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Cruces, Juan José (Universidad de San Andrés), Buscaglia, Marcos (IAE School of Management and Business, Universidad Austral) and Alonso, Joaquín (Mercado Abierto)

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

Juan José Cruces[†] Marcos Buscaglia[††] Joaquín Alonso[‡]

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## Abstract

Most practitioners add the country risk to the discount rate when valuing projects in Emerging Markets. In addition to the problems already pointed out in the literature, in this paper we claim that such practice leads to a pro-cyclical bias in the valuation of long-term projects. The mismatch between the duration of the project and the duration of the most widely used measure of country risk, J.P. Morgan's EMBI, leads to an overvaluation of long-term projects in good times (upward sloping default risk) and to an undervaluation of them when short-term default risk is high (the contrary is true with respect to short-term projects.)

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

**JEL classification codes:** G15, G31

**Keywords**: Emerging Economies, Cost of Capital, Default Risk

[†] Universidad de San Andrés, Victoria, Province of Buenos Aires, Argentina. E-mail address: cruces@udesa.edu.ar

[††] IAE School of Management and Business, Universidad Austral, Pilar, Province of Buenos Aires, Argentina. Tel.: 54-2322-481069. E-mail address: mbuscaglia@iae.edu.ar. Corresponding author.

[‡] Mercado Abierto, S.A., Buenos Aires, Argentina. E-mail address: joaquin@masa.com.ar.

## I. Introduction

Projects in emerging markets are generally perceived as riskier than otherwise similar projects in developed countries. These "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[1], and inflation and currency risks are higher.

Several problems have restricted the use among practitioners of the Capital Asset Pricing Model (CAPM) or its international version, the ICAPM[2], 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). Secondly, local returns are non-normal, show significant first-order autocorrelation (Bekaert et al., 1998), and there are problems of liquidity and infrequent trading. Finally, as correlations between local returns and international returns are so low (see Harvey, 1995), the cost of capital that emerges from the use of these models appears as "too low".

These problems have lead practitioners to account for the "additional risks" by making ad hoc adjustments to the CAPM. Godfrey and Espinosa (1996), for instance, propose to calculate the cost of capital in EM by using

$$E[R_i] = \left( R_f^{US} + \text{Credit Spread} \right) + \frac{s_i}{s_{US}} * 0.60 * \left( E[R_m^{US}] - R_f^{US} \right) \qquad (1)$$

where credit spread is the spread between the yield of a U.S. Dollar-denominated EM sovereign bond 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.[3]

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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.

2 See Adler and Dumas (1983).

3 The 60% adjustment is due to the finding that 40% of the volatilities of domestic markets are explained by variations in credit quality.

Although there are different versions of this model (see Pereiro and Galli, 2000, Abuaf and Chu, 1994, and Harvey, 2000), 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. Pereiro and Galli (2000) show that the vast majority of argentine corporations (including financial and non-financial firms) add the country risk to the US risk free rate. Keck et al. (1998) find similar results in a survey of Chicago School of Business graduates.

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, 2000). Second, in most versions of this model country risk is double counted, since part of the variability in market returns is correlated with country risk (Estrada, 2000). The 60% adjustment of Godfrey and Espinosa does not solve the problem, as it is completely ad-hoc. Third, for internationally diversified 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, 2000). Sometimes the country risk is 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). [4]

In this simple paper, we discuss another problem that the addition of country risk in the discount rate as in equation (1) has; namely, that it implicitly assumes that the default-risk term structure is flat, leading to a pro-cyclical valuation of long term projects in EM.

The country risk measures most widely used are the ones given by J.P. Morgan's EMBI and EMBI+. Table I shows that there is a great cross-country variability in the average duration of the EMBI Global as of August 2000. For example, an investor considering whether to locate an otherwise similar factory in Poland or in Hungary would be using for

[4] Some propose to make additional adjustments to the discount rate to reflect this. These adjustments, however, also lack any sound foundation.

Poland a country spread corresponding to a duration of 6 years, whereas in Hungary he would be using a spread associated with a duration of 2.3 years.

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 good times, when capital is flowing to EM, risk spreads are low at the short end of the curve, but they are upward sloping. In many instances, moreover, the default-risk term structure is downward sloping. This usually happens when the market expects a default in the short term.

The mismatch between the duration of the project and the duration of the EMBI leads to an overvaluation of long-term projects in good times and to an undervaluation of them when default risk is high (the contrary is true with respect to short term projects.)

Figure I.A. illustrates this point. While in August 2001 Mexico and Russia had similar spreads on bonds with short durations, Russia´s risk was much higher at longer horizons. A mechanical application of equation (1) would ignore these data, which are readily available from bond markets, and would have led to an undervaluation of otherwise similar long-term projects in Mexico relative to Russia.

Using sovereign bond data from five Emerging Markets, in this paper we estimate a simple model that captures most of the variation of default probabilities at different horizons for a given country at one point in time. This model can be used to solve the miss-estimation problem.

