The Term Structure of Country Risk and Valuation in Emerging Markets *

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Abstract
The prevailing valuation technique in Emerging Markets adds the country risk spread to the discount rate in an ad-hoc manner. This practice does not account for the term structure of default risk. The mismatch between the duration of the project being valued and the duration of the measure of country risk used, such as J.P. Morgan’s EMBI, leads to an overvaluation (undervaluation) of long-term projects when the term structure of default risk is upward (downward) sloping. Even if the term structure of default risk were flat, this practice implies attenuating the covariance risk premium. Using sovereign bond data from five Emerging Markets, we estimate a simple model that captures most of the variation of expected collection at different horizons for a given country at one point in time. We show the mispricing errors that are likely to be incurred in practice and how our model can be used to avoid them.

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I. Introduction

Investment projects in emerging markets are generally perceived as riskier than otherwise similar projects in developed countries. The “additional risks” include currency inconvertibility, civil unrest, institutional instability, expropriation, and widespread corruption. Emerging markets (henceforth EM) are also more volatile than developed economies: their business cycles are more intense, and inflation and currency risks are higher.¹

Several problems have restricted the use among practitioners of the Capital Asset Pricing Model (CAPM) or its international version, the IAPM, to calculate the cost of capital of projects in EM. First, there is no complete agreement about the degree of integration of EM capital markets to the world market (see Errunza and Losq, 1985, and Bekaert et al., 2001). Second, local returns are non-normal, show significant first-order autocorrelation (Bekaert et al., 1998), and there are problems of liquidity and infrequent trading (Harvey, 1995). Finally, as these additional risks are seldom covariance risks, the cost of capital that emerges from the IAPM appears as “too low”.

Traditional finance theory would suggest dealing with idiosyncratic risks in the numerator and handling covariance risks by adjusting the discount rate of a present value equation. But given the practical difficulty of estimating truly expected cash flows and the lack of consensus among academics on what the appropriate discount rate should be, the standard approach is to use the most likely dividends in the numerator and hike the discount rate to penalize for the additional risks of EM. Godfrey and Espinosa (1996), for instance, propose to calculate the cost of capital in EM (\(k\)) by using

\[
E(k_j) = f + CS_j + 0.6 \frac{\sigma_j}{\sigma_{US}} E(r_{US}^m - f) \tag{1}
\]

¹ Neumeyer and Perri (2001) find that output in Argentina, Brazil, Korea, Mexico and Philippines is at least twice as volatile as it is in Canada.
where \( f \) is the risk free rate, \( CS_j \) is the credit spread between the yield of a U.S. dollar-denominated EM sovereign bond of country \( j \) and the yield of a comparable U.S. bond, and the term preceding the last parenthesis is an “adjusted beta”, that is equivalent to 60% of the ratio of the volatility of the domestic market to that of the U.S. market.\(^2\) Although there are different versions of this model (see Pereiro and Galli, 2000, Abuaf and Chu, 1994, and Harvey, 2001), all of them add the country risk to the U.S. risk free rate in order to define the EM’s “analog” of the U.S. risk free rate.

There are few systematic surveys of cost of capital estimation practices in EM, but those available show that variants of this model are the most widely used among practitioners. Keck et al. (1998) find in a survey of Chicago School of Business graduates that in international valuations most respondents adjust discount rates for factors such as political, sovereign, or currency risks. Pereiro and Galli (2000) show that the vast majority of Argentine firms add the country risk to the U.S. risk free rate.\(^3\)

Several objections have been raised in the literature to the addition of the country risk to the discount rate. First, the model lacks any sound theoretical foundation (Harvey, 2001). Second, in most versions of this model country risk is double counted, since part of the variability in local market returns is correlated with country risk and this correlation is likely to vary across countries (Estrada, 2000). Third, for global investors part of the country risk is diversifiable, and hence it should not be included in the discount rate. Fourth, although this model gives a unique discount rate for all projects, the “additional” risks inherent to EM do not have a uniform impact on all firms and projects (Harvey, 2001). For example, the country risk may be high because the market expects a sharp devaluation that would deteriorate the public sector’s financial position. A devaluation, however, would benefit some sectors (e.g., exporters), and damage others (e.g., importers).

\(^2\) The 60% adjustment is due to the finding of Erb, Harvey and Viskanta (1995) that on average, about 40% of the volatilities of emerging equity markets are explained by variations in credit quality. To avoid double-counting credit risk, only the fraction of equity variation that is unaccounted for by variation in credit spreads is taken into account --see Godfrey and Espinosa (1996) for details.

\(^3\) A number of important investment banks also add the country spread to the discount rate (Harvey, 2001).
In this paper we show that there is a very narrow set of circumstances under which this approach delivers correct values and propose a simple and more general method that provides more accurate values than the current practice.

First and foremost, we show that the mismatch between the duration of the project under valuation and the duration of the most widely used measures of country risk leads to an overvaluation (undervaluation) of long-term projects when the term structure of default risk is upward (downward) sloping. The reverse is true for short-term projects. Second, we show that even if each cash flow were discounted with $CS_j$ in (1) matching the duration of that cash-flow, this would imply attenuating the covariance risk premium.4

The country risk measures most widely used are J.P. Morgan’s Emerging Market Bond Index (EMBI), and its extensions EMBI+ and EMBI-Global (see Pereiro, 2001). Assuming zero covariance risk, using these default risk measures in the discount rate to value long-term projects would bear no additional problem to the ones mentioned above if the default risk term structure were flat. But, in fact, this is not the case. In normal times, default risk spreads are low at the short end of the curve and slope upward for longer durations. Often times, however, the default risk term structure is downward sloping --as when the market expects a default in the short run. Figure I.C. illustrates our first point: if, say, the project at hand had a duration of four years and Argentina’s and Russia’s EMBI spreads had a duration of two years each, valuation according to (1) would have overestimated the value of the Argentinean relative to the Russian project.

