COMOVEMENTS IN EMERGING MARKET BOND RETURNS:
AN EMPIRICAL ASSESSMENT

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Comments welcome

Abstract

The objective of the paper is to empirically assess the comovement of emerging bond returns during episodes of market turmoil from 1997 through 2003. We find evidence of global market comovement mainly driven by the evolution of common external factors during the first half of the period. Although the linkages of emerging market returns with the external factors are particularly strong during periods of market turmoil, global comovement, as measured by adjusted and unadjusted correlation coefficients, is decreasing over the period under consideration. Furthermore we put into question the cross country average correlations method which may not be useful in summarizing market results if the underlying distribution of bond returns is not unimodal (i.e., if there are underlying groups that exhibit high within-group comovement but not between-group comovement). The analysis of correlation matrixes enables us to identify groups of countries moving together during the recent events in emerging markets according to regional patterns and credit quality differentiation. These findings are further refined by performing Principal Component and Cluster Analysis. We find evidence of clear “market tiering” and investors discrimination from the beginning of 2002 onwards.

JEL Classification Numbers: F42, G12, G15

Keywords: bond markets, excess comovement, contagion, market segmentation

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I. INTRODUCTION

A salient feature of emerging markets over the past decade has been their proneness to volatility spillovers and contagion across countries and markets during crisis episodes. The Tequila crisis of 1994-95, the Asian crisis of 1997, the Russian default and the collapse of LTCM in 1998, the Brazilian peso devaluation at the beginning of 1999, the US High Yield crisis in 2000, the Enron scandal in 2001 and the run-up to the Argentine debt default in late 2002, all were accompanied by the transmission of financial market volatility across borders. These sharp spikes in volatility are usually captured by increased cross country market correlations. The main question we are trying to address in this paper is whether these increases in the market comovement are attributable to common shocks or to a “pure” contagion phenomenon. The paper could be embedded in the empirical literature on contagion viewed as excess - comovement that is the transmission of shocks from one market or country to others, unexplained either by common shocks or fundamental links among the countries.

The first authors to have quantified the excess-comovement as measure of contagion in mature markets are Pindyck and Rotemberg (1990, 1993). After taking into account common fundamentals, they showed that there is residual comovement across stocks from very different industries and idiosyncratic fundamentals.

By contrast, little is known with regard to emerging markets as far as the residual comovement is concerned. For instance, in the case of the exchange rate variation, Masson (1999a, b, and c) identifies three components, namely: “monsoonal” shocks or common shocks simultaneously affecting all countries, spillovers occurring through trade and economic relations and a residual, the component unexplained by the previous systematic relations and referred to as “contagion”. Baig and Goldfajn (1998) test for evidence of contagion between the financial markets of East Asian countries. In order to account for residual comovement, they control for own country and cross border news (using a set of dummy variables) and other fundamentals and show evidence of cross-border contagion in the currency and equity markets. The dummy variables they use are proxies for the country’s own fundamentals but they can be also viewed as source of contagion for other countries. The authors estimate the impact of these dummies on the financial markets through country-by-country regressions. They further analyze the residuals of these regressions to see the extent of cross-border correlations after controlling for fundamentals. Valdes (1997) uses secondary market debt prices as well as country credit ratings and shows that fundamentals are unable to explain the cross-country comovement of creditworthiness in Latin American countries. In testing for the presence of excess comovement he uses the methodology developed by Pindyck and Rotemberg (1990, 1993). More precisely, he tests whether pairwise correlations of the variables under analysis are significantly different from zero and checks whether the correlation matrix of these variables is statistically different from the identity matrix. These procedures are carried out using the original data and the new series after controlling for the effect of fundamentals (i.e. those variables that determine the likelihood of repayment of external debt or repatriation of cash-flows in general). He proceeds to a likelihood ratio test under the null hypothesis that there is no groupwise correlation and also uses a Lagrange multiplier test in order to check correlations among cross-equation residuals.

Regarding the interpretation of the excess comovement, the literature attributed this residual comovement either to multiple equilibria (sunspots) or to market behavior. Jeanne (1997) and Jeanne and Masson (1997) develop a Markov-switching model in application to the ERM crisis. According to their vision, discontinuities in the shock transmission process are associated to jumps between multiple equilibria in the currency market. As for the market-based interpretation of contagion, there are mainly three strands of literature.

According to the first one, contagion can be captured by shifts in market investors’ perceptions and attitudes towards risk (Kumar and Persaud (2001)). The second strand of the literature considers that contagion is the result of herding behavior of investors (Lakonishok, Shleifer and Vishny (1992), Christie and Huang (1995) Kim and Wei (1999a), Choe, Kho and Stulz (1999)). Finally, according to the last view, contagion is the result of “wake up calls” by investors (Goldstein (1998), Baig and Goldfajn (1999), Kaminsky and Schmukler (1999)).
The main objective of the present paper is to measure the comovement of emerging debt markets during episodes of market turmoil which took place over the period 1997-2003. In particular we aim at disentangling the respective roles of common external factors and market based/pure-contagion transmission channel in the recent events of market spillovers.

Generally, comovements in emerging bond markets can be captured by the rolling average correlation of bond returns. These returns may be driven by a wide range of underlying factors: external or internal to the asset class or to the issuing country. Therefore we expect that the eventual market comovement be explained by heterogeneous factors.

We can roughly divide these factors in two categories, namely:

- common external factors characterizing developed countries (in particular the US);
- factors other than the common external ones, accounting for the residual comovement of emerging markets. These factors can be attributed to the international investors’ behavior who shift between asset classes and markets according to their anticipations and attitude towards risk.

Global average correlations may prove to be inefficient in assessing market comovements in presence of market segmentation. Therefore we are going to look for groups of countries moving together during the recent events in emerging markets based on the analysis of correlation matrices. These findings are further refined by performing Principal Component and Cluster Analysis over each calendar year from 1997 through 2003.

We furthermore inquire on the underlying factors of market fragmentation in order to answer the following questions: Can the groups be explained by regional aspects, credit rating, index weight, number of crises experienced recently, etc.? Are global investors treating emerging market sovereign bonds indiscriminately or is there evidence of increased market tiering according to the country credit worthiness?