The paper proceeds as follows. In Section II we explain the model we use to estimate the default-risk term structure in EM sovereign debt markets and discuss the effects that a non-flat default-risk term structure has on the valuation of projects. In Section III we describe the data used to estimate the model. In Section IV we present the estimation results. Section V concludes.

## II. The Model

Consider a perpetuity that promises to pay a coupon of \$ $c$ every period (a period represents one year for simplicity). Let $i_t$ be the expected annual rate of return on this bond from period zero up to period t, $g$ the recovery value conditional on default, $p_t$ the period-t probability of payment conditional on previous full payment, and $P_t$ the probability of payment t-periods from now. Given that each coupon payment has "cross-default" provisions with every successive coupon, $P_t$ measures the cumulative probability of no default from inception up to period t.

Then, we can express the bond's current value, Bo, as

$$B_0 = \sum_{t=1}^{\infty} \frac{P_t c + P_{t-1}(1 - p_t) g}{(1 + i_t)^t} \tag{2}$$

where the numerator gives the expected receipts from the bond in period t.

For simplicity, we assume that the recovery value once there is a default on a sovereign bond is zero (i.e., $g = 0$). This assumption does not change the main results of this paper and avoids unnecessary complications in the estimation. We also postulate that [5]

$$P_t = \begin{cases} p_1 & \text{if } t = 1 \\ a P_1^{b\,t} & \text{if } t \geq 2 \end{cases} \tag{3}$$

so we can express

$$B_0 = \frac{P_1 c}{(1 + i_1)} + \sum_{t=2}^{\infty} \frac{a P_1^{b\,t} c}{(1 + i_t)^t} \tag{4}$$

Note that this specification implies that not necessarily $p_1 = p_2 = p_3 \ldots$ In this paper, we use data from U.S. Dollar-denominated EM bonds to estimate equation (3) and illustrate how different implied values of $\alpha$ and $\beta$ change the value of investment projects relative to that assessed by the standard practice.

[5] See Merrick (1999) and Yawitz (1977) for alternative specifications.

**II.1. Implications on Valuation in EM**

Consider the case of a firm located in an EM whose most likely outcome is that it will produce a dividend of \$ d (constant) per period forever. The standard valuation practice in EM is to discount the most likely outcome (central scenario) at a constant discount rate $r_{ô}$. ô stands for the duration of the bond portfolio used to measure the discount rate as in equation (1). In this case, the value of the firm in our example can be calculated as

$$\hat{V} = \sum_{t=1}^{\infty} \frac{d}{(1+r_t)^t} = \frac{d}{r_t} \tag{5}$$

We call $\hat{V}$ "miscalculated value", for reasons that will become apparent below. Traditional finance theory suggests, however, that we should discount the *expected* free cash flows by their respective *expected* returns. Using equation (3), the "true value", V, of the firm in our example would be

$$V = \frac{p_1 d}{(1+f_1)} + \sum_{t=2}^{\infty} \frac{P_t d}{(1+f_t)^t} \tag{6}$$

where $f_t$ is the expected return of investing in this firm, and the numerator gives the expected dividend each period. In equation (6), $f_t$ does not include the country risk and we can easily assume that it is constant, but every term in its numerator is lower than the corresponding one in equation (5) due to the "downward" risks borne by projects in EM (see Estrada, 2000). If per-period default probabilities were constant (i.e., $P_t = p_1^t$), then we could express V as

$$V_c = \frac{d\, p_1}{1+f-p_1} \tag{6b}$$

where the subscript *c* is added to stress that a constant probability of default is assumed. It is easy to show that the *r* that makes $\hat{V} = V_c$, $r_c$, is given by

$$r_c = \frac{1 + f - p_1}{p_1} \tag{7}$$

Suppose now that the default-risk term structure is as in equation (3)[6]. In this case the value of the firm, $V_v$, is

$$V_v = \frac{d}{1 + f}\left\{ p_1 + \frac{a\, P_1^{2b}}{1 + f - P_1^{\,b}} \right\} \tag{6c}$$

where the subscript *v* indicates that default risk per period varies with duration. Again, for any value of á and â there is a value of *r*, $r_v$, that makes $\hat{V} = V_v$. It is given by

$$r_v = \frac{1 + f}{\left( p_1 + \frac{aP_1^{2b}}{1 + f - P_1^{\,b}} \right)} \tag{7b}$$

That is, when the default-risk term structure is non-flat, the mismatch between the duration of the project and the duration of the bond portfolio used to measure the discount rate as in equation (1) introduces a mispricing error, *m*, given by

$$m = \frac{V_v}{\hat{V}} = \begin{cases} \dfrac{r_c}{r_v} & for\ t = 1 \\ \dfrac{r_t}{r_v} & for\ t \geq 2 \end{cases} \tag{8}$$

In Appendix I we show for $t = a = 1$ that if $b > 1\ (b < 1)$, then $r_v > r_c\ (r_v < r_c)$.[7]

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[6] Note that we are using the information given by country risk in order to assess the probability of receiving the most likely dividend. The usual criticisms to this practice have been outlined in Section 1. Here we only want to point out the problems originated by implicitly assuming a flat default-risk term structure. 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.