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4 To overcome some of the criticisms to using (1) Harvey (2001) proposes a model, based on Erb, Harvey and Viskanta (1996), that relates expected returns to credit ratings according to $E(k_j) = \hat{a}_0 + \hat{a}_1 \ln(CCR_j)$, where $CCR_j$ is country $j$’s credit rating, as measured by Institutional Investor’s semiannual survey of bankers. Our first critique also applies to this model, given that a single $CCR$ is used to discount project cash flows of different maturities, when the true credit risk varies by horizon. Moreover, the horizon for which credit ratings are assessed is likely to vary across countries to match that of the loans extended to each nation by banks (see Cruces, 2001, for details). Our second critique is harder to show based on Harvey’s proposal since he mixes the covariance and institutional risks of EM in one $CCR$ measure. Therefore the rest of the paper focuses on equation (1).
In addition, there is a high cross-country variability in the average duration of the EMBI-Global country components (see Figure II).\(^5\) While the average duration for Bulgaria is lower than one year, for Poland it is eight years. This variability undermines the significance of net present value comparisons of otherwise similar projects in different countries, discounted in each country with the EMBI Global as the country spread used in equation (1).

Using sovereign bond data from five Emerging Markets, we estimate a simple model that captures most of the variation in the sequence of expected collection for a given country at one point in time. This model can be used to solve the misvaluation problem.

The paper proceeds as follows. Section II presents the model, discusses the conditions under which the current practice provides the right solution and obtains the correct valuation under a more general set of circumstances. Section III describes the data and section IV presents the estimation results. Section V concludes.

II. The Model

II.1. Bond Prices and Expected Collection

Let \(r_{0,t}\) be the yield to maturity implicit in the price of a risky sovereign zero-coupon bond denominated in U.S. dollars issued at time 0 and maturing at time \(t\). Similarly, let \(f_{0,t}\) be the expected return of holding this bond during the same time interval.\(^6\) In line with Claessens and Pennacchi (1996) and Cumby and Pastine (2001) we assume that EM sovereign bonds carry no systematic risk and so \(f\) is the risk free rate. Let \(Q_t\) be the probability of full payment

\(^5\) Naturally, not all practitioners use the EMBI spread as a measure of country risk, although anecdotal evidence suggests that it is the preferred one (see for instance Pereiro, 2001). The most important feature of the literature and of investment bank brochures we have reviewed, however, is the use of one rate per country regardless of the duration of the project under valuation. Some acknowledge the problem of cross-country comparison and use bonds of similar maturities (but not duration) for all countries. Mariscal and Hargis (1999), for instance, use 10-year Eurobonds, while Shores and Santos (2001) use 30-year bonds.

\(^6\) Both \(r_{0,t}\) and \(f_{0,t}\) are quoted on a per-period basis and we omit the \(j\) country subscript from now to avoid clutter.
on this bond, and $\gamma$, the recovery rate in the event of default. For a one-period bond issued at time zero, these definitions imply,

$$Q_1 (1 + r_{0,1}) + (1 - Q_1) \gamma, (1 + r_{0,1}) = 1 + f_{0,1} \quad .$$

(2)

Rearranging the left-hand side gives the expected collection per dollar due, $P_1$,

$$P_1 = Q_1 + (1 - Q_1) \gamma = \frac{1 + f_{0,1}}{1 + r_{0,1}} \quad .$$

(3)

Similarly, if there is another bond issued at $t=0$ and maturing at $t=2$, we have

$$P_2 (1 + r_{0,2})^2 = (1 + f_{0,2})^2 \quad .$$

(4)

So given a sequence of promised and expected yields for zero-coupon zero-beta bonds of different maturities we can extract the sequence of expected collections for different horizons implicit in bond prices. We call default spread the ratio $(1 + r_{0,t})/(1 + f_{0,t})$. From (3) and (4) it is easy to see that if the default spread is constant for all $t$, then

$$P_t = P_t' \quad .$$

(5)
The case of constant default spreads corresponds to a risky yield curve whose slope is that of the risk free yield curve times $1/P_t$. As we argued in Section I, this case is a rare exception in the data. Most of the time, EM default spreads vary with duration. To account for this, we propose a reduced form model for expected collection over time that seems consistent with the data,\(^8\)

\[
P_t = \begin{cases} 
    P_t & \text{if } t = 1 \\
    \mu P_t^{\delta_t} & \text{if } t \geq 2
\end{cases}. \tag{6}
\]

Note that this model reduces to (5) in the special case of constant default spreads (i.e., $\mu = \delta = 1$).

\section*{II.2. Implications on Valuation in EM}

The volatile environments of EM aggravate the usual difficulties of forecasting dividends many years into the future under different states of nature and their associated probabilities. The standard response to this problem has been to work with the most likely dividends (or the expected dividends under normal circumstances) in the numerator of a present value equation and to add extra factors to the discount rate as in equation (1) to penalize for the upward bias of the most likely dividends in estimating the true expected dividends (see Keck et al., 1998, Pereiro and Galli, 2000, Abuaf and Chu, 1994, Godfrey and Espinosa, 1996). This can be interpreted in terms of the typical “downward” risks of EM noted by Estrada (2000).

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\(^7\) If default spreads are constant for all \(t\), then from (3) and (5) \(r_{0,t} = \frac{1}{P_t} \left( 1 - P_t + f_{0,t} \right) \). In this case, the slopes of the two yield curves will be related by \(r_{0,t+s} - r_{0,t} = \frac{1}{P_t} \left( f_{0,t+s} - f_{0,t} \right) \). Note that when the risk free yield curve is flat, the risky yield curve would also be flat.

