Fixed Income
Quantitative Credit Research

21 September 2005

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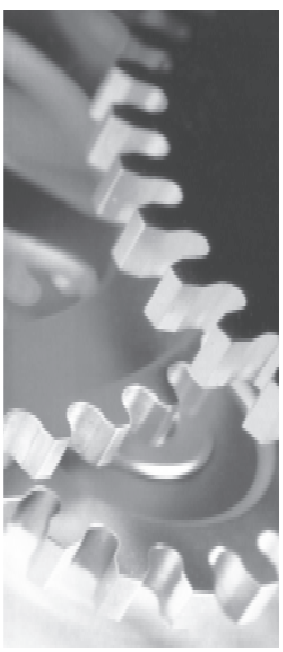

LEHMAN BROTHERS

Emerging Markets in the Lehman Brothers Global Risk Model[1]

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1. INTRODUCTION

The Lehman Brothers Risk Model allows portfolio managers to quantify the expected volatility of performance deviation ("tracking error volatility") between a portfolio and a benchmark and find optimal transactions to reflect specific views. These tools are increasingly important because the need to manage global portfolios, monitor adequate levels of diversification, and search for investment opportunities outside the core has increased the complexity of fixed-income portfolios. It is in this context that Lehman Brothers has expanded its Global Risk Model to include emerging market debt.

For the past decade, the Lehman Brothers Multi-Factor Risk Models have been a valuable tool for fixed income money managers. Our models, delivered through POINT (Portfolio and Index Tool), cover a wide variety of currencies, products and asset classes in a single unified framework: the 23 currencies of the Lehman Brothers Global Aggregate Index, asset classes such as Treasuries, agencies, corporate investment grade and high yield, MBS, ABS, CMBS, CMOs and inflation-linked securities. We also cover derivative products, such as bond futures, interest rate and currency derivatives, and CDS. A detailed practical guide to our risk models and reports can be found in Joneja/Dynkin *et al*. (2005).

In this paper we begin with a brief review of emerging market bonds, the value the risk model can add to more traditional approaches, and a general description of the overall structure of the Lehman Brothers Risk Models. Section 2 describes the emerging markets risk model. We illustrate the model implementation through our portfolio analytical platform, POINT, in section 3. Some readers may prefer to jump directly to the example in the last section before focusing on the details of the risk model laid out in section 2.

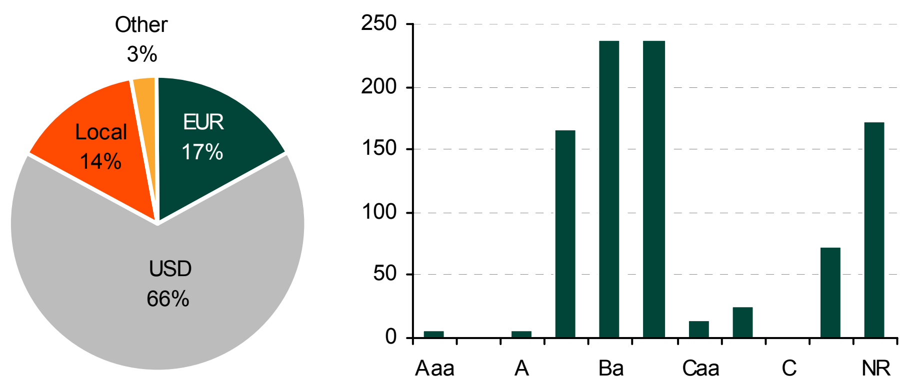
1.1. Emerging markets historical overview

The history of emerging market debt after the Second World War may be described in three distinct steps. Until the early 1990s, the market was small and the majority of the developing countries tended to borrow directly from banks or other international institutions. During the 1990s, the number of countries accessing the international public bond markets increased sharply, as the effects of the emerging markets debt crisis of the 1980s faded. The last years of the 1990s brought a new development into this market: the rise of non-sovereign emerging market debt. As countries develop, their private sectors explode and the dynamics of the market are no longer driven solely by macro/sovereign factors. In fact, recent turmoil episodes like the 2001 Argentina default or the 2002 Brazilian election seem to have had a much smaller contagious effect than previous episodes (e.g., Mondino (2005)).

[1] *I would like to thank A. Cevdet Aydemir, Dev Joneja, Joe Kogan, Bruce Phelps, Jeremy Rosten and Huarong Tang for their helpful comments and suggestions. Gary Wang and Anna Avrouchtchenko contributed to the development and implementation of the risk model in Lehman POINT.*

As of December 2004, the universe of emerging market bonds (described by Lehman Brothers as those bonds with sovereign ratings of Baa3 or below) includes 945 bonds, with a market value of $530 billion on $550 billion outstanding. Figure 1 presents some summary statistics regarding this cross section. About 60% of the issues are government related. Two-thirds of the bonds are USD denominated, 17% are EUR denominated and 14% are local issues from Indonesia, Mexico and the Philippines. Of the bonds, 19% are rated investment grade, 50% are non-distressed high yield (Ba/B), and the other 5% are distressed. 8% of the bonds are in default status while the remaining 18% are non-rated. It is important to note that this profile may change significantly across time. In particular, average ratings in December 2004 are better than historical averages.

Figure 1. Composition of the Lehman Brothers Emerging Market Index: Currency of denomination (left) and index rating (right).



Source: LehmanLive and POINT.

1.2. Risk in emerging markets: Traditional approaches and the Lehman Brothers risk model

The major sources of concern regarding emerging market debt relate to the local economic conditions. These are driven by local variables such as current accounts, inflation, economic growth, public sector spending and debt. However, under the current world market integration, local government and economic agents have only partial control over these indicators. Variables such as global growth, inflation or the general price of commodities play a significant role in determining the state of some of these economies.

Emerging market debt issued in major world currencies (such as USD or EUR) is also very sensitive to the economic environment in these major economic blocks. For instance, the level of interest rates, the business cycle and inflation in the US have a direct impact on the cost of borrowing for emerging market countries. That is why actions from the US Federal Reserve Board are closely followed by these markets.

It is extremely difficult to find an economic model that can integrate these different macro variables to explain the movements we observe in the markets. As a result, emerging market portfolio managers tend to rely on a set of portfolio statistics to measure the characteristics of their portfolios and their sensitivity to different economic variables. They monitor exposure to the yield curve (e.g., the EUR yield curve for EUR-denominated bonds). They also consider the different countries' "betas" – the relative volatility of a country's spread against a benchmark. The "betas" are used to capture a country's sensitivity to general news regarding growth, inflation or commodity prices. Portfolio managers may also look to other characteristics of their portfolios, such as their exposure to different points on the spread curve or their concentration in a specific name/country.

Analysis along these lines allows managers to formulate an educated view regarding such questions as:

- Will I outperform the benchmark if USD interest rates go up?
- If the index spread widens, what is the expected change in Mexican spreads?
- What happens if I extend the average maturity of my Russian bonds?

However, there are many other related and important questions that may be more difficult to address, such as:

- What is my risk exposure to a flattening of the USD curve?
- Is my portfolio riskier under that scenario? What is the risk impact of the flattening on my spreads?
- How much diversification do I get from adding an extra country to my portfolio? And what about expanding to a core plus strategy?
- I think my portfolio is too volatile: Where should I begin to rebalance? Where do I get the most value?
- What are the major active positions in my portfolio? Is it Asia or Venezuela? Or is it my imbalance on the 10-year point of the EUR yield curve? How should I rank them?
- How much risk am I taking for being long maturity in Brazil? How well is that hedged by my short maturity exposure to Mexico?
- What is the extra volatility associated with default events that come from my exposure to distressed bonds?
- Is my security selection diversified in terms of risk?

To answer this second set of questions, we need to translate these “directional” views into numbers. The more complex the portfolio, the harder this task is. The Lehman Brothers Global Risk Model aims to quantify all the different risk exposures of the portfolio and the benchmark in an integrated way, by netting out the effect of possible correlations between all these different effects. The result is a risk report that details and quantifies the characteristics and imbalances of the portfolio.