The paper is organized as follows. The first part is dedicated to the average correlation analysis, adjusted and unadjusted for the presence of common external factors. Section 2 presents the methodological aspects while section 3 summarizes the main results of this approach. In the second part of the paper we put into question the sample average correlation-based method and look for the presence of groups within the eighteen emerging bond markets returns of our sample. The motivations and the methodological aspects of sample tiering are presented in section 4 whereas section 5 exposes our main results. The last section concludes.

I) AVERAGE CORRELATIONS: ADJUSTED AND UNADJUSTED

SECTION 2. CONCEPTUAL ISSUES AND DATA

We use daily and five-day returns for 18 out of 33 emerging countries included in the JP EMBI Global according to the data availability over the period starting on the 3rd of March 1997 and ending on the 7th of March 2003. Data were obtained from Bloomberg. The selected countries (Argentina, Brazil, Bulgaria, Colombia, Croatia, Ecuador, Malaysia, Mexico, Morocco, Panama, Peru, Philippines, Poland, Russia, South Africa, South Korea, Turkey and Venezuela) account for 92% of the Index.

The adjustment for the presence of common external factors was performed using daily and five-day returns computed from the bond index value of total return, according to the following relations:

\[ R_{t/i=1} = \ln(I_t / I_{t-1}) \quad i = 1 \text{ or } 5 \]  

1 The J.P. Morgan Emerging Markets Bond Index Global is a traditional market-capitalization-weighted index currently covering 27 emerging market countries. For further methodological details see the end Notes (i) and JPMorgan (Introducing the JP Morgan Emerging Bond Index Global).

2 We are currently working on an updated version of the paper including data from the 7th of March 2003 onwards.

3 We obtained more significant results whenever returns are computed over a holding period of five trading days as they are less affected by the autocorrelation of day by day returns. Therefore we present only the results using 5-day returns.
where 

$I_t$ represents the closing cumulative total return index level on day $t$ and $I_{t-1}$ the last total index return on the previous and respectively on the last fifth trading day;

$R_t$ denotes the (log) net rate of return between dates $t-1$ and $t$, and respectively $t-5$ and $t$;

$t$ is the trade date (according to the New York bond and holiday calendar and after harmonization with available trade dates for the independent variables)4.

In order to deal with missing data in some limited cases of market closure among the emerging countries in the EMBI global, we computed the inferred price between the last trading day and the opening day5. Finally, we retained 1578 returns computed on a five-day basis.

As far as the three US market indicators are concerned (TB, SPX and HY Indexes), we use the daily closing prices provided by Bloomberg and compute the daily and respectively five days returns according to the relation (1) previously mentioned.

Initially there were 1586 trading dates for EMBI global, 1595 for SPX_Index and 1654 for both US_HY and US_TB Index. After harmonization, we retained 1584 trading dates. Data for non-Asian countries were then lagged by one day in order to adjust for the time difference between Asian and non Asian markets.

In order to measure the emerging bond markets comovement and the transmission of shocks from one country/region to another we adopt an approach based on correlations of bond returns after controlling for common external factors. These factors will affect emerging countries differently according to their macroeconomic characteristics (trade links, international financing requirements, degree of integration in the world economy).

More precisely, the bond returns (daily or computed on a 5-day basis—corresponding to a holding period for international investors) are adjusted for the presence of common external factors by performing rolling linear regressions of individual countries returns against the US Treasury returns (JPM US_TB5-7Y), the comprehensive US Stock Market Index (SPX_Index6) and a total return index of the US High Yield market (JOAO). The rolling regressions were performed over a 60-day window in order to separate the impact of external and respectively idiosyncratic factors of emerging markets comovement. Pairwise correlations are then estimated based on unadjusted and adjusted 5-day returns over the same 60-day window.

By hypothesis, the external factors as endogenous variables, cannot explain any variation in the underlying residuals. Therefore, the residuals could be viewed as adjusted returns which are free from the influence of external common factors. Furthermore, the rolling canonical pairwise correlation of the regression residuals will capture the excess comovement of bond returns beyond common external factors/shocks.

The estimated model can be written as following (for two countries $i, j = 1, 18, \; i \neq j$):

For a given 60-day window:

\[
R_{ij} = \beta_{j0} + \beta_{j1} \cdot R_{US\_TB\_j} + \beta_{j2} \cdot R_{SPX\_Index\_j} + \beta_{j3} \cdot R_{US\_HY\_j} + \varepsilon_{ij} \quad (2)
\]

\[
R_{ji} = \beta_{j0} + \beta_{j1} \cdot R_{US\_TB\_i} + \beta_{j2} \cdot R_{SPX\_Index\_i} + \beta_{j3} \cdot R_{US\_HY\_i} + \varepsilon_{ji} \quad (3)
\]

and the correlation coefficient of residuals thus become a measure of the co movement in bond returns after removing the influence of common external shocks.

\[
\rho_{\hat{e}^2} = \rho(\varepsilon_i, \varepsilon_j) = \frac{(\varepsilon_i, \varepsilon_j)^2}{(\varepsilon_i^2 \cdot \varepsilon_j)} \quad (4)
\]

The essence of the adjustment is then equivalent to a partial correlation between countries returns controlling for the effect of common factors6.

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4 The US and other non Asian data included in the EMBI Global were lagged by one day in order to account for the time difference between Asian and world markets. Therefore in the case of the three Asian countries in the sample (Korea, Malaysia and the Philippines) date $(t)$ corresponds to date $(t+1)$ in the JPMorgan quotations. In this way, the problem of non synchronous trading in different markets around the globe is sensibly reduced but there is still a lot of noise trading which might affect our rolling estimated returns. The use of five day returns seems to improve the explanatory power of the exogenous variables in our model.

As the EMBI global contains only US dollar-denominated instruments, the exchange rate is not taken into account in the return index.
The first question that naturally arises is why focusing on only these three common factors? Trends in emerging debt markets are closely tied to developments in mature markets of industrial countries and in particular in the US. Therefore, in our analysis, we focus on what appeared to us to be the three major benchmarks of the US markets because they are the most likely to induce fluctuations in emerging markets returns.