## III. The 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 appart starting one year from the beginning of each period, we further narrowed the sample to countries whose shorter traded bond had a duration greater than 365 days. This restricted our sample to Argentina, Colombia, Mexico, Russia and Turkey. Appendix I lists the characteristics of all the included bonds.[8]

Because the aim of this paper is to illustrate the effect of different yield curve shapes on valuation, we restricted our attention to three months that seemed representative: April 1997, January 2000 and August 2001. Figure I reports the yield curves for the sample considered, which were constructed by linear interpolation of the available data. Nevertheless, plots of all the yield curves available are posted at http://www.udesa.edu.ar/cruces/coc/yield_curves.pdf.

We focused on effective yields at intervals of one year up to where the available data permitted. From the no arbitrage condition between $t$-year and and $t$+1-year spot yield we

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[7] From the no arbitrage condition and our model of probability of payment [equation (3)] we can deduce, for $t \geq 2$, that $r_t = \frac{1+f-a^{1/t}P_1^b}{a^{1/t}P_1^b}$.

[8] 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.

computed the forward one-year yield starting at time $t$ for each country (see Table II). For a bond that carries no systematic risk, and assuming that recovery conditional on default is zero [i.e. $g = 0$ in (2)], the probability of full payment for period $t$ results from,

$$p_t \left(1 + r_{t-1,t}\right) = 1 + i_{t-1,t} \qquad (9)$$

where $r_{t-1,t}$ is the one-year risky forward rate starting in year $t$-1 and $i$ is the comparable risk free rate. When $t$=1 both rates are spot rates and $p_1$ is the probability of full payment, while for $t$>1, both rates are forward rates and $p_t$ is the probability of full payment conditional on full payment up to time $t$-1.

Table I reports, for each country, $p_t$, the cumulative probability of full payment that would result from assuming $a = b = 1$, $P_1^t$, and the probability of full payment from time zero up to and including time t implicit in bond prices, $P_t$.

Table II shows that while on some occasions $P_t \approx P_1^t$, it is often the case that they differ substantially. As an example of our point, Figure I.A reports that Argentina has a negatively sloping yield curve. This translates in a cummulative probability of full payment up to year 10 implicit in bond prices of 0.3 (Table II.A), which is much higher than what would result from compounding for ten years the first period probability of full payment (0.16). The converse is true for Colombia, which has a steep yield curve in August 2001.

## IV. Estimation Results and their Implications on Valuation in EM

### IV.1. Estimation Results

With these data in hand, we estimated the empirical analog of equation (3),

$$P_t = a\, P_1^{t^b} + e_t \qquad t = 2,...,T \qquad (10)$$

separately for each country and for each time period, by non-linear least squares. The rationale behind separate estimation is that the yield curves in Figure I change dramatically across time and countries so that the efficiency gain resulting from joint estimation of the parameters would come at the expense of assuming a model with constant parameters that is clearly inadequate. This shortcoming could be avoided by the use of conditioning information so that alpha and beta 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 modelling, an issue beyond the scope of this paper.

Table III reports the results of estimating (10), and shows that it provides a good fit to the sequence of default probabilities implicit in bond prices. All parameter signs agree with the intuition that when sovereign spreads are upward sloping $b$s are greater than one, and conversely when they are decreasing. It is noteworthy that all parameter estimates are statistically significantly different from one --the maintained hypothesis in the standard practice reflected in equation (5). Since $b$ is the parameter that affects the cummulative probability of full payment as time passes, it is the one that changes the most as the economic environment changes: from a minimum of about 0.5 as countries approach default (Argentina in August 2001 and Russia in April 1997) to about 5 when the yield curve steeps up.

### IV.2. Implications for Valuation in Emerging Markets

Table IV reports the main findings of this paper. For a range of parameter values that are consistent with the empirical estimates of alpha, beta, $P_1$, and for values of $i$ that are consistent with real returns on long-term bonds, we show $r_v$ from (7b), the mispricing ratio for $t = 1$ as in (8), $V/\hat{V}$, and the duration of a constant free cash flow project.

The top and bottom panels only differ by the value of the risk-free rate ($i$). For 95 percent probability of full payment during the first year, the short-term risky rate is 9 percent when $i$ is 4 percent and it jumps to 12 when $i$ equals 6.

When $b$ is less than one, the short-term sovereign spread is much higher than its long-term counterpart and the true value of a long-term project can be up to 54 percent higher than the value estimated using a one-year discount rate and assuming a flat yield curve. On the contrary, when $b$ is larger than one, the real value can be only one-third of the "miscalculated" value. For a given $b$, higher values of $a$ raise the true value relative to its estimated one since higher $a$s raise expected dividends.

Naturally, when the yield curve steeps up, the constant discount rate that would make the value of the project from (5) equal to that of (6) is much higher than the short term rate.

