c) for Mexico, (d) for Russia, and (e) for South Korea.

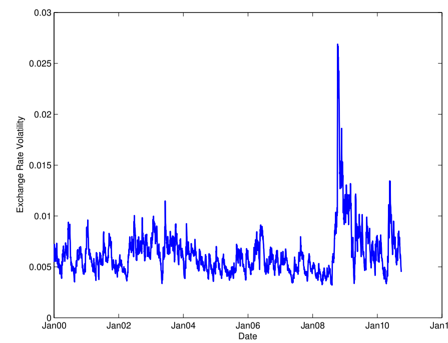
(a) Brazil



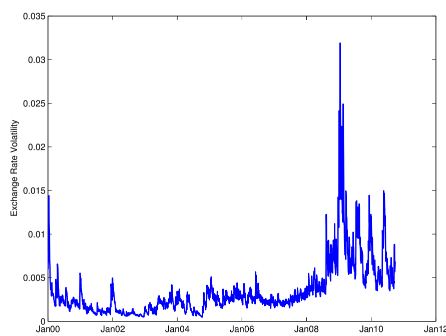
(b) Chile



(c) Mexico



(d) Russia



(e) South Korea

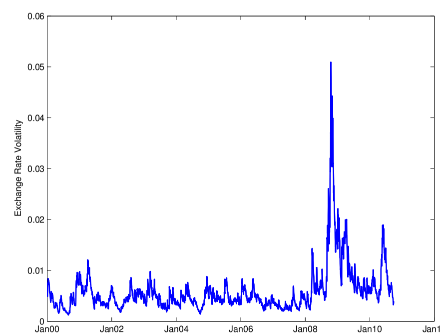
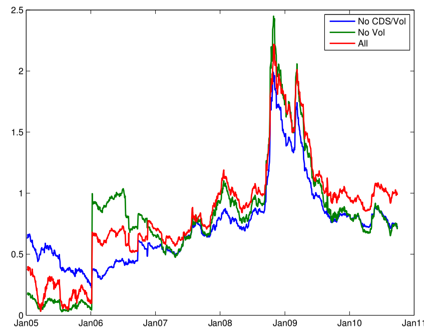
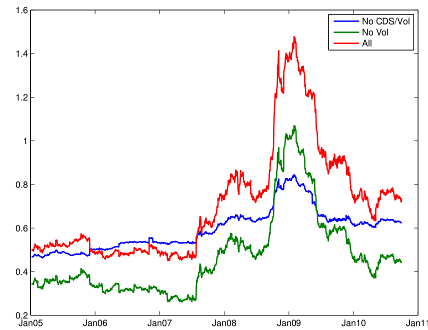


Figure 3: Time Series of Average Default Intensities

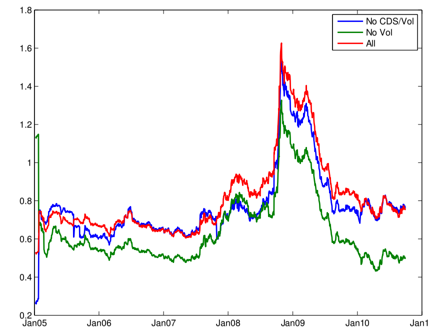
(a) Brazil



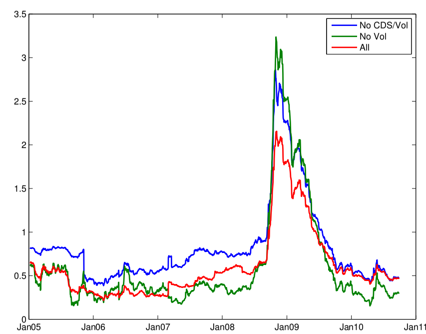
(b) Chile



(c) Mexico



(d) Russia



(e) South Korea