In the first place, we take into account the US Treasury Bill returns for a maturity compatible with that of bonds included in the EMBI Global. The interest rates on Treasury Bills are virtually risk free rates and are commonly accepted as reflecting the general level of interest rates in the US economy. Studies on the international capital movements show that emerging markets bond returns are significantly affected by variations in the US interest rates. The US_TB is characterized by lower risk of variation than emerging market bonds or US_High Yields and also by a lower return. During market rallies, whenever the emerging market prospects are encouraging, investors dump low yielding risk free TB and buy emerging debt securities which offer a higher return. Their higher liquidity and the lower market risk come at the price of lower rates of return than debt or equity securities. Conversely, the global investors may shift to TB in times of stress, whenever they have a perception of increased risk and are uncertain as to the economic prospects in emerging countries.

In the second place, we took into account the SPX_Index - the composite index of US stock market as a proxy for the stock market portfolio. Unlike other stock market indexes (e.g. Dow Jones Industrial Average) which track the value of a portfolio with one share of each stock, the SPX_Index reflects the value of a portfolio that holds shares in each firm in proportion to the number of outstanding shares. The behavior of the SPX_Index is thus similar to that of the entire US stock market. The link between stock returns and those of emerging market bonds could be interpreted as a proxy for the global investors shift between competing asset classes. The investor behavior towards stocks depends on the growth perspectives of the concerned country (higher rates of investment, productivity growth, etc). Therefore, investors tend to prefer equities whenever the economy is doing well and shift to buy safer assets whenever the situation deteriorates.

Finally, we take into account the performance of the high yield sector in the US with the aim of capturing the global investors' behavior regarding two competing asset classes of similar risk. The selected JOAO Index is characterized by an average rating comparable to that of emerging markets (BB and B rated). Therefore the two indexes (HY Index and EMBI global) roughly reflect the same degree of risk. The sign and the importance of the HY coefficients in the regression of each emerging country returns against the three common external factors is an indication of an eventual investors shift between local and emerging market securities of similar risk. Nonetheless, the relationship between HY returns and emerging market debt returns is not straightforward. On the one hand, if there are concerns about the ability of corporate/sovereign issuers to service or to roll-over their debt in the HY/emerging market bond markets, we could expect global investors (in particular cross-over investors) to shift to the alternative market more attractive in terms of risk-return. On the other hand, troubles in the US_HY sector often reverberate through the emerging markets and sell offs in the first market trigger similar sell offs in the latter over the last years. Troubles in the HY sector (as it was the case during the US_HY crisis in the last quarter of 2000) could be associated by global investors with an increase in the overall risk of the portfolio. In this case, investors tend to reduce the exposure in similar securities in terms of risk (in particular, the emerging market bonds).

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5 E.g. Calvo and Reinhart (1996) show that increase in US interest rates, other things equal, are associated with capital outflows from Latin America, in the aftermath of the Mexican crisis of 1994/95.
SECTION 3. DESCRIPTION OF RESULTS

Analysis of beta coefficients in initial regressions

The beta coefficients as the sensitivity of bond market to changes in US_TB, SPX_Index or US_HY measure the variation induced in bond returns by a one percent variation of the exogenous variables. In terms of prices, the beta coefficients measure the growth rate of the emerging market bond price relative to the growth rate of the return on the external factors. Let us summarize the most important findings of our regressions.

US_TB coefficients

The evolution of bond returns sensitivities to changes in the US_TB returns as illustrated in Annex 1 is a good indicator of changes in market behavior through the period under consideration. At the beginning of the period, until the Thai bath devaluation of July 1997, the emerging markets showed positive sensitivity of returns in response to changes in US_TB returns, which indicates investors’ indiscriminate attitude regarding fixed-income securities and possible shifts between asset classes (e.g. between stocks and bonds).

Starting with the Asian crisis, the positive link between TB and emerging markets returns is broken. The first important drought took place around November 1997, followed by a peak of the same magnitude. During this period and until the end of 1999, Malaysia and the Philippines stand out as having the most volatile sensitivity in the sample. The next decoupling of emerging markets returns from the US_TB returns took place during the Russia default and LTCM crisis of September 1998. All emerging countries in the sample show particularly high negative sensitivity. However, Russia stands out with a coefficient of -23, Brazil, Ecuador, Malaysia and Venezuela with sensitivities to changes in the US_TB returns inferior to -10. The negative link between emerging markets and US_TB returns suggests that investors substitute emerging market bonds to risk free zero coupon bonds according to their attitude towards risk.

The Brazilian peso devaluation at the beginning of 1999 induced another significant drop in emerging market bond returns regarding the US_TB returns in the case of Brazil, Argentina, Ecuador, Russia (with a coefficient inferior to -8) and a lesser extent Colombia, Croatia, Mexico, Morocco, Peru and Venezuela (coefficients inferior to -2). No significant impact on Bulgaria, Malaysia, Korea, the Philippines, Poland and Turkey is observed.

The Argentinean sell-off of March 2000 seems to have little impact on the sensitivities of emerging markets relative to the US_TB returns. The Nasdaq turbulence in the third quarter of 2000 induced a wave of positive sensitivity with the US_TB returns. Rises in US_TB returns were accompanied by simultaneous rises in emerging market returns in the case of Argentina, Colombia, Ecuador, Mexico, Panama, Peru Philippines, Russia, South Africa and Venezuela. Countries like Ecuador and Croatia exhibited negative sensitivity during this period and for the rest of countries in the sample the impulse is not significant.

Starting with the beginning of 2001 and until the end of the time period, the variations in the US_TB returns seem to have little impact on country returns in the case of Bulgaria, Croatia, Malaysia, Morocco, Panama, Philippines, Poland, Russia, South Africa, Korea, Mexico and Venezuela. Conversely, the other countries coefficients are characterized by large fluctuations over the whole period.

SPX_Index coefficients

Emerging bond sensitivities to changes in equity market returns could be viewed as a proxy for the global portfolio relocations between bonds and equity. Annex 2 shows that over the period under

6 Particularly volatile during this period
consideration, the impulses from the stock market had a lower impact on all countries (with the exception of Russia in 1998-1999) than those from US_TB and US_HY markets.

The SPX_Index returns reached a low on 27th of October 1997, 7 days after the Hong Kong stock market collapse. Positive coefficients in the rolling regressions covering this period reflect that returns on emerging market bonds also decreased more or less proportionally.