## V. Conclusions and Further Research

Several problems have restricted practitioners from using the CAPM in order to estimate discount rates in Emerging Markets, and have led them to account for the "additional" risks of EM by adding the 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 the default-risk term structure is non-flat, being upward sloping in good times, and downward sloping when the short-term default risk is high.

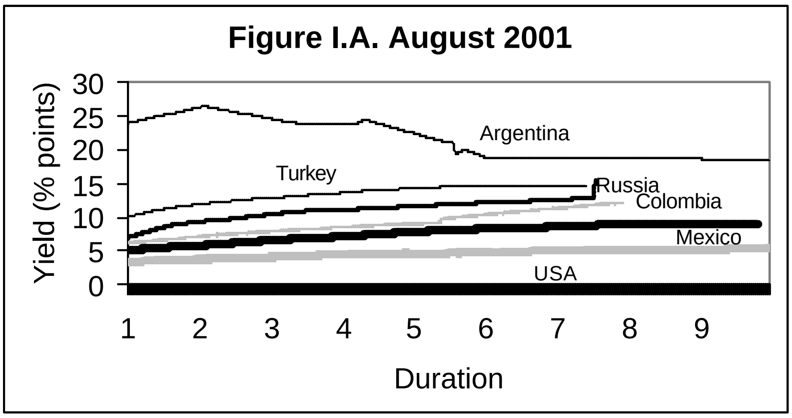
The mismatch between the duration of the project and the duration of the most widely used measures of country risk, J.P. Morgan's EMBI, leads to an overvaluation of long-term projects in good times and to an undervaluation of them when default risk is high (the contrary is true with respect to short term projects.)

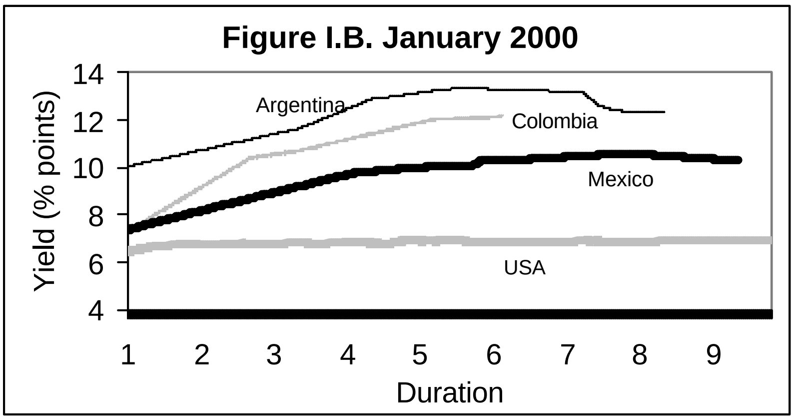
In this paper, using data from five EM, we estimate a simple model of the term structure of default-risk and derive its implications on valuation.

We find that by implicitly assuming that the term structure of default risk is flat, mispricing errors in the range of plus or minus 50 percent can be made for reasonable parameter values. This mispricing can be avoided by using data that are readily available from bond markets.

To enrich the analysis, future research should be directed to the inclusion of recovery values and the use of conditioning information in a model of default-risk term structure.

Figure I. Yields on U.S. Dollar-Denominated Sovereign Bonds



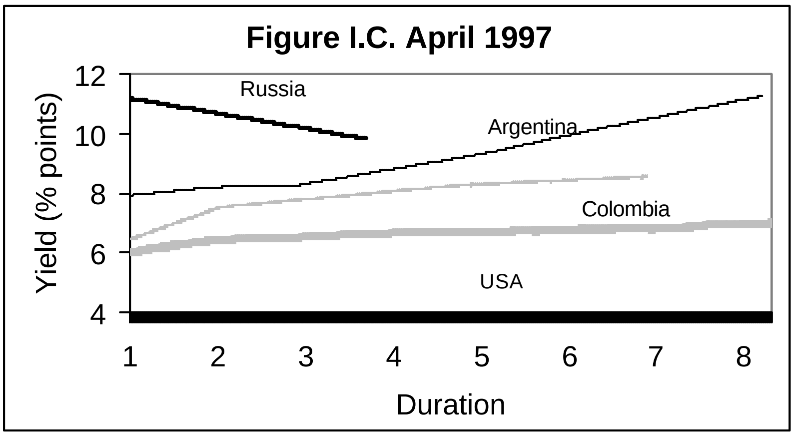



**Table I: Average Duration of Country Components of JP Morgan's EMBI Global Index**

| Country | Duration |
|---|---|
| Algeria | 3.05 |
| Argentina | 4.13 |
| Brazil | 4.94 |
| Bulgaria | 4.59 |
| Chile | 6.20 |
| China | 4.56 |
| Colombia | 5.40 |
| Cote d'Ivore | 6.20 |
| Croatia | 3.80 |
| Ecuador | 5.90 |
| Hungary | 2.33 |
| Lebanon | 2.30 |
| Malaysia | 4.93 |
| Mexico | 4.93 |
| Morocco | 3.24 |
| Nigeria | 1.92 |
| Panama | 6.56 |
| Peru | 7.02 |
| Philippines | 7.14 |
| Poland | 6.01 |
| Russia | 5.78 |
| South Africa | 6.53 |
| South Korea | 3.79 |
| Thailand | 4.98 |
| Turkey | 5.95 |
| Ukraine | 2.59 |
| Venezuela | 4.15 |
| **Mean** | **4.77** |
| **Standard Deviation** | **1.52** |

