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

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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, approximately one-half 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. Altogether, over 60% of the bonds in our sample have yield spreads with statistically significantly positive exposures to either exchange rate or exchange rate volatility innovations. 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. Finally, we eliminate bonds with fewer than 250 daily time series observations. 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

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

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 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 10^{th}, 25^{th}, 50^{th}, 75^{th} and 90^{th} percentiles of parameter estimates and R^2, where percentiles are calculated over all bonds and bonds within each of the five countries in our sample in Panel A. 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 5.0% critical level using Newey-West-adjusted standard errors.. 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 interquartile range for the coefficient on $b_{fx,i,k}$ is also spanned by positive values; the 25^{th} percentile value for the coefficient on innovations in currency volatility is negative. Finally, for the median bond, exchange rate and exchange rate volatility innovations explain 25% of the variation in innovations in bond yields.

Point estimates are not uniformly statistically greater than zero, but a substantial proportion of bonds exhibit coefficients that are statistically significantly greater than zero. As shown in Table 2, 29 bonds (47.5%) have exposures to exchange rate innovations that are statistically significantly positive and 21 bonds have exposures to exchange rate volatility innovations that are statistically significantly positive. In all, 38 bonds (62.3%) have exposures to either exchange rate or exchange rate volatility innovations that are statistically significantly greater than zero. Moreover, although not reported, every bond in our sample has a positive (although not necessarily statistically significantly) point estimate for exposure to exchange rate innovations.

Examining the panels of Table 2 reveals considerable variation across countries in the degree of sensitivity to exchange rate innovations and volatility, the percentage of yield innovations explained by these variables, and the proportion of statistically positive coefficients. At one end of the spectrum, results in Panels A and F of Table 2 present results for Brazil and South Korea, respectively. In both countries, the interquartile range of point estimates for sensitivity of bond yield innovations to exchange rate and exchange rate volatility innovations are positive. In both countries, exchange rate and exchange rate volatility innovations explain approximately 43% of variation in changes in bond yield spreads at the median. Of the eleven bonds in Brazil, 10 (90.1%) exhibit statistically significantly positive exposures to exchange rate innovations, 7 (63.6%) exhibit statistically significantly positive exposures to exchange rate volatility innovations, and 11 (100.0%) bonds exhibit statistically significant positive exposures to one of these innovations. In South Korea, 10 bonds (55.6%) exhibit statistically significantly positive exposures to exchange rate innovations, 12 (66.7%) exhibit statistically significantly positive exposures to exchange rate volatility innovations, and 17 (94.4%) bonds exhibit statistically significant positive exposures to one of these innovations. It is difficult from this initial analysis to suggest that Brazilian or Korean dollar-denominated corporate bonds are immune from exchange rate risk.

At the other end of the spectrum, bonds in Russia exhibit no significantly positive exposure to innovations in exchange rates or the volatility of exchange rates. The distribution of exposures to exchange rate innovations is positive; although none of the individual coefficients is statistically greater than zero, all 10 of the bonds in Russia have positive coefficients. Somewhat interestingly, the distribution of exposures to exchange rate volatility is *negative*; again, no bonds exhibit exposure to exchange rate volatility that is statistically significantly positive. Further, exchange rate and volatility innovations explain only 4% of the variation in bond yield spread innovations at the median. Thus, these results suggest that Russian bonds, in contrast to Brazilian or Korean bonds, are largely immune from risks in exchange rates.

To conclude, we suggest that these results indicate that claiming that dollar-denominated bond yields of emerging market corporate issuers are free of exchange rate risk is somewhat misleading. Although results are not uniform across our sample, the majority of bonds in our sample have yield spread innovations that exhibit statistically significant exposure to innovations in either the level or the volatility of exchange rates. Further, every bond in our sample has a positive, although not necessarily statistically significant, exposure to innovations in exchange rates. As discussed, these exposures are not evenly distributed across countries; sensitivity is more pronounced in Brazil and South Korea, more moderate in Chile and Mexico, and statistically absent in the Russian Federation. In the next section, we examine these bonds in a more disaggregated cross-section to analyze the sources of exchange risk exposure.

2.3 Cross-Sectional Determinants of Foreign Exchange Sensitivity

The companies in our sample are generally large international corporations. As such, they have access to financial and operational hedges that may reduce the sensitivity of their cash flows to exchange rate movements and render the concerns about increased default risk baseless. A large literature has examined the sensitivity of firms' equity returns to foreign exchange risks; Bartram, Brown, and Minton (2010) propose a model of foreign exchange exposure and estimate predicted exposures to exchange rate risk. The authors find that the most important variables determining exchange rate exposure are the percentage of sales and debt denominated in foreign currency 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 two 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. 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. If neither U.S. nor North American sales numbers were available, we treat this variable as missing. 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 debt.* The percent of U.S. dollar debt, $debt_j$ reflects the importance of dollar debt in the overall debt structure of the firm. The variable is calculated as the ratio of dollar-denominated long-term debt to total long-term debt. In some cases, the current portion of long-term debt was not separated from the dollar portion of short-term debt. In these cases, we utilize the ratio of total dollar debt to total long and short-term 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.* Only one firm in our sample did not report usage of foreign currency forwards, futures, or currency swaps in their financial statements. Due to the lack of variation in this variable, we do not include it in our regressions.

All firms in our sample have fiscal years ending in December of the calendar year. We collect data as of fiscal year ends spanning 2001-2010. For each firm, we use data starting from the year that the bonds enter our sample.

Means of these variables are presented in Panel A of Table 3. As shown in the table, many of the firms in our sample have some natural operational hedge against dollar exchange rate risk in the form of U.S sales. In Brazil, the average firm has 65% of its sales denominated in dollars and in Chile, 60% of sales are denominated in dollars. In contrast, the average Mexican firm has only 3% of its sales in dollars and the average South Korean firm only 2% of sales in dollars. Much of this discrepancy can be traced to the types of firms in the sample in these countries. The Brazilian and Chilean firms are more likely to be producers of commodities (mining, forest products, and agricultural products) with significant export sales. In contrast, the Mexican and Korean firms are dominated by telecommunications, media, and utilities, with fewer exported sales. Percentages of sales are widely varied; firms report between zero and 100% of their sales as denominated in U.S. dollars.

The table also suggests that U.S. dollar debt is a significant part of the capital structure of most of the firms in our sample. In each country, dollar debt represents on average more than 50% of total long term debt, with the exception of Korea, where the average firm's U.S. dollar obligations represent 48% of total long term debt. The evidence suggests that dollar exposure of debt is a non-trivial issue for the firms in our sample.[5]

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 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 sensitivity. Results are reported on the basis of pooled regressions. and are presented in Panel B of Table 3. The first set of results pertain to exposure to innovations in the level of exchange rates. The results appear to be consistent with our priors. Firms with a greater percentage of U.S. dollar sales have bond yield spreads with lower sensitivity to innovations in exchange rates, and firms with a capital structure more exposed to dollar debt have a higher sensitivity of yield spreads to innovations in exchange rates. Both of these coefficients are statistically significant at conventional levels.