Another event which intensified the link between the two markets was the Russian default in July 1998 and the LTCM crisis at the end of September 1998. During this period equity returns were negative almost all the time, with an important trough at the end of August (in the aftermath of Russian default) and another in October 1998 (in the aftermath of the LTCM collapse). Negative coefficients during this period reflect an opposite movement of bond and equity returns. The sharp decrease in the SPX_Index was accompanied by a rise of emerging bond market returns. Prices and yields moving in different directions could be an indication of investors shift between markets-in this case from the stock market to the emerging bond market. This is due to the underlying drop in the SPX_Index returns.

As the events in Russia directly affected the emerging sovereign debt market, the sign of coefficients could indicate if the similar drop in other emerging market bond returns is due to contagion from Russia or to external factors. Furthermore it could give information on investors’ behavior / portfolio rebalancing between bonds and equities. In the aftermath of the Russian devaluation we notice that sensitivities of all countries with the SPX_Index started to decline and approached zero which means that the evolution in emerging market returns are less explained by external factors during this period.

In the case in which returns on emerging market bonds are lower than those on equities, there is a part for spillovers from Russia in explaining market comovement. We can notice that during this period the drop in emerging market bonds returns takes place before the drop in SPX_Index returns (with the exception of Croatia) which means that it was a consequence of events in Russia affecting all emerging markets.

The next fall in SPX_Index returns in October seems to modify the link between the two markets as almost all countries suffer a drop in their sensitivities with the equity market. In the aftermath of the LTCM crisis, the equity returns drop sharply in October 1998. A negative coefficient for all the emerging countries in the sample suggests that the emerging bond market was unaffected by this event and returns moved in the opposite direction.

In the aftermath of the Brazilian peso devaluation of January 1999, the link between the two markets became positive and reached a peak in March 1999. However, the coefficients were strictly superior to unity only in the case of Russia meaning that the decrease in emerging market returns couldn’t be entirely explained by external factors and that the market also had a role to play in returns comovement.

The main events at the end of 2001 (Enron collapse) and in 2002 (mainly the Argentinean default) seem to have little impact on the link between stocks and bonds except for Argentina, Brazil, Ecuador, Peru, Philippines and Turkey which show positive sensitivities with the SPX_Index.

**US_HY coefficients**

Annex 3 illustrates the evolution of bond returns sensitivities to US_HY return variations. The US corporate high yield bonds are often viewed by global investors as competing asset class to emerging market bonds. This is due to the higher risk (and returns) associated to the high yield sector compared to TB or US investment-grade bonds, making them similar in some way to the emerging market bonds. Over the period under consideration the US_HY sector experienced downgrading and massive sell offs which had an impact on the emerging bond markets as well.

At the beginning of the sample period the returns on emerging markets bonds display positive and low sensitivities (except for Turkey-negative very low coefficients- and Philippines, Croatia, Brazil and Argentina—not significantly different from zero).

The first drop in coefficients occurs during the Asian crisis, in the aftermath of the Hong-Kong stock exchange collapse. During this period, emerging market returns are far more volatile than returns on HY. They fall dramatically in early October and this movement seem to be unrelated to the evolution of HY returns (which increase and decrease slightly) with the exception of Colombian returns which remains positively correlated with HY returns. After this date sensitivities become significantly
positive and reach an important peak at the beginning of 1998. Positive sensitivities of emerging market returns to changes in HY returns indicate that an increase/decrease in HY returns induces an upward/downward movement in emerging markets. This movement will be of greater amplitude if the coefficient is superior to one and less important if the coefficient is positive and inferior to unity. Positive coefficients could thus reflect a generalized sell-off (in the case of a simultaneous drop in both markets) when a sudden increase in the overall risk of the investors’ portfolio leads them to dump risky assets and to increase the part of safe assets. The simultaneous increase in returns could be the result of investors’ reallocation between different classes of assets (from stocks to fixed-income securities).

HY variations explain a significant part of emerging market variations in all countries (coefficients range from almost 4 in South Africa, Korea and Turkey to 15 for Brazil, Bulgaria, Peru and Ecuador). We can notice a new important drop in sensitivities (to almost -10 in the case of Russia and Ecuador) in the run-up to the Russian default of May 1998 which indicate that markets evolve in opposite directions.

Starting with this date coefficients begin to rise and become positive in July 1998 which reflects the simultaneous drop in emerging markets and HY returns. After an insignificant drop in October 1998, sensitivities rise again to reach a peak in the aftermath of the LTCM crisis, in November 1998. The most sensitive countries are Bulgaria, Ecuador, Russia, Peru and Venezuela with coefficients superior to 10. This is an all time high (over our sample period) for most countries. Returns on emerging countries are low below zero and far more volatile than the returns on corporate bonds.

After this date sensitivities start to decline. Actually at the time of the Brazilian peso devaluation in January 1998, returns on emerging market bonds become negative whereas HY returns keep fluctuating within a small interval. This is an indication that the two markets evolved in opposite directions as a result of investors shift within the same class of risk, between emerging markets and local corporate bond market.

During the first months of 1999 emerging markets sensitivities become almost zero indicating a decoupling of the two markets. Another significant peak is reached in mid 1999, when both returns on emerging markets increase.

In the run up to the Argentinean sell off of January 2000 coefficients become highly positive, of almost 5 for Brazil, Bulgaria, Russia and Venezuela indicating a simultaneous upward movement in HY and emerging markets returns. In the wake of the Argentinean sell-off, coefficients on HY returns decline for the majority of the countries in the sample to insignificantly positive levels or significantly negative levels in the case of Colombia, Croatia, Russia, Venezuela. As for Peru and Philippines, they reach a drought in sensitivities later, in November 2000.

A new rise in coefficients is recorded in the second semester of 2000, during the HY crisis. Positive significant sensitivities are displayed by Colombia, Malaysia, Morocco, Panama, Peru, the Philippines, Poland, Russia and Venezuela.

During 2001 coefficients remain at levels close to zero which suggests that the impact of HY returns is less and less important. The exception is Argentina, with extremely volatile sensitivities (positive in 2001 and negative in 2002).

