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SOVEREIGN SPREAD IN EMERGING MARKETS: A PRINCIPAL COMPONENT ANALYSIS

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Resumen

En este trabajo investigamos el comportamiento diario de los premios soberanos de dieciocho economías emergentes ubicadas en Asia, Europa del Este y América Latina entre septiembre de 1997 y noviembre de 2002. En este período ocurrieron frecuentemente crisis financieras de mercados emergentes y, por ende, una pregunta obvia es que si estos eventos asociados a un país particular se han extendido a otros países, sin importar los fundamentales económicos de estos últimos. Es decir, si los movimientos "simultáneos" que observamos de los spreads de economías emergentes están relacionados a los fundamentales económicos de éstas. En este trabajo encontramos que existe una fuerte correlación regional entre los premios emergentes. Asimismo, también hallamos que los spreads de los países con tasas de ahorro altas, endeudamiento bajo y buenas clasificaciones de riesgo son menos probables de moverse en conjunto con los spreads de los países donde se han originado las crisis financieras.

Abstract

We investigates the behavior of daily bond stripped spreads on sovereign bonds for 18 emerging market economies located in Asia, East Europe and Latin America from September 1997 to November 2002. In the emerging market world, financial crises are seen more often than not. An obvious question is whether these events, each associated with a particular country, spread to other countries, regardless of economic fundamentals at that specific point in time. That is, if the 'simultaneous' movements that we observe in spreads across emerging market economies are linked to economic fundamentals. We find that the correlation across countries is regionally dominated. Spreads from sovereigns with high savings rates, low indebtedness and good credit ratings are less likely to co-move with spreads where financial crises are being originated.

The views expressed in this paper are ours and do not reflect those of Goldman Sachs and/or the Central Bank of Chile. This paper is part of our respective doctoral dissertations at Columbia University. We would like to thank Joseph Stiglitz, Charles Himmelberg, Rajeev Dehejia, Ruslan Bikbov, Jorge Selaive, Charles Calomiris and Michael Johannes for very insightful comments and suggestions. However, any error remaining is our responsibility. Correspondence should be sent to E-mail: sgodoy@bcentral.cl.

Introduction

This paper analyzes empirically the co-movements in daily bond stripped spreads[1] on the sovereign debt securities of 18 emerging market economies in Asia, Eastern Europe and Latin America from September 1997 to November 2002. For this purpose, we perform principal component analysis, forthwith referred as PCA, to examine the variation in spreads in the different regions and for different sub-periods of the mentioned period.

Our results indicate that events in a troubled economy triggered co-movements within that same region. Turbulences in emerging market economies originate in countries with very low credit ratings causing sovereign spreads with intermediate credit rating to be vulnerable to a shift in investor sentiment, but leave countries with high credit ratings, almost unaffected. We therefore find a role played by credit ratings in explaining co-movements. In addition, higher saving rates and lower indebtedness play a similar role to higher credit rating in the sense that help to partially shelter a emerging country from a the effects of a crisis-event occurring in a different country. In consequence, we believe having strong and solid emerging market economies would reduce co-movements in sovereign spreads.

PCA has a long history as a standard mathematical methodology for analyzing time series' statistical properties[2]. This technique has been applied to different financial asset classes. More specifically, PCA has been applied to U.S. Treasury bond yield spreads[3], swap rates[4], stock returns[5], corporate spreads[6], exchange rates[7], derivatives[8], emerging stock market returns[9] and emerging market sovereign spreads[10]. Litterman and Scheinkman (1991) were the first to apply PCA to financial data. More specifically, they calculated the first three principal components, called factors by them, from the excess returns (over the overnight interest rate) for U.S. bonds for different maturities up to 30-year bond. They named the first factor *level*, the second factor *steepness* and the third *curvature*. This paper has been very influential in the subsequent literature on term structure curve models and these latent factors have become standards for this fast growing literature in this area.

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[1] Stripped spreads are defined as the difference in basis points between the stripped yield (that is, the semi-annual yield of the non-collateralized country cash flows) and the US Treasury yield, calculated as the spread over the US curve.

[2] The first papers that introduce this technique were Pearson (1901) and Hotelling (1933). For a brief history of the theoretical development of the principal component analysis see Jolliffe (2000), pages 6-9. For textbooks on this kind of analysis see Jolliffe (1986) and Flury (1988).

[3] Litterman and Scheinkman (1991) and Rebonato (1999).

[4] See e.g. Abad and Novales (2002).

[5] Consider, for instance, Ferson and. Korajczyk (1995), Laloux et al (2000) and Cipollini and Kapetanios (2004). For an earlier application see Feeney and Hester (1964).

[6] See, for example, Collin-Dufresne, Goldstein and Martin (2001) and Kennedy and Slot (2004).

[7] An application is Klaassen (1999).

[8] For instance, see Fengler, Härdle and Schmidt, (2002) and Fengler, Härdle, and Villa (2003).

[9] See Bilson, Brailsford and Hooper (2000) and Fifield, Power and Sinclair (2002).

[10] Check Avellaneda and Scherer (2000) and Cifarelli and Paladino (2002) and Kennedy and Slot (2004).

The following three papers are the closest in spirit to ours. First, Avellaneda and Scherer (2000) applied PCA to sovereign yield spread daily changes for four Latin American countries in the period July 1994-May 2000. They distinguished between 'static' and 'dynamic' principal components. The first corresponded to calculating the components for the whole sample. For the 'dynamic' version, principal components were performed on consecutive windows. In our paper, we extended both versions by increasing the size of the windows (since our sample permitted this) and by considering more regions.

Similarly to Avellaneda and Scherer (2000), Cifarelli and Paladino (2002) also utilized PCA for explaining co-movements of emerging market sovereign spreads. However, their scope is larger than in the case of Avellaneda and Scherer (2000) because their sample included three different regions (Latin America, Asia and East Europe). In addition, Cifarelli and Paladino (2002) distinguished between covariance matrix and correlation matrix for performing PCA. We take advantage of this important distinction, which has not been emphasized enough in the literature.

More recently, Délano and Selaive (2005) used the Bai and Ng (2004) methodology, which is based on PCA, for understanding the variability of emerging market spreads in the period 1998-2004. They found similar results to ours since they also uncovered that the evolution of these spread can be explained in part by changes in the country economic and financial fundamentals.

For emerging markets, the 1990s were characterized by sovereigns issuing increasing amounts of bonds in international and domestic markets. The main reason for this phenomenon lies in the lost decade of the 1980s, when most Latin American economies defaulted on their bank loans, and consequently, the Brady Plan was put forward as a solution for these economies to regain access to credit. This Plan gave birth to new bonds traded in secondary markets and provided investors with a new set of investment opportunities as emerging market economies gained access to capital markets. Since the birth of this Plan, it is believed that the emerging market economies are more vulnerable to experience 'simultaneous' co-movements in asset prices.

As economic trends are shared by emerging market economies, so are the common risks. These common risks are related to country's economic performance and consequently to its capacity to service its payment obligations, to legal and regulatory uncertainty that may emerge, and to exchange rate fluctuations that might set the economy at risk of currency weakening and changes in government policies. These features are reflected in the high yields and large fluctuations of these instruments.

Since the mid-1990s growth of emerging markets trading volumes and asset values have been subject to a sequence of crisis events that heightened the riskiness of investing in less developed countries. The main crisis events in that period were the following: the Asian crisis (mid-1997), the Russian default (August 1998), the Brazilian devaluation (January 1999), the Ecuadorian default on Brady Bonds (June 1999), the Turkish currency and banking crises (mid-2000) and the Argentine default (December 2001) and the Brazilian confidence crisis (October 2002).

The question is whether these events, each associated to a particular country, spread to others regardless of the economic fundamentals at that specific point in time. That is, if the 'simultaneous' movements that we observe in spreads across emerging market economies is linked to economic fundamentals. A simple plot of sovereign spreads suggests a strong correlation among countries, even though the connections between some of these countries are weak.

The analysis is organized as follows. Section 2 describes the sovereign debt stripped spread data, used in this paper. Section 3 reviews chronologically the main financial events that help to create our windows of trading days for calculating the principal components. Section 4 explains the results using principal component analysis and attempts to provide an economic interpretation to the results obtained. Finally, section 5 presents our conclusions.

1. Data

Our analysis is carried out using stripped sovereign spreads from three emerging market regions: Asia, East Europe and Latin America. In particular, we use daily data for Argentina, Brazil, Bulgaria, China, Colombia, Ecuador, Indonesia, Malaysia, Mexico, Peru, Philippines, Poland, South Africa[11], Thailand, Turkey, Venezuela, Russia and South Korea from September 12, 1997 to September 24, 2002. Table 1 shows the details of each of the underlying bonds used. All these sovereign bonds are dollar-denominated and some of them are collateralized. However, given that we are using stripped yield spreads we feel comfortable comparing them and believe this does not affect the creditworthiness of the sovereign. Figure 1 depicts emerging market spreads by region.

Table 1; Description of the data

Country	Coupon Rate	Maturity Date	Credit Rating
Argentina	11.375%	1/30/2017	SD
Brazil	10.125%	5/15/2027	B+
Bulgaria	6.750%	7/28/2011	BB-
China	7.300%	12/15/2008	BBB
Colombia	7.625%	5/15/2007	BB
Ecuador	(1)	8/15/2025	CCC+
Indonesia	7.750%	8/1/2006	CCC+
Malaysia	8.750%	6/1/2009	BBB+
Mexico	11.375%	9/15/2016	BBB-
Peru	(2)	3/7/2017	BB-
Philippines	9.875%	1/15/2019	BB+
Poland	(3)	10/27/2014	BBB+
South Africa	9.125%	5/19/2009	BBB-
Thailand	7.750%	4/15/2007	BBB-
Turkey	11.875%	1/15/2025	B-
Venezuela	9.250%	9/15/2027	B-
Russia	12.750%	6/24/2028	BB-
South Korea	8.875%	4/15/2008	A-

(1) steps up gradually from 4% to 10% in year seven

(2) steps up gradually from 4% initially to 5% in year 2003

(3) steps up gradually from 3.25% initally to 7% in year 2003

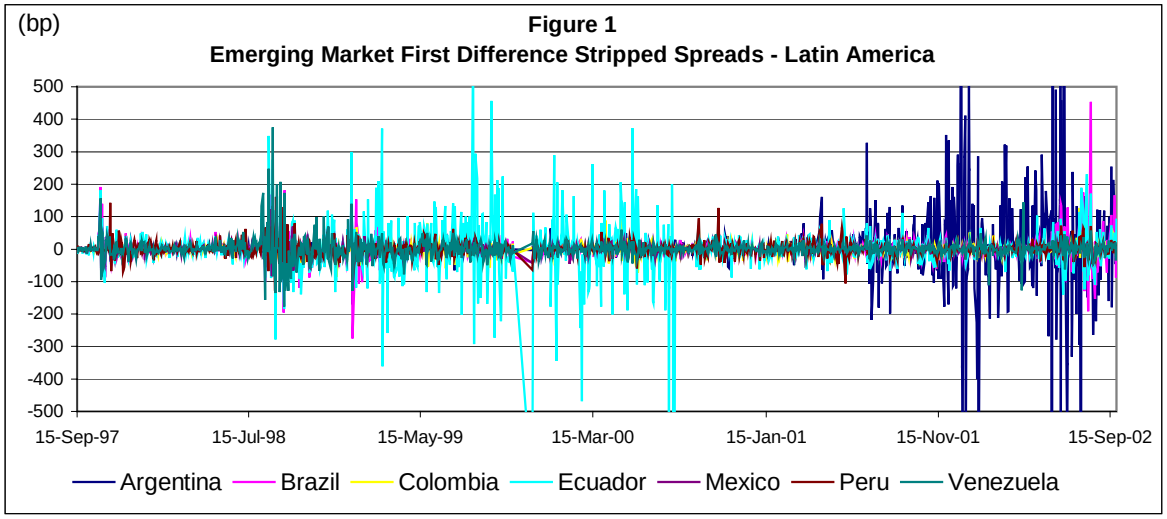
Source: Goldman Sachs. Standard & Poor's

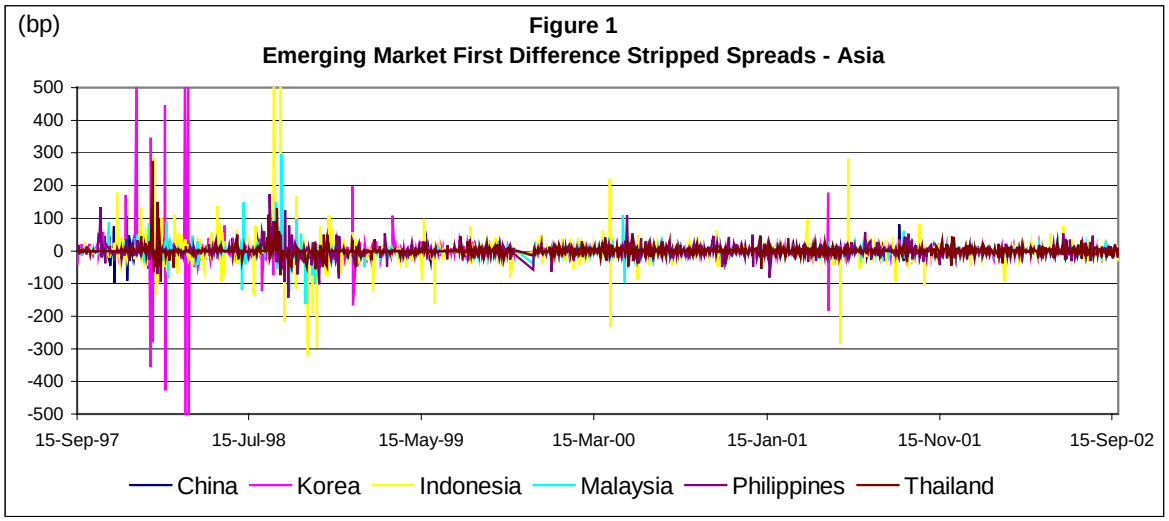
One thing to note about the data is that we are not concerned about the serial correlation that the lack of liquidity produces in certain emerging market assets. We note that liquidity is considered to be quite good for the major Brady bonds, less so for most Eurobond issues and particularly less so for any other debt assets in the emerging market universe.

Figure 1 provides evidence for the different crisis in emerging markets over our sample period. It is interesting to note the more important economic and political events that occurred over our sample period as they potentially indicate the root of the crisis. They

[11] We include South Africa under the East European region for geographical proximity.

also provide a reading of what events triggered the spillovers, if any, between the different countries. Moreover, the sovereign bond market responds to political and economic events, particular in the case of these countries, and it is almost the norm for sovereign yield spreads to widen substantially in the presence of chaotic events.