The relation between the sensitivity of bond yield spreads to volatility of exchange rates, shown in the second set of results in Table 3 are a bit more difficult to interpret. Firms with a greater percentage of U.S. sales have *more* exposure of yield spreads to innovations in foreign exchange volatility, although the estimate is not statistically significant. Firms with a greater percentage of its debt denominated in dollars have *less* exposure of bond yield spreads to exchange rate volatility. The implication is that dollar debt acts as something of a hedge against exchange rate volatility.

2.4 Sovereign Risk, Exchange Rates, and Corporate Yield Spreads

The results documented thus far suggest that dollar-denominated corporate bond yield spreads are influenced by fluctuations in the level and volatility of local currencies relative to the dollar, and that the sensitivity to these risks can be linked to some extent to the degree of operational exposure that firms have to exchange rate risk. Recent research has suggested that links between exchange rates and fixed income spreads are related to other variables as well. In particular, Longstaff, Pan, Pedersen, and Singleton (2011) show that there is a link between exchange rate innovations and innovations in sovereign credit default swap spreads. Similarly, Carr and Wu (2007) demonstrate

[5]Table 3 reports that the minimum U.S. dollar debt in Brazil is 0%. One firm, Telemar Norte, paid off nearly all of its U.S. dollar obligations by the end of our sample period. However, it had significant dollar exposure at other times in the sample.

that in Brazil and Mexico, sovereign spreads are correlated with the implied volatility of currency options. These studies suggest that there is a strong link between sovereign risk and exchange rates; we examine the effect of this link on the sensitivity of corporate bond yields to exchange rate risks.

To this end, we repeat the bond-level regressions in equation (1) including sovereign credit default swap (CDS) spreads from Datastream. Since the five-year CDS is generally the most liquid and widely traded contract, we use this spread in our analysis. The results of these regressions are shown in Table 4. 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. t-statistics are adjusted for heteroskedasticity, and we present the proportion of foreign exchange coefficients statistically significantly greater than zero at the 5.0% critical level in parentheses beneath the t-statistics. The numbers in parentheses below the t-statistics for the remaining covariates represent the proportion of coefficients that are statistically different than zero at the 5.0% critical level.

The results reported in Table 4 indicate that including sovereign CDS spreads in the regression absorbs a substantial amount of the statistical significance of exchange rate and exchange rate volatility innovations. Median point estimates of exposure to exchange rate risks remain positive, but the interquartile range for all bonds now includes negative sensitivities. Eleven bonds (18.03%) exhibit positive and statistically significant exposures to innovations in exchange rate levels and twelve bonds (19.67%) exhibit positive and statistically significant exposures to innovations in exchange rate volatility. In total, 20 bonds, or approximately one-third of the total, exhibit positive and significant exposure to innovations in exchange rate levels, volatility, or both. This represents a sharp decrease from our earlier results where nearly two-thirds of bonds had some statistically significant exposure to exchange rate level or volatility risk.

Approximately two thirds of the bonds have statistically significant exposure to innovations in sovereign CDS spreads. This exposure varies in significance across countries. Sovereign risk appears extremely important in Brazil (81.8% of bonds), Russia (100.0% of bonds), and South Korea (66.7% of bonds). The proportion of significant exposures is somewhat less pronounced in Chile (54.6% of bonds) and Mexico (36.4% of bonds). In the overall sample, as well as in each country, the interquartile range includes only positive estimates. Thus, the results seem to strongly support the idea that increased sovereign risk, as measured by sovereign CDS spreads, are positively related to increased corporate risk in these countries.

The disaggregated data also suggests that while the statistical significances of exposures are reduced by inclusion of sovereign CDS spreads, significances continue to vary substantially across countries. Cross-sectional variation in statistical significance largely mirrors our earlier results omitting the CDS innovation. In Brazil, seven bonds (63.6%) have positive and significant exposure to innovations in exchange rates or exchange rate volatility. In Chile, the five bonds (45.5%) with positive and significant exposures omitting CDS spreads continue to have positive and significant exposures. The largest changes in statistical significance are in Mexico and South Korea. In our earlier results, four bonds were significantly exposed to exchange rate level risk in Mexico; after accounting for CDS spreads, only one bond is significantly exposed. In South Korea, virtually all bonds had positive and significant exposure to either level or volatility innovations; controlling for sovereign risk, seven, or 38.9% of bonds retain some statistically significant exposure.

The results of this section suggest that a significant portion of the impact of exchange rate risk on dollar-denominated yield spreads can be accounted for via sovereign CDS spreads. However, Longstaff, Pan, Pedersen, and Singleton (2011) suggest that much of the variation in sovereign spreads can be accounted for via global systematic factors rather than country-specific risk. Our interpretation of their results, in connection with our own, is that there are common risk factors that affect sovereign and corporate bond yields, and that these risk factors manifest themselves in variation in sovereign CDS spreads and exchange rate level and volatility innovations. The central question that we address in this paper is whether yield spreads on dollar-denominated corporates are immune from variation in exchange rates and exchange rate volatility. Even though the evidence in this section suggests that the sensitivity of dollar yield spreads to exchange rate innovations may be due to variation in factors common to exchange rates and sovereign CDS, the results still suggest that when exchange rates and their volatility change, there is an impact on the price of dollar-denominated corporate bonds. This sensitivity suggests that whether due to a factor common with sovereign CDS or specific to exchange rates, that dollar denominated corporate bonds are exposed to risks in exchange rates.

3 Modeling Dollar-Denominated Corporate Bond Prices

The evidence in the preceding section suggests that dollar-denominated bond prices are affected by sovereign credit risk and risk in the volatility of exchange rates. We specify and estimate a reduced-form model of risky bond prices following Duffie and Singleton (1997, 1999). In contrast to their model, spreads are allowed to be affected by not only the factors in the risk free term structure, but also sovereign credit risk and foreign exchange volatility. Thus, our model suggests that some of the variation in bond-specific hazard rates are absorbed by these systematic factors.

3.1 Pricing Risky Bonds

We specify a reduced-form model of bond prices following Duffie and Singleton (1999). Specifically, we assume that the price of a zero-coupon bond with default risk is given by

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

with R_s representing the instantaneous default-adjusted discount rate,

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

where r_t is the instantaneous risk free rate, i indexes bonds, δ is the rate of recovery on the debt, and $\lambda_{i,t}\,(1-\delta_i)$ is the spread in excess of the risk-free rate.