In the wake of the Turkey devaluation we notice a drop in coefficients although they remain at an insignificant level, except for Peru. It is worth noticing that during this period emerging market returns dropped dramatically whereas HY returns fluctuate closely to zero suggesting a weak association between emerging and HY markets.

Over the last part of the sample period there are generally no more extreme variations in returns. The exceptions are the Philippines with sensitivities rising to significant levels during 2001, Colombia, Ecuador and Venezuela whose sensitivities increase significantly mid-2002 and finally, Turkey, the most volatile, displaying positive sensitivities until 2003.

As a general remark, let us say that, starting roughly with the last quarter of 2001, the emerging countries sensitivities to the evolutions on the HY sector are far less volatile than they were at the beginning of the sample period (which comforts the results of decreasing correlation between emerging market returns and the three external factors at the end of the sample period).
Interpretation of the adjusted and unadjusted cross-country average correlations

Analytically, unadjusted correlation higher than the adjusted one\(^7\) implies that the two country returns are correlated in the same way (that is both positively or negatively correlated) with the common external factor.

Conversely, rolling adjusted correlation coefficients higher than the unadjusted ones indicate that a part of the “true” comovement of emerging markets was overshadowed by general trends taking place in mature markets. In the case in which emerging markets are oppositely linked to the common external factors, removing the impact of these common external factors will actually strengthen the linkages between emerging countries bond returns.

Figure 1 below illustrates the evolution of aggregate correlations, adjusted and unadjusted for the presence of common external factors. Aggregate correlations were computed as the average of all pairwise canonical correlations of different countries within the sample. One can notice a secular decline for both adjusted and unadjusted series over the whole period under consideration. However, the decline is more marked in the case of the adjusted returns. Most of the time, adjusted returns are below the unadjusted ones, which indicates that common external factors had a part to play in explaining emerging market comovements. The most notable exception concerns the period leading to the Brazilian devaluation or the aftermath of the LTCM crisis characterized by adjusted returns higher than the unadjusted ones. Moreover, adjusted returns reach during this period the highest level of the sample period.

Generally, the linkages of emerging markets returns with the three external factors are particularly strong (both positive and negative) during periods of market turmoil (of large market movements).

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\(^7\) i.e. the correlation of regression residuals
II) ARE AVERAGE CORRELATIONS A GOOD SUMMARY INDICATOR?

Average correlations may not be useful in summarizing market results if the underlying distribution of bond returns is not unimodal (i.e. if there are underlying groups that exhibit high within-group comovement but not between-group comovement). Of course, this may happen temporarily, or group memberships may change through time. Thus, there is a need to look for some evidence of market tiering.

SECTION 4. LOOKING FOR GROUPS: METHODOLOGY

The choice of the calendar year as a time unit for performing Principal Component and Cluster Analysis was motivated by the fact that any transitory movement in correlation coefficients or in the underlying groups tends to disappear with the increase in time period.

The simple observation of pairwise correlation coefficients allowed us to distinguish the presence of groups of countries in our sample but the clusters composition needs further refinement in order to reflect the complexity of the simultaneous movements within each group. Therefore we use different types of Factor Analysis methods (Principal Components and Cluster Analysis) in order to identify homogenous groups in our sample.

**Principal components analysis**

In order to assess the global comovement of bond market returns we perform principal component analysis on adjusted bond returns of the sample countries for each calendar year of the period under consideration.

Tables 4 and 5 below report the eigenvalues for each component, that is its variance (in absolute value and as a percentage of the overall variance of initial series) for both adjusted and unadjusted returns.

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<td>57.70%</td>
<td>56.44%</td>
<td>49.92%</td>
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Table 4: Factor eigenvalue and percentage part of the variance explained by the first two principal components (5-day unadjusted returns)

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<td>55.84%</td>
<td>59.43%</td>
<td>37.38%</td>
<td>40.82%</td>
<td>40.74%</td>
<td>32.35%</td>
<td>23.64%</td>
</tr>
<tr>
<td>PC(2)</td>
<td>1.46</td>
<td>1.98</td>
<td>1.98</td>
<td>1.53</td>
<td>1.55</td>
<td>2.07</td>
<td>2.73</td>
</tr>
<tr>
<td></td>
<td>8.11%</td>
<td>10.55%</td>
<td>10.99%</td>
<td>8.50%</td>
<td>8.60%</td>
<td>11.51%</td>
<td>15.19%</td>
</tr>
<tr>
<td>Cumulative</td>
<td>63.95%</td>
<td>69.98%</td>
<td>48.37%</td>
<td>49.32%</td>
<td>49.35%</td>
<td>43.85%</td>
<td>38.82%</td>
</tr>
</tbody>
</table>

Table 5: Factor eigenvalue and percentage part of the variance explained by the first two principal components (5-day adjusted returns)

By convention, the principal components are ordered by their explanatory power. The first one explains the most important part of initial series comovement while the second one explains a smaller percentage of the total variance than the first one and so on. The evolution of the part of overall variance explained, each year, by the first two principal components is illustrated in Annex 4.

The explanatory power of the first principal component increases in 1998 (during the Asian and Russian crises) to almost 60 percent. In the following years, the first principal component explains less and less of the variation of adjusted returns of emerging countries: 37 percent in 1999, 41 percent in 2000 and 2001, 32 percent in 2002 and only 24 percent in 2003. The contribution of the second principal component in explaining the overall variance in the sample is rather constant over the period 1997-2002 (around 10 percent) and increases in the last year to almost 14 percent.
Overall, the two first common factors account for 64 percent of the variance of adjusted returns in 1997, 70 percent in 19978, only 50 percent in 1999-2000, and less than 40 percent over the last two years of the sample period.

As there are eighteen normalized variables, there will be eighteen orthogonal vectors explaining the overall variance in the sample. For each year we retained the number of principal components necessary to describe at least 80 percent of the overall variance. As indicated in the Annex 4, we need more and more orthogonal factors to account for the variation of countries adjusted returns or in other terms, individual returns seem to be less and less correlated with one major factor and thus less and less dependent on one another. In 1997-1998, the first five principal components accounted for 80 percent of the overall variation whereas in most recent years, eight or nine principal components are needed to explain the same portion of the variation in the series of adjusted returns.