(bp)
Figure 1
Emerging Market First Difference Stripped Spreads - Latin America
500
400
300
200
100
0
-100
-200
-300
-400
-500
15-Sep-97
15-Jul-98
15-May-99
15-Mar-00
15-Jan-01
15-Nov-01
15-Sep-02
Argentina
Brazil
Colombia
Ecuador
Mexico
Peru
Venezuela


(bp)
Figure 1
Emerging Market First Difference Stripped Spreads - Asia
500
400
300
200
100
0
-100
-200
-300
-400
-500
15-Sep-97
15-Jul-98
15-May-99
15-Mar-00
15-Jan-01
15-Nov-01
15-Sep-02
China
Korea
Indonesia
Malaysia
Philippines
Thailand

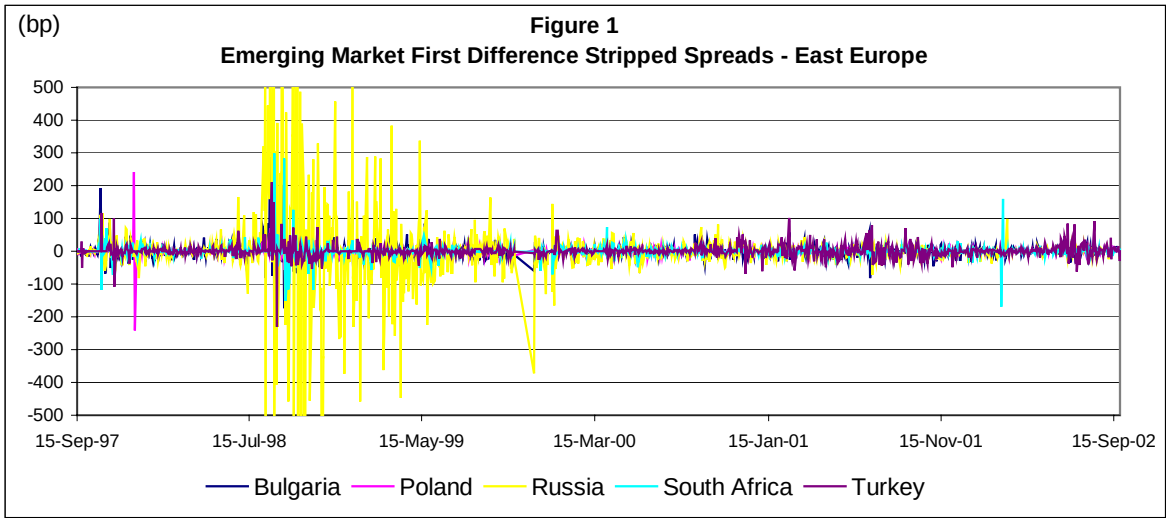

(bp)
Figure 1
Emerging Market First Difference Stripped Spreads - East Europe
500
400
300
200
100
0
-100
-200
-300
-400
-500
15-Sep-97
15-Jul-98
15-May-99
15-Mar-00
15-Jan-01
15-Nov-01
15-Sep-02
Bulgaria
Poland
Russia
South Africa
Turkey

Table C1 in the Appendix C presents the statistics of the data previously described for each of the Latin American countries. The tables for Asia and East Europe can be found in the Appendix C as Tables C2 and C3, respectively. The first set of statistics corresponds to the whole sample, and the following sets correspond to the different time windows.

Latin American returns on the underlying bonds (given by the first difference of the spreads) have higher means, on average, than the East European and Asian spreads and returns. Volatility is quite high for the three regions.

Recall that skewness and kurtosis correspond to the third and fourth moment of the distribution respectively. Skewness is a measure of symmetry, or more precisely, a lack of symmetry. A distribution is symmetric if it looks the same to the left and right of the mean. Instead, kurtosis is a measure of whether the data are peaked or flat relative to a normal distribution. That is to say, a distribution with high kurtosis tends to have a distinct peak near the mean, decline rather rapidly, and have heavy tails. For a normal distribution, the skewness should be at zero and the kurtosis should be at three.

In the tables in Appendix C we observe that both skewness and kurtosis for the sample period in the three regions are quite far from the values for a normal distribution. This is significant because distributions with a high measure of kurtosis usually have fatter tails, meaning that extreme standard deviation events occur with a higher probability than in a normal distribution. In particular, if we match the next description of events and the different windows, we will observe that the windows for the regions where financial crises took place show high levels of kurtosis. This represents that extreme events –such as financial crises- happen more often than what the probability theory of a normal distribution suggests. We also observe levels of skewness to be high for countries that have experienced financial crises in the past.

If we look at the correlation among the different spreads[12], we observe that countries in each region appear to have a strong positive correlation. Asian spreads show a weak positive correlation with the Latin American spreads and a mild positive correlation with the East European spreads. The East European spreads in turn present a mild positive correlation with Latin American spreads. It is important to notice the case of Argentina, for which spreads have a negative correlation with all the countries, except with those that experienced a financial crises over the sample period.

Our main interest is to look at linkages in sovereign spreads both within and across regions. But before starting this analysis we verify whether the spreads are indeed stationary. In consequence, we do cointegration tests. They are done in Appendix D. Based on these tests we concluded the spreads' levels are I(1) and, thus, we perform our analysis using the first differences.

[12] See Table C4 in the Appendix C.

2. Recollection of Events and Windows

In our analysis we split the data into eight windows containing 157 trading days each. The first window goes from September 15, 1997 to April 21, 1998. This window begins immediately right after the devaluation of the Thai Baht in July 1997. It covers the midst of the turbulence in Asian assets when Asian spreads widened substantially. In Thailand, political events widened the spreads even more; by October 1997 the Minister of Finance resigned from his post and in November of the same year Prime Minister Chavalit resigned. In December 1997 the banking system was subject to great uncertainty after many finance companies were suspended. By January 1998 a new state-owned commercial bank was created to manage assets of the finance companies had been closed. At the same time, the Thai government created a two-tier Baht exchange market and dismantled currency controls causing domestic interest rates to spiral.

The effects of these events throughout the region prompted a weakening of the Asian currencies (in particular the Philippines[13], Malaysia[14], Korea[15] and Indonesia[16]). Central banks were obliged to raise liquidity at the expense of reserves and, as a consequence, local interest rates rose dramatically. The market's perception of these economies worsened during this period and indeed, the credit rating agencies modified the outlook on these countries from stable to negative, as well as changing the credit rating for different asset classes.

By October 1997 there were some spillover concerns in Latin America. The Brazilian stock market suffered substantially after the market crash in Hong Kong. Following this, the central bank was forced to use $5 billion in reserves to defend the currency and cut interest rates from 38% to 34.5%. In January 1998 Moody's, the rating agency, described the Argentine financial system as weak and signaled the need for important reforms. By February of that year, the IMF approved a three-year $2.8 billion line of credit to support economic reforms in Argentina such as the reduction of the VAT tax by 50%, an increase in the corporate tax rate from 33% to 35% and a 10% reduction in social security contributions by employers. Over this same period, Ecuador was suffering from heavy rains caused by El Nino that disrupted fruit and vegetable crops, adversely affected the country's business and infrastructure. The government announced the need for $2 billion

[13] In September 1997, the Philippine central bank relaxed monetary policy and overnight rates reached levels of 71%, liquidity reserve requirements changed from 6% to 4%. The Philippine peso lost 5% of its value in October. By February 1998, the central bank was already committed to reduce overnight rates to 15.5%. However, by March 1998, the Indonesian rupiah weakened by 20% spreading fear in the region again.

[14] After the devaluation of the Thai Baht, the Malaysian central bank engaged in defending the currency until the ringgit dropped to three-year lows.

[15] In November 1997, the government stopped defending the won and arranged a $20 billion loan from the IMF. By December, Korea had already obtained a $55 billion bailout package from the IMF. Additionally, the G-7 along with the IMF raised $10 billion in aid.

[16] In July 1997, the Indonesian rupiah plunged close to 7% after the devaluation of the Thai baht. In August the rupiah dropped almost 40% against the dollar. In October, the IMF announced an aid package and Moody's cut the country's sovereign credit rating. By November, sixteen bankrupted banks were closed. In December, there were serious concerns over the health of President Suharto and a shortage of dollars triggered a sharp decline in the rupiah.

in spending over the next 10 years to repair the damage caused by El Nino. The currency devalued by 7.5% in March of that year.

In Russia, a sequence of political and economic events started to evolve in November 1997 with financial stress forcing the central bank to hike its refinancing rate from 21% to 28%. The government was reshuffled and in December, the World Bank approved $1.6 billion in loans to Russia. By March 1998, the central bank cut its refinancing rate from 36% to 30%. President Yeltsin fired the cabinet, and at the same time, a new general bankruptcy law was enacted.

The second window covers the period from April 22, 1998 to November 27, 1998 characterized by Russia's default. In April 1998 interest rates in Thailand were at six-year highs. In Malaysia, the economy contracted 5.9% in the second quarter of 1998 and September was a chaotic month: the ringgit was fixed to 3.8/US dollar, capital controls were instituted, IFC announced that it would remove Malaysia from IFC Investable Asia and IFCI Composite Index, and the former Minister of Finance was arrested. In October, the Prime Minister announced the budget for 1999, which due to the stimulus package, resulted in the first fiscal deficit since 1992. The Philippine peso weakened 6.6% against the dollar in June and in Indonesia, domestic prices reached 68.7% in July 1998. The Korean economy was also under stress: unemployment rate reached 7.6% in July (the highest observation since 1966), interest rates fell to 7% in October, having reached 30% at the beginning of the year, and the economy contracted by 8.1% in the third quarter, the worst decline in 45 years.

The Russian government failed to collect sufficient funds through the auction of T-bills in June to repay its outstanding debt. A three-month moratorium on debt payments was subsequently declared in August of 1998. This came with a devaluation of the ruble by 50%, and a stock market crash. News of future debt re-scheduling led to losses for investors. Talks with the IMF over a $22.6 billion loan program began in November. By July 1998, Russian sovereign spreads widened by 1,000 basis points and continued to do so until October 1998, when the peak of 8,338 basis points was reached. All the East European countries moved in tandem, but with milder impact. Over the period of the Russian debacle, the Asian sovereigns mimicked the turmoil in East Europe, in particular, Indonesian sovereign spreads reached 2,000 basis points in September 1998.

The third window covers the period from November 30, 1998 to July 14, 1999. This period is marked by the devaluation of the real in Brazil and the sovereign debt default in Ecuador. In December 1998, the Russian government signed a GKO/OFZ[17] restructuring plan, which redeemed 10% of GKO/OFZ with cash, exchanged 20% for zero-coupon bonds and exchanged 70% for new fixed coupon securities with maturities between four and five years. In April 1999 the IMF and the government agreed on $4.4 billion in new loans, and by July an IMF loan and agreement to reschedule $8 billion with the Paris Club were due.

[17] The GKO are the Ruble-denominated Russian bonds.

By the end of November 1998 there were concerns about spillovers from Russia to Brazil. The IMF agreed to grant Brazil a $41.5 billion emergency credit line. But on January 15, 1999 the central bank announced that it was giving up on the defense of the real, and the so called Plan Real. The real plunged 41% after it free floated, and two months later it had appreciated by 21%. Given the events in Brazil, Argentina, as a main trading partner, suffered substantially. In May 1999, GDP contracted 3% and the unemployment rate reached 14.5%. In Ecuador, in February 1998, the central bank was forced to abolish the crawling peg exchange rate regime and allow the currency to float freely, as well as freezing bank accounts in order to avoid a bank run. By April 1999, bad loans had increased 95% year-on-year and the head and the board of the central bank resigned in protest of the government's failure to address the banking crisis. By June, the country had defaulted on its Brady bond debt. It is worth noting that at the time of the default in Ecuador, other Latin American spreads seemed not to widen as a result.

The fourth window goes from July 15, 1999 to March 21, 2000. This is a period of tranquility relative to the other three, where Latin America and Turkey showed some mild volatility. In Brazil, by September 1999, the central bank had reduced the overnight rate to 19%, and the government had lowered the reserve ratio on both demand and time deposits to spur lending. In Argentina, Fernando De La Rua was elected in October 1999 with great expectations, especially after he presented the budget for 2000. Investors were confident that he would be able to deal with the year long recession. Through the same month, Ecuador defaulted on $500 million in Eurobond debt. The government took over 15 of the 40 banks. In January 2000, the currency fell 20% and the President had to call a state of national emergency. A change in Ecuador's monetary base from the sucre to the US dollar was announced. At the same time, President Mahuad was driven out of office and Vice President Gustavo Noboa assumed power with the support of the military. In February 2000, Congress approved the move to dollarization and the privatization of state-owned power and telephone companies.

In Turkey, in August 1999, an earthquake killed 17,000 people. In October the country received $510 million in emergency international aid from the IMF. In December of that year, the government agreed with the IMF to control inflation and to work on capital markets and banking legislation. Thereafter, Turkey obtained the support of the IMF with a $4 billion two-year stand-by loan to fight inflation and $3 billion of a three-year loan from the World Bank for structural and financial reforms. It was announced that GDP grew 5.6% in 1999. At the beginning of 2000, the government announced its privatization plan in order to raise $47.6 billion.

The fifth window starts in March 22, 2000 and ends in November 2, 2000, capturing the crisis in Turkey. In March, the central bank of Brazil was forced to lower the overnight rate to inject liquidity and maintain low rates due to the weakening of the real caused by turbulence in the US market. In June, the central bank cut interest rates again and Congress passed the Fiscal Responsibility Law, which imposed strict spending limits addressing the long-standing problem of fiscal imbalance in Brazil. The real continued to appreciate due to the events in Argentina. In Argentina, deflation continued and the government failed to meet its IMF-package fiscal targets; it was forced to reduce salaries

to cut spending. In August, allegations that a number of senators received bribes in exchange for backing the labor reform bill triggered a political crisis, forcing the Vice-President to resign. In April, Ecuador agreed with the IMF a loan for $304 million conditional on achieving 4% fiscal deficit and 1% GDP growth. In October, the Turkish lira depreciated to its lowest level. In November a banking crisis was influenced by the anxiety over bank liquidity problems and rumors of takeovers. The daily average overnight rate reached more than 1,000%.

The sixth window starts in November 3, 2000 and ends in June 20, 2001. This period is described by economic stress in Argentina. Standard & Poor's lowered the sovereign credit rates of Argentina with a $39.7 billion IMF aid package to prevent a debt crisis. In December the IMF bailed out Argentina. In March 2001, Domingo Cavallo took over as the Economics Minister. A market-based solution was sought for the government's near inability to service debt, by swapping $29.5 billion of short-term obligations for long-term bonds. But, Argentines were unconvinced by the government's pledge to maintain the currency regime, and began to withdraw huge amounts from the banking system. In Brazil, the economy looked much better: GDP growth was 4% and there was a trade surplus. This series of good economic news boosted Brazilian asset prices. In Ecuador, the IMF and the government reached an agreement for a $300 million loan program by February.

In Turkey, by December 2000, several banks had been seized and the crisis was contained with a $10 billion package from the IMF. As part of this package, Turkey agreed to strengthen its banking system and accelerate privatization. As a consequence, new capital markets, banking and accounting laws were initiated. The IMF approved these macro reforms. In January 2001, the seized banks were sold and in order to fight the banking crisis, the central bank boosted liquidity through the sale of $3.5 billion of foreign currency; the Turkish lira was floated. The head of the central bank and the undersecretary of treasury resigned and in May the IMF approved an additional $8 billion loan package.

The seventh window covers the period from June 21, 2001 to February 7, 2002. In Argentina, the $8 billion bailout package from the IMF failed to prevent a worsening of the crisis and the country defaulted on its obligations. In November 2001, Standard & Poor's lowered Argentina's sovereign rating to default status. At the beginning of December, the government responded by imposing restrictions on deposit outflows and capital flight. Argentines protested to the newly restructured government bonds and lack of access to bank deposits. Minister Cavallo and President De La Rua were forced to resign. On December 15, 2001, Argentina defaulted on $155 billion of sovereign debt, and on December 27 the government announced it was exiting the currency board and the currency floated. Three more interim leaders followed before Eduardo Duhalde became president. In January 2002, Argentina imposed capital controls. The economy contracted 4.5% in 2001 and expectations for 2002 are for an economic contraction of 9%.

The last window covers the period from February 8, 2002 to September 26, 2002. This window covers the uncertainty in Argentina following the default, as well as the volatility

in Brazil due to the presidential elections and weak economic fundamentals. Argentina started negotiations with the IMF in February. Members of the IMF visited Argentina and found the economic situation to be critical (including a rising inflation). They announced that an agreement would be only possible under drastic economic reforms and targets. In June, the government announced an inflation target of 80% (while had been previously set at 15%). In September, the Argentine Treasury announced its default on the multilaterals.

In Brazil, by April 2002 there were questions over whether the central bank was going to be able to meet its inflation target of 4.5% for 2002, which is the anchor of monetary policy in Brazil. In addition to this, the left-wing party led the presidential polls in May, a lead maintained until election. In June, Moody's changed its economic outlook for Brazil from positive to negative, on the basis that the economy would have difficulty maintaining an adequate primary budget surplus and refinancing its debt. In the same month, Brazil used $10 billion from the IMF credit line to defend the real, and borrowed $4.8 billion to buyback debt. By the end of June, the central bank moved its inflation target for 2002 from 4.5% to 5.5%. In August, Brazil obtained a $30 billion loan from the IMF to help boost investor confidence. In September, the central bank used its reserves to pay $2.8 billion in debt due that month and repurchased $19.7 million of floating-rate debt due the following year. This action bolstered bond prices. Note that since April 2001, Argentine spreads widened very rapidly and reached a peak of 8,000 basis points in June 2002. The Latin American sovereigns showed a mild volatility over this period, and at the very end of the period we see Brazil and Ecuador spreads rising. The Asian and Eastern European assets seem to remain calm throughout this period.