\(^8\) See Merrick (2001) and Yawitz (1977) for alternative specifications.
Consider the case of a firm located in an EM whose expected dividends conditional on normal circumstances are $\hat{d}$ (constant) per period forever.\(^9\) Let \( r_{0,\tau} + \beta MP \) be the constant per-period discount rate stemming from (1), where \( \tau \) stands for the interest rate duration of the bond portfolio used to measure the country risk, and \( \beta MP \) is analogous to the last term in (1).\(^10\) In this case, the common practice is to compute the value of the firm as

\[
\hat{V} = \sum_{r=1}^{\infty} \frac{\hat{d}}{(1 + r_{0,\tau} + \beta MP)^r} = \frac{\hat{d}}{r_{0,\tau} + \beta MP} . \tag{7}
\]

We call \( \hat{V} \) “miscalculated value”, for reasons that will become apparent below. Note that, from (4),

\[
1 + r_{0,\tau} = \frac{1 + f_{0,\tau}}{P_{\tau}^{\hat{f}}} , \tag{8}
\]

so that (7) is equivalent to

\[
\hat{V} = \sum_{r=1}^{\infty} \frac{\left(P_{\tau}^{\hat{f}}\right)^r \hat{d}}{(1 + f_{0,\tau} + P_{\tau}^{\hat{f}} \beta MP)^r} = \frac{P_{\tau}^{\hat{f}} \hat{d}}{1 + f_{0,\tau} + P_{\tau}^{\hat{f}} \beta MP - P_{\tau}^{\hat{f}}} . \tag{9}
\]

Therefore, the standard approach is tantamount to adjusting central scenario dividends by direct compounding of the \( \tau \)-th root of the expected collection \( \tau \)-periods hence, and using in the denominator an expected return where the market premium is attenuated by \( P_{\tau}^{\hat{f}} \).

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\(^9\) We use “most likely dividends,” “central scenario dividends,” and “expected dividends conditional on normal circumstances” interchangeably.

\(^{10}\) Here \( r_{0,\tau} = f_{0,\tau} + CS_{0,\tau} \) in (1).
We argue that this is not the best way to convert central scenario dividends into expected dividends, as it does not make an efficient use of the data available from bond markets. Our proposed alternative consists in using the actual sequence of expected collections on government bonds, \( P_t \), as a proxy for the likelihood that central scenario dividends will be realized in each period. The idea is that in the states of nature in which the government breaks its promise to lenders it might also break its promise to foreign direct investors about respecting property rights and it might impose similar losses on both types of investors.\(^{11}\)

On the one hand, the government could be more likely to violate the rights of direct investors than those of bondholders. Given that the secondary market for direct investment claims is much less liquid than that for sovereign bonds, it is relatively more costly for direct investors to get rid of their firms than it is for bondholders and the government may take advantage of this fact.

On the other hand, direct investors are stakeholders in the local economy and have more retaliatory power than bondholders. While both types of investors can threaten to curtail future investment, direct investors can backfire immediately by laying off workers (so raising civilian unrest), postponing the liquidation of foreign exchange earnings (so further reducing the demand for local currency in times of runs on the currency), or delaying investments currently underway, etc. So the government may actually be less hostile towards direct investors.

We use the working assumption of equal expected collection of central scenario cash flows for the bond and equity markets, implicitly assuming that these effects might cancel one another out. Equation (9) shows that the standard practice tacitly makes a similar assumption, though it uses an adjustment factor in the numerator, which -under our hypothesis- may be inconsistent with the information provided by bond markets. Our proposal does not provide a solution to the fact that expected collections may vary by sector of industry. Our contribution is to compute the mispricing errors that arise from (9) when the term structure of default risk is non flat and to provide a simple solution to adjust the valuation for any term structure of...
expected collection. Moreover, our proposal is immune from the attenuation of the covariance risk premium noted in (9).

We can think that the amount of dividends received and the maintenance of the current property rights are not independent events. Let $g_{DL}(d,l)$ denote the joint probability density function of these two random variables. While $D$ is a continuous positive random variable, $L$ is discrete and equals 1 under normal circumstances and 0 when the government (at least partially) violates property rights. Then, expected year-$t$ dividends are

$$E(D_t) = \sum_{l=0}^{\infty} d_l g'_{DL}(d,l) \, dl$$

(10)

Given that the joint density is always equal to the product of the conditional and the marginal densities, (10) can be rearranged as,

$$E(D_t) = \Pr(L_t = 1)E(D_t \mid L_t = 1) + \Pr(L_t = 0)E(D_t \mid L_t = 0)$$

(11)

Note that $\hat{d}_t$ is equal to $E(D_t \mid L_t = 1)$. If we associate $\Pr(L_t = 1)$ with the probability of full payment on sovereign debt in year $t$ and assume that foreign director investors will be confiscated a similar amount than bondholders in the event of default in that year, then we can set $E(D_t \mid L_t = 0) = \gamma, \hat{d}_t$. Plugging this in (11) gives,

$$E(D_t) = [Q_t + (1 - Q_t)\gamma, \hat{d}_t] = P_i \hat{d}_t$$

(12)

Conditional on these assumptions, the “true value”, $V$, of the firm would be

$$V = \sum_{i=1}^{\infty} \frac{P_i \hat{d}}{(1 + \delta_i)^t}$$

(13)

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12 See Robichek and Myers (1966) and Chen (1967) for an old debate about the effects on discount rates of alternative assumptions about the resolution of uncertainty over time.
where \( i_{0,t} \) is the expected rate of return of investing in this firm, and the numerator gives the expected dividend each period. In equation (13) \( i_{0,t} \) does not include the sovereign spread and we can easily assume that it is constant.\(^{13}\) In financially integrated markets where the CAPM holds, \( i \) would approximately be equal to the risk-free rate plus the beta of the firm with respect to the world portfolio times the world market portfolio premium.\(^{14}\) In segmented markets, beta and the market premium would be measured locally.