We specify the risk free term structure following Duffee (1999) as a two-factor term structure model in the affine class of models derived by Duffie and Kan (1996). We assume that the risk free rate can be expressed as an affine function of two state variables,

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

where 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, $(1-\delta_i)\lambda_{i,t}$, is modeled using 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, sovereign credit spreads, exchange rate volatility and a default risk variable,

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

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.[6] Duffie and Singleton (1999) note that one can view the hazard rate as the arrival intensity of a 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,

$$\ln P_{i,t}(\tau) = A_i(\tau) + \mathbf{B}'(\tau)\mathbf{x}_{i,t}^* + B_i(\tau) h_{i,t}, \tag{9}$$

where $x_{i,k,t}^* = (1+\beta_{i,k})x_{k,t}$ for $k = 1, 2$. The coefficients $A_i(\tau)$, $\mathbf{B}(\tau)$, 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

$$P_{i,t}(\tau, c) = E_t^Q \left[c \sum_{m=1}^{T-t} e^{-\int_t^{t+m} R_{i,s} ds} + e^{-\int_t^T R_{i,s} ds} \right], \tag{10}$$

where m indexes the periodic coupon payments.

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

$$\mathbf{Y}_t(\boldsymbol{\tau}) = a_f \boldsymbol{\iota} - \frac{1}{\tau} \left(\mathbf{A}(\boldsymbol{\tau}) + \mathbf{B}'(\boldsymbol{\tau}) \mathbf{x}_t \right) + \mathbf{u}_t \tag{11}$$

[6] 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.

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:

$$\begin{pmatrix} x_{1,t} \\ x_{2,t} \end{pmatrix} = \begin{pmatrix} \theta_1 (1 - e^{-\kappa_1}) \\ \theta_2 (1 - e^{-\kappa_2}) \end{pmatrix} + \begin{pmatrix} e^{-\kappa_1} & 0 \\ 0 & e^{-\kappa_2} \end{pmatrix} \begin{pmatrix} x_{1,t-1} \\ x_{2,t-1} \end{pmatrix} + \begin{pmatrix} w_{1,t} \\ w_{2,t} \end{pmatrix}, \tag{12}$$

where

$$\mathbf{w}_t \sim \mathcal{N}\left(\mathbf{0}, \begin{pmatrix} Q_{1,t} & 0 \\ 0 & Q_{2,t} \end{pmatrix}\right) \tag{13}$$

$$Q_{k,t} = x_{k,t}\frac{\sigma_k^2}{\kappa_k}\left(e^{-\kappa_k} - e^{-2\kappa_k}\right) + \theta_k \frac{\sigma_k^2}{2\kappa_k}\left(1 - e^{-\kappa_k}\right)^2, \quad k = 1, 2. \tag{14}$$

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 (10), measured with error:

$$P_{i,t}(\tau, c) = c \sum_{m=1}^{\tau} P_i(m) + P_i(\tau) + u_{i,t}, \tag{15}$$

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:

$$h_{i,t} = \frac{\theta_i \kappa_i}{\kappa_i + \eta_i}\left(1 - e^{-\kappa_i}\right) + e^{-\kappa_i} h_{i,t-1} + w_{i,t}, \tag{16}$$

where

$$w_{i,t} \sim \mathcal{N}(0, Q_{i,t}), \tag{17}$$

$$Q_{i,t} = h_{i,t-1}\frac{\sigma_i^2}{\kappa_i}\left(e^{-\kappa_i} - e^{-2\kappa_i}\right) + \theta_i \frac{\sigma_i^2}{2\kappa_i}\left(1 - e^{-\kappa_i}\right)^2. \tag{18}$$

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

We present the 25^{th} percentile, medians, and 75^{th} percentile of parameter estimates across all countries and within countries Table 5. For brevity, we do not present parameter estimates for the processes governing the evolution of the risk-free term structure, the sovereign credit spread, or the exchange rate volatility. Instead, we focus on the parameters underlying the default intensity process, κ, θ, λ, and σ, and the sensitivities to the risk-free term structure, β_1 and β_2.

The median point estimate of the mean reversion parameter, κ_i, is greater than two, suggesting strong mean reversion in default intensity. The median coefficient is approximately one order of magnitude larger than that reported in Duffee (1999). It is not immediately obvious why mean reversion in hazard rates should be so much higher in dollar-denominated corporate bonds issued in emerging markets. Duffee (1999) cites little variation across credit ratings in the median mean reversion parameter. We suspect that the difference may be due to the fact that additional factors are needed to price these bonds, although this suspicion remains conjecture. Variation in the point estimate appears wide across bonds and countries. At the extremes, the median point estimate in Chile is 0.69 compared to 3.22 in the Russian Federation.

The median point estimate of the long-run mean of the default intensity process, θ, is larger than, but comparable to the magnitude for Baa bonds in Duffee (1999). He reports a median estimate of 0.63 for Baa-rated bonds, which is comparable to the median estimate of 0.74 reported in Table 5. Russian bonds exhibit the highest median long-run mean of 0.82, while the lowest median is in Chile, with a point estimate of 0.58. The dispersion in point estimates is highest in Mexico, ranging from 0.27 at the 25^{th} percentile to 1.06 at the 75^{th} percentile. As the parameter can be interpreted as the long-run mean of the hazard rate, the results suggest that long-run means of the default intensities of emerging market dollar-denominated corporate bonds are somewhat higher than those of U.S. Baa-rated bonds.

The median estimate of the price of risk, λ, is -0.13, implying that investors demand compensation for variation in default risk. This median estimate is considerably smaller in magnitude than the median estimate in Duffee (1999) of -0.24. The parameter is difficult to estimate precisely; as shown in the table, the interquartile range contains zero. At the 25^{th} percentile, the point estimate is -0.47, whereas the 75^{th} percentile estimate is 0.25. Since positive point estimates suggest a discount for default risk, these estimates are puzzling. Moreover, in two countries, Chile and Russia, the median point estimate is positive. Only in Brazil are the median and 75^{th} percentile estimates negative. Duffee (1999) also notes difficulty in estimating the prices of risk, although the interquartile range in his estimates consist only of negative values.

Median estimates of the exposure to term structure factors, β_1 and β_2 are negative, at -0.64 and -0.42, respectively. These results are also consistent with those presented in Duffee (1999), and with the intuition in Longstaff and Schwartz (1995) that a rise in interest rates increases the drift of the risk neutral drift, resulting in a lowering of default probabilities. Russian bonds appear to be especially sensitive to the risk-free term structure with median point estimates of β_1 and β_2 of -1.45 and -0.86, respectively. These sensitivities are generally larger than those reported in Duffee (1999), suggesting that these bonds' yields have greater exposure to the factors in the U.S. term structure than U.S. corporate bonds.