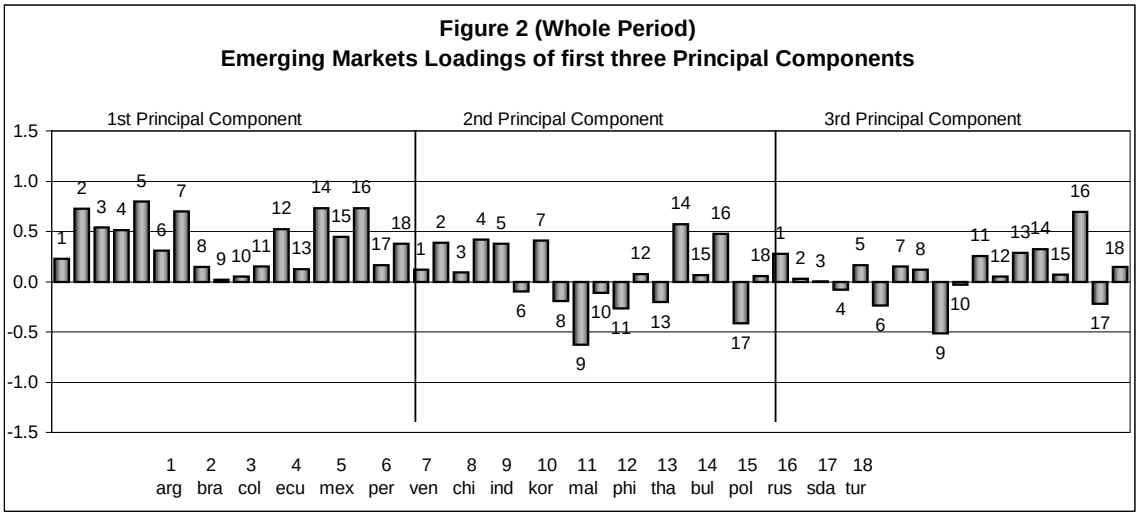
As we mentioned before, our main concern in this paper is to look at co-movements of sovereign spreads either within or across regions. We carry out this objective using PCA to explain the variation in spreads in the different regions and for the different periods. The details of this methodology are offered in Appendix E.

3. Results

3.1. Whole Period Principal Components

In our analysis, we find that the first principal component can be associated with emerging market total volatility[18] (see Figure 2). In addition, then first principal component also reflects a market distinction for the Asian region. The Asian spreads have the lowest correlation with this component[19]. Table 2 illustrates that during this period the Asian countries had systematically higher credit ratings than their Latin American and East European counterparts. In addition, Table 3 shows that the three regions have had a similar amount of capital inflow during the 1990s, but the Asian countries included in the sample have had much higher saving rates (as a percentage of GDP) than other regions. The better ratings and higher savings enable us to conclude that this region is a safer region, and thus less affected by the global volatility of the emerging markets.

Figure 2 (Whole Period)
Emerging Markets Loadings of first three Principal Components



The second component reflects the market's clear distinction between Russia and the spreads in other countries. We believe this result can be influenced by the default that occurred in Russia in 1998[20]. In other words, the Russian spreads are important during this period for explaining the variability of emerging market spreads. Finally, the third component tends to show more of an East European factor, essentially due to Russia. Similar to the results for the second component, we believe this is related to the Russian default in 1998.

[18] This result is similar to the result found by Avellaneda and Scherer (2000). However, in their case this was only done for Latin America. See more on this below.
[19] The exception will be the Philippines, which, as will be noted later, tend to show a distinctive behavior from the other Asian countries.
[20] This event corresponds to the second period in our analysis. See the discussion ahead in the paper.

Table 2: Standard & Poor's Sovereign Ratings

	Beg. of Period 1	Beg. of Period 2	Beg. of Period 3	Beg. of Period 4	Beg. of Period 5	Beg. of Period 6	Beg. of Period 7	Beg. of Period 8	End of Period 8
Latin American Region									
Argentina	BB	BB	BB	BB	BB	BB	B	SD	SD
Brazil	BB-	BB-	BB-	B+	B+	B+	BB-	B+	B+
Colombia	BBB-	BBB-	BBB-	BBB-	BB+	BB	BB	BB	BB
Ecuador	na	na	na	na	na	B-	CCC+	CCC+	CCC+
Mexico	BB	BB	BB	BB	BB+	BB+	BB+	BBB-	BBB-
Peru	BB	BB	BB	BB	BB	BB-	BB-	BB-	BB-
Venezuela	B+	B+	B+	B+	B	B	B	B	B-
Asian Region									
China	BBB+	BBB+	BBB+	BBB+	BBB	BBB	BBB	BBB	BBB
Indonesia	BBB	B-	CCC+	CCC+	CCC+	B-	CCC+	CCC	CCC+
Korea	AA-	BB+	BB+	BBB-	BBB	BBB	BBB	BBB+	A-
Malaysia	A+	A-	BBB-	BBB-	BBB	BBB	BBB	BBB	BBB+
Philippines	BB+	BB+	BB+	BB+	BB+	BB+	BB+	BB+	BB+
Thailand	A	BBB-	BBB-	BBB-	BBB-	BBB-	BBB-	BBB-	BBB-
Eastern European Region									
Bulgaria	na	na	B	B	B	B+	B+	BB-	BB-
Poland	BBB-	BBB-	BBB-	BBB	BBB	BBB	BBB	BBB	BBB+
Russia	BB-	BB-	CCC-	SD	SD	SD	B+	B+	BB-
South Africa	BB+	BB+	BB+	BB+	BB+	BB+	BB+	BB+	BBB-
Turkey	B	B	B	B	B	B+	B-	B-	B-

Source: Bloomberg

Table 3: Economic Indicators

	% of regional GDP	GDP Growth Rate (%)	GDP per capita (2000 US$)	Trade (Export + Import) (% of GDP)	Domestic Saving (% of GDP)	Gross Private Capital Flows (% of GDP)	Net Private Capital Flows (% of GDP)	Net Foreign Direct Investment (% of GDP)
Latin American Region								
Argentina	17.4	3.9	12377	19.0	14.8	12.2	5.0	2.7
Brazil	40.8	2.0	7625	18.5	18.2	8.6	3.5	1.9
Colombia	5.3	2.8	6248	36.2	16.3	8.1	3.6	2.2
Ecuador	1.1	1.9	3203	58.8	19.4	16.2	5.5	2.9
Mexico	27.0	3.6	9023	50.5	19.3	9.1	5.0	2.2
Peru	3.1	3.1	4799	30.4	15.9	8.2	5.0	2.8
Venezuela	5.3	2.4	5794	51.1	22.1	16.7	2.8	2.7
Region (1)	100.0	2.8	7828	31.0	17.8	10.0	4.2	2.4
Asian Region								
China	45.7	9.6	3976	40.5	40.3	8.3	4.8	4.0
Indonesia	10.6	4.6	3043	58.6	26.1	7.6	4.0	0.7
Korea	25.8	6.4	17380	66.6	34.6	12.1	3.0	0.8
Malaysia	5.0	7.2	9068	182.9	34.5	14.7	6.6	5.2
Philippines	4.3	2.9	3971	84.6	21.2	15.7	4.9	1.8
Thailand	8.6	5.0	6402	90.4	33.1	14.5	5.6	2.6
Region (1)	100.0	5.0	4394	63.3	35.7	10.9	4.4	2.8
Eastern European Region								
Bulgaria	1.5	-2.6	5710	97.9	12.0	13.8	4.4	2.6
Poland	14.4	3.7	9051	51.9	20.3	7.8	5.8	2.7
Russia	46.7	-4.0	8377	57.2	25.7	8.5	1.5	0.6
South Africa	16.3	1.5	9401	45.3	14.6	10.8	2.2	0.9
Turkey	21.2	4.0	6974	43.1	23.9	7.9	3.8	0.5
Region (1)	100.0	3.7	8234	51.3	21.6	9.0	2.7	1.0

(1) Only includes the above mentioned countries.

Source: World Development Indicators, World Bank, except \7 Institute of International Finance

At a regional level –as can be seen in Figure A1 in the Appendix A- the first principal component reflects regional volatility. The first principal component is associated positively with all the spreads. The second and third components reflect a market distinction between Argentina and the remaining countries. This distinction is related to the fact that events in Argentina provided an important source of shocks during the whole period. This finding differs from the results obtained by Avellaneda and Scherer (2000). Based on the second principal component, they found that the market distinguished Venezuela from the rest of the Latin American countries. This difference can be explained by different methods used, by a different sample of countries[21] and a different sample period[22].

In Asia the first component reflected total regional volatility, as Figure A2 in the Appendix A illustrates. The second and third principal components are strongly correlated with Korean spreads. Korea has the highest GDP per capita in the region, the second highest saving rate as percentage of GDP (See Table 2), the highest credit rating (See Table 3) and the lowest external debt as a percentage of GDP (See Table 4). The fact that the market differentiates Korea from the other countries is therefore not surprising.

[21] Our study has more Latin American countries, but they have more bond spreads because they use two spreads for each country.

[22] Although there is some overlap in the sample period, our sample period starts later on, and is longer.

Again, as we will show later, Korea also recovered quickly from the financial troubles that it experienced at the beginning of this period.

Table 4: External Debt (1990-2002 Average as % of GDP)

	Total External Debt	Medium/Long term debt	Short term debt
Latin American Region			
Argentina	46.22	38.53	6.70
Brazil	34.57	26.98	7.14
Colombia	39.52	33.45	6.06
Ecuador	90.37	78.89	4.59
Mexico	35.83	26.54	9.29
Peru	60.73	46.83	7.76
Venezuela	44.89	39.47	5.43
Total	39.14	30.99	7.53
Asian Region			
China	17.95	13.64	4.31
Indonesia	73.81	58.85	13.91
Korea	28.22	15.72	12.49
Malaysia	47.68	36.21	11.47
Philippines	68.62	57.41	11.21
Thailand	58.76	38.56	19.84
Total	32.72	23.47	9.12
Total (excluding China)	46.81	32.84	13.70
Eastern European Region			
Bulgaria	97.37	65.72	27.37
Poland	43.76	38.81	4.39
Russia	31.07	25.11	4.76
South Africa	24.96	17.88	7.08
Turkey	49.24	38.70	10.50
Total	36.78	29.49	6.58
Total (Excluding Russia)	41.76	33.32	8.16

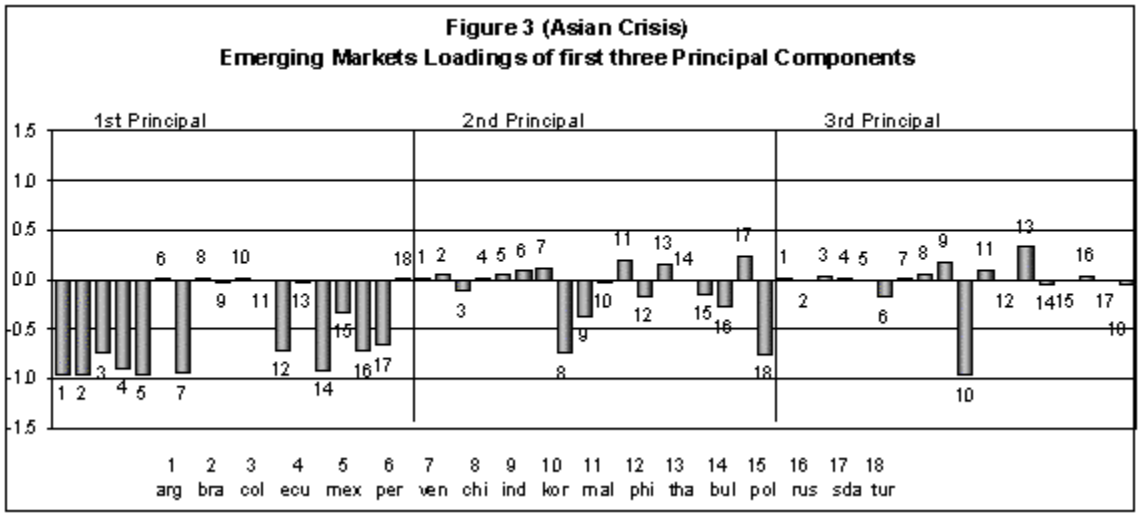
Source: Institute of International Finance

Finally, in the case of the emerging European countries, the first principal component can be associated with regional volatility and Russia (See Figure A3 in the Appendix A). Several factors explain this result: (1) the Russian economy is the largest in this region; (2) Russia was a fundamental source of shocks during this period; and (3) as a result of the second fact the ratings for Russian spreads were the worst in the region and it was the only economy that called a default (See Table 3) [23]. Finally, the third component is related to a Turkish factor that can be explained by the financial crisis this country experienced during the timeframe.

[23] The second component also shows a strong correlation with Russian spreads, which is related to the factors explained for the first component.

3.2. First Period Principal Components (Asian Crisis) [Sep/15/1997 - April/21/1998]

The first principal component reflects a shock coming from Asia. Almost all the non-Asian countries are negatively correlated with the first component, while the Asian countries are not correlated. See Figure 3. We interpret this finding as the market differentiating between Asian and non-Asian economies. The second and third components also tend to show this market distinction. In addition, the second and third components are also highly associated with an Asian country- China in the case of the second component and Korea in the case of the third component.



In the Latin American region –as can be seen in Figure A4 in the Appendix A - the Asian shock affected all countries in a similar manner, except in the case of Peru where the market made a clear distinction. The first principal component is strongly correlated with all Latin American countries' spreads except for Peru, and the second component is highly correlated only with Peru.

This can be explained by two factors: in Figure B1 in the Appendix B it is possible to see that among the sample of Latin American countries, Peru has had the strongest commercial ties with Asia. Secondly, prior to the Asian crisis, there was an important build up of capital flows in this country (see Figure B2 in the Appendix B). Thus, Peru was in a weak financial position to cope with the turbulences that occurred during this period in emerging markets.

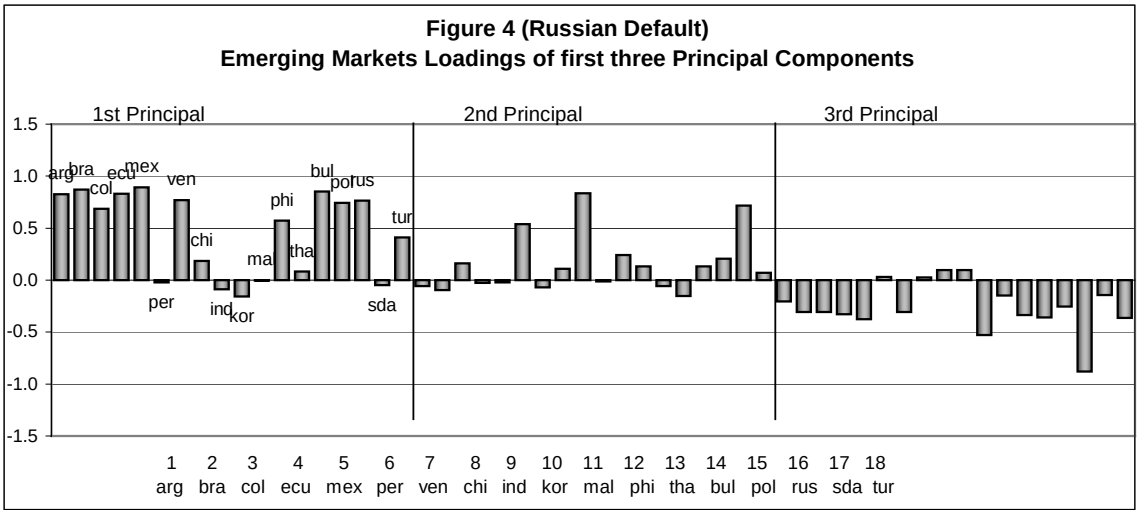
In the Asian region, it is clear that the action was centered on two countries: Korea and Indonesia. The first principal component was highly (negative) correlated with Indonesian spreads. See Figure A5 in the Appendix A. Several factors can explain why these spreads behaved distinctively: (1) Indonesia spreads suffered an important downgrading. See Table 3. (2) Indonesia had a lower savings rate in the 1990s than other

The second component has a strong (negative) correlation with Korean spreads. This is understandable because Korea was one of the Asian countries that suffered the most from the financial crisis. The extent of the impact is evident if we consider credit ratings. Korea went from AA- (equivalent to a developed country and investment grade) to BB+ (similar to a Latin American country and only just above Indonesia). The third component did not show a clear pattern.