Emerging markets seem to be less and less integrated. The drop in the explanatory power suggests the absence of a general common factor driving the comovement across emerging countries. At the same time, it highlights the ineffectiveness of the overall average as measure of a global measure of market linkages.

**Use of Principal Component Analysis to identify clusters**

If there are only two or at most three principal components which explain most of the total variation in the original variables, the factor scores of all cases (i.e. all countries) on these factors may reveal the presence of clusters. The factor loadings for each country in the sample could be viewed as a measure of association between individual countries adjusted returns and the principal components which account for the major part of the total variance. In fact, they represent the correlations of the variables (countries) with the factors. Therefore countries displaying factor loadings of opposite signs for the first or the second principal components can be assigned to different clusters. The sample fragmentation becomes more difficult whenever factors exhibit only positive or negative weights-indicating that the factor corresponds to a similar (upward or downward) movement in individual country returns.

In the case of emerging markets adjusted returns all countries display positive correlations with the first principal component. The first factor can therefore be interpreted as a general factor, common to all emerging markets. We can notice that some countries are highly correlated with this first factor indicating the presence of a set of “core” countries moving together whereas the other countries are less sensitive to general trends (see Annex 5).

As far as the second factor is concerned, it could be viewed as a differentiating factor among the emerging countries in our sample. The countries loadings are positive or negative (and significant in many cases) which clearly indicates the presence of two groups of countries moving together in opposite directions. We can notice that as the two principal components are orthogonal, countries highly correlated with the first factor tend to exhibit negative correlations with the second factor. Therefore, one intuitive criterion for identify the eventual presence of two clusters of countries is to group together countries highly correlated on the first factor (e.g. PC (1) > 0.8) and less correlated with the second (e.g. PC (2) < -0.05) in one cluster, and countries less correlated on the first factor (and therefore less correlated with all other emerging countries) and positively correlated with the second factor, in another cluster. This strategy ensures that although countries in the second cluster are not always significantly correlated with all countries in their cluster, the within -cluster correlations are higher than the correlations between clusters.

---

8 The eigenvalues (see tables 4 and 5) for a given factor measure the variance in all the sample variables which is accounted for by that factor. If a factor has a low eigenvalue then it contributed little to the explanation of variances in the series of adjusted returns and might be ignored as redundant.

In order to establish the number of factors driving the comovement in emerging bond markets we can apply the Kaiser criterion according to which all components with eigenvalues less than unity should not be taken into account. However, we chose a widely used variance explained criteria which consist in keeping enough factors to account for 90 or sometimes 80 percent of the overall variance.
Cluster analysis:

We furthermore refine our analysis by performing cluster analysis on the series of adjusted returns of emerging countries with the aim of identifying a set of country groups (in particular two subgroups to keep the analysis coherent with the previous two methods) which both minimizes the within group variation and maximizes the between group variation. Figures 9 to 15 in Annex 7 illustrate the clusters composition computed by the K-means procedure. Within each cluster, countries are ordered according to their distance to the cluster center that is the average distance within-group. From the scatter plots of cluster membership by their distance to the cluster center we can notice that the majority of countries in each cluster are situated to a distance inferior to 16. Farther than this limit, countries are regarded as outliers which highly modify the final classification.

SECTION 5. AGGREGATE RESULTS

The evolutions of the average correlation coefficients within and between groups, using the whole sample, according to the PCA taxonomy are illustrated on figures 2-8 in Annex 6. The results of cluster analysis are illustrated on figures 9-15 in Annex 7. Our analysis highlights the presence of two distinct clusters in the sense that countries in each cluster are highly correlated with countries within and almost independent from the evolutions of countries outside the cluster. The more the average between-clusters approaches zero, the better the split between the two groups.

Inspite the fact that our analysis is run year by year, we can identify some permanent features regarding the composition as well as the relative evolution of the two groups of emerging countries. The first group, characterised by a higher variance, is generally composed of countries rated as underinvestment grade and mainly from Latin America. Over the whole period, countries in this group are characterized by a higher within average correlation than the average correlation between clusters. This group we called the “core group” drives most of the comovement in emerging debt markets.

The second group of countries, mainly from Europe, South Africa and Asia, displays lower comovement than the first group. This feature could indicate that the debt instruments issued by these countries are perceived as less risky than those issued by countries in the first cluster. Indeed, all country debt in this category is rated as investment grade.

As far as the crises occurrence is concerned, countries having experienced a crisis in the near past are perceived as riskier by investors and fall within the first high variance cluster, excepted for the three Asian countries which are systematically ranked in the second cluster. Over the period under consideration, average correlations within clusters decline and the average between clusters become closer to zero indicating a wider investors’ discrimination towards the end of the period. More precisely, we identify a significant drop in all pair wise correlations in the second half of 2002 as the averages within and between clusters fall to extremely low levels. However, the average within the core group is still above the average within the second group. This downward trend is pursued in 2003.

However, the two clusters appear to be extremely different in terms of within correlations. More precisely, a rise/fall in the first cluster average correlations is accompanied by an opposite movement of the within average in the other cluster. This feature suggests the presence of market segmentation rather than global comovement of emerging markets in the first half of 2003.

Interpretation of the principal components

We are trying to address the question whether there is possible to interpret the first two factors in terms of emerging markets, as we already removed the influence of common external factors (SPX, HY and TB). As the output of the unrotated PCA indicates, the first principal component is a factor

\[9\] Which is in line with the correlation analysis (based on adjusted and unadjusted returns, see section 3).
which makes the emerging markets move together, especially during periods of market turmoil. If there is evidence of indiscriminate behavior of global investors and generalized sell-off across emerging markets (whenever a negative event occurs in one connected market) this should be put into light by the first principal component. The first factor should capture market-wide movements.

Over the period, one can notice that markets are less and less intertwined as the explanatory power of this underlying factor declines. However, every year, there is still a bunch of countries highly linked to this common factor which indicates that these emerging countries are more vulnerable to negative events taking place in another emerging market.

We can notice that in 1997 and 1998, the countries most exposed to a generalized sell off exhibiting correlation coefficients of more than 0.80 with the first factor are rated underinvestment grade (with the exception of Poland in 1998, rated investment grade). Over the last three years, the country rating seems to play an important part in investors’ decisions as all countries exhibiting significant (superior to 0.5) positive correlation coefficients with the first factors are underinvestment grade, irrespective of the country region. The first principal component can be thus identified at least over the last three years with the investors risk aversion based on the potential of individual country default.