Given the proposed model for \( P_t \) in (6), equation (13) can be solved as

\[
V = \frac{\hat{d}}{1 + f + \beta MP} \left\{ P_t + \frac{\mu P_t^{25}}{1 + f + \beta MP - P_t^\delta} \right\} \tag{14}
\]

and so the practitioner, by using (9) instead of (14) would be introducing a mispricing error \( m \), given by

\[
m = \frac{\hat{V} - V}{V} \tag{15}
\]

We can analytically distinguish between two sources of this mispricing error. The first one arises, as is the main argument in this paper, from the use of a constant country spread rate (\( CS_j \)) that is obtained from a bond portfolio with a duration different from that of the project under valuation. To see that, let \( \beta = 0 \) in equations (9) and (14). We can express them, respectively, as

\[
\hat{V} = \frac{P_t^{1\hat{\delta}} \hat{d}}{1 + f - P_t^{1\hat{\delta}}} = \frac{\hat{d}}{1 + f} \left\{ P_t^{1\hat{\delta}} + \frac{P_t^{2\hat{\delta}}}{1 + f - P_t^{1\hat{\delta}}} \right\} \tag{9a}
\]

\(^{13}\) Note that \( i_{0,t} = f_{0,t} + \beta MP \). In Section V we show that given that the term structure of the risk-free rate is relatively flat, assuming \( f_{0,t} = f \) is not a likely source of error.

\(^{14}\) Plus a term that reflects a premium for real exchange rate risk. See Adler and Dumas (1983).
and

\[ V = \frac{\hat{d}}{1+f} \left[ P_1 + \frac{\mu P_1^{25}}{1+f-P_1^\delta} \right] \]  

(14a)

From (9a) and (14a), and assuming that \( \tau \) is smaller than the duration of a perpetuity, it can be easily shown that \( \delta > 1 (\delta < 1) \) implies \( m > 0 (m < 0) \).

Let \( r_{0,v} = (1+f) \left[ P_1 + \frac{\mu P_1^{25}}{1+f-P_1^\delta} \right] \) in (14a) (so that \( V = \hat{d}/r_{0,v} \)) where \( v \) is the duration of the perpetuity. From this and equation (7) in the special case of \( \beta = 0 \), the mispricing ratio becomes

\[ m = \frac{\hat{V}-V}{V} = \frac{r_{0,v}-r_{0,\tau}}{r_{0,\tau}} \]  

(15a)

The mispricing ratio has a straightforward interpretation. If the default spread is upward sloping and \( \tau \) is smaller than the duration of the project, \( v \) (so that \( r_{0,v} > r_{0,\tau} \)), then the standard practice overestimates the value of the project \((m>0)\). This is because such method uses in the numerator of (9) a direct compounding of an expected collection that is very high for the short run, and that when compounded directly over time, gives values of expected collections for long-run dividends that are too high relative to what is implicit in contemporaneous long bond prices. Hence the overestimation.

It could be argued, then, that just by using the “right” credit spread in the denominator of each term in (7) we would get a correct valuation. This indeed is not the case. Using the “right” rate from the term structure of sovereign yields to discount central scenario dividends gives a value of the firm equal to
\[
\hat{V} = \sum_{r=1}^{\infty} \frac{\hat{d}}{(1 + r_{0,t} + \hat{\beta} MP)^r}
\]  
(7a)

which, conditional on (6), can be written as

\[
\hat{V} = \frac{P_i \hat{d}}{(1 + f + P_i \hat{\beta} MP)^i} + \sum_{r=2}^{\infty} \frac{\mu P_i^{\delta_r} \hat{d}}{(1 + f + \sqrt[\mu P_i^{\delta_r} \hat{\beta} MP})^i}.
\]

(7b)

Assume, for the sake of simplicity, that the default spread is constant (i.e., \( \mu = \delta = 1 \)). Then, there is no source of confusion as to what country risk spread should be used. Specializing (7b) and (14) for this case, we can appreciate the second type of mispricing error that the current practice induces,

\[
m = \frac{\hat{\beta} MP (1 - P_i)}{1 + f + P_i \hat{\beta} MP - P_i}.
\]

(15b)

Note that given \( P_i < 1 \), this mispricing will always be positive. So that even if the “right” yields were extracted for each duration from the sovereign rate spot curve (or if the risky and risk free yield curves were flat), the current practice implicitly attenuates the market risk premium and introduces a second source of mispricing error in the valuation.

In section IV we use data from U.S. dollar-denominated EM bonds to estimate the \( P_i \)'s and equation (6), and illustrate the mispricing ratios that are likely to be observed for empirically reasonable values of \( \mu \) and \( \delta \).

III. Data

We collected effective annual ask yields and durations of non-guaranteed U.S. dollar-denominated EM sovereign bonds (typically called “global bonds”). Data are from
Bloomberg for the last trading day of each month since September 1995 until December 2001. Also included are comparable U.S. Treasury yields, which are taken as the risk free rate.

The sample was narrowed to those emerging countries which had data for more than one bond at any point throughout the sample: Argentina, Brazil, Colombia, Ecuador, Mexico, Poland, Russia, Thailand, Turkey, and Venezuela. Since we focus on yields spaced one-year apart starting one year from the beginning of each period, we further narrowed the sample to countries whose shorter traded bond had a duration smaller than 365 days for three months that we considered representative of likely yield curve configurations: April 1997, January 2000 and August 2001. This restricted our sample to Argentina, Colombia, Mexico, Russia and Turkey. For those sample months for which the shortest bond had a duration greater than one year, we estimated the one-year yield by linear extrapolation of the two nearest bonds available.