Finally, in the case of the emerging European countries, the first principal component can clearly be associated with regional volatility. See Figure A6 in the Appendix A. The second principal component shows that the market differentiated Turkish spreads. We do not have a clear explanation for this regional distinction. Even though Turkey had accumulated a large amount of short–term debt before this period (see Figure B3 in the Appendix B), the overall indebtedness was not especially high for the region (see Figure B4 in the Appendix B). Moreover, the credit rating for Turkey did not change during this window, nor did the country have important commercial ties with Asia at the time. In sum, this market distinction can be viewed as evidence of some market irrationality. The third component is highly (negatively) correlated with Polish spreads. We interpret this as the relative isolation of this country from the overall volatility caused in emerging markets by the Asian crisis. This can be related to the fact that Poland has by far the best rating in the region, and has had relatively lower external short-term indebtedness (see Table 4).

3.3. Second Period Principal Components (Russian Default) [April/22/1998 - Nov/27/1998]

The first principal component reflected the isolation of the Asian sovereign market from the Russian default shock (except Philippines). See Figure 4. Again, we attributed the relative isolation of Asia to better ratings and higher savings than that of other regions. In addition, it is interesting to notice that the Philippines has both credit ratings and saving rates more like countries from other region countries (see Tables 2 and 3). We can therefore consider the Philippines as a ‘non-Asian’ country being affected by the turbulence in a similar way to countries from the other two regions.



The second component showed the market clearly distinguished Indonesia from other emerging market. The explanation for this is similar to the Philippines's case , that is, low savings rate, low growth rates and credit ratings similar to countries from other regions (see Tables 2 and 3). In addition, Indonesia had a huge build-up of external debt over this timeframe, as Figure B5 in the Appendix B shows. Finally, only the third component reflected an apparent market distinction for Russian spreads.

Figure A7 in the Appendix A shows that in Latin America the Russian crisis affected all countries in a similar way, except in the case of Peru where the market made a clear distinction. The behavior of the first principal component is similar to the behavior observed in the previous period, that is, all countries had a positive correlation with the first component, except Peru, which is not correlated. The second and third component also showed that the market distinguished Peruvian spreads from other Latin American ones. Peru accumulated a significant amount of external debt during the previous periods. There was a build-up of external capital flows prior to the Asian crisis (see Figure B6 in the Appendix B). These two factors rendered Peru financially weak and unable to face the instability that occurred during this episode.

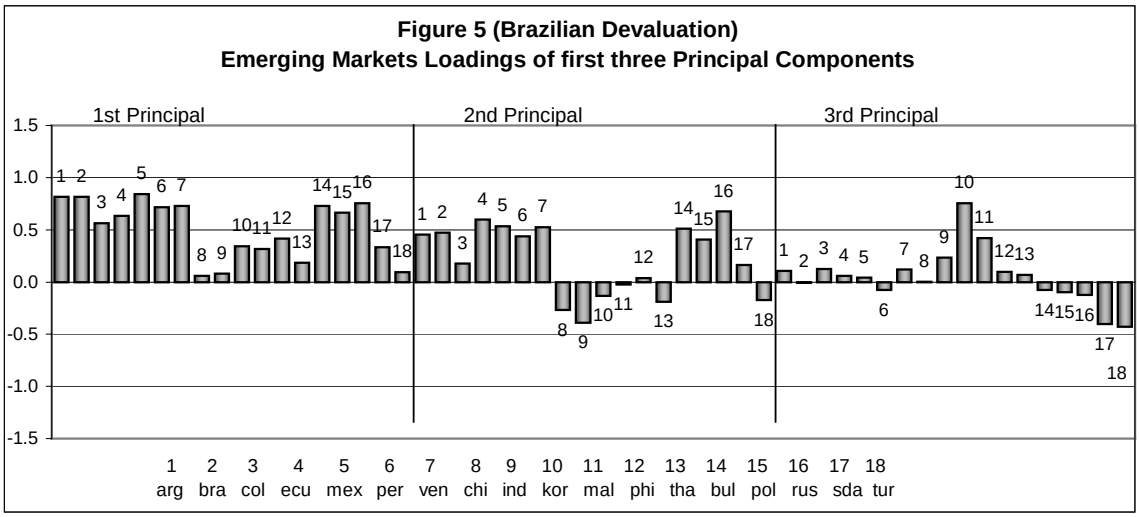
Using Asian principal component, it is clear that the market singled out three Asian economies: Malaysia and Indonesia. See Figure A8 in the Appendix A. The first component is strongly associated with Malaysian spreads. The case of Malaysia is interesting because it was the only country that imposed capital controls, and naturally as a consequence, the market takes account of this. The third component is highly (negatively) correlated with Indonesian spreads. The logic for this differentiation is the same as for the general case already discussed.

Finally, as expected in East Europe, it is the Russian default that dominates the story. The first and third principal components are strongly associated with Russians spreads. See Figure A9 in the Appendix A. The second component is highly correlated with South African spreads. This reflected the market distinguishing for South Africa because it does not have major ties with the region. In addition, it did not accumulate substantial debt in

the 1990s, (See Figure B7 in the Appendix B). Credit ratings were also, in general stable and the second highest in the region.

3.4. Third Period Principal Components (Brazilian Devaluation) [Nov/30/1998 - July/14/1999]

The first and second components showed that the Asian region was relatively unaffected by the upheaval brought on by the Brazilian devaluation. See Figure 5. We believe that this relative isolation is related to the higher savings rate and credit ratings that the region had. However, the third component is highly correlated with Korea, which reflects that some of the instability in Brazil was transmitted to this particular country.



Using Latin American principal components, we find that in this period the market made a difference between Ecuador and the other Latin American countries. The second principal component showed a distinctive negative correlation with Ecuadorian spreads. See Figure A10 in the Appendix A. We suspect that this distinction is associated with two factors: an important accumulation of capital flows before this period (See Figure B2 in the Appendix B) and maybe some market anticipation of the default in Ecuador that occurred in the following period. The third component is strongly (negative) correlated with Colombia. We suspect that in this case that this relative isolation of the Brazilian turbulence is related to the fact that oil prices started to increase systematically from January 1999, thus alleviating the external position of Colombia. However, in this country a political turmoil caused demand to fall, resulting in a widening of the spread as well as a depreciation of the Colombian peso.

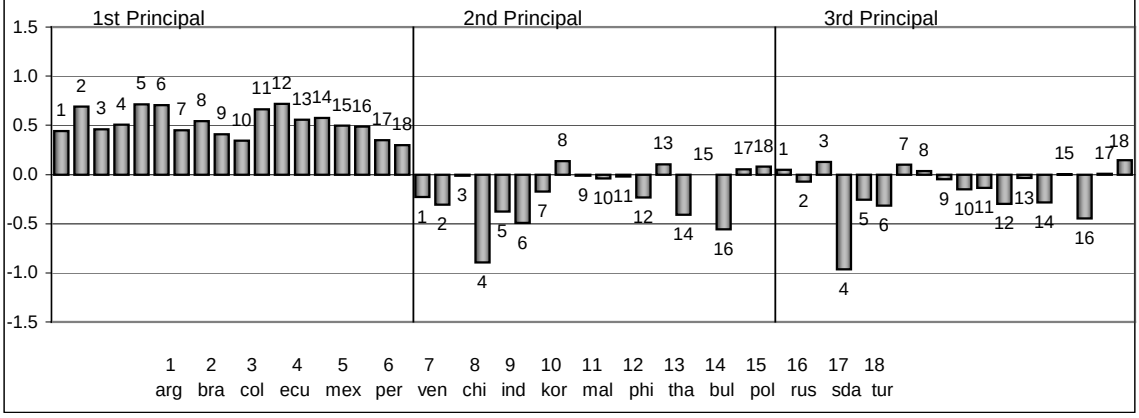
In the Asian region, the first principal component can be related to regional volatility, as seen in Figure A11 in the Appendix A. The second component does not show a clear pattern and the third principal component can be associated with Indonesian spreads. Once more, we can see that the relative financial weakness of Indonesia (large external debt, low savings rate and a credit downgrade) comes out in the estimation of the principal components.

In East Europe it is evident that the Russian debacle still weighed on the region. All principal components were strongly associated with Russian spreads. See Figure A12 in the Appendix A.

3.5. Fourth Period Principal Components (Ecuadorian Default) [July/15/99 – March/21/00]

In this period it is apparent that the market distinguished between Ecuador and the rest of the emerging market countries. The second and third are highly (negatively) correlated with the Ecuadorian spreads, which is the only one experiencing such a strong correlation. See Figure 6. The first component was associated with general volatility in emerging markets.

Figure 6 (Ecuadorian Default)
Emerging Markets Loadings of first three Principal Components



Similar to the general case, when we consider the only the Latin American region the principal components reflect the effect of the Ecuadorian default. The second component is strongly (negatively) correlated with Ecuadorian spreads. See Figure A13 in the Appendix A. The first component can be attributed to regional volatility, and third component shows no clear pattern.

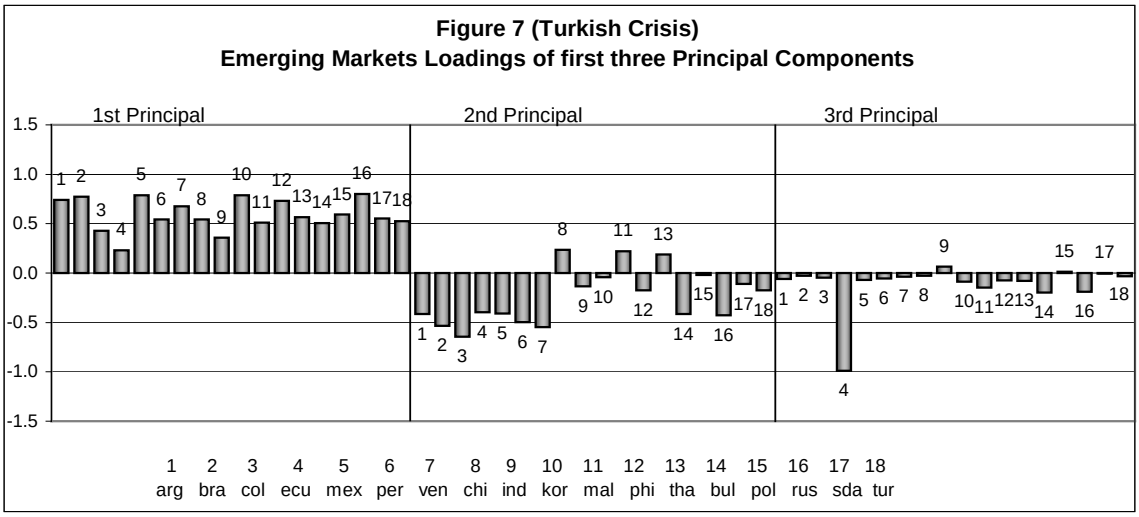
In Asia, the first principal component is affected by high regional volatility. See Figure A14 in the Appendix A. In addition, the other components show that Indonesia and Korea behaved distinctively during the timeframe. The second component is strongly (negatively) correlated with Indonesian spreads. Again this can be associated to the financial weakness already discussed. The third component is strongly negative correlated with Korean spreads. We believe that this differentiation is related to the fact that Korea was clearly on a post-crisis recovery path. See Figure B8 in the Appendix B.

In East Europe, Russian spreads seem to be the only spreads affected during this period. The three principal components are highly correlated with these spreads. See Figure A15 in the Appendix A. We suspect that the effects of the crisis were still on-going

3.6. Fifth Period Principal Components (Turkish Crisis) [March/22/2000 - Nov/1/2000]

In Figure 7 it is possible to see that in this period the first component is associated to the volatility of emerging market spreads. The second component illustrated some relative isolation of Asian spreads, probably related to the strength of this region and, finally, the third component showed a market distinction for Ecuador.
The differentiation of Ecuador is again evident if one considers just the Latin American region. The second and third components are highly (negative) correlated with these spreads. See Figure A16 in the Appendix A. The first component can be related to regional volatility.

Figure 7 (Turkish Crisis)
Emerging Markets Loadings of first three Principal Components



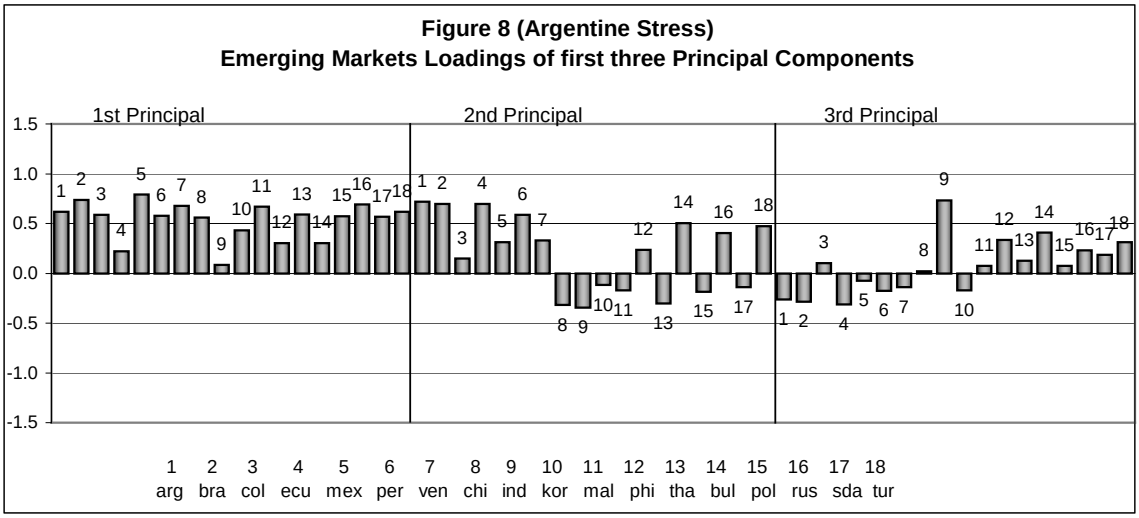
In Asia the first principal component can also be associated with regional volatility. See Figure A17 in the Appendix A. Moreover, the spreads that show a distinct behavior are Indonesia and the Philippines. The second component is strongly (negative) correlated to these spreads. We relate this distinction to the relatively low savings rate, low credit ratings and high level of indebtedness of Indonesia. Finally, the third component is highly correlated with the Philippines' spreads. The same argument can be made here as for Indonesia.

In East Europe the first principal component can be linked with regional volatility. See Figure A18 in the Appendix A. In addition, we find some effect of the Turkish crisis. The third principal component is positive correlated with Turkish spreads and this is the only positive correlation in the region for this component. The rest of the components again showed the importance of Russia.

3.7. Sixth Period Principal Components (Argentine Stress) [Nov/03/2000 - June/20/2001]

In this period we found little evidence that the problems in Argentina affect the other emerging market countries. The first principal component is highly correlated with Argentine spreads, but it is also strongly correlated with other countries. The second component did not show a clear pattern. See Figure 8. This lack of evidence can be related to the fact that the percentage of the variance explained by the first principal component is almost the lowest when compared to other periods (See Section 2.5.10. for explanation). The third component is strongly associated with Korean spreads. Again, we believe the market is making a distinction for this country based on its relative financial strength, and the fact that this country recovered very quickly from the Asian. See Figure B8 in the Appendix B.