Source: J.P. Morgan (2000)

## Table II.A: Sovereign Rates and Implied Default Probabilities - August 2001

| $t$ | USA | Argentina | | | | Colombia | | | | Mexico | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Forward | Forward | $p_t$ | $P_1^t$ | $P_t$ | Forward | $p_t$ | $P_1^t$ | $P_t$ | Forward | $p_t$ | $P_1^t$ | $P_t$ |
| 1 | 3.33 | 24.00 | 0.83 | 0.83 | 0.83 | 6.13 | 0.97 | 0.97 | 0.97 | 5.06 | 0.98 | 0.98 | 0.98 |
| 2 | 4.01 | 28.56 | 0.81 | 0.69 | 0.67 | 8.03 | 0.96 | 0.95 | 0.94 | 6.51 | 0.98 | 0.97 | 0.96 |
| 3 | 4.52 | 21.65 | 0.86 | 0.58 | 0.58 | 9.25 | 0.96 | 0.92 | 0.90 | 7.96 | 0.97 | 0.95 | 0.93 |
| 4 | 5.40 | 21.64 | 0.87 | 0.48 | 0.50 | 10.34 | 0.96 | 0.90 | 0.86 | 9.00 | 0.97 | 0.94 | 0.90 |
| 5 | 5.52 | 17.51 | 0.90 | 0.40 | 0.45 | 11.01 | 0.95 | 0.88 | 0.81 | 10.36 | 0.96 | 0.92 | 0.86 |
| 6 | 5.29 | 3.45 | 1.00 | 0.34 | 0.45 | 17.08 | 0.90 | 0.85 | 0.73 | 10.37 | 0.95 | 0.91 | 0.82 |
| 7 | 6.22 | 16.68 | 0.91 | 0.28 | 0.41 | 16.97 | 0.91 | 0.83 | 0.67 | 10.86 | 0.96 | 0.89 | 0.79 |
| 8 | 5.64 | 17.97 | 0.90 | 0.23 | 0.37 | 18.90 | 0.89 | 0.81 | 0.59 | 11.59 | 0.95 | 0.88 | 0.74 |
| 9 | 6.34 | 17.76 | 0.90 | 0.19 | 0.33 | . | . | . | . | 9.64 | 0.97 | 0.86 | 0.72 |
| 10 | 6.65 | 17.54 | 0.91 | 0.16 | 0.30 | . | . | . | . | . | . | . | . |

| $t$ | Russia | | | | Turkey | | | |
|---|---|---|---|---|---|---|---|---|
| | Forward | $p_t$ | $P_1^t$ | $P_t$ | Forward | $p_t$ | $P_1^t$ | $P_t$ |
| 1 | 6.99 | 0.97 | 0.97 | 0.97 | 10.04 | 0.94 | 0.94 | 0.94 |
| 2 | 11.57 | 0.93 | 0.93 | 0.90 | 13.71 | 0.92 | 0.88 | 0.86 |
| 3 | 12.59 | 0.93 | 0.90 | 0.84 | 14.68 | 0.91 | 0.83 | 0.78 |
| 4 | 13.31 | 0.93 | 0.87 | 0.78 | 16.11 | 0.91 | 0.78 | 0.71 |
| 5 | 13.59 | 0.93 | 0.84 | 0.72 | 16.81 | 0.90 | 0.73 | 0.64 |
| 6 | 14.58 | 0.92 | 0.81 | 0.66 | 15.74 | 0.91 | 0.69 | 0.58 |
| 7 | 15.46 | 0.92 | 0.78 | 0.61 | 15.01 | 0.92 | 0.64 | 0.54 |
| 8 | . | . | . | . | . | . | . | . |
| 9 | . | . | . | . | . | . | . | . |
| 10 | . | . | . | . | . | . | . | . |

Note: Based on closing prices from end of August 2001of dollar-denominated sovereign bonds, taken from Bloomberg. The rates for the first year are spot rates while for subsequent years they are forward one year rates implied by the linearly interpolated yield curves of each country assuming that recovery value conditional on default is zero and that EM bonds carry no systematic risk. Given cross-default provisions, the cummulative probability that payments in year t will be honored in full and on time is the product of the probability that all payments be made in like manner up to and including year t. For Argentina in t=6 in Table II.A its forward rate was lower than the risk free rate --we assumed that this was due to measurement error and declared p6=1.