We formally detail the model and highlight some of the data used in section 2. However, in what follows we analyze two specific situations to illustrate what the risk model may add to more traditional approaches. Note that the examples use only a limited set of the information used in the global risk model and are constructed for illustration purposes only.

Example 1

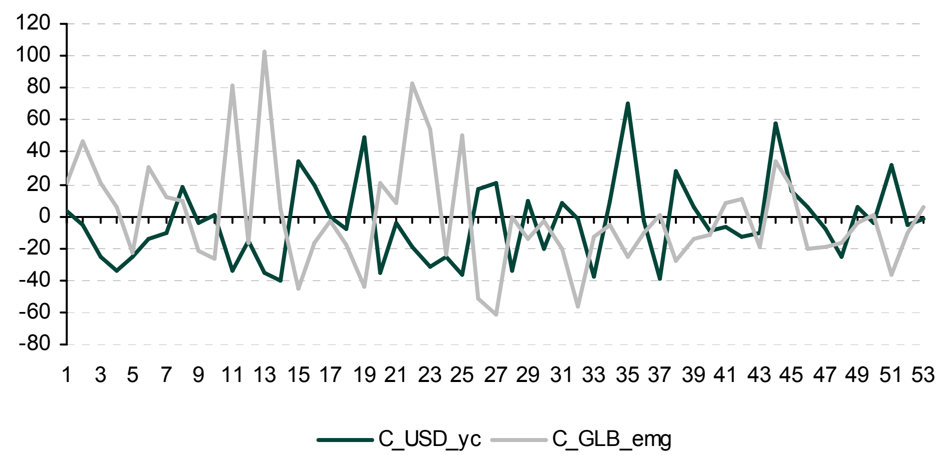
Suppose we have a generic emerging market portfolio that is short in duration and spread duration. Our working assumption is that the USD yield curve is set to rise, and we want to take full advantage of this view. We are short duration, so if interest rates do go up, we will outperform the benchmark. Suppose also that given the current market conditions, we expect spreads to tighten when interest rates go up. So our short spread duration may cancel some of our gains.

How can we quantify the extent of the trade-off? The risk model provides valuable guidance. Figure 2 shows data used by the risk model, namely the monthly changes in Treasury yields and in the OAS of the USD emerging markets index, from September 2000 to January 2005.

Specifically, we see a negative correlation (-0.44) between the two series. It confirms our reasoning that we may not be able to fully capitalize on our view about interest rates. What should we do? Ideally, we want to keep our duration exposure but increase our spread exposure. We explore two alternatives, both of which can be evaluated using our risk model.

The first alternative is to use cash bonds to rebalance the portfolio: buying bonds with small exposure to the Treasury curve but with larger exposure to changes in spreads. But there are probably too many bonds that fulfill this requirement. In this process, the risk model enables investors to fully quantify the net effect of a particular set of bonds on the portfolio's exposure to interest rates, emerging market spreads and many other risk factors.

Figure 2. Changes in the USD yield curve and on the OAS of the USD Lehman Brothers Emerging Market Index (bps/month)



Source: POINT.

A second alternative is to sell credit default swaps (CDS) written against emerging market or similar kind of debt. These instruments have low sensitivity to the interest rate curve and larger positive exposures to spread movements. The CDS allow us therefore to achieve our goals. But how can we quantify this alternative? Will we achieve better results by buying CDS from Brazilian or Mexican debt or an index of emerging market CDS? Should we buy the 3-, 5- or 7-year CDS? What extra risk/diversification will the portfolio have if we buy instead a CDX based on US credit names (like the CDX.NA.IG.4-V1 5Y)? To answer these questions, we need to know the correlation between cash bonds and CDS/CDX spreads from emerging markets, between these and yield curve movements, and so on. Also, because the correlation between emerging market cash bonds and their respective CDS spread is not perfect, we need to quantify the additional sources of risk we may be adding to the portfolio (e.g., basis risk).

How do the risk characteristics of our original portfolio compare with the new one? Is it more volatile? Was it successful in reducing our spread imbalances? Am I "buying" with the CDS/CDX some exposures I do not like or for which I have no specific views? The risk model quantifies these different issues into a unified set of *easily comparable* numbers. It details the exposures to different kinds of risks, providing a solid description of the risk of the current portfolio as well as guidance on potential portfolio changes.

In the case under consideration, the risk model would tell investors that buying the US credit-based CDX will have almost no effect on changing the correlation between spreads and Treasury yields. The old portfolio has a correlation of -0.44 against -0.38 for the "hedged" portfolio[2]. Moreover, we end up with exposure to US credit spreads, something that our initial portfolio did not have. Investors can use the risk model to evaluate other scenarios.

* * * * *

Example 2

Portfolio managers traditionally use a country's beta as a major indicator of its risk. "Beta" is defined as the sensitivity of a country's change in spreads to changes in spreads for the emerging market index. The idea is that countries with higher betas are riskier. However, betas are a very limited risk measure. Two countries may have similar betas but nevertheless present different risk characteristics. To illustrate this point, consider the cases of Turkey, Brazil and Venezuela. They have similar betas against the emerging market index, about 1.50, but are they close risk substitutes[3]? To analyze this, we look at the standard deviation of the changes in spreads on the country portfolio against the USD emerging markets index (the "Spread" Tracking Error Volatility). Figure 3 presents some results.

Figure 3. Betas and Tracking Error Volatility (TEV) for specific countries

Country	Beta	TEV(bp/month)
Brazil	1.58	82
Venezuela	1.54	60
Turkey	1.54	84

Source: POINT.

Although the TEVs for Brazil and Turkey are close, the one for Venezuela is significantly smaller. Betas capture only the spread co-movement between the country and the benchmark. TEV, on the other hand, captures both the movements associated with the benchmark (the beta) and movements away from the benchmark (non-systematic movements). From the figure, one can infer that, historically, non-systematic volatility in Venezuela is significantly smaller than that in the other two countries.

All three countries tend to move by the same amount when the index moves. But both Turkey and Brazil have additional spread movements that are not explained by the index at all. This represents extra risk that is captured by the risk model but is neglected by the country-beta approach.

This example shows some of the limitations of the traditional approach to risk. The risk model addresses these limitations by looking explicitly at both variances and covariances of the different risk factors the portfolio is exposed to.

* * * * *

Experienced portfolio managers are able to incorporate all this information into the risk analysis of their portfolios. However, as more alternatives are considered, it becomes increasingly difficult to quantify the effect of these combined risks on the portfolio. Our risk model provides investors with a tool to do that.

In the remaining part of the paper, we introduce readers to the risk model. The model is designed to be intuitive and simple. However, familiarity with the model and its output comes with time. The best way to build it is for investors to work in POINT with a portfolio they are familiar with.

[2] *The Global Risk Model will not display any particular correlations, but the results are based on those correlations.*

[3] *These betas are constructed using the risk model country factors. These factors proxy monthly changes in OAS since 1997 and rely on a specific treatment of outliers. The estimation of specific betas will vary based on the time span of the data used and on the frequency of estimation (monthly, weekly, daily, etc).*

1.3. Structure of the Lehman Brothers High Yield Credit Risk Model

The Lehman Brothers Global Risk Model is a unified framework for risk analysis: all product-specific models are developed within a consistent structure. In particular, the new Emerging Markets Risk Model has a structure close to the one for high yield bonds. Therefore, we begin with a brief description of the high yield model. See Chang (2003) for a more complete description of the model.

The motivation behind the model is that high yield bonds have two major sources of credit risk: (i) *market spread risk* that reflects investors' assessments of liquidity risk and changes in *future* default risk of the bond; and (ii) *default risk* that captures the risk of outright default over the short term. To capture these two kinds of risk, we describe the monthly return from bond *i* as:

$$R_{it} = (1 - I_{it}) R_{it}^{Market} + I_{it} R_{it}^{Default} \tag{1}$$

Here I is an indicative random variable for a default event – it has a value of 1 if the issuer *i* defaults during period *t*, and 0 otherwise. If there is no default during the period, the return for the bond is driven by market factors - R_{it}^{Market}. However, if the firm does default, the return is driven instead by the default process - $R_{it}^{Default}$[4].