Figure 8 (Argentine Stress)
Emerging Markets Loadings of first three Principal Components



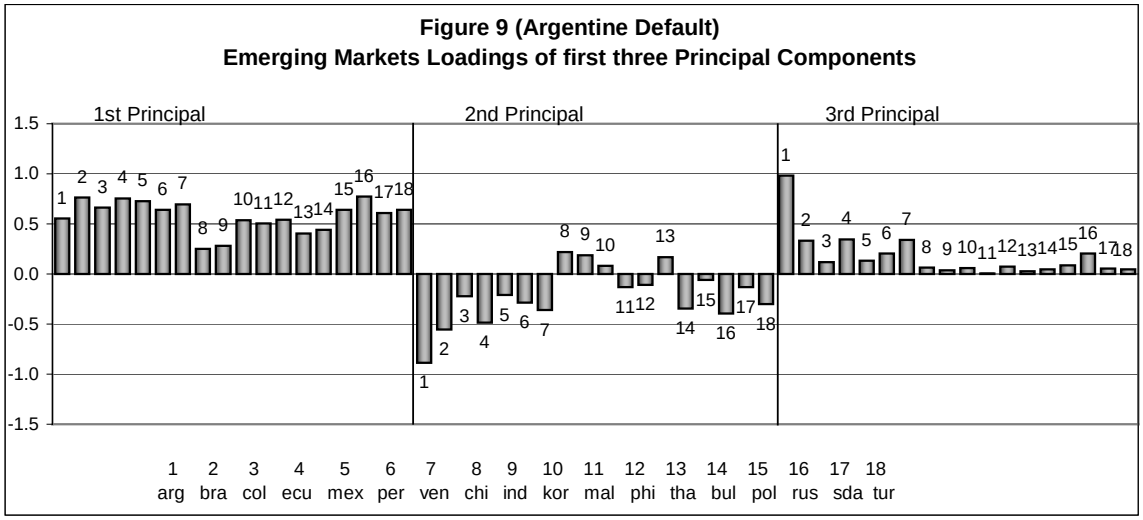
For the Latin American countries, the first principal component can be associated to regional volatility. That is, as a first approximation, the shock of this period affected all Latin American countries similarly. In addition, the second and third components are linked to Ecuadorian spreads, which we associate to the relative financial weakness of this country. See Figure A19 in the Appendix A.

In Asia the first principal component can be related to regional volatility. Thus, the shock in this period influenced all the Asian countries likewise. See Figure A20 in the Appendix A. The second principal component shows that in this period the market made a distinction for Philippines. The third component shows a distinctive behavior toward Indonesian spreads.

In East Europe, the first principal component can be coupled with a high regional volatility. In addition, the second component does not show a clear pattern. However, markets differentiated Turkey (third principal component) from the other countries in the region. See Figures A21 in the Appendix A. In the case of Turkey we suspect that this distinction is related to the crisis that this country experienced during the previous lingering on for more than one period.

3.8. Seventh Period Principal Components (Argentine Default) [June/21/2001 - Feb/7/2002]

The principal components confirm the importance of the shock emanating from Argentina. The second principal component is strongly associated with Argentine spreads and the third component is highly correlated with these spreads as well[24]. See Figure 9.



In Latin America, it is possible to see the strong influence of the Argentine default. The first principal component is highly correlated with the Argentine spreads. The second principal component is also highly correlated with these spreads, and the third component is strongly (negative) associated with these. See Figure A22 in the Appendix A.

In the Asian Region, the first principal component can be associated with regional volatility, that is, as a first approximation, the shock of this period influenced all Asian countries in a similar way. In addition, the PCA shows that in this period the market made a distinction for Indonesia (second component) and for the Philippines (third component). In this period of high volatility (see Section 2.5.10.) the relative financial weakness of these two countries is captured by this analysis. See Figure A23 in the Appendix A.

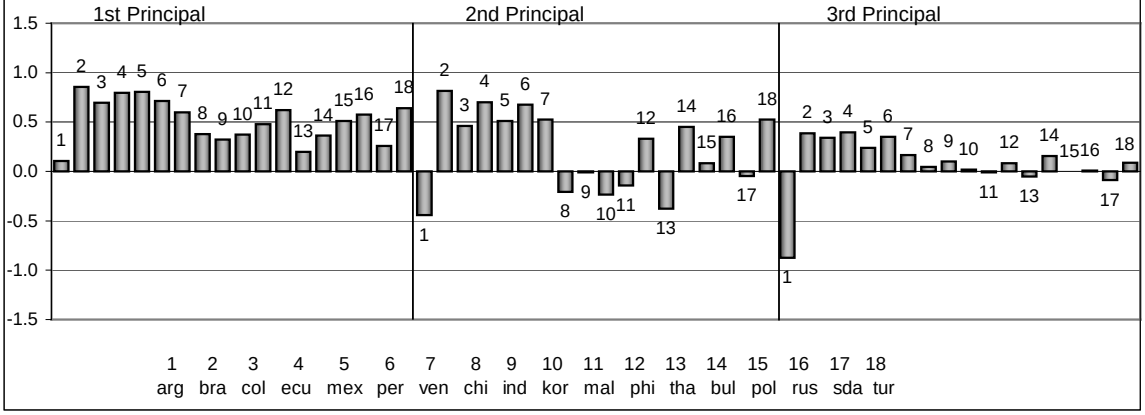
In East Europe, the first principal component can be linked to a high regional volatility. In addition, the market differentiated Bulgaria (second principal component) and Turkey (third principal component) from the other countries in the region. Similar to the previous period, these countries show financial weakness, which are reflected in these components. See Figure A24 in the Appendix A.

[24] The only component that does not show this association with Argentine spreads is the first principal component, which can be associated with general volatility.

3.9. Eighth Period Principal Components (Brazilian 'Fear') [Feb/8/2002 - Sep/26/2002]

Overall, the PCA shows that the Argentine default was a shock that lingered on for more than one period. The second and third components show that the market made a clear distinction between Argentine spreads and the other emerging markets. See Figure 10.

Figure 10 (Brazilian 'Fear')
Emerging Markets Loadings of first three Principal Components



The Latin American regional picture is similar to the global emerging market one in the sense that the Argentine default persisted for more than one period. All the principal components are clearly associated with Argentine spreads. See Figure A25 in the Appendix A.

In Asia, the first principal component can be clearly associated to regional volatility, that is, this period's shock similarly affects all Asian countries. However, the market made a clear distinction for Indonesia and the Philippines. As before, we see that these countries are clearly identified by the component analysis, and we consider this fact to be related to their financial weakness. See Figure A26 in the Appendix A.

For East Europe, the first principal component can be linked to a high regional volatility, as individual countries were affected likewise. In addition, the market differentiated South Africa (second and third principal component) from the other countries in the region. See Figure A27 in the Appendix A. Once again the financial strength of South Africa is evident.

3.10. Analysis of Co-Movements in the Eight Periods

In this section we analyze the eight windows in which we divide our sample using the percentage of variance explained by different components. Similar to the previous sections, we start with the principal components for all the emerging markets included in the sample.

For the covariance method, Avellaneda and Scherer (2000) proposed the following categories:

1. Extreme Coupling: Percentage of variance explained by first principal component is above 80%.
2. Strong Coupling: Percentage of variance explained by first principal component is between 65-80%.
3. Weak Coupling: Percentage of variance explained by first principal component is below 65%.

The above categories are not useful for the correlation method used in this paper because this method standardizes the original spreads before computing the principal components; the influence of extreme observations is significantly reduced. To understand the concept, think of a sample of observations where one variable has a large variance (say, variable 1) and the other variables have a small variance. In this case the first principal component will be almost perfectly correlated with variable 1, and at the same time will explain almost all the variance[25]. If we reduce the variance of variable 1 and increase the variance of the other variables, the percentage of variance explained by variable 1 will decrease (and also its correlation with the first component). This is the effect produced by standardizing the variables. More succinctly, for the same sample of observations, the first component will explain a lower percentage of the variance and, thus, we need to reduce the thresholds for classifying different episodes.

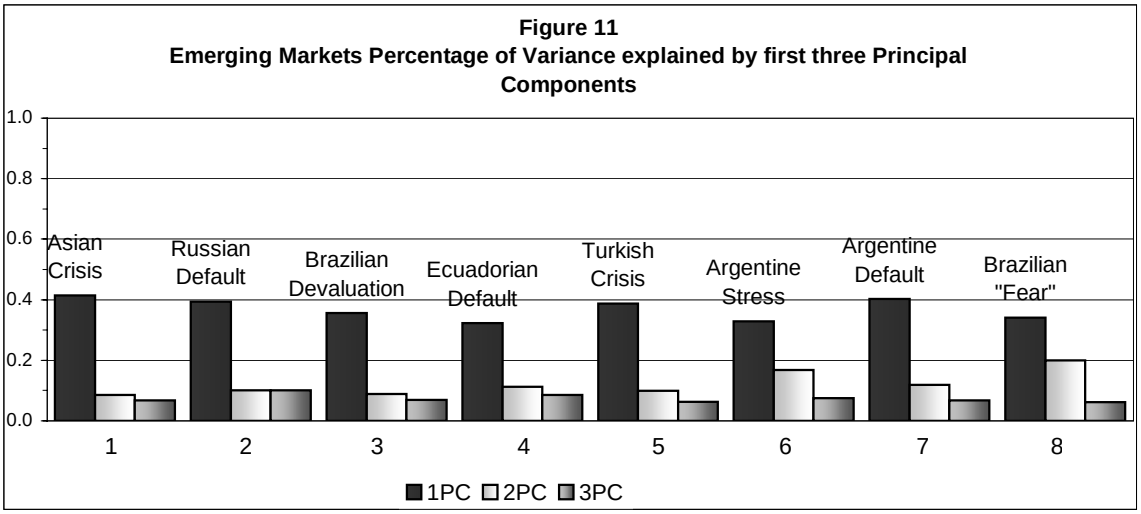
We will use the following thresholds:

1. Extreme Coupling: Percentage of variance explained by first principal component is above 50%.
2. Strong Coupling: Percentage of variance explained by first principal component is between 35-50%.
3. Weak Coupling: Percentage of variance explained by first principal component is below 35%.

Following this taxonomy we find no episode of extreme co-movement. Nonetheless, we observed five important periods of strong coupling: the Asian crisis, the Brazilian devaluation, the Russian default, the Turkish crisis and the Argentine default. Finally, we find three periods of weak co-movement: the Ecuadorian default, the Brazilian 'fear' and the Argentine stress. See Figure 11.

[25] See also the example provided in Jolliffe (2000) page 40-42. It illustrates quite accurately our point.

Figure 11
Emerging Markets Percentage of Variance explained by first three Principal Components



In Latin America, we find six episodes of extreme coupling. They are the Asian crisis, the Russian default, the Brazilian devaluation, the Argentine stress, the Argentine default and the Brazilian 'fear'. See Figure A28 in the Appendix A. Finally, the other two periods (Ecuadorian default and Turkish crisis) were timeframes of strong coupling and we find no period of tranquility for the Latin American countries included in the sample. This last fact shows that our whole period has been a very turbulent time for this region.

In the Asian region we find three periods of extreme coupling: the Ecuadorian default; the Turkish crisis and Brazilian 'fear'. In Figure A29 in the Appendix A, it is also possible to see that the Argentine stress and consequent default are periods have strong coupling. Moreover, we do find an odd result: the Asian crisis and the Russian default are periods of tranquility. This is counterintuitive given that, in these periods financial turmoil was rife. In East Europe (Figure A30 in Appendix A) we find only one period of extreme coupling: the default in Argentina. All other periods can be considered as strong co-movement periods.

4. Conclusions

We investigated the idea of co-movements in sovereign spreads across eighteen emerging market economies located in Asia, East Europe and Latin America. We are interested in understanding the impact that country-specific disturbances have on other economies. We conduct our investigation by using the technique of Principal Components. We believe that focusing on the results obtained from PCA would provide a satisfactory explanation of how events in one nation spillover to another. Notice that in this analysis we do not take into consideration the effects that economic policies in developed countries have on these emerging markets. However, we acknowledge that an increase in the US interest rate, for example, would have consequences for most emerging market spreads.

The objective of the paper is to provide a test for the existence of co-movements in sovereign spreads and 'attempt' to find the determinants of these co-movements. An important conclusion is that our PCA –using the percentage of variance explained by the first component- could identify episodes of turbulence in the correct regions and countries according to a historical recollection of events. In addition, along with every episode we found that the first principal component can be clearly associated with general or regional volatility, and the other components are connected with some specific countries. Moreover, we can on occasions connect the behavior of the components with some economic-financial fundamentals of specific countries.

More specifically, Asia is clearly a region more resilient to global instability than the others. We attribute this to better economic and financial fundamental within this region, such as higher growth rates and the capacity to recover from shocks, higher saving rates, lower indebtedness and better credit ratings. In addition, Indonesia and Korea seem to have a key influence on the behavior of the spreads of this region and, sometimes, on the global behavior of spreads. Malaysia and the Philippines also have some impact, but this is relatively minor compared to Korea and Indonesia. Argentine spreads are very significant in explaining the behavior of Latin American spreads. Ecuador also seems to have some influence, but it is clearly minor compare to Argentina. Finally, in the case of East Europe, Russian spreads are by far the most significant in terms of influencing the behavior of this region's spreads, while Bulgaria has a minor impact.

We believe having strong and solid emerging market economies would reduce co-movements in sovereign spreads. Therefore, we suggest that authorities in emerging markets should work on policies to strengthen their economies, as well as establishing the difference between them and their neighbors. The influence of multilateral banking in these economies is quite large, thus, authorities within these countries should be prudent when asking these institutions for assistance. Otherwise they might be channels for reproducing turbulences across countries. Market participants also need to learn more about emerging market economies to do not over-react to events in one country and thus generate spillover effects across the region.

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Appendix A: Principal Component Figures

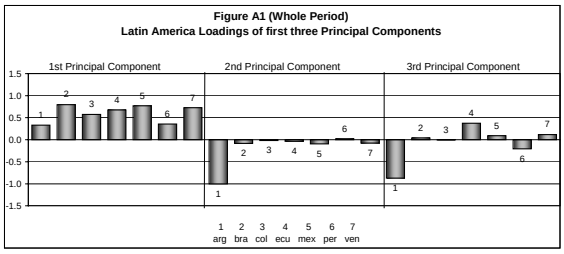

Figure A1 (Whole Period)
Latin America Loadings of first three Principal Components

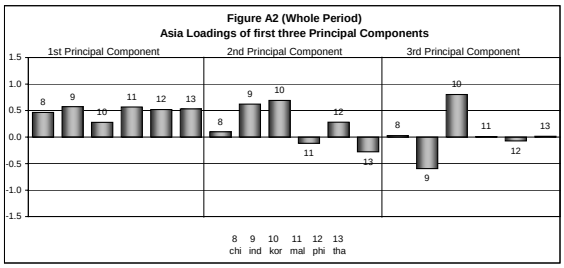

Figure A2 (Whole Period)
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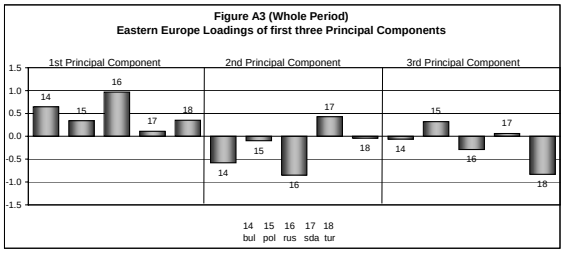

Figure A3 (Whole Period)
Eastern Europe Loadings of first three Principal Components

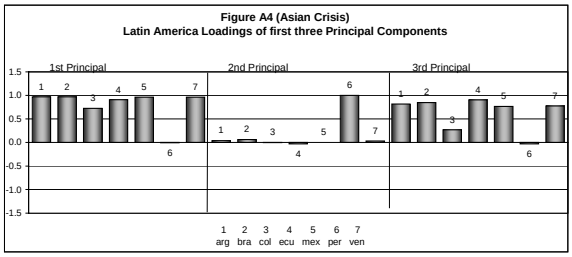

Figure A4 (Asian Crisis)
Latin America Loadings of first three Principal Components

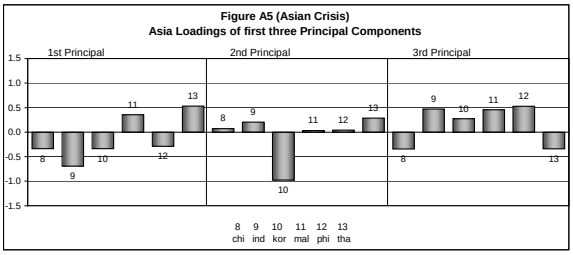

Figure A5 (Asian Crisis)
Asia Loadings of first three Principal Components

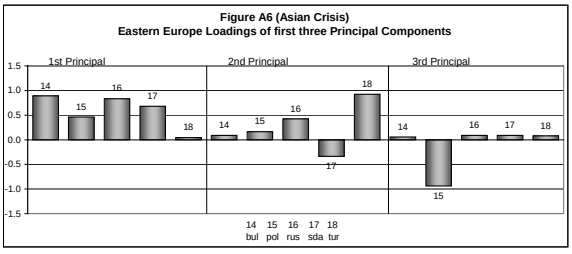

Figure A6 (Asian Crisis)
Eastern Europe Loadings of first three Principal Components