## Table II.B: Sovereign Rates and Implied Default Probabilities - January 2000

| $t$ | USA | Argentina | | | | Colombia | | | | Mexico | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Forward | Forward | $p_t$ | $P_1^t$ | $P_t$ | Forward | $p_t$ | $P_1^t$ | $P_t$ | Forward | $p_t$ | $P_1^t$ | $P_t$ |
| 1 | 6.44 | 10.04 | 0.97 | 0.97 | 0.97 | 7.30 | 0.99 | 0.99 | 0.99 | 7.38 | 0.99 | 0.99 | 0.99 |
| 2 | 7.02 | 11.40 | 0.96 | 0.94 | 0.93 | 10.97 | 0.96 | 0.98 | 0.96 | 8.95 | 0.98 | 0.98 | 0.97 |
| 3 | 6.86 | 12.75 | 0.95 | 0.91 | 0.88 | 13.41 | 0.94 | 0.98 | 0.90 | 10.46 | 0.97 | 0.97 | 0.94 |
| 4 | 6.93 | 15.56 | 0.93 | 0.88 | 0.82 | 13.01 | 0.95 | 0.97 | 0.85 | 11.95 | 0.96 | 0.97 | 0.90 |
| 5 | 7.40 | 16.07 | 0.93 | 0.85 | 0.75 | 14.75 | 0.94 | 0.96 | 0.80 | 11.30 | 0.97 | 0.96 | 0.87 |
| 6 | 6.40 | 14.29 | 0.93 | 0.82 | 0.70 | 13.33 | 0.94 | 0.95 | 0.75 | 11.87 | 0.95 | 0.95 | 0.83 |
| 7 | 7.01 | 12.48 | 0.95 | 0.79 | 0.67 | . | . | . | . | 11.27 | 0.96 | 0.94 | 0.79 |
| 8 | 6.58 | 6.70 | 0.999 | 0.77 | 0.67 | . | . | . | . | 11.59 | 0.96 | 0.93 | 0.76 |
| 9 | 7.48 | . | . | . | . | . | . | . | . | 8.91 | 0.99 | 0.92 | 0.75 |

**Table II.C: Sovereign Rates and Implied Default Probabilities - April 1997**

| $t$ | USA | Argentina | | | | Colombia | | | | Russia | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Forward | Forward | $p_t$ | $P_1^t$ | $P_t$ | Forward | $p_t$ | $P_1^t$ | $P_t$ | Forward | $p_t$ | $P_1^t$ | $P_t$ |
| 1 | 5.99 | 7.92 | 0.98 | 0.98 | 0.98 | 6.43 | 0.996 | 0.996 | 0.996 | 11.19 | 0.95 | 0.95 | 0.95 |
| 2 | 6.81 | 8.46 | 0.99 | 0.97 | 0.97 | 8.52 | 0.98 | 0.99 | 0.98 | 10.20 | 0.97 | 0.91 | 0.92 |
| 3 | 6.76 | 8.48 | 0.98 | 0.95 | 0.95 | 8.39 | 0.99 | 0.99 | 0.97 | 9.21 | 0.98 | 0.87 | 0.90 |
| 4 | 7.01 | 10.28 | 0.97 | 0.93 | 0.92 | 8.84 | 0.98 | 0.98 | 0.95 | . | . | . | . |
| 5 | 6.84 | 11.28 | 0.96 | 0.91 | 0.89 | 9.24 | 0.98 | 0.98 | 0.93 | . | . | . | . |
| 6 | 7.10 | 13.05 | 0.95 | 0.90 | 0.84 | 9.11 | 0.98 | 0.98 | 0.91 | . | . | . | . |
| 7 | 7.15 | 14.17 | 0.94 | 0.88 | 0.79 | . | . | . | . | . | . | . | . |
| 8 | 7.78 | 15.28 | 0.94 | 0.87 | 0.74 | . | . | . | . | . | . | . | . |

**Table III: Estimates of Alpa and Beta for Different Samples**

$$P_t = a\ P_1^{tb} + e_t \qquad t = 2,\ldots,T$$

August 2001

| | $T$ | $a$ | $b$ | $R^2$ |
|---|---|---|---|---|
| Argentina | 10 | 0.78 | 0.53 | 0.972 |
| | | (0.026) | (0.034) | |
| Colombia | 8 | 1.12 | 2.71 | 0.960 |
| | | (0.037) | (0.26) | |
| Mexico | 9 | 1.05 | 2.53 | 0.995 |
| | | (0.007) | (0.07) | |
| Russia | 7 | 1.05 | 2.21 | 0.990 |
| | | (0.006) | (0.04) | |
| Turkey | 7 | 1.03 | 1.51 | 0.9900 |
| | | (0.006) | (0.02) | |

January 2000

| | $T$ | $a$ | $b$ | $R^2$ |
|---|---|---|---|---|
| Argentina | 8 | 1.047 | 1.87 | 0.974 |
| | | (0.023) | (0.14) | |
| Colombia | 6 | 1.08 | 7.55 | 0.999 |
| | | (0.004) | (0.13) | |
| Mexico | 9 | 1.06 | 4.55 | 0.994 |
| | | (0.007) | (0.14) | |