The pricing errors of the model are slightly larger than, but comparable to those reported in Duffee (1999). The median RMSE is 13.52 basis points, with a 25^{th} percentile of 10.77 basis points and a 75^{th} percentile of 22.17 basis points. In contrast, Duffee (1999) reports a median estimate of approximately 10 basis points, a 25^{th} percentile of 7 basis points, and a 75^{th} 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. This variation is also quite marked across countries. Chilean and Mexican bonds exhibit smaller median RMSE and interquartile range than do other countries, suggesting that the model fits these bond prices somewhat better. Brazilian bonds' median pricing error of 13.23 basis points is similar to the overall median, but the range of RMSE extends from 9.66 basis points to 31.77 basis points. Finally, the median pricing error in Russia is quite high at 25.94 basis points. Thus, the model seems to fare better at pricing obligations in some countries than others.

3.4 Sensitivity of Default Intensity to Exchange Rate Variation

As discussed above, the default intensities, $h_{i,t}$, recovered from the estimation above are interpreted as the arrival intensity of a jump following default, which in turn reflect information about the probability of default and loss given default. In contrast to the yield spread, the default intensity reflects the component of the spread that is not related to pure interest rate risk. In this section, we examine whether foreign exchange level and volatility innovations have power to explain variation in these default intensities. The resulting evidence provides insight into whether, as suggested in the introduction, exchange rate risk is related to the risk of default in dollar-denominated corporate bonds.

Similar to our investigation of yield spreads, we aggregate data to the monthly level by selecting end-of-month observations on default intensities, exchange rates, and exchange rate volatility. We then regress the first difference of the default intensity of each bond on the first difference in log exchange rates and exchange rate volatility, as in equation (1). We present results of these regressions in Table 6. The Table reports quantiles of point estimates and the percentage of point estimates that are significantly greater than zero at the 5% critical level. As above, standard errors utilize the Newey-West correction for autocorrelation.

Results in Panel A represent the distribution of parameter estimates across countries. The median point estimates for exposure of default intensities to both foreign exchange innovations and volatility innovations is positive, and for the median bond these innovations explain approximately 20% of the variation in default intensity. Exchange rate level innovations are more uniformly positive than volatility innovations; at the tenth percentile, the point estimate of level innovation exposure is positive, whereas the point estimate of volatility innovation exposure is negative. However, slightly less than one-third of the point estimates of level innovation exposure are significantly greater than zero, whereas slightly more than one-third of the volatility innovation exposure point estimates are significantly greater than zero. Overall, 55.7% of bonds have positive and significant exposure to level innovation risk, volatility innovation risk, or both.

As is the case with exposures of bond yield spreads to innovations in exchange rates and innovations in volatility, there is considerable variation across countries in terms of explanatory power and magnitude of coefficients. In Brazil, exchange rate risk accounts for nearly 40% of the variation in default intensity of the median bond. Volatility seems to be a somewhat more important factor, with nearly two-thirds of the bonds exhibiting positive and significant exposure to volatility innovations, compared to approximately one-fifth with positive and significant exposure to level innovations. Overall, 73% of the bonds in Brazil are positively exposed to level innovations, volatility innovations, or both. Similarly, the median Korean bond exhibits positive exposure to both level and volatility innovations; 39% of bonds are positively and significantly exposed to level innovation risks and 72% to volatility innovation risks. Overall, 89% of Korean bonds are positively and significantly exposed to level risk, volatility risk, or both, and exchange rate risks capture 43% of the variation in default intensities of these bonds.

Explanatory power of exchange rate risks for Chilean and Mexican bonds are more modest. At the median, exchange rate risks explain 14% of the variation in Chilean default intensities and 18% of the variation in Mexican default intensities. The statistical significance of the results are considerably different across these countries, however. In Chile, nearly three-quarters of bonds exhibit positive and significant exposures to level innovation risk and approximately one-fifth of bonds exhibit positive and significant exposures to volatility innovation risk. In total, 82% of bonds exhibit positive and significant exposure to level innovations, volatility innovations, or both. In Mexico, only one bond exhibits positively statistically significant exposure to level innovation risk. Finally, in the Russian Federation, the default intensities of bonds are not significantly exposed to either form of exchange rate risk.

We draw two conclusions from this analysis. First, there are fewer bonds with significant exposure of default intensity to exchange rate risks than yield spreads. This suggests that some of our earlier findings were due to the common effect of exchange rate risks and risk free term structure risks on the variation in risky bond spreads. Second, exchange rate risks explain a fairly substantial proportion of default intensity. At the median, roughly 20% of the variation default intensity can be traced to a common source with exchange rate risks, and in Brazil and Korea, approximately 40% of the variation in default intensity can be traced to exchange rate risks. These results suggest that a sizeable fraction of the variation in what is typically thought of as firm-specific default risk can actually be traced to sources of exchange rate risk. That is, the results suggest that default risk in these bonds in part reflects variation in exchange rate risk, as suggested in the introduction.

3.5 Pricing Errors and Exchange Rate Risk

Our final analysis asks whether innovations to level and volatility of exchange rates have the potential to explain errors in pricing of bonds implied by our reduced form model. Put differently, in this section, we ask indirectly whether a model incorporating priced exchange rate risks might improve the ability of the model to fit the data. We do not formally pursue a model incorporating level and volatility innovation risk, as such a model would imply a fixed price of exchange rate level and volatility risk across bonds, at least within the same country. Tackling this problem is difficult for econometric reasons, as suggested above in the context of a price of default risk that is fixed across bonds.

Consistent with our earlier analyses, we aggregate pricing errors on bonds to the monthly frequency by selecting the observation at the end of the month. We regress these errors bond-by-bond on innovations in the exchange rate and the volatility of the exchange rate, measured by the MA(1), EGARCH(1,1) specification. Results of the estimation are presented in Table 7. We report 10^{th}, 25^{th},50^{th},75^{th}, and 90^{th} percentiles of point estimates and regression R^2. We also report the proportion of coefficients that are significantly different than zero at the 5% significance level, with standard errors corrected via the Newey-West procedure.

The most informative results in the table are the percentage of variation in pricing errors explained by the innovations and the proportion of coefficients that are statistically different than zero. Panel A of the table shows that for the median bond, innovations in exchange rate volatility and levels explain 10.68% of the variation in pricing errors; at the 90^{th} percentile the innovations explain 32.32% of the variation in pricing errors. Thus, as the table suggests, there is considerable potential scope for exchange rate risk innovations to explain the pricing errors of individual bonds. The table also shows that just under one-third of the level coefficients and one-fifth of the volatility coefficients are statistically different than zero. Overall, 44% of bonds have either level innovation coefficients, volatility innovation coefficients, or both that are statistically significant. The table also shows that exchange rate innovations absorb the most median variation in South Korea (23.23%), Mexico (13.36%), and the Russian Federation (9.03%).