Figure A7 (Russian Default)
Latin America Loadings of first three Principal Components
(Correlation Method)

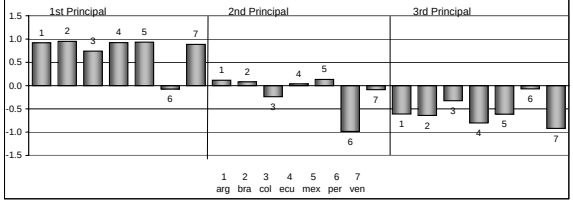

Figure A8 (Russian Default)
Asia Loadings of first three Principal Components (Correlation Method)

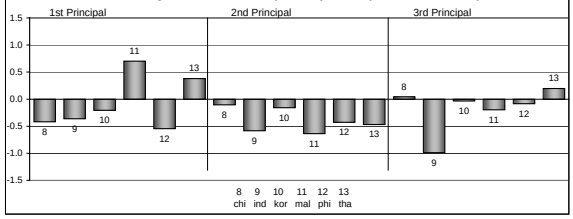

Figure A9 (Russian Default)
Eastern Europe Loadings of first three Principal Components

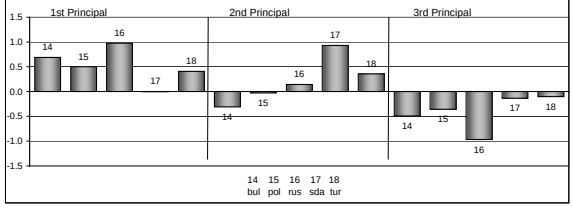

Figure A10 (Brazilian Devaluation)
Latin America Loadings of first three Principal Components

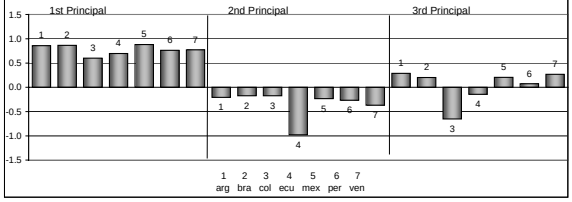

Figure A11 (Brazilian Devaluation)
Asia Loadings of first three Principal Components

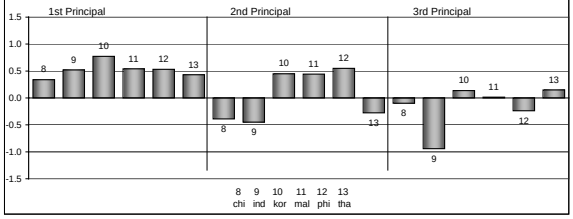

Figure A12 (Brazilian Devaluation)
Eastern Europe Loadings of first three Principal Components

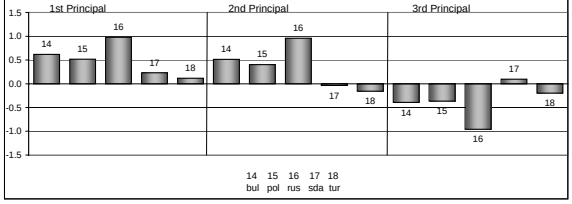

Figure A13 (Ecuadorian Default)
Latin America Loadings of first three Principal Components

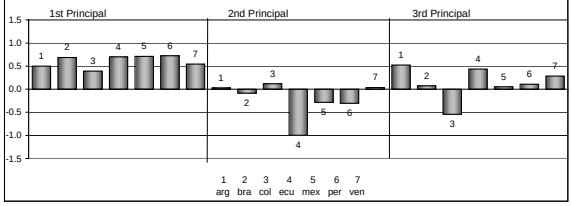

Figure A14 (Ecuadorian Default)
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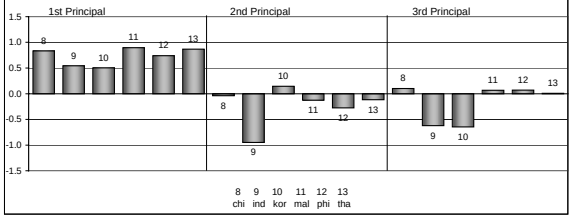

Figure A15 (Ecuadorian Default)
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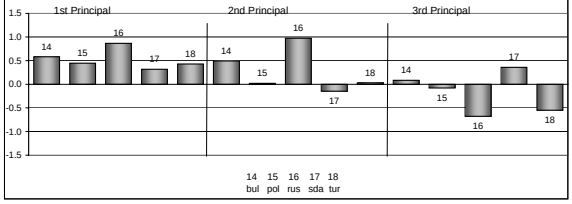


Figure A16 (Turkish Crisis)
Latin America Loadings of first three Principal Components

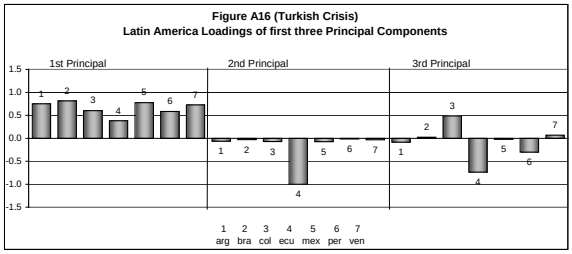


Figure A17 (Turkish Crisis)
Asia Loadings of first three Principal Components

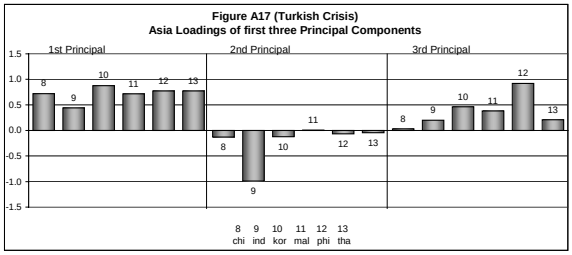


Figure A18 (Turkish Crisis)
Eastern Europe Loadings of first three Principal Components

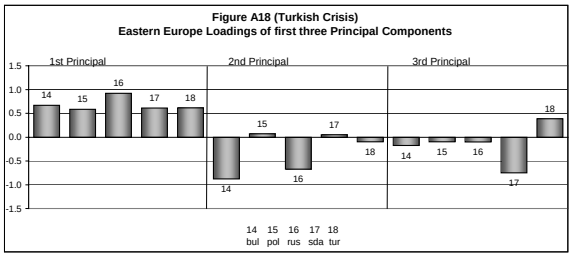


Figure A19 (Argentine Stress)
Latin America Loadings of first three Principal Components

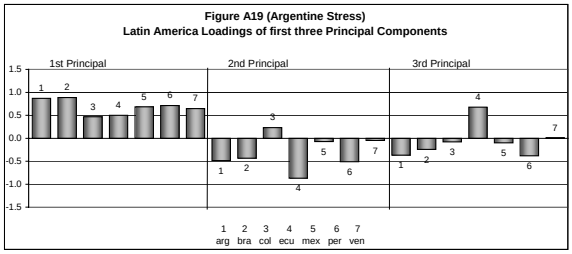


Figure A20 (Argentine Stress)
Asia Loadings of first three Principal Components

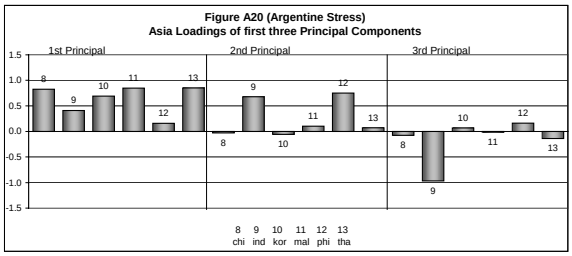


Figure A21 (Argentine Stress)
Eastern Europe Loadings of first three Principal Components

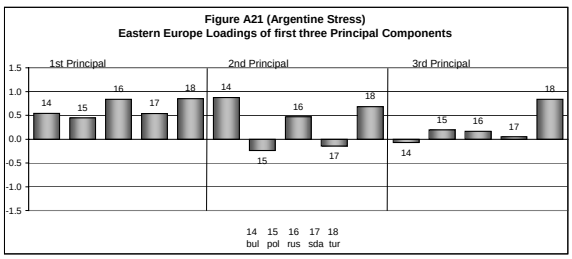


Figure A25 (Brazilian 'Fear')
Latin America Loadings of first three Principal Components

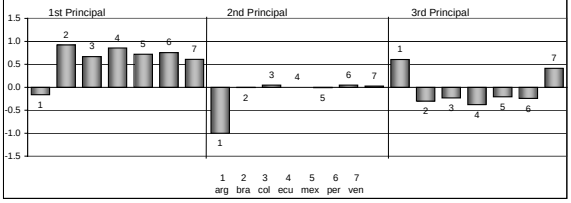


Figure A26 (Brazilian 'Fear')
Asia Loadings of first three Principal Components

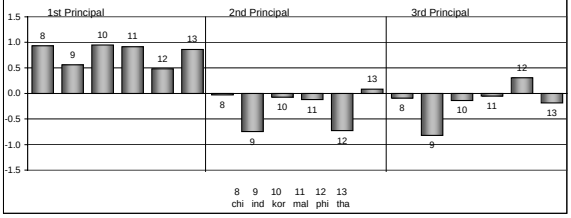


Figure A27 (Brazilian 'Fear')
Eastern Europe Loadings of first three Principal Components

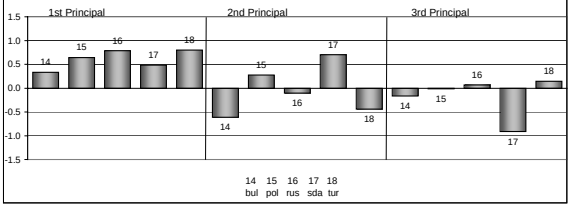
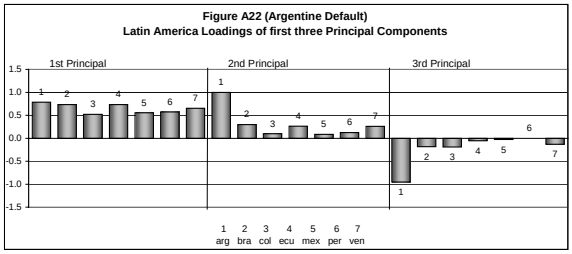


Figure A22 (Argentine Default)
Latin America Loadings of first three Principal Components



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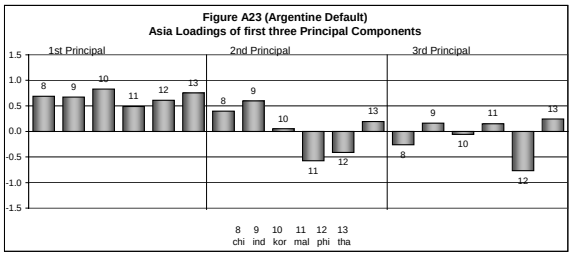

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Eastern Europe Loadings of first three Principal Components

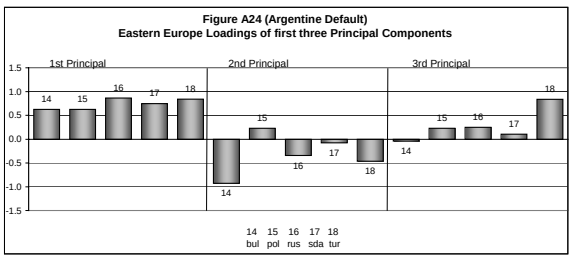


Figure A28
Latin America Percentage of Variance explained by first three Principal Components

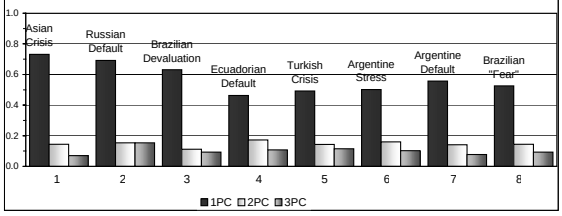


Figure A29
Asia Percentage of Variance explained by first three Principal Components

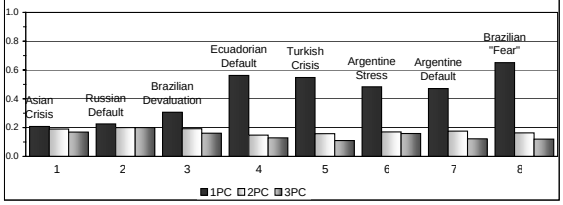
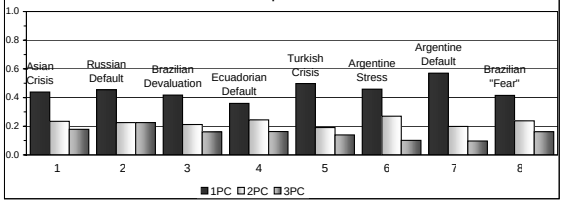
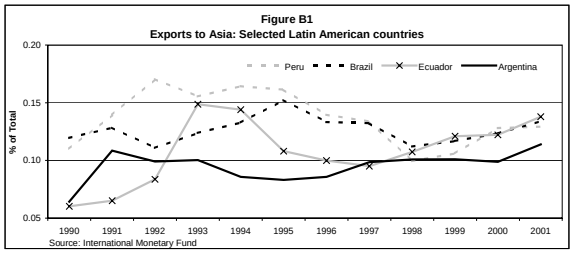
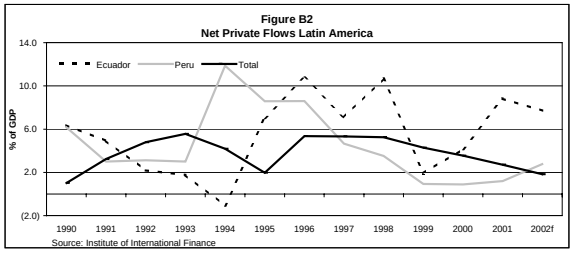


Figure A30
Eastern Europe Percentage of Variance explained by first three Principal Components



Appendix B: Economic Figures





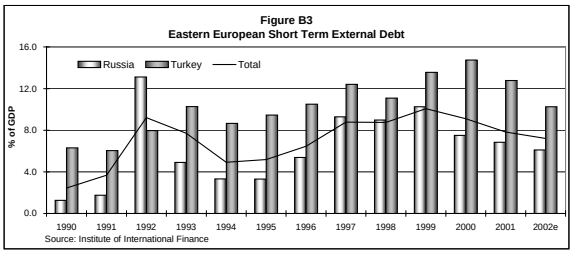
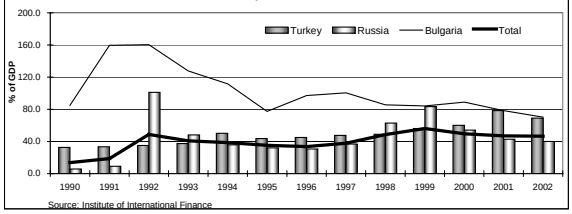
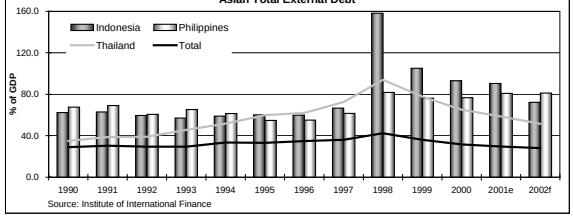


Figure B4
Eastern European Total External Debt



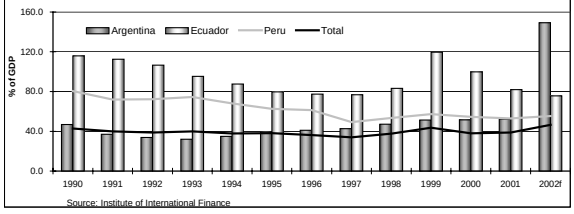
Source: Institute of International Finance