Figure I reports the yield curves for the sample considered, which were constructed by linear interpolation of the available data. The horizontal axis shows the duration of the respective bonds measured in years. Very few of the bonds used are actually zero coupon. However, we used the fact that for zero coupon bonds, duration and maturity are equal and that the main determinant of yield for a given credit quality is duration. Therefore, we assumed that each country had outstanding, at each month in the sample, a set of zero coupon bonds for maturities at one year intervals into the future. The duration of the longest zero coupon bond so constructed was smaller than that for the bond outstanding of highest duration. In line with Claessens and Pennacchi (1996) and Cumby and Pastine (2001) we assumed that

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15 The appendix lists the characteristics of all the included bonds. The only bond that is partially guaranteed is Russia-99, which had debentures as collateral. If the bond were stripped, the non-guaranteed part of the bond should have a greater duration and a higher yield, so the April 1997 Russian yield curve would have had an even greater downward slope than that reported in Figure I.C.

16 Plots of all available yields available are posted at http://www.udesa.edu.ar/cruces/cc/yield_curves.pdf.

17 Theoretically, it would be more appropriate to bootstrap the available bonds to generate a spot rate curve. Unfortunately, given the paucity of EM bonds this procedure would hinge on imputing yields for horizons that fall in between available bonds. We found more reasonable to pair each bond’s yield to maturity and duration and to interpolate those points to generate an implicit zero-coupon bond yield curve.
these bonds had no systematic risk and so set their expected returns equal to the risk free rate for each duration. With this information we used equation (3) to estimate the sequence of expected collections for different horizons that are consistent with bond prices.

Figure III shows $P_t$ and $(P_t)'$ from this computation (it also shows the estimated $P_t$ from model (3) which will be discussed below). It shows that while on some occasions $P_t = P_t'$, it is often the case that they differ substantially. For example, Figure I.A shows that Argentina had a negatively sloping yield curve in August 2001. This translates in an expected collection for year 10 implicit in bond prices of about 0.30, which is about twice the 0.16 that would result from direct compounding of the first year expected collection. The reverse is true for Colombia, which had a steep yield curve at that time.

IV. Estimation Results and their Implications on Valuation in EM

IV.1. Estimation of Expected Collection Model

With these data in hand, we estimated the empirical analog of equation (6),

$$\ln(P_t) = \ln(\mu) + \delta t \ln(P_t) + e_t \quad t = 2, \ldots, T$$

separately for each country and for each month, by OLS. The rationale behind separate estimation is that the yield curves in Figure I change dramatically across time and countries so that assuming a model with constant parameters would be inadequate. This shortcoming could be avoided by the use of conditioning information so that $\mu$ and $\delta$ depend on lagged instruments. While that is an interesting approach that we propose to explore in future research, it would lead us into yield curve modeling, an issue beyond the scope of this paper.

We estimated (16) for all months in the sample and report the key parameters. Figure IV reports the estimated $\mu$ and $\delta$ for all months in the sample. It is apparent that most of the action of the expected collection model is around the parameter $\delta$, while $\mu$ is rather stable.
around one over time for all countries. Most of the time $\delta$ is greater than one, corresponding to an upward sloping default spread term-structure. Nevertheless, $\delta$ smaller than one are not uncommon, as in Mexico and Argentina in mid-1998, Russia in early 1997, Colombia around February 1996 and finally as Argentina approached the sovereign default of 2001.

Given the possible measurement error implicit in the extrapolation, we focus the subsequent analysis on the results for three representative months at which the shortest traded bond had a duration lower than one year. Table I reports the results for those three points along the sample.\(^{18}\) All parameter estimates are statistically different from zero and the model fits well the sequence of expected collection implicit in bond prices --a feature that is clearly identifiable from the plots of fitted values in Figure III. Also, the estimated values agree with the intuition that when sovereign spreads are upward sloping, $\delta$s are greater than one, and conversely when they are decreasing. It is noteworthy that, in spite of having few observations for each regression, we can reject the null that the parameters are equal to one -- the maintained hypothesis in the standard practice reflected in equation (9) if the $\tau$ used is one year. Since $\delta$ is the parameter that affects the expected collection as time passes, it is the one that changes the most as the economic environment changes: from a minimum of about 0.4 as countries approach default (Argentina in August 2001 and Russia in April 1997) to about 8 when the yield curve steeps up.

IV.2. Implications for Valuation in Emerging Markets

This section reports the main findings of the paper. We have argued above that from an analytical point of view we can distinguish between two sources of mispricing error that the prevailing valuation technique in EM induces. The first one arises from the addition of a constant country risk spread to the cost of capital, while the second appears even if the “right” country risk spread is added to the discount rate for each period. For each source we present two alternative measures of the mispricing error, one based on the valuation of a

\(^{18}\) Given the deterministic time trend, the estimator of $\delta$ is superconsistent --it converges to its true value faster than in a stationary regression. If the errors are Gaussian, then the usual OLS $t$-tests have exact small sample $t$-distributions. Even if the innovations are not Gaussian, the $t$-tests are asymptotically valid (see Hamilton, 1994, p.460-462 for details).
perpetuity and the use of empirically reasonable parameter values, and the other based on the valuation of projects of different durations and the use of observed interest rates in the selected emerging markets.

Table II shows $r_{0,t}$ and the mispricing ratio $m$ for $\tau = 1$ and $\beta = 0$ as in (15a), for a range of empirically reasonable parameter values. For $\mu = 1$ and $\delta = 1.5$, for instance, the constant discount rate that would correctly value the project is 12 percent while the estimated value assuming a flat term structure of default risk (i.e. a constant discount rate of 9 percent) would be 30 percent higher than the true value.