Taken together with the results of the preceding section, we suggest that a model that incorporates both exchange rate risks and latent default risk is likely to improve on our ability to price emerging market dollar-denominated corporate bonds. The results of the preceding section indicate that a considerable degree of the variation in default intensities that we generally would attribute to firm default risk are actually absorbed by exchange rate level and volatility innovations, suggesting some common source of risk that drives variation in yield spreads. The results in this section indicate that including exchange rate innovation risk is likely to absorb a non-trivial amount of pricing error in these bonds. However, a model that incorporates these features is likely to be difficult to implement, as it would necessitate a multi-country term structure model and default risk that depends on exchange rate state variables.

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 and foreign exchange risk, a system of four variables follows risk neutral dynamics

$$\begin{pmatrix} dx_{1,t} \\ dx_{2,t} \\ dv_t \\ dh_{i,t} \end{pmatrix} = \left[\begin{pmatrix} \kappa_1 & 0 & 0 & 0 \\ 0 & \kappa_2 & 0 & 0 \\ 0 & 0 & \kappa_v & 0 \\ 0 & 0 & 0 & \kappa_i \end{pmatrix} \begin{pmatrix} \theta_1 \\ \theta_2 \\ \theta_v \\ \theta_i \end{pmatrix} - \begin{pmatrix} \kappa_1+\eta_1 & 0 & 0 & 0 \\ 0 & \kappa_2+\eta_2 & 0 & 0 \\ 0 & 0 & \kappa_v+\eta_v & 0 \\ 0 & 0 & 0 & \kappa_i+\eta_i \end{pmatrix} \begin{pmatrix} x_{1,t} \\ x_{2,t} \\ v_t \\ h_{i,t} \end{pmatrix} \right] dt$$
$$+ \begin{pmatrix} \sigma_1 & 0 & 0 & 0 \\ 0 & \sigma_2 & 0 & 0 \\ 0 & 0 & \sigma_v & 0 \\ 0 & 0 & 0 & \sigma_i \end{pmatrix} \begin{pmatrix} \sqrt{x_{1,t}} & 0 & 0 & 0 \\ 0 & \sqrt{x_{2,t}} & 0 & 0 \\ 0 & 0 & \sqrt{v_t} & 0 \\ 0 & 0 & 0 & \sqrt{h_{i,t}} \end{pmatrix} \begin{pmatrix} dW_{1,t}^Q \\ dW_{2,t}^Q \\ dW_{v,t}^Q \\ dW_{i,t}^Q \end{pmatrix}, \tag{A.1}$$

where $x_{1,t}$ and $x_{2,t}$ are state variables governing the default-free term structure, v_t is the foreign exchange variance, 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

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

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

$$\ln P_{i,t}(\tau) = A_i(\tau) + B_{i,1}(\tau) x_{i,1,t}^* + B_{i,2}(\tau) x_{i,2,t}^* + B_{i,v}(\tau) v_{i,t}^* + B_{i,h}(\tau) h_{i,t},$$

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

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

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

where $\gamma_j = \sqrt{(\kappa_j + \eta_j)^2 + 2\sigma_j^2}$, 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 exchange rates and exchange rate volatility,

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

where $\Delta S_{i,k,t}$ is the change in the spread over comparable Treasury security of bond i in country k at time t, $\Delta FX_{k,t}$ is the change in the exchange rate in country k at time t, and $\Delta FXV_{k,t}$ is the change in the volatility of the exchange rate in country k at time t. Exchange rate volatility is 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 10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th} percentiles of point estimates and R^2. Additionally, the final column of the table labeled $b_x > 0$ reports the percentage of coefficient $b_{fx,i,k}$ or $b_{v,i,k}$. that are statistically significantly greater than zero at the 5% critical level using Newey-West-corrected standard errors. Results in Panel A shown for all countries and results by country are shown in Panels B-F.

Panel A: All Countries

	P10	P25	P50	P75	P90	$b_x > 0$
$b_{fx,i,k}$	0.76	3.70	5.80	8.46	13.96	47.5
$b_{v,i,k}$	−5.88	−1.02	0.76	3.01	6.35	34.4
R^2	3.35	7.37	25.29	42.50	49.67	

Panel B: Brazil

	P10	P25	P50	P75	P90	$b_x > 0$
$b_{fx,i,k}$	3.47	3.70	5.91	10.18	13.96	90.9
$b_{v,i,k}$	0.59	0.77	2.41	13.85	16.95	63.6
R^2	28.87	30.80	42.96	47.05	48.93	

Panel C: Chile

	P10	P25	P50	P75	P90	$b_x > 0$
$b_{fx,i,k}$	0.69	0.76	3.83	4.32	4.82	45.5
$b_{v,i,k}$	−1.26	−0.42	−0.02	1.83	2.64	18.2
R^2	0.71	1.10	12.38	24.46	25.26	

Panel D: Mexico

	P10	P25	P50	P75	P90	$b_x > 0$
$b_{fx,i,k}$	0.63	4.53	7.79	8.55	8.86	36.4
$b_{v,i,k}$	−0.72	−0.61	0.51	1.61	1.92	0.0
R^2	2.25	11.42	22.83	30.42	34.10	

Table continued on next page.

Panel E: Russian Federation

	P10	P25	P50	P75	P90	$b_x > 0$
$b_{fx,i,k}$	7.30	8.46	14.63	23.69	25.20	0.0
$b_{v,i,k}$	−12.56	−11.43	−8.28	−5.59	−4.67	0.0
R^2	2.41	3.58	3.96	4.67	6.05	

Panel F: South Korea

	P10	P25	P50	P75	P90	$b_x > 0$
$b_{fx,i,k}$	0.43	2.92	4.16	5.90	6.50	55.6
$b_{v,i,k}$	−1.02	0.75	3.99	5.19	7.08	66.7
R^2	15.42	26.07	42.50	58.34	73.11	

Table 3: Cross-Sectional Determinants of Foreign Exchange Sensitivity

In Table 3, 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 2. 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*	*sales*	*debt*	*sales*	*debt*	*sales*	*debt*	*sales*	*debt*
Mean	0.65	0.56	0.60	0.70	0.03	0.67	0.17	0.76	0.02	0.48
Min	0.00	0.00	0.00	0.32	0.00	0.49	0.00	0.33	0.00	0.09
Max	1.00	0.80	1.00	0.83	0.18	0.90	0.35	1.00	0.26	1.00