1.3.1. Market Risk

In the model, market return is decomposed as follows:

$$R_{it}^{Market} = R_{it}^{Carry} + R_{it}^{YC} + R_{it}^{SS} + R_{it}^{VOL} + R_{it}^{Spread}, \tag{2}$$

where the first component is known in advance (e.g., coupon payments), and the remaining four are not (e.g., how much will spreads change). Return from carry captures coupon accrual and the return due to the passage of time. The yield curve (*YC*) return measures returns associated with changes only in the respective Treasury curve. Swap spread (*SS*) returns capture returns due to changes in swap spreads, and the volatility return captures the return that is due to embedded optionality, if any. Finally, the spread return captures the return due to changes in spreads over swap rates. For instance, for non-distressed high yield bonds, spread return is modeled as:

$$R_{Spread,t}^{i} = OASD_{t-1}^{i}\left[F_t^B + (TTM_{t-1}^{i} - TTM_{t-1}^{B})F_t^{TTM} + (OAS_{t-1}^{i} - OAS_{t-1}^{B})F_t^{OAS} + \varepsilon_{i,t}\right]$$

where F_t^B, F_t^{TTM} and F_t^{OAS} represent the risk factors, and the superscript *B* stands for the bucket to which the bond belongs. In the case of high yield non-distressed bonds, we have 11 buckets, based solely on industry.

This decomposition delivers a model where bond market returns are explained by two kinds of risk: the systematic risk – part of the return explained by the yield curve, volatility, swap spreads and spread factors; and the idiosyncratic risk – the portion of return not explained by the systematic factors (the $\varepsilon_{i,t}$ term above). As we show later, the role of these two kinds of risk varies widely across portfolios and across asset classes.

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[4] *From a continuous time perspective, equation (1) states that the price of a credit can be viewed as the combination of a diffusion process* R_{it}^{Market} *and a jump process* I_{it}.

1.3.2. Default risk

The return given default is modeled separately as:

$$R_{it}^{Default} = (recovery_{i,t} - price_{i,t-1}) / price_{i,t-1}$$

Once portfolios are considered, a major force driving the volatility of this return is the correlation of default across all names in the portfolio.

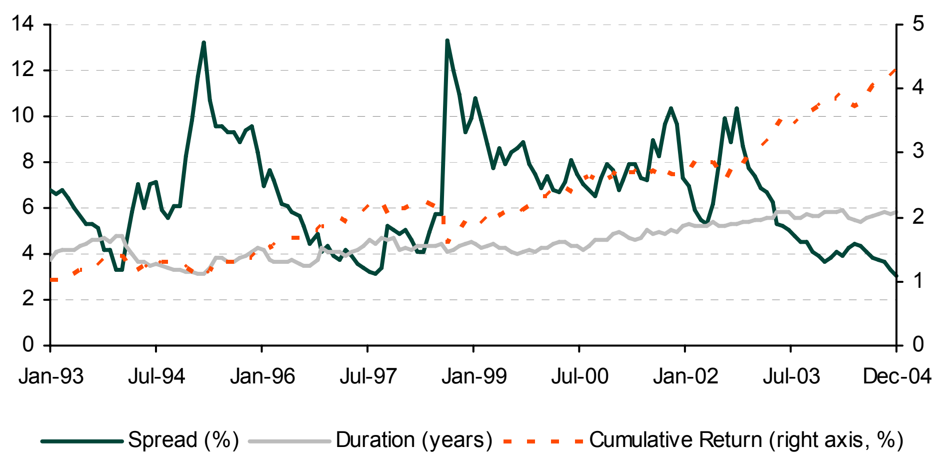
Bond returns – and credit risk – in our model are therefore explained by three types of risk: systematic, idiosyncratic and default risk. We use this rich specification to model the risk of emerging market bonds. In what follows, we detail the specifics of this asset class.

2. THE EMERGING MARKETS RISK MODEL

2.1. Market return

We begin with a very broad description of the dynamics of the USD Lehman Brothers emerging market index[5]. Figure 4 reports the spread (OAS), durations and cumulative total return (right axis) from this index. One can see that the index has returned on average about 1% per month over the past 12 years. This means that an investment of $100 in 1993 would be valued at over $400 by the end of 2004. The bulk of that return comes from the past two years, when spreads to Treasuries decreased from 10% to just above 2%. This high return is associated with the relatively high risk of this asset class measured, for instance, by the high volatility of the spreads. Finally, note that the duration of the index increased from about four years in 1993 to six years in 2004. This seems to suggest an increase in issuance and/or in the maturity of the debt issued.

Figure 4. Lehman Brothers Emerging Market Index (USD) statistics: spread, duration and cumulative total return (right axis)



Source: LehmanLive.

We now turn to the description of the market return specification for the emerging markets risk model. The starting point is equation (2). Specifically, for emerging markets, we use six key rate durations plus a convexity term to model the return from the yield curve (again, see Chang (2003) for details). We model the return from the change in swap spreads similarly:

[5] *The analysis here is restricted to USD-denominated bonds because a longer time series is available for this currency.*

$$R_{it}^{SS} = \sum_{j=1}^{6} SSKRD_{i,j,t} \times \Delta SS_{j,t}$$

where $\Delta SS_{j,t}$ stands for the change in the jth swap spread in period t (j = 6 months, 2, 5, 10, 20 and 30 years) and:

$$SSKRD_{i,j,t} = OASD_{it} \times (KRD_{i,j,t} / \sum_{m=1}^{6} KRD_{i,m,t})$$

where *OASD* stands for option-adjusted spread duration and *KRD* for key rate duration.

In addition we set the return from volatility to zero due to the sparse information regarding embedded options in emerging market debt[6]. We are left with the spread return. Following the structure of our existing models, the first goal is to establish groups of bonds – "buckets" – with similar risk profiles. The specific groups that we end up with are based on two criteria. First, the grouping must have an intuitive appeal: for instance, most people would agree that firms in the same industry do share a set of common risk factors. In this regard, grouping bonds by industry seems to make sense. Second, the factors estimated from the model must be statistically robust. Therefore, we want to avoid groups with a small number of observations or whose characteristics vary significantly across time. In the investment grade credit models these considerations led us to define groups based on country, industry and rating. However, a different strategy is used to model distressed bonds in the high yield model: all bonds are pulled together independently of country or industry.

In emerging markets, we begin with an approach similar to that of the existing models. This procedure ensures a unified framework across all risk models. To do so, we construct a sample using data from emerging markets available from Lehman Brothers. Emerging market debt is defined as bonds from countries with sovereign ratings of Baa3 or below. The sample we use spans the period from January 1997 to December 2004 (96 months), with a total of 29,580 individual bond return observations from 46 countries and includes both EUR- and USD-denominated bonds[7].

We first group the bonds into three major geographical regions – Latin America, Europe and Asia – and three rating buckets[8]. Figure 5 presents some summary statistics for this partition.

Figure 5. Sample summary statistics by region and rating

Rating	**Aaa-Baa**			**Ba-B**			**Caa-C**		
Statistics	**America**	**Asia**	**Europe**	**America**	**Asia**	**Europe**	**America**	**Asia**	**Europe**
Observations	4,377	1,151	657	10,456	4,444	2,990	3,777	1,038	690
Number of Months	88	82	88	96	96	96	92	85	68
Avg. Number of Bonds per Month	50	14	7	109	46	31	41	12	10
Min. Number of Bonds per Month	20	1	1	22	23	4	1	1	1

Source: POINT.