Figure B5
Asian Total External Debt



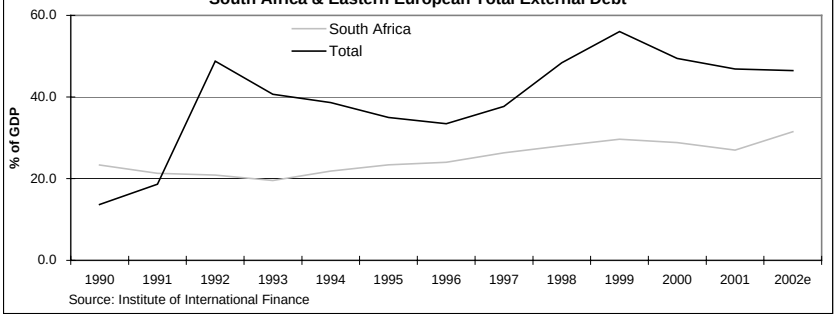
Source: Institute of International Finance

Figure B6
Latin American Total External Debt- Selected Countries



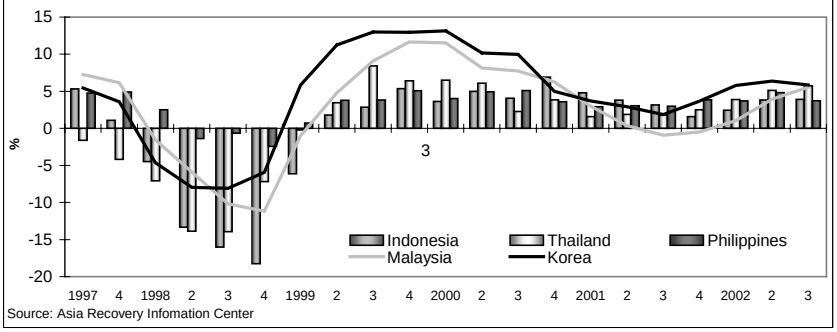
Source: Institute of International Finance

Figure B7
South Africa & Eastern European Total External Debt



Source: Institute of International Finance

Figure B8
Asian Quarterly GDP Growth- Selected Countries



Source: Asia Recovery Infomation Center

Appendix C: Spreads Statistics

Table C1. Statistics First Difference Sovereign Stripped Spreads - Latin America

		Argentina	Brazil	Colombia	Ecuador	Mexico	Peru	Venezuela
Total	Mean	3.8874	1.2785	0.7149	1.0629	0.0832	0.3686	0.4987
Sample	Median	1	0	0	0	0	0	0
	Stand. Dev.	186.0201	35.8940	18.3801	89.8253	15.3458	20.8771	29.5597
	Kurtosis	310.3277	30.3752	9.6205	145.4984	21.6627	10.6963	34.3316
	Skewness	-0.1799	1.9555	0.9531	-7.1753	1.1315	1.0690	2.5436
Sep. 15/97	Mean	0.4968	0.3885	0.6433	0.9236	0.1783	0.1783	0.7197
April 21/98	Median	0	-1	0	-1	-1	-2	-1
	Stand. Dev.	20.7196	26.3725	8.5568	26.4358	15.6264	19.5846	20.8981
	Kurtosis	14.5009	21.7403	16.0614	15.6354	29.3887	19.6810	21.8425
	Skewness	2.0923	3.1903	2.4336	2.1774	3.0713	2.0989	2.0929
April 22/98	Mean	0.8854	2.3185	2.0382	2.5159	1.1847	1.3694	4.4777
Nov 27/98	Median	0	0	0	2	0	-1	2
	Stand. Dev.	38.0723	51.3687	23.5630	66.4811	29.2136	32.2956	64.9856
	Kurtosis	8.5973	6.4586	6.7641	8.0729	5.8010	6.6159	8.7901
	Skewness	0.4332	0.8882	1.6071	0.8170	0.8124	1.0865	1.6959
Nov 30/98	Mean	1.2866	0.1274	0.1975	6.6879	-0.4841	-0.0573	-2.0573
Jul 14/99	Median	2	0	0	3	0	0	-2
	Stand. Dev.	26.6559	42.3336	22.4641	84.2005	18.7673	22.7171	31.4297
	Kurtosis	16.7466	13.9858	3.6042	4.6034	18.6162	4.9211	3.6001
	Skewness	-0.3015	-0.9806	0.1639	0.1347	-0.0167	0.5017	0.3295
July 15/99	Mean	-1.5096	-1.4522	-0.6369	7.5541	-1.1146	-1.0955	-0.4013
Mar 21/00	Median	0	0	0	6	0	-1	0
	Stand. Dev.	13.0023	14.6823	13.4546	136.2083	10.3608	11.2710	16.3601
	Kurtosis	3.5664	0.1778	2.9998	9.5312	2.9423	6.5317	0.5885
	Skewness	0.5028	0.0652	-0.9724	-0.6808	-1.0981	-0.7351	-0.0869
Mar 22/20	Mean	1.7771	1.0191	1.2866	-12.7834	0.6242	1.9299	0.3185
Nov 01/00	Median	2	1	0	0	0	1	1
	Stand. Dev.	14.6294	12.7130	23.0576	172.5957	9.5933	20.4752	13.9817
	Kurtosis	0.5371	0.2981	8.5538	79.3730	1.0202	11.3511	2.6771
	Skewness	-0.0396	-0.0425	-0.1462	-7.8494	-0.2403	1.6609	0.2791
Nov 03/20	Mean	0.9108	0.6433	-1.7707	0.2229	-0.3248	-0.4076	-0.2675
Jun 20/01	Median	-2	-1	-1	2	-1	-1	0
	Stand. Dev.	27.1233	13.9950	14.6847	28.0283	7.7063	21.5867	9.8537
	Kurtosis	8.7101	1.2947	0.5337	3.0748	0.0428	4.3965	0.2959
	Skewness	1.3447	0.3115	-0.0699	0.2496	0.1055	-0.2207	0.0449
Jun 21/01	Mean	19.2803	0.0510	-0.1465	-1.1210	-0.1783	-1.2611	1.9745
Feb 7/02	Median	17	0	-1	-2	0	-1	1
	Stand. Dev.	181.6823	21.3580	13.3545	27.4290	9.3401	12.0587	13.2954
	Kurtosis	12.5546	0.9361	3.3913	1.9008	1.3503	0.8180	1.1690
	Skewness	-0.2353	0.0753	0.6139	0.4488	0.2282	-0.0452	0.1645
Feb 08/02	Mean	7.9720	7.1324	4.1079	4.5029	0.7803	2.2930	-0.7743
Sep 26/02	Median	13	3	2	2	0	1	1
	Stand. Dev.	491.2621	64.5137	21.3373	50.3558	9.7299	19.8301	24.8381
	Kurtosis	50.2497	14.9409	10.5970	4.1181	2.2098	3.2102	12.6960
	Skewness	-0.1061	2.0822	2.3094	0.9687	0.5064	0.7437	-0.1390

Table C2. Statistics First Difference Sovereign Stripped Spreads - Asia

		China	Indonesia	Korea	Malaysia	Philippines	Thailand
Total	Mean	-0.0069	0.1761	-0.0332	0.0311	0.2428	0.0230
Sample	Median	0	0	0	0	0	0
	Stand. Dev.	11.0163	41.7320	44.5517	18.3843	18.0834	16.1563
	Kurtosis	23.8845	102.7441	104.7502	72.3479	18.5055	81.4398
	Skewness	0.4956	5.2322	1.8229	3.4493	0.8360	5.3069
Sep. 15/97	Mean	0.2420	3.1019	0.7834	0.9682	0.6815	1.3121
April 21/98	Median	0	0	-1	0	0	0
	Stand. Dev.	19.3935	41.2550	118.8753	17.2264	16.9634	30.1041
	Kurtosis	13.8419	16.9276	14.4447	15.3499	26.4916	48.4996
	Skewness	-0.0533	2.7068	0.7530	1.7237	2.8488	5.6104
April 22/98	Mean	0.6051	1.4904	-0.4013	2.1656	0.9490	0.5987
Nov 27/98	Median	0	0	0	0	0	0
	Stand. Dev.	12.8046	90.2755	18.5627	41.2514	31.8824	23.3992
	Kurtosis	13.9249	33.9000	13.9299	19.9436	10.0962	10.5753
	Skewness	0.5998	3.9644	-1.6559	2.1657	0.6136	1.9483
Nov 30/98	Mean	-0.5414	-1.6943	-0.0955	-1.9745	-0.2611	-1.0510
Jul 14/99	Median	0	0	-1	0	0	0
	Stand. Dev.	5.6540	29.8431	25.3968	9.9163	14.5568	10.5823
	Kurtosis	17.1297	9.4228	36.1216	5.1411	9.9951	10.1476
	Skewness	0.6901	-0.7282	1.5754	-0.9991	-0.5711	-0.4208
July 15/99	Mean	-0.0701	-0.6624	-0.1783	-0.8726	-0.1975	-0.4586
Mar 21/00	Median	0	0	0	0	0	0
	Stand. Dev.	8.7260	18.9231	9.5625	10.8502	11.5122	10.1226
	Kurtosis	0.1247	4.0013	0.8623	0.5556	9.7934	2.2244
	Skewness	0.0596	-0.4839	0.2066	-0.2716	-1.7145	0.5984
Mar 22/20	Mean	0.2229	1.0828	0.4013	0.3631	2.0764	0.0892
Nov 01/00	Median	0	0	1	0	1	0
	Stand. Dev.	7.5359	32.3491	8.3050	15.3882	18.6975	9.9359
	Kurtosis	0.9898	30.7633	0.9064	26.5632	6.9558	4.6290
	Skewness	0.1201	-0.4781	0.1599	0.6840	1.0940	0.7312
Nov 03/20	Mean	-0.1656	0.7389	-0.4204	0.0064	-0.9745	-0.2102
Jun 20/01	Median	0	0	0	0	-1	0
	Stand. Dev.	9.2139	34.6309	22.3194	9.4777	16.0124	10.4194
	Kurtosis	4.4205	57.2358	54.1023	1.1751	4.2838	6.4494
	Skewness	0.4969	-0.0583	-0.2739	-0.3614	-0.5518	-0.4168
Jun 21/01	Mean	-0.2866	-1.7452	-0.2293	-0.2420	-0.6561	-0.0318
Feb 7/02	Median	0	0	0	0	0	1
	Stand. Dev.	10.4207	18.9915	10.1967	9.6399	14.9622	10.5820
	Kurtosis	24.4864	11.6336	3.8147	10.6846	2.3826	5.0502
	Skewness	3.0401	-1.3580	0.0700	1.8918	0.6073	-0.2259
Feb 08/02	Mean	-0.0612	-0.9033	-0.1251	-0.1652	0.3243	-0.0644
Sep 26/02	Median	0	0	0	0	1	1
	Stand. Dev.	8.7733	16.8297	9.1244	8.6276	12.0575	10.4379
	Kurtosis	0.0314	12.9307	0.2997	0.8135	3.8926	1.1791
	Skewness	0.0866	-1.2763	0.1055	-0.1542	0.7941	0.0567

Table C3. Statistics First Difference Sovereign Stripped Spreads - East Europe

		Bulgaria	Poland	Russia	South Africa	Turkey
Total	Mean	-0.0762	0.1272	0.2187	0.0873	0.4888
Sample	Median	0	0	-1	0	0
	Stand. Dev.	27.7649	13.4097	127.3489	19.8868	19.7588
	Kurtosis	65.3795	167.7010	46.9500	89.8586	31.7067
	Skewness	2.5322	0.2296	0.9490	4.1155	0.7701
Sep. 15/97	Mean	-0.0127	-0.0573	1.0701	0.6115	0.1019
April 21/98	Median	0	0	-1	0	0
	Stand. Dev.	25.7468	28.8411	25.2602	16.9447	17.6708
	Kurtosis	21.0229	62.1718	6.3910	25.5096	26.4998
	Skewness	3.1236	0.1016	1.4002	-0.8162	1.2952
April 22/98	Mean	0.8917	0.3822	22.2420	2.4204	1.4013
Nov 27/98	Median	0	0	4	0	0
	Stand. Dev.	63.7421	16.3631	325.2476	43.9213	35.1672
	Kurtosis	16.3276	6.6422	6.3850	25.1817	20.8355
	Skewness	1.3467	0.5470	0.2632	3.1046	0.2128
Nov 30/98	Mean	1.0892	0.1401	-13.2038	-1.4904	-0.1465
Jul 14/99	Median	-1	0	-8	0	0
	Stand. Dev.	24.1009	8.8828	139.3197	13.0878	11.2847
	Kurtosis	11.0162	1.9588	3.2571	5.4662	4.8385
	Skewness	1.9088	0.1880	0.3481	-1.1859	0.3563
July 15/99	Mean	-1.6051	-0.4586	-6.1338	-1.1592	-0.4968
Mar 21/00	Median	1	0	-2	-1	-1
	Stand. Dev.	12.7379	7.7240	51.2707	10.0144	10.7331
	Kurtosis	2.6313	0.7698	17.6041	21.9491	14.5825
	Skewness	-0.8120	0.3017	-2.4514	-3.1732	2.4296
Mar 22/20	Mean	1.2675	0.2930	0.5605	0.8089	0.7325
Nov 01/00	Median	0	0	0	0	0
	Stand. Dev.	13.7651	7.5049	23.8887	11.3861	8.1117
	Kurtosis	2.4627	1.3634	0.9266	12.2261	4.4599
	Skewness	0.2538	-0.2402	0.2938	1.1530	1.1296
Nov 03/20	Mean	-0.8153	-0.1975	-1.4204	-0.6752	1.7325
Jun 20/01	Median	0	0	-2	0	0
	Stand. Dev.	13.8424	6.2424	16.8272	7.5754	21.8087
	Kurtosis	1.8733	0.8890	0.3806	2.5688	4.6863
	Skewness	0.3930	-0.3112	0.1088	-0.2407	0.7847
Jun 21/01	Mean	-1.0382	0.0764	-1.6879	0.1146	-1.4331
Feb 7/02	Median	-1	0	-1	-1	-1
	Stand. Dev.	16.1725	7.8996	16.4347	9.8332	20.5043
	Kurtosis	6.1822	3.3680	4.3800	4.5602	2.7281
	Skewness	-0.1697	0.0427	0.1792	0.8780	0.8181
Feb 08/02	Mean	-0.3867	0.8389	0.3227	0.0678	2.0190
Sep 26/02	Median	0	2	0	1	1
	Stand. Dev.	9.0535	7.0509	12.8739	19.9795	19.4256
	Kurtosis	3.4571	0.3981	21.8989	59.3164	6.3947
	Skewness	-0.1056	-0.4848	2.7032	-0.6770	1.2287

Table C4. Correlation Matrix First Difference Sovereign Stripped Spreads

	Argentina	Brazil	Colombia	Ecuador	Mexico	Peru	Venezuela	China	Indonesia	Korea	Malaysia	Philippines	Thailand	Bulgaria	Poland	Russia	South Africa	Turkey
Argentina	1																	
Brazil	0.0921	1																
Colombia	0.0358	0.5098	1															
Ecuador	0.0359	0.3021	0.1872	1														
Mexico	0.0951	0.7281	0.5166	0.3235	1													
Peru	0.0159	0.3111	0.2836	0.1418	0.2050	1												
Venezuela	0.0770	0.6018	0.4312	0.2789	0.6809	0.1816	1											
China	0.0193	0.0562	0.1510	0.0107	0.1359	0.0054	0.0729	1										
Indonesia	0.0091	0.0329	0.0408	0.0131	0.0492	0.0470	0.0106	0.0891	1									
Korea	0.0026	0.0028	0.0817	-0.0015	0.0332	0.1285	-0.0423	0.0900	-0.0010	1								
Malaysia	0.0160	0.0472	0.1193	0.0281	0.0738	0.0755	-0.0015	0.1011	0.0506	0.0992	1							
Philippines	0.0569	0.4069	0.3561	0.1777	0.5096	0.1653	0.3983	0.1859	0.0548	0.1260	0.0937	1						
Thailand	0.0238	0.0273	0.1246	0.0420	0.1151	0.0097	0.1321	0.2235	-0.0250	0.0050	0.2620	0.1167	1					
Bulgaria	0.0802	0.5493	0.3590	0.2678	0.6066	0.1253	0.5725	0.0666	0.0034	-0.0999	0.0093	0.4150	-0.0061	1				
Poland	0.0530	0.3450	0.3263	0.1371	0.4830	0.0300	0.3397	0.1628	0.0431	0.1140	0.0712	0.3195	0.1030	0.3317	1			
Russia	0.0407	0.2980	0.2245	0.1781	0.4135	0.1285	0.3274	0.0729	0.0064	-0.0496	0.1622	0.2272	0.0558	0.4782	0.2119	1		
South Africa	0.0189	0.0576	0.1550	0.0330	0.1637	0.2198	0.1275	0.0999	0.0253	0.2793	0.1467	0.1576	0.1174	-0.0275	0.1454	0.0611	1	
Turkey	0.0503	0.3145	0.2218	0.0808	0.3019	0.1244	0.2252	0.1491	0.0353	0.0178	0.1108	0.2491	0.0511	0.2537	0.1932	0.2175	0.1340	1

Appendix D: Stationarity Analysis

A common assumption to start any statistical work is that the data is stationary. However, unless the spreads share the same random walk component, our results do not converge in probability and may give the impression of being chance-related. Therefore, we do cointegration tests to check if the data is stationary. More precisely, a vector time series y_t, is cointegrated if there exists a matrix α with dimensions nxr such that:

$$w_t = \alpha' y_t$$

We use the augmented Dickey-Fuller to test the sovereign spread time series for a level of cointegration 1, I(1), against a level of cointegration 0, I(0). We also use the cointegrating augmented Dickey-Fuller to complete our test for stationarity. We use the former to test pairs of countries, that is, we want to test whether the condition $y_t = \alpha x_t$ can be interpreted as an equilibrium condition between the two series. Since the series do not have zero mean we include a constant term when we run the tests. These results are shown in Tables D1 and D2.