Panel B: Regression Results

	coup	*mat*	*sales*	*debt*	$\bar{R}^2$
	Dependent Variable is $b_{fx,i,k}$				
Estimate	−0.11	1.94	−3.88	2.14	26.19
t-stat	−2.80	10.13	−4.51	2.10	
	Dependent Variable is $b_{v,i,k}$				
Estimate	0.02	−1.42	0.23	−1.86	18.53
t-stat	−0.64	−8.26	0.30	−2.04	

Table 4: Sensitivity of Spreads to Foreign Exchange Innovations and Volatility

Table 4 presents results regressing innovations in yield spreads on emerging market dollar-denominated bonds on innovations in exchange rates and exchange rate volatility,

$$\Delta S_{i,k,t} = a_{i,k} + b_{fx,i,k}\Delta FX_{k,t} + b_{v,i,k}\Delta FXV_{k,t} + b_{c,i,k}\Delta CDS_{k,t} + \epsilon_{i,k,t},$$

where $\Delta S_{i,k,t}$ is the change in the spread over comparable Treasury security of bond i in country k at time t, $\Delta FX_{k,t}$ is the change in the exchange rate in country k at time t, $\Delta FXV_{k,t}$ is the change in the volatility of the exchange rate in country k at time t, and $\Delta CDS_{k,t}$ is the change in the five-year CDS spread for country k at time t. Exchange rate volatility is 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. CDS spreads are obtained from Bloomberg. 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 10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th} percentiles of point estimates and R^2. Additionally, the final column of the table labeled $b_x > 0$ reports the percentage of coefficient $b_{fx,i,k}$ or $b_{v,i,k}$. that are statistically significantly greater than zero at the 5% critical level using Newey-West-corrected standard errors. Results in Panel A shown for all countries and results by country are shown in Panels B-F.

Panel A: All Countries

	P10	P25	P50	P75	P90	$b_x > 0$
$b_{fx,i,k}$	−17.32	−4.92	0.53	2.30	4.56	18.0
$b_{v,i,k}$	−1.65	−0.50	0.82	2.47	3.92	19.7
$b_{c,i,k}$	0.29	0.55	0.78	1.98	3.28	67.2
R^2	14.34	30.47	49.71	67.93	74.12	

Panel B: Brazil

	P10	P25	P50	P75	P90	$b_x > 0$
$b_{fx,i,k}$	−4.87	0.67	1.38	5.31	6.64	36.4
$b_{v,i,k}$	0.12	0.64	1.86	10.51	12.70	54.5
$b_{c,i,k}$	0.13	0.36	0.60	3.28	4.03	81.8
R^2	40.97	42.42	51.49	70.14	73.50	

Panel C: Chile

	P10	P25	P50	P75	P90	$b_x > 0$
$b_{fx,i,k}$	−0.39	−0.18	2.26	3.12	3.76	45.5
$b_{v,i,k}$	−2.40	−1.01	−0.56	0.49	0.82	0.0
$b_{c,i,k}$	0.29	0.50	0.77	1.05	1.07	54.5
R^2	2.89	9.73	25.64	36.97	42.49	

Panel D: Mexico

	P10	P25	P50	P75	P90	$b_x > 0$
$b_{fx,i,k}$	−0.25	0.41	2.30	3.36	3.91	9.1
$b_{v,i,k}$	−0.55	−0.46	0.82	1.31	2.21	0.0
$b_{c,i,k}$	0.04	0.14	0.59	0.66	0.70	36.4
R^2	6.30	14.81	29.42	39.72	52.85	

Table continued on next page.

Panel E: Russian Federation

	P10	P25	P50	P75	P90	$b_x > 0$
$b_{fx,i,k}$	-31.69	-26.13	-18.32	-15.76	-12.72	0.0
$b_{v,i,k}$	-1.51	-0.35	2.35	3.08	6.79	0.0
$b_{c,i,k}$	1.80	1.98	2.23	3.70	4.15	1.0
R^2	58.34	65.96	72.72	76.31	77.48	

Panel F: South Korea

	P10	P25	P50	P75	P90	$b_x > 0$
$b_{fx,i,k}$	-10.03	-4.92	-3.54	0.83	4.56	5.6
$b_{v,i,k}$	-1.65	-0.24	1.01	3.28	4.15	33.3
$b_{c,i,k}$	0.37	0.73	1.25	1.98	2.12	66.7
R^2	27.34	42.59	59.29	72.44	82.70	

Table 5: Parameter Estimates and Pricing Errors

Table 5 presents parameter estimates of the defaultable component of bond prices as affected by exchange rate risk,

$$P_{i,t}(\tau, c) = E_t^Q \left[c \sum_{m=1}^{T-t} e^{-\int_t^{t+m} R^*_{i,k,s} ds} + e^{-\int_t^T R^*_{i,k,s} ds} \right]$$

where the risk-neutral defaultable yield, $R^*_{i,k,s}$, in country k is specified as

$$R_{i,k,s} = a_i + h_{i,t} + \boldsymbol{\beta}_i' (\mathbf{x}_t - \bar{\mathbf{x}}).$$

The variables $\mathbf{x}_t = \{x_{1,t}, x_{2,t}\}$ are the state variables implied by parameter estimates from the risk free term structure, and $h_{i,t}$ is the hazard rate, which follows the stochastic differential equation

$$dh_{i,t} = (\kappa_i \theta_i - (\kappa_i + \eta_i))\, dt + \sigma_i \sqrt{h_{i,t}} dW^Q_{i,t}.$$

Parameters are estimated via the extended Kalman filter using discrete time Euler approximations to continuous time dynamics. Parameters are estimated for 61 bonds across five countries using daily observations on bond yields. We report 25th percentile, median, and 75th percentile estimates and model root mean squared error for the full sample and within each country.

Country	Pct	κ	θ	λ	σ	β_1	β_2	α	RMSE
All	25	1.303	0.499	-0.471	0.122	-1.649	-1.037	-0.982	10.772
	50	2.211	0.741	-0.134	0.278	-0.638	-0.424	-0.787	13.521
	75	4.062	0.858	0.252	0.612	-0.055	-0.144	-0.307	22.172
Brazil	25	1.566	0.705	-0.749	0.151	-1.693	-1.436	-1.284	9.659
	50	2.797	0.792	-0.417	0.405	-1.455	-0.871	-0.972	13.229
	75	4.815	1.098	-0.087	0.746	-0.145	-0.726	-0.720	31.769
Chile	25	0.002	0.388	-0.252	0.093	-0.377	-0.396	-0.982	9.462
	50	0.690	0.583	0.170	0.132	-0.055	-0.170	-0.460	10.900
	75	1.542	0.802	0.789	0.220	0.033	0.020	-0.084	15.311
Mexico	25	0.770	0.268	-0.637	0.205	-1.649	-0.721	-1.051	8.475
	50	2.685	0.658	-0.068	0.417	-0.541	-0.362	-0.504	10.864
	75	4.616	1.062	0.874	0.767	-0.042	-0.143	-0.202	12.741
Russia	25	2.241	0.694	-0.363	0.445	-4.291	-2.682	-0.927	22.663
	50	3.215	0.822	0.247	0.612	-2.305	-1.446	-0.860	25.939
	75	4.062	0.893	0.570	0.693	-1.540	-1.296	-0.459	45.735
S. Korea	25	1.283	0.402	-0.572	0.076	-1.492	-0.641	-0.961	11.970
	50	1.641	0.760	-0.175	0.186	-0.516	-0.354	-0.807	16.703
	75	5.902	1.064	0.008	0.460	0.000	-0.130	-0.307	19.364