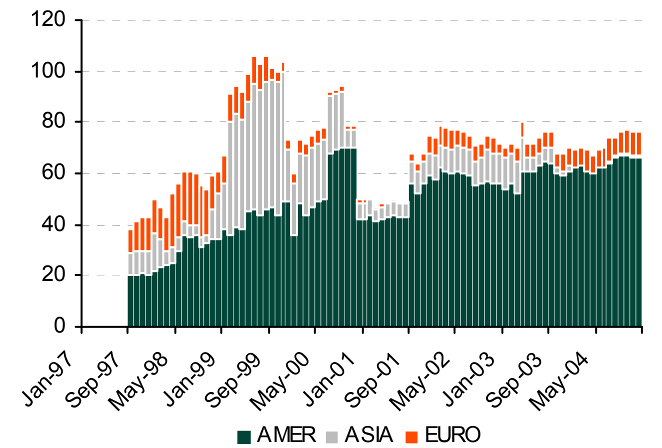
A quick analysis of the figure suggests that this partition may have some problems due to some relatively thin buckets: both investment grade (Aaa-Baa) and high yield distressed (Caa-C) for Asia and Europe. A closer look at the data is given in Figure 6. We can see that the time series profile of these buckets is not stable across time. Concerning investment grade, there are almost no data from Europe during 2000 and 2001. The same happens with

6 We will revisit this issue as more analytics become available for these bonds.
7 Data are available from earlier years for some Latin American countries.
8 Countries from the Middle East and Africa are included in the Asia block. Their inclusion does not materially change any of the results presented. See Appendix 1 for a full description of country/region mapping.

Asia during the past two years. When we look into the regional profile of high yield distressed bonds, almost the opposite happens: Europe has a relatively high number of distressed bonds after the Russian crisis in July 1998. This number begins to fade after 2000. Asia has a relatively high number of distressed bonds after the crisis in 1997. This number simply collapses after 2000.

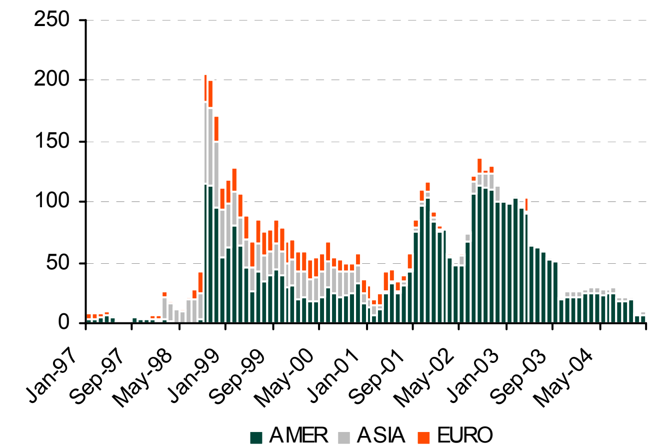
Figure 6. Number of investment grade bonds (left) and distressed bonds (right) per geographic region

Figure 6a. Investment grade bonds per geographic region



Source: POINT.

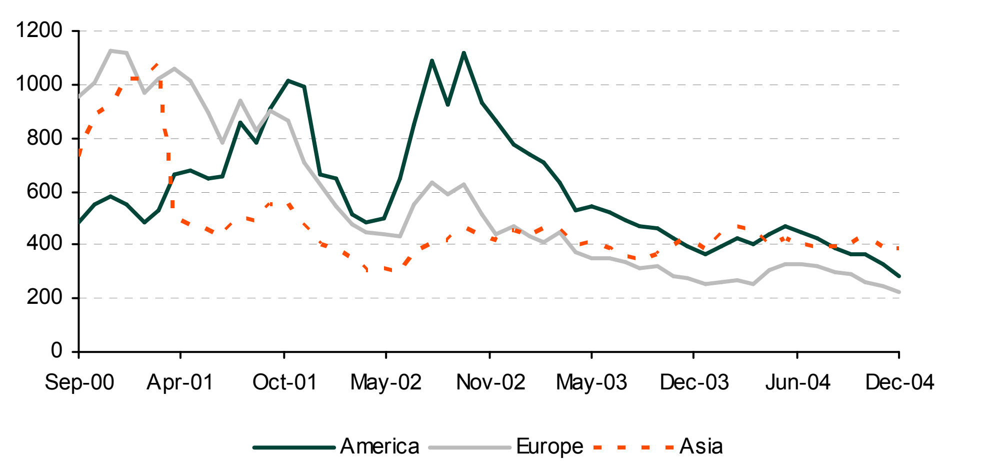
Figure 6b. Distressed bonds per geographic region



Source: POINT.

The existence of long periods when these buckets are very thinly populated poses a problem when estimating systematic risk factors. The volatility of thin buckets may be primarily driven by idiosyncratic events and we would be wrong in labeling this volatility as systematic. In other words, we cannot estimate with confidence a time series of systematic factors driving the return of these buckets. We therefore choose to merge the three investment grade buckets into a single one. We do the same for the three distressed buckets. By doing so we lose some information, but we hope to avoid any serious misrepresentation of risk.

Figure 7. Emerging markets OAS per regional block: America, Europe and Asia (bp)



Source: LehmanLive.

Regarding high yield non-distressed bonds (Ba-B), the evidence in Figure 5 suggests that we have enough data to estimate systematic factors for the three regions. But if bonds behave similarly across all three regions, there is no reason to do so. Although more information will be given later, Figure 7 sheds some light on this issue. It shows the monthly OAS for emerging market bonds denominated in USD from August 2000 to December 2004, grouped by regional block. It is apparent that although sharing some secular trends over the past four years, there are plenty of episodes when their behavior differs substantially. For instance, comparing America and Europe, one can see that their spread behavior was quite different during the first period of the sample. Also, the Argentina default of late 2001 seemed to have a strong regional effect, much bigger across Latin America than in Europe or Asia. The same is true during the events of September 2001. The figure also shows a flat OAS for Asia since mid-2002, much in contrast with both America and Europe. Finally, the OAS for European emerging market bonds has steadily decreased over these years, while the Asian OAS had an early dramatic decrease, and stayed flat almost since early 2001. In contrast, Latin American bonds have seen much more volatile behavior. This analysis supports our choice of three major regional factors – America, Asia and Europe – to describe the spread return for Ba/B-rated emerging market bonds.

In fact, we went further with this exercise, and estimated individual country factors. Portfolio managers with exposures centered on a small set of emerging market countries may find that the country-specific risk their portfolios are exposed to is being washed away by the aggregation within blocks. To avoid this dilution, we estimate individual factors for countries that are major issuers in the emerging markets[9]. Figure 8 presents the partition with the 12 buckets we use to model emerging market bonds. Later in this paper, we provide additional evidence regarding individual country factors.

In addition, we could have modeled sovereign and non-sovereign debt separately. We decided not to because we found similar volatility behavior for these two types of bonds. However, we do differentiate their default treatment (see below)[10]. Finally, some of the bonds from emerging markets are "Brady bonds". These are bonds whose principal is partially guaranteed, usually by US government bonds. The existence of these guarantees distorts the usual bond analytics. Taking that into account, we use the corrected ("stripped") analytics for these bonds, whenever needed. We also take into account their guaranteed principal when computing recovery rates.

We can now detail the model we use to estimate the return from changes in spreads for emerging market bonds. Our study suggests that there are systematic differences in spread volatility across ratings and regions. To accommodate this evidence, we estimate spread volatilities along these dimensions and attribute a common "bucket" risk factor to all bonds belonging to the same rating/region bucket (F_t^B and $F_t^{Distress}$). However, two bonds in the same bucket can still exhibit different risk profiles. We use two more risk factors to fine tune these systematic differences. One is based on the time to maturity (TTM) of the bond as compared with its bucket: even if two bonds belong to the same rating and region group, we still expect different volatilities if their time to maturity is very different. We capture this asymmetry with our "slope" risk factor. The other systematic risk factor is based on the option-adjusted spread (OAS) of the bond, again compared with the average of the bucket: we may have two bonds with the same rating, from the same country and with the same time to maturity. However, one may trade at much higher spreads – e.g., if it is less liquid – than

[9] These are also the countries for which we have enough data to perform our estimation exercise in a meaningful way.