April 1997

| | $T$ | $a$ | $b$ | $R^2$ |
|---|---|---|---|---|
| Argentina | 8 | 1.08 | 2.46 | 0.958 |
| | | (0.02) | (0.23) | |
| Colombia | 6 | 1.019 | 4.52 | 0.995 |
| | | (0.003) | (0.18) | |
| Russia | 3 | 0.97 | 0.47 | . |
| | | . | . | |

| | | | | |
|---|---|---|---|---|
| Minimum | | 0.78 | 0.47 | |
| Maximum | | 1.12 | 7.55 | |

Estimated by non-linear least squares. Approximate Std. Errors in parentheses. Since only two observations of $P_t$ are available for Russia in April 1997, we logged the model and solved for the two unknowns. No statistics are involved in that particular case.

**Table IV: Ratio of Correctly to Miscalculated Value for Different Parameter Specifications**

| Assumptions: | | $i$ = | 4% | $P_1$ = | 0.95 | $r_1$ = | 9% | |
|---|---|---|---|---|---|---|---|---|
| $a$ | **Row Content** | $b$ | | | | | | |
| | | **0.5** | **0.8** | **1.0** | **1.5** | **2.5** | **4.0** | **7.0** |
| **0.8** | $r_v \mid V=V$**hat** | 8% | 10% | 12% | 15% | 22% | 31% | 50% |
| | $V/V$**hat** | 1.15 | 0.92 | 0.82 | 0.63 | 0.44 | 0.30 | 0.19 |
| | **Dur. Proj.** | 13.1 | 10.7 | 9.6 | 7.7 | 5.6 | 4.2 | 3.0 |
| **1.0** | $r_v \mid V=V$**hat** | 7% | 8% | 9% | 12% | 18% | 27% | 44% |
| | $V/V$**hat** | 1.41 | 1.13 | 1.00 | 0.77 | 0.53 | 0.35 | 0.22 |
| | **Dur. Proj.** | 15.9 | 13.0 | 11.6 | 9.1 | 6.6 | 4.7 | 3.3 |
| **1.1** | $r_v \mid V=V$**hat** | 6% | 8% | 9% | 11% | 17% | 25% | 41% |
| | $V/V$**hat** | 1.54 | 1.24 | 1.09 | 0.84 | 0.57 | 0.38 | 0.23 |
| | **Dur. Proj.** | 17.3 | 14.1 | 12.5 | 9.9 | 7.0 | 5.0 | 3.4 |

| Assumptions: | | $i$ = | 6% | $P_1$ = | 0.95 | $r_1$ = | 12% | |
|---|---|---|---|---|---|---|---|---|
| $a$ | **Row Content** | $b$ | | | | | | |
| | | **0.5** | **0.8** | **1.0** | **1.5** | **2.5** | **4.0** | **7.0** |
| **0.8** | $r_v \mid V=V$**hat** | 11% | 13% | 14% | 17% | 24% | 34% | 52% |
| | $V/V$**hat** | 1.08 | 0.91 | 0.82 | 0.66 | 0.48 | 0.34 | 0.22 |
| | **Dur. Proj.** | 10.3 | 8.8 | 8.1 | 6.7 | 5.1 | 3.9 | 2.9 |
| **1.0** | $r_v \mid V=V$**hat** | 9% | 10% | 12% | 14% | 20% | 29% | 46% |
| | $V/V$**hat** | 1.32 | 1.11 | 1.00 | 0.80 | 0.57 | 0.40 | 0.25 |
| | **Dur. Proj.** | 12.4 | 10.6 | 9.6 | 7.9 | 5.9 | 4.4 | 3.2 |
| **1.1** | $r_v \mid V=V$**hat** | 8% | 10% | 11% | 13% | 19% | 27% | 44% |
| | $V/V$**hat** | 1.44 | 1.21 | 1.09 | 0.87 | 0.62 | 0.43 | 0.27 |
| | **Dur. Proj.** | 13.5 | 11.4 | 10.4 | 8.5 | 6.3 | 4.7 | 3.3 |

## Appendix I

Let $t = a = 1$ for simplicity. We want to show that if $b > 1\ (b < 1)$, then $r_v > r_c\ (r_v < r_c)$. Assume, by contradiction, that $b > 1$ but $r_v \le r_c$. This would imply that

$$\frac{1}{r_v} \ge \frac{1}{r_c}$$

$$\Leftrightarrow \frac{p_1}{1+f} + \sum_{t=2}^{\infty}\left(\frac{P_1{}^b}{1+f}\right)^t \ge \frac{p_1}{1+f} + \sum_{t=2}^{\infty}\left(\frac{P_1}{1+f}\right)^t$$

For every *t*, the term between parenthesis on the left hand side is bigger than the corresponding term on the right hand side if and only if $P_1^b \ge P_1$, which is a contradiction.