The second component tries to capture as much variance unexplained by the first one as possible. Therefore, countries like Malaysia, Korea, the Philippines, Croatia or Morocco—which are investment grade, are often positively correlated with this factor. However this factor captures principally geographical aspects than risk based strategies of global investors as Malaysia and Korea systematically exhibit loadings superior to 80 percent whereas the other countries are insignificantly (positive and negative) correlated. By opposition with the first principal component we can consider that this second factors captures the comovement among high grade countries. In 1997, only Malaysia and Korea carry significant high correlations coefficients with the second principal component. In 1998, only Malaysia and Colombia, in 1999 only Malaysia, Croatia and Korea are positively and significantly correlated with this factor. In 2000, no country appears to be significantly correlated with the second principal component. Over the last two years, it becomes a regional factor, showing in what measure emerging markets are driven by the evolution of returns of Asian countries. More precisely, Korea and Malaysia have extremely high loadings, superior to 0.8 whereas for the other countries in the sample the highest correlation drops below 0.2.

Another way to better interpret the first principal components is to perform rotated PCA over the same series of country adjusted returns. The factor loadings can be rotated (that is described by a different system of coordinates than the initial one) with the aim at making the output more understandable by facilitating the interpretation of factors. The results of the rotated PCA year by year are given in Annex 8.

Conclusion

The objective of the present paper was to assess the respective part of common external factors and market behavior in explaining comovements in emerging bond returns. We tried to address the following questions regarding the linkages among emerging debt markets: Are markets integrated or segmented? Are global investors treating them indiscriminately or there is evidence of market tiering? What are the underlying factors driving the market segmentation? Are returns in each emerging country driven by common external factors or an idiosyncratic shock occurring on one emerging market is likely to propagate across the other emerging markets? Our analysis covered 18 out of 33 emerging countries included in the EMBI global over the period from 1997 through 2003. In order to distinguish between common external and idiosyncratic factors in explaining bond markets comovement, we performed 60-day rolling regressions of initial emerging bond returns against three external factors (US_TB, SPX_Index and US_HY). The correlation coefficients of residuals thus became a measure of the excess-comovement of emerging bond markets that is the comovement unexplained by common external factors and generally attributed to market behavior.

As far as the links of emerging market returns with the three external factors are concerned, we noticed that the links with the US_TB decrease over time (as reflected by sensitivities and correlation coefficients close to zero from the end of 1999 onwards). However, links with HY and
SPX Indexes are high and extremely volatile over the sample period indicating that these two external factors had a role to play in explaining emerging market comovements. Still, during the first half of the sample period, these two external factors had a more homogenous impact on emerging bond returns compared with the latter part of the period. In the latter part one can notice that emerging markets behave differently as regards to the external factors. More precisely, there is a group of countries characterized by regression and correlation coefficients extremely volatile whereas in the second group the impact of external factors seems to be almost inexistent.

Although the linkages of emerging market returns with the external factors are particularly strong during periods of market turmoil, global comovement, as measured by adjusted and unadjusted correlation coefficients, is decreasing over the period under consideration.

Furthermore we put into question the average correlations method which may not be useful in summarizing market results if the underlying distribution of bond returns is not unimodal. We identified groups of countries moving together based on the analysis of correlation matrices for each year from 1997 though 2003. These findings were further refined by performing Principal Component and Cluster Analysis. The results of the Factor analysis methods were convergent and indicate the presence of two groups of countries within the EMBI global sample. One of them, which we labeled the “core group” driving the major part of the markets comovement, is characterized by high within average correlations whereas the other is characterized by a relatively low within average. By construction of the two clusters, countries in each group are more correlated with countries within the same group than with countries outside their group. We found evidence of increased market tiering according to the region and the country credit worthiness.

References

Final Notes:

i The EMBI global is a traditional, market capitalization-weighted index which currently covers 33 emerging market countries. Included in the EMBI global are US-dollar denominated Brady Bonds, Eurobonds, traded loans and local market debt instruments issued by sovereign and quasi-sovereign entities.

It differs from its predecessor – the Emerging Markets Bond Index Plus (EMBI+) - by the country selection criteria (the per capita income level as defined by the World Bank and the country debt restructuring history instead of selecting country solely on a sovereign credit rating basis). Precisely, EMBI Global includes countries classified as having low or middle per capita income by the World Bank or having restructured their external or local debt in the last 10 years or currently being in process of restructuring its external or local debt. By contrast, countries included in the EMBI+ must only be rated (BBB-)/(Baa3) or lower by S&P and Moody’s.

These two selection criteria allow the EMBI global to include a number of higher rated countries that international investors have nevertheless considered part of the emerging market universe. The index considers for inclusion emerging markets issues denominated in US dollars with a minimum current face outstanding of US$500 million and at least 2 1/2 years to maturity at the time of the inclusion in the index. No additional liquidity tests are required as it is the case with the EMBI+.

ii The total return from one trading day to the next, on a single instrument included in the EMBI global takes into account the bond price and the coupon payment (or/amortization if applicable) according to the following relation:

\[
TR_t = \frac{ESV_{t+1}}{ESV_{t-1}} + C_{t+1} + AM_{t+1} - 1
\]

where

\( ESV_{t+1} \) is the effective settlement value that is principally the bond price.

\( C_{t+1} \) is the coupon payment to which a holder on trade date \( t \) is entitled on value date \( v(t) \); (that is the date used to compute the accrued interests and generally coincides, but not always, with the settlement date) The coupon payment is determined by the instrument structure, ex-coupon conventions and holiday calendar

\( AM_{t+1} \) is the bond amortization (if applicable), also determined by the instrument structure, ex-coupon conventions and holiday calendar;

iii The price of day \( t \) between the first day of market closure (denoted by \( k \)) and the first day of market opening (denoted by \( n \), with \( n>k \)) is computed according to the relation:

\[
R_t = R_{i+1} + \left( \frac{R_t - R_{i+1}}{n-k+1} \right)(i-k+1)
\]

iv SPX Index stands for Standard & Poor’s 500 (S&P500) Composite Stock Price Index which serves as a common yardstick against which all US stock performance is measured. It is especially used to compare and evaluate the performance of institutional portfolios and has become one of the US Department of Commerce’s 12 economic indicators.