[10] We differentiate their default treatment given the evidence that recovery rates for non-sovereigns are smaller. Interestingly, we did not find significant difference of behavior in the spread movements across the two sets of bonds. This may be because the recovery rates are quite small anyway for all these bonds (25% for sovereigns and 10% for non-sovereigns).

the other. This difference in profile can be relevant for risk purposes and is fully captured by the risk model through the "spread" risk factor. Differences in spread volatility not explained by these systematic risk factors are labeled as idiosyncratic.

More formally, spread return for non-distressed bonds is modeled as:

$$R^i_{Spread,t} = OASD^i_{t-1}\left[F^B_t + (TTM^i_{t-1} - TTM^B_{t-1})F^{TTM}_t + (OAS^i_{t-1} - OAS^B_{t-1})F^{OAS}_t + \varepsilon_{i,t}\right] \quad (3)$$

where B is one of the eleven non-distressed (Aaa-B) "buckets" described in Figure 8. So F^B_t is the "bucket" risk factor, F^{TTM}_t is the "slope" factor, and F^{OAS}_t the "spread" factor. The loadings to each of these factors are as described above. Finally, $\varepsilon_{i,t}$ is the idiosyncratic term.

For distressed bonds the model is similar, but returns are modeled directly, as these bonds are usually traded on price rather than spreads:

$$R^i_{Spread,t} = F^{Distress}_t + (TTM^i_{t-1} - TTM^{Distress}_{t-1})F^{TTM}_t + (\Pr ice^i_{t-1} - \Pr ice^{Distress}_{t-1})F^{\Pr ice}_t + \varepsilon_{i,t} \quad (4)$$

Factors and idiosyncratic errors are estimated monthly and their time series are used to construct both the covariance matrix and a consistent estimator for the volatility of the idiosyncratic error. Our robust estimation procedure (along the lines of the Huber M estimator) reduces the weight of the outliers and delivers monthly R-squared of 50%/60%[11]. Moreover, we use two alternative methodologies to aggregate the monthly statistics: an equal-weighted (standard) approach, where all observations are given the same weight regardless of how old they are; and a time-weighted approach, that attributes a higher weight to the more recent observations (Berd and Naldi (2002)). The latter approach uses an exponential weighting scheme with half-life defined at one year. This option is particularly useful if one believes future market volatility conditions are closer to recent volatility conditions than to historical averages.

Figure 8. Partition for emerging markets risk factors

<table>
<tr><th>Rating / Block</th><th>Aaa-Baa</th><th>Ba-B</th><th>Caa-C</th></tr>
<tr><td>America</td><td rowspan="3">EMG Investment Grade</td><td>EMG America
Argentina
Brazil
Mexico
Venezuela</td><td rowspan="3">EMG
Distressed</td></tr>
<tr><td>Asia</td><td>EMG Asia
Philippines</td></tr>
<tr><td>Europe</td><td>EMG Europe
Russia
Turkey</td></tr>
</table>

Source: POINT.

Figure 9 presents the standard deviation of several systematic risk factors, both from the emerging markets model (EMG) and from two other Lehman Brothers risk models: the USD

[11] *These numbers are substantially higher than those from models like the high yield model. We discuss later why this may be the case.*

investment grade (IG) and the global high yield (HY) risk models. We present the factor volatilities for both the unweighted and time-weighted methodologies. All numbers are in basis points per month. Recall from (3) and (4) that while non-distressed factors proxy for changes in OAS, the distressed factors model returns directly, so their units are distinct.

The figure shows that historically (unweighted), the factor volatility of emerging markets has been about double that of the corresponding factors from developed countries. As suggested by Figure 5, Asia seems to be an exception, with volatilities very close to those from high yield non-distressed bonds. Another interesting point to note is that this general gap is significantly reduced when we take instead the time-weighted volatilities. This expected result reflects the dramatic drop in spread volatilities from emerging markets bonds in recent years. The exception seems to be distressed bonds, where the gap did not close: although the average monthly returns (in absolute value) from high yield distressed bonds drops to 2.7% when we overweight recent observations, the one from emerging market distressed bonds is still very high, about 6.4% per month. This may still be the result of the Argentina default in late 2001.

Figure 9. Systematic risk factor volatilities (basis points/month)

Asset Class	Unweighted	Time Weighted
Investment Grade		
IG Non Corporates Baa	16.9	16.1
EMG Investment Grade	38.2	20.3
High Yield Non-Distressed		
HY non-distressed	48.4	42.2
EMG America	88.9	65.3
EMG Asia	58.1	28.9
EMG Europe	98.5	53.7
High Yield Distressed		
HY Distressed	367	270
EMG Distressed	766	637

Source: POINT.

Similarly, Figure 10 presents the idiosyncratic risk (volatility of the idiosyncratic error) for bonds from the same risk buckets. The analysis of the investment grade numbers is similar to the one made above for the systematic factors. However, the story is very different for the high yield buckets. Note that for both distressed and non-distressed high yield bonds, the idiosyncratic volatilities are smaller than those from the global high yield model.

The evidence suggests that in relative terms, emerging markets bonds tend to move together much more closely than their counterparts from more developed countries. This result is consistent with the idea that emerging markets volatility is driven by a set of macroeconomic factors, from which no individual bonds can diverge too much. This "macro" influence is only attenuated for the investment-grade bonds, possibly because investors perceive these bonds as being less correlated with their specific country's fate: their risk is not pure sovereign risk. This perception may arise from recent default episodes, where the old across-the-board moratoria were significantly less severe. For example, during the recent defaults from Pakistan, Ukraine and Russia, payments did not stop on debt owned by foreigners (Levey and Truglia (2001)).

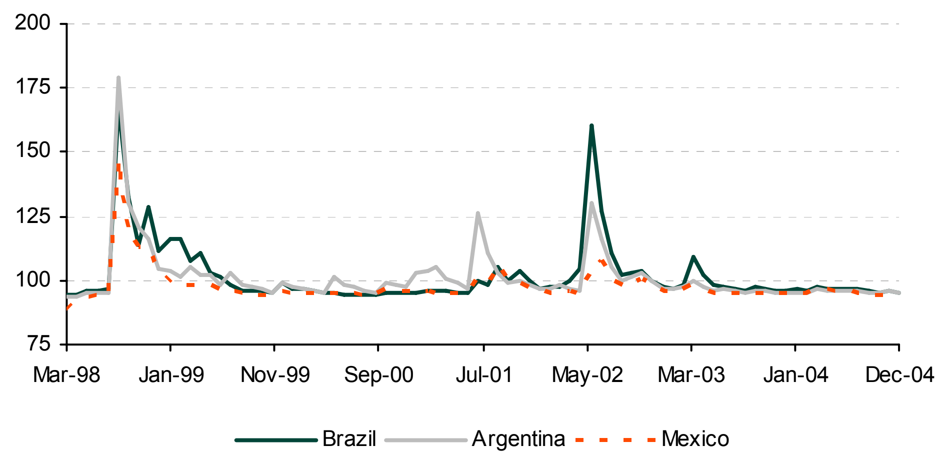
Figure 10. Idiosyncratic risk factor volatilities (basis points/month)

Asset Class	Unweighted	Time Weighted
Investment Grade		
IG Non Corporates Baa	19.2	17.0
EMG Investment Grade	38.9	26.2
HY Non-Distressed		
HY non-distressed	82.1	71.6
EMG America	59.2	45.9
EMG Asia	67.0	39.6
EMG Europe	55.4	35.8
HY Distressed		
HY Distressed	972	762
EMG Distressed	732	589

Source: POINT.

Figure 11 supports the rationale behind the use of individual country factors. Specifically, it presents the volatility in basis points of the systematic spread return of three hypothetical portfolios, each with a high yield, non-distressed, one-year OASD bond from a specific country[12]. We use the time-weighted volatilities for this example. For most of the time, the volatilities are quite similar. However, countries' risk profiles may differ substantially in the aftermath of particular shocks. For example, the volatilities increase significantly following the Russian crisis, but much less so for the Mexican portfolio. Moreover, the Argentina default of late 2001 triggered an increase in volatilities, but it was essentially a country-specific shock. On the other hand, the uncertainty around the Brazilian elections of October 2002 led to higher – but much smaller – volatilities across the border. This asymmetric behavior justifies our use of individual country factors, when possible, against the use of the more aggregated regional block factors.