When $\delta$ is less than one, the short-term sovereign spread is much higher than its long-term counterpart and the estimated value can miss up to 35 percent of the true value. On the contrary, when $\delta$ is larger than one, the estimated value under the current practice (using $\tau = 1$) can overestimate the true value of a project by a factor of about three or four.

For a given $\delta$, higher values of $\mu$ lower the estimated relative to the true value since a higher $\mu$ raises expected dividends. Naturally, when the yield curve steepens up, the constant discount rate that would make the value of the project from (7) equal to that of (14) is much higher than the short-term rate.

As noted in Section I, however, instead of using a one-year sovereign spread, it is common to use J.P. Morgan’s Emerging Bond Market Indices (EMBI) or some other single measure of country risk in equation (1). To have a clear sense of the magnitude of the mispricing error that the current practice might have induced when the duration of the project differed from that of the bond portfolio used to calculate the EMBI, we calculated it for each country and each month in the sample for projects of various durations.

For each country and each month in the sample we first calculated the hypothetical $P_t$ ($t = 1, \ldots, 10$) that would have arisen from the estimated $P_t$, $\mu$ and $\delta$ and the use of equation (6). From (8) and the term structure of the risk-free rate ($f_{0,t}$), we obtained the hypothetical term structure of the risky interest rate for each month. We also calculated the hypothetical risky interest rate corresponding to the duration of the EMBI for each country and each month in the sample ($r_{0,\tau}$). With these data in hand, we computed the mispricing error for zero-beta
projects of different durations as follows. For a project of duration \( s \), the mispricing error is given by

\[
m_s = \frac{\hat{V}}{V_s} - 1 = \frac{\$1}{(1 + r_{0,s})^s} - 1
\]

Figure V reports the mispricing error, \( m_s \), for projects with durations of one year, five years, and 10 years and shows some interesting results:19

- The mispricing error for projects of five years of duration is small in all countries except Mexico, precisely because the duration of the EMBI has been close to five years in those countries.

- The overvaluation of 10-year duration projects has typically been very high in all countries throughout the sample: 9.5 % in Argentina –up to January 2001-, 11.1 % in Colombia, 4.0 % in Mexico, 18.4 % in Russia, and 10.1 % in Turkey. The maximum overvaluation of projects of this duration reached 25.2 % in Argentina (1999), 23.3 % in Colombia (2001), 11.1 % in Mexico (1997), 105.9 % in Russia (1999), and 18.9 % in Turkey (2001).

- In periods in which the term structure of the risky interest rate was inverted, as in Argentina during 2001, the undervaluation of projects of 10 years of duration reached 50 %.

- Short-term projects were typically undervalued by around 3 %.

To have an idea of the relative magnitude of the mispricing error \( m_s \), note that most practitioner-oriented books recommend the use of a 10-year Treasury bond rate as the risk-free rate in a U.S. valuation (e.g. Copeland et al., 2000). The mispricing error that would have arisen from the use of this rate in the valuation of U.S. projects with a duration different from that of the bond was in the range of –1 percent (for projects with a duration of four years) to

19 The mispricing errors for projects of other durations are available from the authors on request.
+1.4 percent (for projects with a duration of 10 years) in the period December 1997-December 2001. That is, assuming a flat sovereign yield curve can severely distort valuations in EM, while assuming a flat yield curve for the risk free rate in valuing projects in developed countries does not have much effect on the results.

The use of the “right” credit spread rate in the denominator of each term in equation (7), while incorrect from a theoretical point of view (as we have shown above), implies small mispricing errors from a practical one. To see this, Table III shows -for a range of reasonable parameter values- the mispricing ratio $m'$ when $\beta \neq 0$. As there is no closed form solution for (7b), the results are obtained from numerically computing $V$ and $\hat{V}'$ for a 100-period long project. For a project of $\beta = 1$, for instance, when $\mu = 1$ and $\delta = 1.5$, the overvaluation would be of only 2.4 percent.

Using the same data as in Figure V above, in Table IV we report, for different durations and betas, the average mispricing errors that would have arisen from discounting the most likely dividends by a rate that includes the “right” country spread for that duration (instead of using the information from the bond markets to derive the right $P$s to convert most likely dividends into expected dividends). As expected, mispricing errors increase with the size of beta and with the duration of the project. The typical mispricing error in this case is, however, quite small. For a project of 10 years of duration and $\beta = 1$, the average mispricing error is 3.64 %, while its maximum is 8.04 % (not reported).

V. Conclusions and Further Research

The prevailing valuation technique in Emerging Markets accounts for the “additional” risks of these countries by adding a single measure of country risk to the discount rate.

In this paper we claim that such practice does not make an efficient use of the information given by sovereign debt markets. In particular, it does not account for the fact that default spreads may be non-constant and, hence, the mismatch between the duration of the project under valuation and the duration of the commonly used measures of country risk, such as J.P. Morgan’s EMBI, leads to an overvaluation (undervaluation) of long-term projects when the
term structure of default risk is upward (downward) sloping. The reverse is true for short-term projects.

We establish that such practice amounts to reducing central scenario dividends by a power of the expected collection for a horizon equal to the duration of the bonds used to measure the country spreads when $\beta = 0$. This would not be subject to additional criticisms to those already raised in the literature if the default spreads were constant but it is problematic when they are not. In normal times, however, default risk is low at the short end of the curve and slopes upward for longer durations. Moreover, often times the default risk term structure is downward sloping --as when the market expects a default in the short run.

We use data from five EM to estimate a simple model of the term structure of default risk and derive its implications on valuation. We find that mispricing errors in the range of minus 30 to plus 400 percent can be made for reasonable parameter values under current practice

When $\beta > 0$, if each cash-flow is discounted at a duration-matched rate taken from the sovereign spot rate curve, this amounts to attenuating the premium for covariance risk --though the mistake incurred is not nearly as important.