S&P500 is a market capitalization-weighted index that tracks the continuous price only and daily total return performance of 500 common stocks of leading domestic and foreign companies in leading industries within the US that are listed on the New York Stock Exchange (NYSE), the American Stock Exchange (AMEX) and the Nasdaq National Market System. The S&P500, a measure of large capitalization stocks, accounts for about 64% of the market value of shares listed on the three exchanges.

v In this case, the estimated model would be the following:

\[
R_t = \beta_0 + \beta_1 R_{t,i} + \beta_2 R_{t,j} + \beta_3 R_{t,Index} + \beta_4 R_{t,TB} + \epsilon_t
\]

That could be explained by the fact that, in the bivariate case, the partial correlation of unadjusted returns is no more than the canonical correlation between the residuals of the partial regressions of these returns on a constant and the common external factors.

Therefore the partial correlation coefficient between the two countries returns, while the other dependent variables are constant, becomes:

\[
\rho(R_{t,i}, R_{t,j} / R_{t,Index}, R_{t,TB}) = \frac{(R_{t,i}^*, R_{t,j}^*)^2}{(R_{t,i}^* R_{t,j}^*) (R_{t,j}^* R_{t,j}^*)}
\]

where \( R_{t,i}^* \) and \( R_{t,j}^* \) are respectively the residuals of a regression of initial returns on the three external factors and a constant. These terms are actually equal to \( \epsilon_t \) and respectively \( \epsilon_j \) in relation (4).
The two pair wise correlation coefficients are therefore equivalent, that is

\[ \rho(R_j, R_j) = \rho(R_{ij}, R_{ij}) \]

However, in spite of the fact that the output is the same in terms of linear association between returns, the first method enables us to have also a measure of bond returns sensitivity to variations of the external factors previously mentioned.

A first approach for identifying groups of countries moving together was based on the matrixes of adjusted correlations of five-day returns captured on seven successive years from 1997 to 2003. Emerging countries were divided into several groups based on the maximum coefficient in the matrixes of adjusted correlations in such a way that each country in a given group exhibited the strongest correlation with another country of the same group. According to this criterion, we noticed that the comovement of emerging bond returns presented marked regional features in the first year of the sample period. More precisely, in 1997 there was evidence of market segmentation, with a Latin American group, an Asian group and two European & Middle Eastern groups. The only exceptions to the regional segmentation were Russia which was viewed as “Latin” by global investors (maybe because its sovereign debt was mainly composed of Brady Bonds) and Colombia which had strong linkages with European bonds (that could be due to the fact that Colombian bonds were the only rated investment grade from Latin America and thus seen as less risky by global investors). With the exception of 1998, when correlation analysis proved to be ineffective in detecting groups of countries, markets in Asia (Korea, Malaysia and the Philippines) showed higher comovement within the group than with other emerging markets until 2001. At the same time there was higher comovement within the Latin American group than cross regional comovement-except for Poland (highest correlated with Mexico) and Bulgaria (highest correlated with Brazil) falling in the Latin group in 1999 and respectively in 2000.

Starting with 2001, factors behind market tiering became less obvious. For instance, the Philippines appeared to be more correlated with Latin American countries than with Malaysia and Korea. The fact that the Philippines was the only under investment grade of the three Asian countries in our sample, could explain its risk perception by global investors. But, at the same time, Mexico, upgraded in 2002 to investment grade, remained highest correlated during 2002 and 2003 with Brazil (underinvestment grade and even downgraded in mid 2002 from (BB-) to (B+)). For the last two years of our sample, there was no straightforward evidence of one single factor driving the bond market clustering.

This multivariate procedure capture the simultaneous movement of bond returns using a small set of factors called principal components. It condenses the complexity of the simultaneous movements of emerging markets bond returns, capturing these movements using just a few vectors. The choice of this method was also motivated by the fact that normality is not a necessary assumption for PCA as it is for OLS regressions. Precisely, the method provides a first linear combination of initial variables such as the maximum variance is extracted from the variables. It then removes this variance and seeks a second linear combination which explains the maximum proportion of the remaining variance and so on. The results are orthogonal (uncorrelated) factors and the higher the degree of comovement among country series, the smaller the number of factors explaining a given portion of the overall variance. For each year, the cases (rows) are represented by the cross-sectional returns whereas the variables (columns) are the eighteen emerging countries in the sample. The procedure starts by standardizing the initial data so that each variable have a zero mean and a unit standard deviation. In this way all series will be uniformly treated and the construction of the principal components will not be influenced disproportionately by the series of adjusted returns exhibiting the largest variance in our sample.

As it is usually recommended in the case of large samples, we performed K-means clustering on the transposed and standardized observations in order to ensure that variables receive equal treatment (as variables with large values would contribute more to the calculations of distance measures than those with small values). In our case, the rows or the cases are represented by the eighteen countries and the variables are the adjusted returns on each trading day for all the countries in the sample. The K-means cluster analysis begins by the use of the first K cases (k=2) in the data file as temporary estimates of the K cluster centers. Initial cluster centers are selected by assigning each case in turn to the cluster with the closest center and then the clusters are recomputed again. This process continues until no further changes occur in cluster centers and the maximum number of iterations (10 by default) is reached. The procedure is based on the Euclidian distance as a measure of similarity (or distance) for different pair of observations (cases represented by the eighteen countries in our case). If we think of each case as plotted in a two-dimension system, then the Euclidian distance is the square root of the sum
of the square of the X-distance and the square of the Y-distance. As the cluster analysis is not based on the correlation matrix (this option can only be chosen with the hierarchical clustering—inadequate for large number of cases), the results of this method will be slightly different from the PCA and other correlation-based methods. Clustering resembles Principal Component analysis as both aim at identifying related groups of variables. However, cluster analysis is more ad-hoc, the number of clusters is intuitive and the presence of outliers strongly affects the final output. Therefore we use clustering in order to support the findings of PCA especially in the case of the countries very close to one another and to the cluster center.