Figure 11. Spread volatilities for Brazil, Argentina and Mexico (basis points/month)



Source: POINT.

[12] *We also assume that each of the bonds has average time to maturity and OAS.*

Finally, it is interesting to consider the correlation between emerging markets systematic risk factors and those outside this asset class. This may help us identify contemporaneous movements across different markets. This information can be used for portfolio hedging or diversification. These correlations are only indicative, as they can change significantly with market conditions. Figure 12 shows the (unweighted) risk model correlations[13].

Figure 12. Correlations across different asset classes

Risk Factors	EMG Inv. Grade	EMG America	EMG Asia	EMG Europe	EMG Distressed
A. Emerging Markets Spreads					
EMG Inv. Grade	1.000				
EMG America	0.884	1.000			
EMG Asia	0.921	0.811	1.000		
EMG Europe	0.877	0.850	0.846	1.000	
EMG Distressed	0.666	0.596	0.595	0.630	1.000
B. 5-Year Interest Rate					
USD_kr_5Y	-0.294	-0.267	-0.272	-0.265	-0.215
EUR_kr_5y	-0.140	-0.127	-0.130	-0.126	-0.102
GBP_kr_5y	-0.075	-0.069	-0.070	-0.068	-0.055
C. Other Credit Spreads					
USD Inv. Grade Credit	0.410	0.372	0.380	0.370	0.300
EUR Inv. Grade Credit	0.248	0.225	0.230	0.224	0.181
GBP Inv. Grade Credit	0.219	0.198	0.203	0.197	0.160
HY Distressed	0.392	0.356	0.364	0.354	0.287

Source: POINT.

As discussed before, Panel A shows that spreads move quite closely across the different regions. This suggests limited gains in regional diversification across emerging markets. Correlations seem to break only for the distressed group – although they are still quite large. The evidence in Panel B seems to suggest that the negative correlation between spreads and interest rates decays with rating. It is also relatively larger (in absolute value) for USD-denominated bonds. This latter relationship may be driven by the fact that the emerging market of USD-denominated bonds is larger than for other currencies (Figure 1). Still, this correlation is substantially smaller (in absolute value) than that for the other asset classes – e.g., the correlation between USD interest rates and USD credit spreads is about -0.50. Several reasons may explain this fact: the weaker relationship between the (foreign) interest rates and the state of the local economies across emerging markets. Investors may use some exposure to emerging markets to reduce the impact of interest rate changes on spreads (one needs to exercise caution though: recall the discussion in "Example 1" above). Finally, note the positive correlations between emerging market and other credit spreads, suggesting some degree of both economic and market integration/globalization. Again, this is especially true for USD credit spreads. The level of these correlations – clearly much smaller than one – seems to suggest that one can significantly reduce exposure to USD credit spread by diversifying into emerging markets. The net effect of this analysis is simplified by the risk model. There one can measure these and other trade-offs in a clear and concise way.

[13] *Weighted correlations are not too different.*

2.2. Default risk

Portfolio default volatilities in our model are driven by three factors: default probabilities, recovery rates, and correlation of default among the bonds of the portfolio. To illustrate this point, we begin with equation (1) without the market return component:

$$R_t^i \approx I_i R_{Default,t}^i$$

Although in general the recovery rate is stochastic at the beginning of the period, we treat it as deterministic, for the sake of tractability. Consequently, the standard deviation of the return due to default for a portfolio with two bonds with the same default probability *p*, return upon default *R,* portfolio weight (50%) and a correlation of default ρ is approximately:

$$stdev(\mathrm{Re}turn\ due\ to\ default) \approx \sqrt{0.5\,p(1+\rho)}\,|R|$$

Note that the volatility is increasing in the probability of default and correlation. Moreover, the larger the loss upon default, the greater the volatility (we model *R* as having an upper bound of -10%). In what follows we analyze in more detail each of these three variables.

The default probability of a given bond is driven by the financial situation of its issuer. We assume that once default occurs for one issuer, it occurs for all its bonds. Therefore, the default probability of a bond is independent of its subordination, and all bonds from the same issuer have the same probability of default[14]. We base the default probability of a particular issuer on the rating of its senior unsecured debt[15]. Figure 13 shows the current annual default rates being used across different ratings. These numbers are updated monthly and are based on historical numbers. Again, we offer two sets of default rates: an historical average and a 12-month trailing average.

Figure 13. Annual historical default rates: long-run and 12-month trailing average (December 2004)

Average	Baa1	Baa2	Baa3	Ba1	Ba2	Ba3	B1	B2	B3	Caa-C
Long run	0.10%	0.18%	0.33%	0.60%	1.09%	1.98%	3.59%	6.50%	11.77%	21.33%
12-month trailing	0.06%	0.10%	0.19%	0.34%	0.62%	1.12%	2.03%	3.68%	6.67%	12.09%

Source: POINT.

The procedure used to attribute recovery rates to a particular bond has changed across all Lehman Brothers risk models from the one reported in Chang (2003). However, for emerging markets the changes are smaller. For the sake of completeness, we begin by describing the new general procedure. We then detail the specific assumptions used for emerging markets.

The recovery rates are based on the bond's specific subordination type. This approach replaces – for all bonds for which we calculate default TEV – the use of industry as the determinant of recovery rates. The change is based on several studies, principally Moody's model to predict loss given default detailed in LossCalc (Gupton and Stein (2002)). They find that:

1. Seniority is the main predictor of recovery rates.

---

[14] *For sovereign bonds this is not necessarily true. Governments can selectively default on part of their debt only. However, for simplicity, we ignore this difference.*
[15] *If the issuer does not have any senior unsecured debt, its rating is interpolated from bonds with other subordinations.*

2. Recovery rates per seniority are well predicted by their historical average and a macro indicator that captures the default "business cycle".
3. The industry effect is small and useful only if short-term industry-specific recovery rate averages are available. This is because the industry-specific recovery rates vary across business cycles.

Our approach uses the first two findings. In particular, we make recovery rates a function of seniority; we provide both a long-run historical average and a 12-month trailing average of recovery rates for senior unsecured debt. The latter series captures the essentials of the business cycle dynamics. The current values for both the long-run average and the 12-month trailing series are given in Figure 14. For all European bonds, we use 80% of these values.

We can also confirm that our 12-month trailing averages fully capture one additional important feature of the behavior of default cycle: recovery rates are usually high (low) when default rates are low (high). This correlation results in default return volatilities that can be significantly different depending on the specific average series used. For example, the default volatility for a senior unsecured B2 bond goes from 17.6% to 10.2% when one changes from using long-run averages to 12-month trailing averages.

Figure 14. Annual historical recovery rates: long-run and 12-month trailing average (December 2004)

Average	Sr. Super Secured	Sr. Secured	Sr. Unsecured	Sr. Sub.	Sub.	Jr. Sub.	Pref. Stock
Long run	71	50	31	27	27	17	9
12-month trailing	81	60	47	39	32	31	20

Source: POINT.

As mentioned previously, we treat the recovery process for emerging market bonds differently. The experience with defaults in emerging markets is significantly different from that in developed countries. The actual number of defaults is also much smaller, so we cannot model them with a partition as fine as that in Figure 14. Instead, we set recovery rates for emerging market bonds using an established fact about emerging market defaults: recovery rates for sovereign bonds tend to be higher than their corporate counterparts. In particular, we set the recovery rate to 25% for emerging market sovereign bonds and 10% for emerging market non-sovereign bonds. These numbers are conservative estimates. Their historical averages are higher, but sensitive to the small number of actual defaults.