From the results of the augmented Dickey-Fuller we can tell that most series are I(1) and thus, we reject the augmented Dickey-Fuller hypothesis of I(0) for most countries -except for Korea, Philippines and Poland- because the t-statistics are, in absolute terms, less than the critical value of –2.588 at the 90% level. For the results of the cointegrating augmented Dickey-Fuller test we find that most pairs of countries are not cointegrated because the t-statistics do not exceed the 90% critical value of 3.038 in absolute terms. Note, that for the countries that we did not reject the augmented Dickey-Fuller hypothesis of I(0), we find them now to be cointegrated with another pair of series, such as in the case of Korea and Poland. In sum, sovereign spreads for the 18 emerging markets considered here are I(1) and thus, we proceed to use first difference of these spreads in our analysis.

Table D1. Statistics Augmented Dickey-Fuller

	ADF t-statistic					
	1 lag	**2 lags**	**3 lags**	**4 lags**	**5 lags**	**6 lags**
Argentina	-1.475644	-1.15473	-1.031068	-1.110305	-0.985141	-0.856405
Brazil	-0.788073	-0.337123	0.00954	-0.295342	-0.60943	-0.1677
Colombia	-1.144775	-1.2423	-1.230868	-1.419126	-1.590058	-1.535465
Ecuador	-1.850127	-1.746675	-1.737958	-1.759799	-1.809669	-2.040861
Mexico	-2.955591	-2.700332	-2.487163	-2.491607	-2.786599	-2.512161
Peru	-2.839226	-2.656787	-2.559465	-2.550457	-2.867692	-2.689935
Venezuela	-2.856024	-2.816489	-2.708961	-2.590656	-3.121263	-3.09331
China	-2.56406	-2.314346	-2.180826	-2.116457	-2.035937	-2.122014
Indonesia	-2.649326	-2.675409	-2.661734	-2.621293	-2.531782	-2.559905
South Korea	-4.100015	-3.54589	-2.840594	-3.313405	-3.508555	-3.495886
Malaysia	-1.663383	-1.666322	-1.712799	-1.809629	-1.908127	-1.916762
Philippines	-2.755222	-2.750596	-2.669132	-2.747156	-3.080531	-3.03909
Thailand	-1.913955	-1.958785	-1.979974	-1.883131	-1.89082	-1.978317
Bulgaria	-2.503429	-2.662471	-2.573948	-2.880664	-3.1056	-2.824288
Poland	-5.402034	-3.90347	-3.800929	-3.465258	-3.457396	-3.157051
Russia	-1.617098	-1.599557	-1.899755	-1.878835	-1.849482	-1.879924
South Africa	-2.450519	-2.380598	-2.378734	-2.672573	-2.444043	-2.388054
Turkey	-1.728918	-1.878409	-1.998947	-1.939465	-1.903374	-1.703309

The ADF critical values are: 1% Crit Value = -3.458; 5% Crit Value = -2.871; 10% Crit Value = -2.594

Table D2. Augmented Dickey-Fulley Test for Co-integration variables

	Argentina	Brazil	Colombia	Ecuador	Mexico	Peru	Venezuela	China	Indonesia	Korea	Malaysia	Philippines	Thailand	Bulgaria	Poland	Russia	South Africa	Turkey
Argentina		-1.78	-1.04	-0.99	-1.47	-0.93	-0.96	-1.98	-1.61	-2.06	-1.21	-0.98	-1.33	-2.81	-0.87	-1.31	-1.47	-1.33
Brazil	-0.99		-1.09	-0.14	1.17	-1.20	0.66	0.15	0.36	-1.43	0.23	0.93	-0.04	0.07	-1.18	0.41	0.48	-1.09
Colombia	-1.56	-2.35		-1.36	-0.96	-2.29	-1.79	-0.70	-0.37	-1.92	-0.95	-0.90	-1.14	-0.55	-2.10	-0.84	-0.58	-1.83
Ecuador	-2.11	-2.02	-1.75		-2.04	-1.98	-1.87	-1.97	-2.01	-2.26	-2.11	-2.03	-2.14	-1.90	-1.90	-1.94	-2.02	-2.17
Mexico	-2.78	-1.88	-2.13	-2.51		-2.67	-2.09	-4.31 *	-4.04 *	-2.56	-4.62 *	-1.93	-3.48 *	-1.84	-2.22	-3.85 *	-4.92 *	-2.34
Peru	-2.68	-3.09	-3.23	-2.64	-2.79		-3.05	-2.55	-2.19	-2.78	-2.25	-3.09	-2.37	-2.20	-3.69 *	-2.53	-2.34	-3.98 *
Venezuela	-3.12	-2.13	-3.09	-2.97	-2.64	-3.32		-2.42	-3.17	-3.57 *	-3.21	-2.51	-2.80	-2.11	-2.73	-3.44 *	-2.90	-3.28
China	-2.80	-1.88	-1.34	-2.09	-4.08 *	-1.91	-1.59		-4.26 *	-2.33	-3.90 *	-1.82	-3.10	-3.56 *	-1.78	-3.54 *	-4.55 *	-2.01
Indonesia	-2.89	-2.06	-1.56	-2.54	-4.03 *	-2.03	-2.74	-4.49 *		-2.62	-3.97 *	-2.52	-3.08	-3.69 *	-2.48	-4.12 *	-4.25 *	-2.27
Korea	-4.04 *	-4.07 *	-3.77 *	-3.70 *	-3.53 *	-3.59 *	-3.94 *	-3.64 *	-3.58 *		-3.61 *	-3.50 *	-4.16 *	-3.63 *	-3.42 *	-3.51 *	-3.53 *	-3.97 *
Malaysia	-2.06	-1.43	-1.22	-1.97	-4.20 *	-1.21	-2.15	-3.67 *	-3.48 *	-2.05		-1.63	-3.12	-2.77	-2.21	-2.98	-3.87 *	-1.62
Philippines	-3.06	-2.27	-2.36	-3.01	-2.40	-3.24	-2.45	-2.71	-2.91	-3.01	-2.81		-2.81	-2.28	-2.04	-2.82	-2.72	-3.00
Thailand	-2.22	-1.85	-1.59	-2.06	-3.07	-1.54	-1.67	-2.93	-2.60	-2.84	-3.21	-1.75		-2.34	-2.03	-2.41	-2.71	-2.01
Bulgaria	-3.84 *	-2.70	-2.08	-2.74	-2.09	-2.35	-1.85	-3.91 *	-3.92 *	-2.99	-3.54 *	-2.12	-3.03		-1.23	-3.28	-3.50 *	-2.61
Poland	-3.14	-3.67 *	-3.67 *	-3.08	-3.08	-4.22 *	-3.20	-3.04	-3.26	-3.11	-3.60 *	-2.68	-3.35	-2.09		-3.02	-3.34	-3.21
Russia	-2.10	-1.20	-1.01	-1.78	-3.37 *	-1.63	-2.40	-3.31	-3.64 *	-1.88	-2.98	-1.56	-2.29	-2.45	-1.38		-5.48 *	-1.67
South Africa	-2.64	-1.85	-1.56	-2.37	-4.82 *	-1.97	-2.36	-4.67 *	-4.12 *	-2.41	-4.24 *	-2.14	-3.04	-3.20	-2.41	-5.78 *		-2.23
Turkey	-1.91	-2.33	-2.09	-1.89	-1.52	-3.42 *	-2.15	-1.61	-1.43	-2.53	-1.52	-1.90	-1.79	-1.43	-1.86	-1.56	-1.56	

Note: We run the Augmented Dickey-Fuller Co-inegration test to see if the series are co-integrated. We use 6 lags in our test. We present the output for only lag 6,

but all lags produce the same inferences. The columns represent the x variable and the rows represent the y variable.

Critical Values for Augmented DF test for co-integration : 1% Crit Value = -3.88; 5% Crit Value = -3.359; 10% Crit Value = -3.038.

Appendix E: Principal Component Analysis

As Flury (1988) established, the PCA is a statistical method that has three main purposes: 1) transforming a set of correlated variables into a set of uncorrelated variables; 2) looking for linear combination of variables with relatively large or small variability and 3) decreasing the dimensionality of a given data set of correlated variables, while keeping as much of the variables' variability as possible.

This is accomplished by obtaining orthogonal linear combinations of the original variables, the so-called principal components, where the first principal component retains most of the variability existing in the original variables, the second variable retains the second most variability existing in the original variables, and so on.

In algebraic notation, a random vector can represent our data set,

$$X = [X_1\ X_2 \ldots X_N]$$

The variance covariance matrix of X is,

$$\mathrm{Var}(X) = \Sigma \tag{1}$$

The first principal component is a column (N*1) vector that is the linear function of X

$$PC_1 = \beta_1' * X \tag{2}$$

that maximizes,

$$\mathrm{Var}(\beta_1' * X) = \beta_1' * \Sigma * \beta_1 \tag{3}$$

subject to the constraint

$$\beta_1' * \beta_1 = 1 \tag{4}$$

This implies [26]that β_1 is the eigenvector corresponding to the largest eigenvalue of Σ, say λ_1.

To obtain the second principal component,

[26] For a demonstration of this well known result see Jolliffe (2000), Chapter 1 and Flury (1988), Chapter 2.

$$PC_2 = \beta_2' * X \quad (5)$$

It is necessary to follow the same former procedure but add a new constraint,

$$\beta_2' * \beta_1 = 0 \quad (6)$$

that is, PC_1 and PC_2 are uncorrelated. It is clear that β_2 is the eigenvector corresponding to the second largest eigenvalue of Σ, say λ_2. This procedure continues until we obtain the N^{th} principal component. That is,

$$PC_N = \beta_N' * X \quad (7)$$

Now,

$$PC = [PC_1\ PC_2 \dots PC_N]$$

that is, PC is the matrix whose columns are all the 'ordered' principal components. PC_1 is the principal component that corresponds to β_1, which is the eigenvector corresponding to the largest eigenvalues of Σ; PC_2 is the principal component that corresponds to β_2, which is the eigenvector corresponding to the second largest eigenvalues of Σ, and so on until PC_N.

Therefore, by definition,

$$PC = \beta' * X \quad (\text{where } \beta = [\beta_1\ \beta_2 \dots \beta_N])$$

β is the matrix whose columns are the 'ordered' eigenvectors, that is, β_1 is the eigenvector corresponding to the largest eigenvalues of Σ, β_2 is the eigenvector corresponding to the second largest eigenvalues of Σ and so on until β_N.

It is possible to show that[27]

$$Var(PC) = \beta' * \Sigma * \beta = \Lambda \quad (\text{where}, \Lambda = \text{diag}[\lambda_1\ \lambda_2 \dots \lambda_N])$$

Λ is the matrix that has on the diagonal, ordered by size, the eigenvalues corresponding to Σ and all other elements are zeros.

[27] See Flury (1988), Chapter 2 and Appendix.

From an economic point of view, PCA provides three important outputs that are used extensively in this paper,

1) The PC's themselves: they summarize the variability of the 'large' number of variables in a 'small' uncorrelated number of variables.
2) The loadings: they correspond to the correlation between the PC's and the original variables. In mathematical notation,

$$LOADING(i,j) = Correl(PC_i, X_j)$$

3) The percentage of variance explained by i^{th} PC: this is calculated by dividing the eigenvalue associated to the corresponding PC to the total sum of the eigenvalues. For PC_i,

$$\%VAR_i = \frac{\lambda_i}{\sum_{j=1}^{N} \lambda_j}$$

At this point of the analysis is important to point out that the sign attached to each of the loadings is completely arbitrary[28]. This is especially important for cases when these loadings are all negative for the first principal component.

The above analysis is carried out for population principal components. In the case of sample principal components it is possible to use the unbiased sample version of Σ [29]and the results will follow under normal sampling and maximum likelihood estimation[30].

Here it is important to notice that the procedure illustrated by equations (1) to (7) can be performed in the same way with the correlation matrix instead of the covariance matrix. The differences in the principal components obtained by these two methods will be discussed in the following paragraphs.

Consider the following principal components (obtained with the procedure illustrated by equations (1) to (7))

$$PC = \beta^{*'} * X^{*} \qquad \text{(where } X^{*} \text{ is the standardized version of X)} \qquad (8)$$

---

[28] See Jolliffe (2000), Chapter 4. Cifarelli and Paladino (2002) also made this point.
[29] That is,

$$S = \left(1/N-1\right) * \sum_{j=1}^{N} [(X_j - \mu_{X_j}) * (X_j - \mu_{X_j})')]$$

where X_j $(j = 1,2,\ldots N)$ is a column vector of X and μ_{X_j} is the mean of the element of X_j.

[30] See Flury (1988) pages 14-20 and Jolliffe (2000), Chapter 3.

That is, let X^*_j (j =1,2, …N) be a column vector of X^* and x^*_j an element of X^*_j, so each element $x^*_j = (x_j - Mean(X^*_j))/Std(X^*_j)$, where $Std(X^*_j)$ is the standard deviation of the elements of column vector X^*_j.

It is clear (by definition of correlation) that if in equation (3) we replace Σ (covariance matrix) for R (correlation matrix) and follow the procedure illustrated by equations (1) to (7), it is mathematically equivalent. In other words, employing the correlation matrix for obtaining principal components is equivalent to obtaining the principal component from the standardized version of the original variables.

Essentially, using the correlation matrix allows us to calculate principal components that are independent of the unit of measure of the variables. This is the main advantage of using the correlation matrix. Throughout this paper, we will call this method the correlation method as opposed to the covariance method that used the covariance matrix to obtain the components.

Consequently, the biggest pitfall of using the covariance method is that it is very sensitive to the unit of measure of the variables. When there is a large difference in the variance of these variables, the variables with the largest variances tend to dominate the first few principal components.

There are two instances where this problem can occur: (1) when the variables are measured in different units (which is not the case in our paper), and (2) when the variables are measured in the same units, but there is a large difference in the variance of the variables; and this is the case in our paper. Nonetheless, since our variables are all measured in the same unit, it is possible to argue that the choice of standardization can be arbitrary. We initially use both methods for obtaining principal components.[31]

In spite of this arbitrariness we prefer to use the correlation method to obtain our final results. When we used the covariance method in all eight windows we found that there is one series of country spreads that is practically equal to the first component. To understand this, think of a sample of observations where one variable has a huge variance -say, variable 'A'- and the other variables have a tiny variance. In this case the first principal component will be virtually the same as variable 'A'. This example replicates almost perfectly what occurs in each of the eight windows when we use covariance matrix.

[31] See chapter 2 in Jolliffe (2000) for a more extensive discussion about the different advantages and disadvantages of either method.

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