## Appendix II: Characteristics of the Bonds Used

| Argentina | | | |
|---|---|---|---|
| **Coupon** | **Maturity** | **Code** | **ISIN** |
| 8.25% | 15-Oct-97 | (Arg-97) | XS0040079641 |
| 10.95% | 1-Nov-99 | (Arg-99) | US040114AJ99 |
| 9.25% | 23-Feb-01 | (Arg-01) | US040114AK62 |
| 8.375% | 20-Dec-03 | (Arg-03) | US040114AH34 |
| 11% | 4-Dec-05 | (Arg-05) | US040114BA71 |
| 11% | 9-Oct-06 | (Arg-06) | US040114AN02 |
| 11.75% | 7-Apr-09 | (Arg-09) | US040114BE93 |
| 11.375% | 15-Mar-10 | (Arg-10) | US040114FC91 |
| 11.75% | 15-Jun-15 | (Arg-15) | US040114GA27 |
| 11.375% | 30-Jan-17 | (Arg-17) | US040114AR16 |
| 12.125% | 25-Feb-19 | (Arg-19) | US040114BC38 |
| 12% | 1-Feb-20 | (Arg-20) | US040114FB19 |
| 9.75% | 19-Sep-27 | (Arg-27) | US040114AV28 |
| 10.25% | 21-Jul-30 | (Arg-30) | US040114GB00 |
| 12.25% | 19-Jun-18 | (Arg-18) | US040114GG96 |
| 12% | 19-Jun-31 | (Arg-31) | US040114GH79 |
| 0% | 15-Mar-02 | (LETE 90) | ARARGE033134 |

| Turkey | | | |
|---|---|---|---|
| **Coupon** | **Maturity** | **Code** | **ISIN** |
| 8.75% | 5-Oct-98 | (Tur-98) | XS0060514642 |
| 9.00% | 15-Jun-99 | (Tur-99) | US900123AC41 |
| 10% | 23-May-02 | (Tur-02) | XS0076567774 |
| 8.875% | 12-May-03 | (Tur-03) | XS0086996310 |
| 11.875% | 5-Nov-04 | (Tur-04) | US900123AK66 |
| 9.875% | 23-Feb-05 | (Tur-05) | XS0084714954 |
| 10% | 19-Sep-07 | (Tur-07) | XS0080403891 |
| 12.375% | 15-Jun-09 | (Tur-09) | US900123AJ93 |
| 11.75% | 15-Jun-10 | (Tur-10) | US900147AB51 |
| 11.875% | 15-Jan-30 | (Tur-30) | US900123AL40 |

| Colombia | | | |
|---|---|---|---|
| **Coupon** | **Maturity** | **Code** | **ISIN** |
| 7.125% | 11-May-98 | (Col-98) | USP28714AE62 |
| 8% | 14-Jun-01 | (Col-01) | US19532NAA46 |
| 7.5% | 1-Mar-02 | (Col-02) | US19532NAE67 |
| 7.25% | 15-Feb-03 | (Col-03) | US195325AH80 |
| 10.875% | 9-Mar-04 | (Col-04) | US195325AP07 |
| 7.625% | 15-Feb-07 | (Col-07) | US195325AK10 |
| 8.625% | 1-Apr-08 | (Col-08) | US195325AM75 |
| 9.75% | 23-Apr-09 | (Col-09) | US195325AR62 |
| 11.75% | 25-Feb-20 | (Col-20) | US195325AU91 |

| Mexico | | | |
|---|---|---|---|
| **Coupon** | **Maturity** | **Code** | **ISIN** |
| 9.75% | 6-Feb-01 | (Mex-01) | US593048AV35 |
| 8.5% | 15-Sep-02 | (Mex-02) | US593048AQ40 |
| 9.75% | 6-Apr-05 | (Mex-05) | US91086QAB41 |
| 9.875% | 15-Jan-07 | (Mex-07) | US593048BB61 |
| 8.625% | 12-Mar-08 | (Mex-08) | US593048BF75 |
| 10.375% | 17-Feb-09 | (Mex-09) | US593048BG58 |
| 9.875% | 1-Feb-10 | (Mex-10) | US91086QAD07 |
| 11.375% | 15-Sep-16 | (Mex-16) | US593048BA88 |
| 11.5% | 15-May-26 | (Mex-26) | US593048AX90 |

| Russia | | | |
|---|---|---|---|
| **Coupon** | **Maturity** | **Code** | **ISIN** |
| 3% | 14-May-99 | (Rus-99) | RU0004146067 |
| 9.25% | 27-Nov-01 | (Rus-01) | XS0071496623 |
| 11.75% | 10-Jun-03 | (Rus-03) | USX74344CZ79 |
| 8.75% | 24-Jul-05 | (Rus-05) | XS0089372063 |
| 8.25% | 31-Mar-10 | (Rus-10) | XS0114295560 |
| 11% | 24-Jul-18 | (Rus-18) | XS0089375249 |
| 5% | 31-Mar-30 | (Rus-30) | XS0114288789 |

* ISIN is the International Securities Identification Number.

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