Table 6: Sensitivity of Default Intensity to Foreign Exchange Innovations and Volatility

Table 6 presents results regressing innovations in default intensities of emerging market dollar-denominated bonds on innovations in exchange rates and exchange rate volatility,

$$\Delta h_{i,k,t} = a_{i,k} + b_{fx,i,k}\Delta FX_{k,t} + b_{v,i,k}\Delta FXV_{k,t} + \epsilon_{i,k,t},$$

where $\Delta h_{i,k,t}$ is the change in the default intensity of bond i in country k at time t, $\Delta FX_{k,t}$ is the change in the exchange rate in country k at time t, and $\Delta FXV_{k,t}$ is the change in the volatility of the exchange rate in country k at time t. The default intensity is recovered using the Kalman filter and parameters estimated from a reduced-form pricing model similar to Duffie and Singleton (1999). Exchange rate volatility is 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 10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th} percentiles of point estimates and R^2. Additionally, the final column of the table labeled $b_x > 0$ reports the percentage of coefficient $b_{fx,i,k}$ or $b_{v,i,k}$. that are statistically significantly greater than zero at the 5% critical level using Newey-West-corrected standard errors. Results in Panel A shown for all countries and results by country are shown in Panels B-F.

Panel A: All Countries

	P10	P25	P50	P75	P90	$b_x \neq 0$
$b_{fx,i,k}$	0.06	0.41	0.93	2.52	4.77	29.51
$b_{v,i,k}$	−1.25	−0.14	0.13	1.05	2.44	36.07
R^2	4.28	8.31	19.71	38.59	52.07	

Panel B: Brazil

	P10	P25	P50	P75	P90	$b_x \neq 0$
$b_{fx,i,k}$	0.55	1.19	1.49	2.26	3.57	18.18
$b_{v,i,k}$	0.47	0.84	2.03	3.47	3.72	63.64
R^2	16.95	21.43	39.54	46.71	46.88	

Panel C: Chile

	P10	P25	P50	P75	P90	$b_x \neq 0$
$b_{fx,i,k}$	0.17	0.27	0.85	1.32	2.65	72.73
$b_{v,i,k}$	−0.53	−0.38	0.06	0.68	0.74	18.18
R^2	5.30	8.31	14.16	27.42	33.22	

Panel D: Mexico

	P10	P25	P50	P75	P90	$b_x \neq 0$
$b_{fx,i,k}$	0.00	0.30	0.68	2.94	3.15	9.09
$b_{v,i,k}$	−0.14	−0.01	0.05	0.37	0.76	0.00
R^2	1.11	7.21	17.71	20.14	25.57	

Table continued on next page.

Panel E: Russian Federation

	P10	P25	P50	P75	P90	$b_x \neq 0$
$b_{fx,i,k}$	0.17	1.18	3.79	7.61	9.96	0.00
$b_{v,i,k}$	-6.33	-5.36	-2.13	-0.78	-0.11	0.00
R^2	2.25	3.64	4.56	6.84	7.50	

Panel F: South Korea

	P10	P25	P50	P75	P90	$b_x \neq 0$
$b_{fx,i,k}$	0.01	0.19	0.61	1.00	1.46	38.89
$b_{v,i,k}$	-0.13	0.09	0.49	1.11	3.21	72.22
R^2	17.36	24.25	43.00	54.33	70.06	

Table 7: Explanatory Power of Exchange Rate Innovations for Bond Pricing Errors

Table 7 presents results regressing yield spread pricing errors of emerging market dollar-denominated bonds on innovations in exchange rates and exchange rate volatility,

$$\Delta h_{i,k,t} = a_{i,k} + b_{fx,i,k}\Delta FX_{k,t} + b_{v,i,k}\Delta FXV_{k,t} + \epsilon_{i,k,t},$$

where $\Delta h_{i,k,t}$ is the change in the default intensity of bond i in country k at time t, $\Delta FX_{k,t}$ is the change in the exchange rate in country k at time t, and $\Delta FXV_{k,t}$ is the change in the volatility of the exchange rate in country k at time t. The pricing error is the error from the Kalman filter estimate of a reduced-form pricing model similar to Duffie and Singleton (1999). Exchange rate volatility is 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 10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th} percentiles of point estimates and R^2. Additionally, the final column of the table labeled $b_x > 0$ reports the percentage of coefficient $b_{fx,i,k}$ or $b_{v,i,k}$. that are statistically significantly different than zero at the 5% critical level using Newey-West-corrected standard errors. Coefficients are multiplied by 100. Results in Panel A shown for all countries and results by country are shown in Panels B-F.

Panel A: All Countries

	P10	P25	P50	P75	P90	$b_x > 0$
$b_{fx,i,k}$	−0.26	0.19	0.72	1.05	2.36	32.79
$b_{v,i,k}$	−0.99	−0.47	0.03	0.22	0.46	18.03
R^2	0.65	2.86	10.68	20.22	32.32	

Panel B: Brazil

	P10	P25	P50	P75	P90	$b_x > 0$
$b_{fx,i,k}$	−0.26	0.02	1.04	3.03	3.24	54.55
$b_{v,i,k}$	−0.57	−0.50	−0.22	−0.06	0.06	9.09
R^2	2.59	2.86	5.31	11.16	17.15	

Panel C: Chile

	P10	P25	P50	P75	P90	$b_x > 0$
$b_{fx,i,k}$	−0.98	−0.21	0.03	0.39	0.71	9.09
$b_{v,i,k}$	−0.10	−0.07	0.12	0.39	0.43	0.00
R^2	0.40	0.75	3.17	11.02	11.47	

Panel D: Mexico

	P10	P25	P50	P75	P90	$b_x > 0$
$b_{fx,i,k}$	0.21	0.22	0.81	0.96	1.05	45.45
$b_{v,i,k}$	−0.64	−0.60	−0.36	0.10	0.20	9.09
R^2	1.71	5.05	13.36	22.08	25.43	

Table continued on next page.