Finally, the default volatility depends also on the default correlation. See Chang (2003) for a description of the implementation of this feature in our risk models. In short, we treat default as a systematic event: the aggregate default rate moves with the business cycle, with distressed credit conditions tending to propagate across firms.

We model default based on a model inspired by Merton (1974). Specifically, we approximate asset returns by stock returns (equity is just a call option on the company's assets). We then model the correlation of stock returns to get an estimate of the default correlation. (In particular, we use a larger cross section of individual stock returns from emerging market countries to calibrate this model to emerging market debt.) Crucial to this methodology is the use of the Student-*t* distribution to model asset returns. Empirical evidence suggests that this distribution does a much better job of explaining stock returns than the usual alternative normal distribution. This is because the *t* distribution delivers two important features: fatter tails and tail-dependence. The first implies that extreme outcomes are more likely than with the normal distribution, and the second generates more extreme co-movements. Because default itself is an extreme event, these two characteristics have a significant influence on the results of the analysis. This is particularly relevant for emerging markets. For this asset class, extreme events are even more usual, as are the propagation effects.

3. POINT IMPLEMENTATION

In this section, we examine a sample risk report for an emerging market portfolio. The report is produced through our portfolio analytical platform, POINT. POINT delivers several risk measures relating to the portfolio, benchmark and the difference between the two. A full description of the report statistics and some insights on the interpretation of the report numbers are available at the Global Risk Model Glossary in POINT.

In the example below, the portfolio is USD-denominated investment grade Brazilian bonds. The benchmark is the US non-corporate Baa credit index. It is mainly composed of Mexican bonds. We present this example purely to illustrate the level of detail in POINT risk analysis. We run the report on January 31, 2005 using the "weighted" option.

Figure 15. Portfolio/Benchmark Comparison Report (partial)

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Portfolio/Benchmark Comparison

Portfolio : us em brazil
Benchmark : US Credit Non Corporate Baa

Parameter	Portfolio	Benchmark	Difference
Market Value	5060023	72545964	
Coupon (%)	3.87	7.9	-4.03
Average Life (Yr)	6.09	10.07	-3.98
Yield to Worst (%)	6.15	5.16	0.99
ISMA Yield (%)	6.23	5.16	1.07
OAS (bps)	247	120	128
OAD (Yr)	4.38	6.22	-1.84
ISMA Duration (Yr)	4.48	6.22	-1.73
Duration to Maturity (Yr)	4.48	6.22	-1.74
Vega	-0.01	-0.0	-0.0
OA Spread Duration (Yr)	4.47	6.12	-1.65
OA Convexity (Yr^2/100)	0.23	0.71	-0.47
Total TE Volatility (bps/month)			**159.35**
Systematic Volatility (bps/month)	173.63	183.83	
Non-systematic Volatility (bps/month)	51.9	65.07	
Default Volatility (bps/month)	42.87	33.12	
Total Volatility (bps/month)	**186.23**	**197.8**	

Source: POINT.

The first report presented by POINT is the "Portfolio/Benchmark Comparison". This shows important statistics about the portfolio and benchmark, including the number of positions, currencies, market value. This report also provides a snapshot of significant analytics such as OAD, OASD, OAS. Figure 15 presents a partial view of this report. One can see that the portfolio is almost two years short duration compared with the benchmark. Such a position would suggest that the portfolio manager wants significantly less exposure to interest rate movements. The portfolio also has significantly higher spreads. At the bottom, this report also presents some summary risk measures, such as the Tracking Error Volatility (TEV) or the volatilities along the major risk sources: systematic, idiosyncratic and default risk. The TEV, that is, the expected standard deviation of the difference in returns between the portfolio and the benchmark, is 159 basis points per month. We can also see that although the duration of the portfolio is much shorter, its systematic risk is close to that of the benchmark (174bp/month vs 189bp/month). As we will see later, this is because the portfolio is exposed to the highly volatile emerging markets risk factors. The overall risk due to default or idiosyncratic events is also not too different[16].

Figure 16 presents the "Tracking Error" report. It decomposes the total TEV across several major sources of risk, namely currency, yield curve, swap spreads, volatility, investment grade spreads, high yield spreads, emerging markets spreads, idiosyncratic and default risk.

Numbers are presented for the isolated and the cumulative TEV for each of these sources. We also show the percentage of the tracking error variance that is attributed to each of these major sources. One can see that the mismatch in durations accounts for a 46bp/month TEV. The investment grade component of the TEV accounts for an isolated 101bp/month, while the emerging markets exposure mismatch is responsible for an isolated TEV of 119bp/month.

Figure 16. Tracking Error Report

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Tracking Error

Portfolio : us em brazil
Benchmark : US Credit Non Corporate Baa

Global Risk Factor	Isolated TEV (bps)	Cumulative TEV (bps)	Difference in cumulative (bps)	Percentage of tracking error variance (%)
Global				
Yield Curve	45.61	45.61	45.61	6.97
Swap Spreads	12.4	50.49	4.88	-0.0
Volatility	0.36	50.25	-0.24	-0.04
Investment-Grade Spreads	101.05	100.45	50.19	16.82
Credit and Agency Spreads	101.05	100.45	50.19	16.82
Emerging Markets Spread	118.57	126.63	26.19	39.39
Systematic risk	126.63	126.63	0.0	63.15
Idiosyncratic risk	82.5	151.13	24.5	26.8
Credit default risk	50.51	159.35	8.22	10.05
Total risk		**159.35**	**-0.0**	**100.0**

Source: POINT.

[16] *Even though the volatilities are similar, their specific characteristics may not be.*

Interestingly, note that the investment grade spreads account for 16.8% of the TE variance, while the emerging market spreads account for only 39.4%. Therefore, when all effects are taken into account, the overall effect of the non-corporate imbalances shrinks significantly. This striking result is due to covariances between these spreads and all other risk factors.

In Figure 17 we detailed this information. In particular, note that we have an imbalance on the OASD exposure of six years for the non-corporate Baa bucket and four years for emerging markets. The volatility of these factors is similar (recall that we are using weighted estimates). This means that an average monthly *uncorrelated* increase in the spread implies a change of comparable magnitude in the tracking error[17]: 97.4bp/month for the non-corporate bonds compared with -89.2bp/month for the Brazilian ones. However, in the real world risk factors are correlated. So the report also shows the correlated TE, that is respectively 43.8bp/month and -82.56bp/month. While the exposure to non-corporates is somewhat diluted by the correlation with other factors, the exposure to the Brazilian bonds is not. So at the end (see last column) the Brazilian exposure is responsible for 29% of the TE variance, while the mismatch in non-corporate spreads accounts for only 16.8%.

Figure 17. Factor Exposure – Full Detail Report (partial view)

LEHMAN BROTHERS | POINT Global Risk Model

Factor Exposure - Full Details **1/31/2005**

Portfolio : us em brazil
Benchmark : US Credit Non Corporate Baa

Factor name	Sensitivity/Exposure	Portfolio exposure	Benchmark exposure	Net exposure	Factor volatility	TE impact of an isolated 1 std. dev. up change (bps)	TE impact of a correlated 1 std. dev. up change (bps)	Marginal contribution to TEV (bps)	Percentage of tracking error variance (%)
CREDIT IG SPREAD & VOL.									
USD Corporate volatility	Volatility Duration	0.0	0.0040	-0.0040	96.83	0.36	-24.89	15.126	-0.04
USD Non-Corporate BAA	OASD (Yr)	0.0	6.038	-6.038	16.13	97.4	43.8	-4.434	16.8
USD Corporate Spread Slope	OASD*(TTM-AvgTTM) (Yr^2)	0.0	48.794	-48.794	0.17	8.49	11.22	-0.012	0.38
USD Corporate Liquidity	OASD*(OAS-AvgOAS) (Yr*%)	0.0	2.722	-2.722	6.98	18.99	11.53	-0.505	0.86
USD Foreign Corporates BAA	OASD (Yr)	0.0	5.963	-5.963	3.29	19.63	-15.71	0.324	-1.21
EMERGING MARKETS SPREAD									
Global EMG Investment Grade	OASD (Yr)	4.467	0.079	4.388	20.33	-89.23	-82.56	10.536	29.01
Global EMG Non-Distressed Slope	OASD*(TTM-AvgTTM) (Yr^2)	3.311	-0.106	3.417	0.92	-3.15	59.73	-0.346	-0.74
Global EMG Non-Distressed Liquidity	OASD*(OAS-AvgOAS) (Yr*%)	3.412	-0.015	3.428	11.05	-37.88	-74.56	5.171	11.12

Source: POINT.