To correct the mispricing, we propose a valuation procedure based on our model that treats the institutional uncertainties of emerging markets separate from the covariance risk in a way that is more amenable to financial theory than the standard practice and yet accounts for the high idiosyncratic volatility of EM.

There are two directions for further research. First, it would be useful to generate expected collections per dollar of central scenario cash flows that vary by industrial sector, since the instability of EM has heterogeneous impact across sectors (Eaton and Gersovitz, 1984). Second, by using conditioning information to model the term structure of default risk, one could estimate how its shape responds to fundamentals. If yield spreads are upward sloping in booms and downward sloping in recessions, and if a sizable share of the market is appraising investments in the way that practitioner surveys indicate, then this would induce an extra procyclicality in private investment in EM.
Figure I. Yields on U.S. Dollar-Denominated Sovereign Bonds

Figure I.A. August 2001

Figure I.B. January 2000

Figure I.C. April 1997

Duration in Years

Yield (% points)
Figure II: Interest Rate Duration of Selected EMBI-Global Country Components
December 1997 - March 2002


Source: J.P. Morgan
Fig. III: Expected Collection for Different Horizons (in Years)

August 2001

Argentina

Colombia

Mexico

Russia

Turkey

January 2000

Argentina

Colombia

Mexico

April 1997

Argentina

Colombia

Russia

Note: The source data for this figure are posted at http://www.udesa.edu.ar/cruces/cc/fig_3_source.xls.
Figure IV: Estimates of Mu and Delta for each Month in the Sample and 95% confidence intervals

Argentina

Colombia

Mexico

Russia

Turkey

Delta
Mu
Figure V: Mispricing Error when Using EMBI Spread to Discount Cash Flows of Projects of Different Durations

Argentina

Colombia

Mexico

Russia

Turkey

- duration = 1 year
- duration = 5 years
- duration = 10 years
Table I: Estimates of Mu and Delta for Different Samples

\[ \ln(P_t) = \ln(\mu) + \delta \ln(P_{t-1}) + \epsilon_t \quad t = 2, \ldots, T \]

<table>
<thead>
<tr>
<th></th>
<th>(T-1)</th>
<th>(\mu)</th>
<th>(\delta)</th>
<th>(R^2)</th>
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<tr>
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<td>10</td>
<td>0.75</td>
<td>0.40</td>
<td>0.98</td>
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<tr>
<td></td>
<td></td>
<td>(0.022)</td>
<td>(0.019)</td>
<td></td>
</tr>
<tr>
<td>Colombia</td>
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<td>1.14</td>
<td>2.86</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.04)</td>
<td>(0.249)</td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>8</td>
<td>1.06</td>
<td>2.55</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.007)</td>
<td>(0.07)</td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>6</td>
<td>1.06</td>
<td>2.31</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.005)</td>
<td>(0.029)</td>
<td></td>
</tr>
<tr>
<td>Turkey</td>
<td>6</td>
<td>1.04</td>
<td>1.50</td>
<td>0.99</td>
</tr>
<tr>
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<td>(0.007)</td>
<td>(0.024)</td>
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<th>(\delta)</th>
<th>(R^2)</th>
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<td>(0.169)</td>
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<td>7.33</td>
<td>0.99</td>
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<td>(0.256)</td>
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<td>1.06</td>
<td>4.53</td>
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<td>(0.008)</td>
<td>(0.159)</td>
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<table>
<thead>
<tr>
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<th>(\mu)</th>
<th>(\delta)</th>
<th>(R^2)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1.10</td>
<td>7.86</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.02)</td>
<td>(0.628)</td>
<td></td>
</tr>
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<td>1.04</td>
<td>5.45</td>
<td>0.98</td>
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<tr>
<td></td>
<td></td>
<td>(0.007)</td>
<td>(0.4)</td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>2</td>
<td>0.95</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Minimum   | 0.75    | 0.37    |
Maximum   | 1.14    | 7.86    |

Estimated by OLS. Standard errors in parentheses. For \(\mu\), the standard deviations estimated by the delta method are identical up to four digits with those resulting from assuming normal errors and using the exact lognormal variance. \(P\)-values from the \(t\)-distribution are smaller than one percent for all parameter estimates. No statistics are involved for Russia in April 1997 since only two usable observations are available in that case.
Table II: Percentage Misestimation for Alternative Values of Mu and Delta when Beta = 0

Assumptions:

<table>
<thead>
<tr>
<th></th>
<th>f = 4%</th>
<th>P₁ = 0.95</th>
<th>r₀,₁ = 9%</th>
<th>β MP = 0 * 5.5% = 0</th>
</tr>
</thead>
</table>

\[
m = \frac{\hat{V} - V}{V} = \frac{r_{0,v} - r_{0,1}}{r_{0,1}}
\]

<table>
<thead>
<tr>
<th>Mispricing</th>
<th>(\mu)</th>
<th>(\delta)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td>0.8</td>
<td>-13%</td>
<td>8%</td>
</tr>
<tr>
<td>1.0</td>
<td>-29%</td>
<td>-12%</td>
</tr>
<tr>
<td>1.1</td>
<td>-35%</td>
<td>-19%</td>
</tr>
</tbody>
</table>

\[r_{0,v}\]

<table>
<thead>
<tr>
<th>(\mu)</th>
<th>(\delta)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>0.8</td>
<td>8%</td>
</tr>
<tr>
<td>1.0</td>
<td>7%</td>
</tr>
<tr>
<td>1.1</td>
<td>6%</td>
</tr>
</tbody>
</table>
### Table III: Percentage Misestimation for Alternative Values of Mu and Delta when Beta = 1 and Vhat uses the "Right" Spread from the Sovereign Yield Curve

\[ m' = \frac{\hat{V} - V}{V} \]