Panel E: Russian Federation

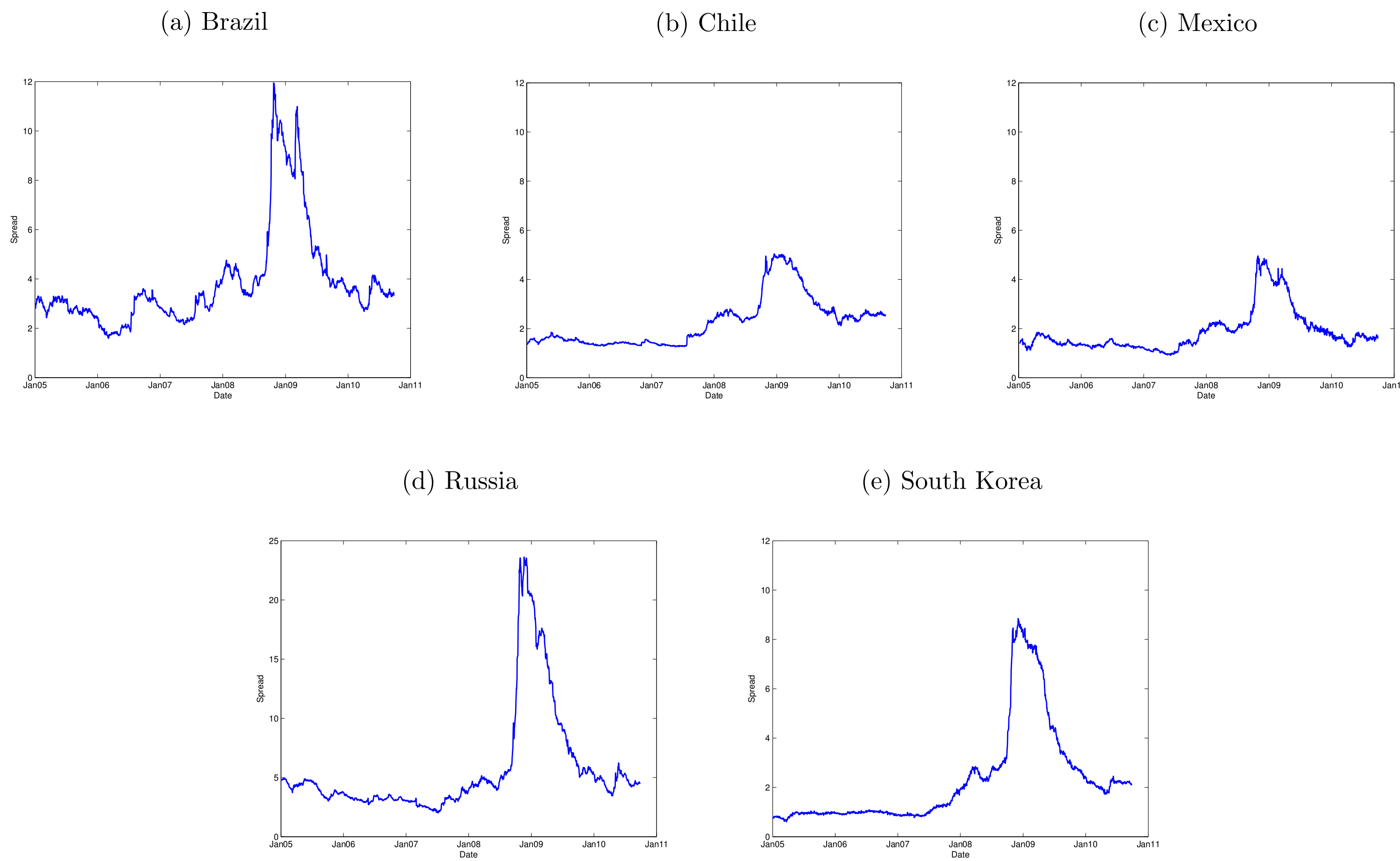
	P10	P25	P50	P75	P90	$b_x > 0$
$b_{fx,i,k}$	-2.00	2.86	1.34	2.21	2.97	20.00
$b_{v,i,k}$	-1.85	-1.66	-0.47	0.08	2.28	30.00
R^2	0.42	1.53	9.03	14.48	22.00	

Panel F: South Korea

	P10	P25	P50	P75	P90	$b_x > 0$
$b_{fx,i,k}$	0.12	0.40	0.92	1.20	2.96	33.33
$b_{v,i,k}$	-0.77	0.04	0.24	0.47	0.74	33.33
R^2	0.47	6.78	23.23	36.11	47.85	

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.

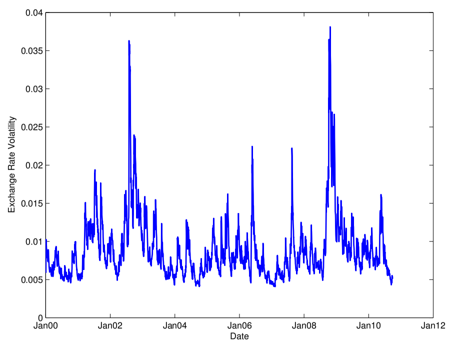


(a) Brazil (b) Chile (c) Mexico (d) Russia (e) South Korea

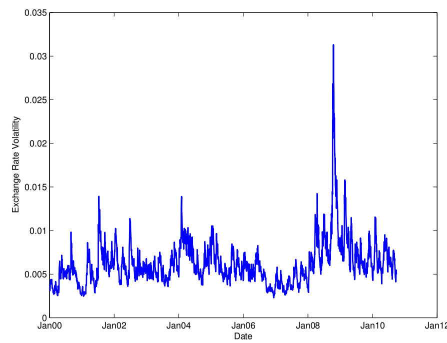
Figure 2: Time Series of Exchange Rate Volatility

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.

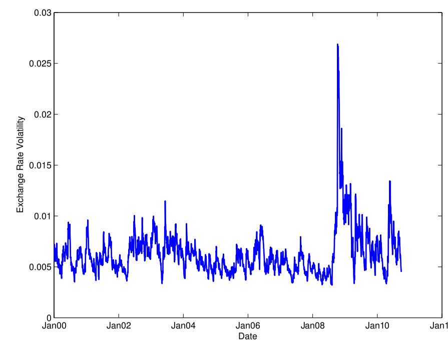
(a) Brazil



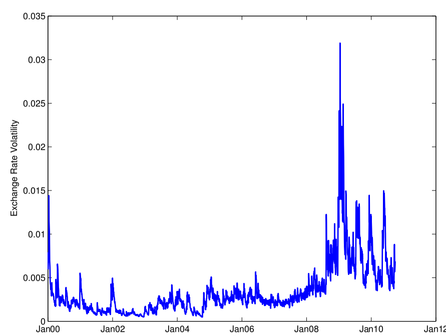
(b) Chile



(c) Mexico



(d) Russia



(e) South Korea