Regarding idiosyncratic risk, POINT provides two reports. In the first one, "Portfolio Issue-Specific Risk Report", we conduct issue-level risk analysis for the major holdings of the portfolio. The second, "Credit Ticker Report" (Figure 18), presents a similar analysis but with all issues from the same issuer grouped together. So if an investor has offsetting positions on two different bonds from the same issuer, the overall "issuer" risk will be small.

Interestingly, the biggest source of idiosyncratic TEV is from bonds that are not in the portfolio: Mexican sovereign bonds (62.97bp/month). This issuer is an important part of the benchmark, and the fact that we do not carry it in the portfolio creates a large imbalance. Also note that the portfolio is highly concentrated in two issuers, AMBEV and PETBRA. These two account for 58% of the portfolio. This helps explain the large idiosyncratic error we reported above.

[17] *This uncorrelated measure is an artificial construction, in the sense that we keep all other factors constant. The number is useful to give an idea of the isolated exposure to a particular factor.*

Figure 18. Credit Ticker Report (Partial)

LEHMAN BROTHERS | POINT Global Risk Model

Credit Tickers **1/31/2005**

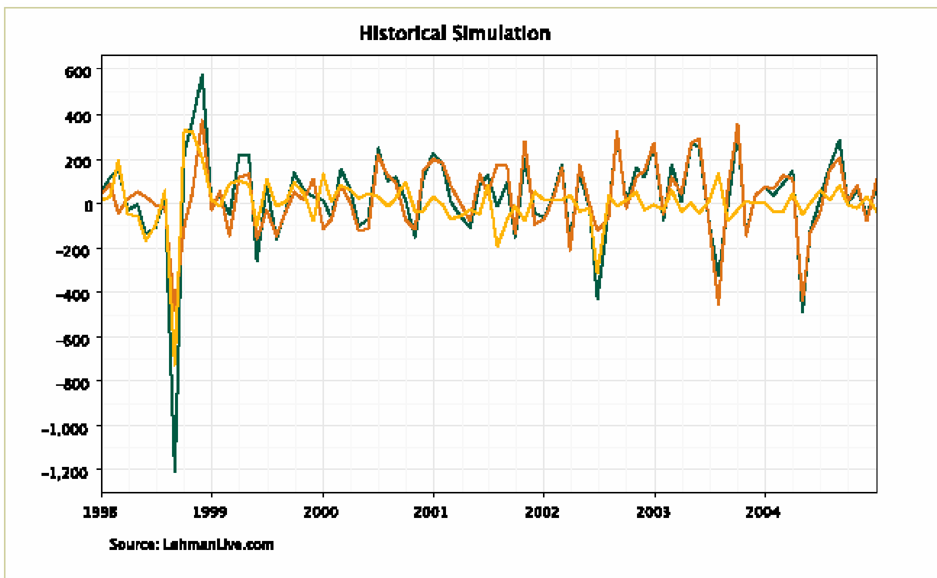
Portfolio : us em brazil
Benchmark : US Credit Non Corporate Baa

Ticker	Name	Sector	Rating	Currency	# Issues in portfolio	Portfolio weight (%)	Benchmark weight (%)	Net weight (%)	Net contribution to OASD (Yr)	Systematic TEV (bps)	Idiosyncratic TEV (bps)
MEX	UNITED MEX STATES-GLOBAL	SOVEREIGNS	BAA2	USD	0	0.0	56.21	-56.21	-3.921	116.6	62.97
AMBEV	CIA BRASILEIRA DE BEBIDAS	FOOD_AND_BEVERAGE	BAA3	USD	3	24.47	0.0	24.47	1.356	51.14	35.59
PETBRA	PETROBRAS INTL FINANCE-GLOBAL	FOREIGN_AGENCIES	BAA1	USD	5	34.01	2.37	31.63	1.049	37.76	27.53
BRADES	BANCO BRADESCO S.A.	BANKING	BAA1	USD	3	11.56	0.0	11.56	0.687	30.27	18.02
PEMEX	PEMEX FINANCE LTD	FOREIGN_AGENCIES	BAA1 BAA3	USD	0	0.0	16.93	-16.93	-0.878	26.79	14.16

Source: POINT.

Finally, POINT presents a "Historical Simulation Report" (Figure 19). The aim of this report is to help visualize the hypothetical systematic historical return of a portfolio with the same loadings. We use current loadings and past factor return realization to get that historical simulated return.

Figure 19. Historical Simulation Report (partial view)



Legend	Axis	31-Dec-97 to 31-Dec-04	Last	Minimum		Maximum		Mean	Std. Dev
	Left	Portfolio Est. Return	76.800	-1207.680	31-Aug-98	578.130	30-Nov-98	29.187	213.190
	Left	Benchmark Est. Return	112.250	-481.120	31-Aug-98	371.920	30-Nov-98	27.431	157.164
	Left	Difference	-35.650	-728.540	31-Aug-98	324.870	30-Sep-98	1.757	118.872

Source: POINT.

We can see from the graph that events such as the Russian crisis in 1998 had an extraordinary negative impact on Brazilian bonds. The general effect on the non-corporate Baa bonds is smaller, giving rise to a significant difference in performance. Other episodes, including the Brazilian elections in 2002, also caused high return differentials. This graph can be used to quantify the effect of similar stress events in the future. Note that the standard deviation of the difference between the two series (about 120bp/month) is close to the systematic TEV reported in Figure 16 above (126bp/month).

4. CONCLUSION

In this paper we describe the Lehman Brothers Emerging Markets Risk Model. The model includes three fully integrated types of risk: systematic, idiosyncratic and default risk. Systematic risk factors are based on specific regions: America, Asia and Europe. We further include country-specific risk factors when relevant, in both an economic and statistical sense.

Default correlations are modeled using a t-copula that allows for a higher level of tail dependence. The departure from the typical normal copulas is especially important in emerging markets, where tail events and credit contagion is more pronounced. Compared with similar asset classes, such as high yield, bonds from emerging markets tend to move more closely with one another, suggesting a stronger role for a macro-wide/sovereign risk factor.

Finally, we show how POINT delivers intuitive risk reports. These reports provide a detailed analysis of the major sources of risk. This exercise helps to identify and quantify the risk of the specific active exposures that managers choose for their portfolios.

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APPENDIX 1: COUNTRY – BLOCK MAPPING

In this appendix we show our mapping of specific countries to regional blocks. Note that the Asian block is in fact a residual bock, in the sense that all countries that do not fall into the America or Europe block are attributed to the Asian block. This attribution is marginal and does not affect the major results of the model. Moreover, note that this list of countries changes over time given that emerging market countries are defined as those with sovereign ratings of Baa3 or below.

Country	Block
Algeria	Asia
Argentina	America
Brazil	America
Bulgaria	Europe
Colombia	America
Costa Rica	America
Croatia	Europe
Dominican Republic	America
Ecuador	America
Egypt	Asia
El Salvador	America
Guatemala	America
India	Asia
Indonesia	Asia
Iran	Asia
Ivory Coast	Asia
Jamaica	America

Country	Block
Jordan	Asia
Kazakhstan	Asia
Lebanon	Asia
Mexico	America
Morocco	Asia
Nigeria	Asia
Pakistan	Asia
Panama	America
Peru	America
Philippines	Asia
Romania	Europe
Russia	Europe
Turkey	Europe
Ukraine	Europe
Uruguay	America
Venezuela	America
Vietnam	Asia

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