**Panel A - Assumptions:**

<table>
<thead>
<tr>
<th></th>
<th>( f = 4% )</th>
<th>( P_1 = 0.95 )</th>
<th>( r_{0,1} = 9% )</th>
<th>( \beta \ MP = 5.5% )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mispricing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \mu )</td>
<td>( \delta )</td>
<td>( \delta )</td>
<td>( \delta )</td>
<td>( \delta )</td>
</tr>
<tr>
<td>0.8</td>
<td>2.1%</td>
<td>2.5%</td>
<td>2.8%</td>
<td>3.2%</td>
</tr>
<tr>
<td>1.0</td>
<td>1.2%</td>
<td>1.7%</td>
<td>1.9%</td>
<td>2.4%</td>
</tr>
<tr>
<td>1.1</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

**Panel B - Assumptions:**

<table>
<thead>
<tr>
<th></th>
<th>( f = 4% )</th>
<th>( P_1 = 0.95 )</th>
<th>( r_{0,1} = 9% )</th>
<th>( \beta \ MP = 10.0% )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mispricing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \mu )</td>
<td>( \delta )</td>
<td>( \delta )</td>
<td>( \delta )</td>
<td>( \delta )</td>
</tr>
<tr>
<td>0.8</td>
<td>3.1%</td>
<td>3.8%</td>
<td>4.1%</td>
<td>4.8%</td>
</tr>
<tr>
<td>1.0</td>
<td>1.6%</td>
<td>2.3%</td>
<td>2.7%</td>
<td>3.5%</td>
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<tr>
<td>1.1</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

Note: for some configurations of the parameters, the imputed expected collection per dollar due are greater than 1, so the corresponding cells are marked n.a..
Table IV: Panel Average Mispricing Error From Attenuation of Covariance Risk Premium When Each Cash Flow is Discounted at a Time-Matched Rate

<table>
<thead>
<tr>
<th>Duration of the project in years</th>
<th>Beta</th>
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<tbody>
<tr>
<td></td>
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</tr>
<tr>
<td>1</td>
<td>0.17%</td>
</tr>
<tr>
<td>5</td>
<td>1.22%</td>
</tr>
<tr>
<td>10</td>
<td>2.63%</td>
</tr>
</tbody>
</table>

Note: A market premium of 5.5 percent per annum was used for this table
## Appendix: Characteristics of the Bonds Used

### Argentina

<table>
<thead>
<tr>
<th>Coupon</th>
<th>Maturity</th>
<th>Code</th>
<th>ISIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.25%</td>
<td>15-Oct-97</td>
<td>(Arg-97)</td>
<td>XS0040079641</td>
</tr>
<tr>
<td>10.95%</td>
<td>1-Nov-99</td>
<td>(Arg-99)</td>
<td>US040114AJ99</td>
</tr>
<tr>
<td>9.25%</td>
<td>23-Feb-01</td>
<td>(Arg-01)</td>
<td>US040114AK62</td>
</tr>
<tr>
<td>8.375%</td>
<td>20-Dec-03</td>
<td>(Arg-03)</td>
<td>US040114AH34</td>
</tr>
<tr>
<td>11%</td>
<td>4-Dec-05</td>
<td>(Arg-05)</td>
<td>US040114BA71</td>
</tr>
<tr>
<td>11%</td>
<td>9-Oct-06</td>
<td>(Arg-06)</td>
<td>US040114AN02</td>
</tr>
<tr>
<td>11.75%</td>
<td>7-Apr-09</td>
<td>(Arg-09)</td>
<td>US040114BE93</td>
</tr>
<tr>
<td>11.375%</td>
<td>15-Mar-10</td>
<td>(Arg-10)</td>
<td>US040114FC91</td>
</tr>
<tr>
<td>11.75%</td>
<td>15-Jun-15</td>
<td>(Arg-15)</td>
<td>US040114GA27</td>
</tr>
<tr>
<td>11.375%</td>
<td>30-Jan-17</td>
<td>(Arg-17)</td>
<td>US040114AR16</td>
</tr>
<tr>
<td>12.125%</td>
<td>25-Feb-19</td>
<td>(Arg-19)</td>
<td>US040114BC38</td>
</tr>
<tr>
<td>12%</td>
<td>1-Feb-20</td>
<td>(Arg-20)</td>
<td>US040114FB19</td>
</tr>
<tr>
<td>9.75%</td>
<td>19-Sep-27</td>
<td>(Arg-27)</td>
<td>US040114AV28</td>
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<tr>
<td>10.25%</td>
<td>21-Jul-30</td>
<td>(Arg-30)</td>
<td>US040114GB00</td>
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<tr>
<td>12.25%</td>
<td>19-Jun-18</td>
<td>(Arg-18)</td>
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<tr>
<td>12%</td>
<td>19-Jun-31</td>
<td>(Arg-31)</td>
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<tr>
<td>0%</td>
<td>15-Mar-02</td>
<td>(LETE 90)</td>
<td>ARARGE033134</td>
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### Colombia

<table>
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<td>8%</td>
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<td>7.5%</td>
<td>1-Mar-02</td>
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<td>7.25%</td>
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<td>10.875%</td>
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<td>7.625%</td>
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<td>8.625%</td>
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<td>(Col-08)</td>
<td>US195328AM75</td>
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<td>(Col-09)</td>
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<td>11.75%</td>
<td>25-Feb-20</td>
<td>(Col-20)</td>
<td>US195325AU91</td>
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### Mexico

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### Turkey

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<td>5-Oct-98</td>
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### Russia

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* ISIN is the International Securities Identification Number.
References


J.P. Morgan, Emerging Markets Bond Index Monitor, various issues.


Shores, Andrew, and Gustavo Santos, 2001, Strategy: Revision of Discount Rates, Credit Suisse First Boston, September.