Determinants of Spread and Creditworthiness for Emerging Market Sovereign Debt: A Panel Data Study

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Abstract

This study uses a panel-data framework to identify the determinants of the spread over US Treasuries of emerging market sovereign issues as well as of the creditworthiness of the issuers, where the latter is represented by the Institutional Investor's creditworthiness index. We use a sample of 16 emerging market economies, together with time series data for the period 1998 to 2002 when analysing the spread, and from 1987 to 2001 when analysing the creditworthiness. The results suggest that for both the spread and the creditworthiness, significant explanatory variables include the economic growth rate, the debt-to-GDP ratio, the reserves-to-GDP ratio, and the debt-to-exports ratio. In addition, the spread is also determined by the exports-to-GDP ratio, and the debt service to GDP, while the creditworthiness is influenced by the inflation rate and a default dummy variable.

* The opinions expressed here are those of the authors and not necessarily of the Banco de la República, the Colombian Central Bank, nor of its Board of Directors.

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1 Introduction

Initiated by Mexico's Brady bond issue in 1989, emerging market sovereign issues surged during the 1990s. This has generated an increasing need for both investors and issuers to understand what factors determine bond prices and, therefore, also spreads.

Only few earlier studies have been conducted in the area, and of these only one, which was made by Goldman Sachs,[1] uses a panel data framework similar to the one used in this study. The Goldman Sachs study is, however, based on monthly time-series data, and they use linear interpolation to transform annual and quarterly data into monthly data, which might put the validity of their results into question. Interestingly, Goldman Sachs report that their model significantly outperforms the EMBI Global total-return index.

In addition to a need of a further study in the area, a motivation for the study conducted here, was to verify the results of the Goldman Sachs study. The model developed by Goldman Sachs (the so called GS-ESS) is used by Colombia's Ministry of Finance as an important building block in a model of the country's debt. The results of our study do, indeed, differ significantly from those yielded by the Goldman Sachs study. This suggests that the model used by the Ministry of Finance should be adjusted in accordance with the results presented here.

Our study aims to identify the main economic determinants both of the spread of emerging market sovereign issues and of the creditworthiness of the issuer. The two should be closely connected. The study uses a panel data framework and a sample of 16 emerging market countries. Annual time-series data is used for the period 1998 to 2002 in the case of the spread, and 1987 to 2001 in the case of the creditworthiness. We are, furthermore, using the JP Morgan EMBI Global spread composite for the individual countries as a measure of the sovereign spread, and the Institutional Investor's creditworthiness index to represent the creditworthiness.

[1] Ades, Kaune, Leme, Masih and Tenengauzer (2000).

The results of the study suggest that for both the spread and the creditworthiness, significant explanatory variables include the economic growth rate, the debt-to-GDP ratio, the reserves-to-GDP ratio, and the debt-to-exports ratio. In addition, the spread is also determined by the exports-to-GDP ratio, and the debt service to GDP, while the creditworthiness is influenced by the inflation rate and a default dummy variable.

The remainder of the paper is organised as follows: Chapter 2 discusses the definitions and measurements of the sovereign spread and the creditworthiness used in the study. A relatively thorough survey of earlier studies in the field is also included in this chapter. Chapter 3 continues by discussing the theoretical relationships between the creditworthiness, the sovereign spread and their underlying determinants, and a number of potential such determinants are identified and discussed. The panel-data framework used in the study is introduced in chapter 4, and chapter 5 defines the data set used and presents the estimations and the results of the study. Chapter 6, finally, concludes the paper.

2 Creditworthiness and the Sovereign Spread

With the surge in emerging market sovereign bond issues during the 1990s, sovereign creditworthiness, as well as the spread of emerging market issues over US Treasuries, has received increasing attention from investors, issuers and academics alike. Section 2.1 discusses the measure of the sovereign spread that is used in this study, and in section 2.2 the creditworthiness measure is defined. A relatively thorough survey of previous studies in the area is conducted in section 2.3.

2.1 The Sovereign Spread and the JP Morgan EMBI

The yield spread of a US dollar denominated bond is typically defined as the difference in yield between that bond and a benchmark US Treasury bond of a similar maturity[2] and is normally expressed in basis points.[3] The return on emerging market issues is normally expressed as their spread rather than their absolute yield.[4]

We will throughout this paper use the EMBI[5] Global spread composites, as calculated by JP Morgan, to represent the sovereign spread for the different countries studied. The EMBI Global composites are weighted averages of the spreads of US dollar-denominated individual bonds issued by a particular emerging market country.[6] Some studies have

[2] Normally the latest issued US Treasury of that maturity. It can alternatively be defined as the spread to the US Treasury yield curve at the exact maturity of the emerging market bond.
[3] One basis point is 1/100 of a percent.
[4] The return of high-grade US corporate issues is normally expressed as the spread over US Treasuries, while that of high-yield (speculative grade) corporate issues normally is expressed as the absolute yield. However, Vine (2001) questions whether it is wise to express the return of emerging market sovereign issues as a spread rather than a yield, since these are generally speculative-grade issues, and expressing their return as a spread ties them to the US Treasury yield, with which they have little in common.
[5] Emerging Market Bond Index.
[6] The EMBI Global composite, which was introduced in August 1999, is the most comprehensive emerging markets debt benchmark. It followed the EMBI and EMBI Plus, where the former is a pure Brady bond composite, and the latter includes eurobonds as well. The EMBI Global includes, in addition to Brady bonds and eurobonds, US dollar-denominated traded loans and local market debt instruments issued by sovereign and quasi-sovereign entities. Only issuers from low- and middle-income countries are included in the index, and only issues with a time to maturity of 2.5 years or more and a current face value outstanding of at least USD 500 million. The index is calculated as an average weighted by the current

selected a benchmark bond for each country studied and used its spread; others have looked at the spreads of several individual bonds. Since we are in this study looking at the spread related to the risk of a sovereign issuer rather than the spreads of individual bonds, the EMBI Global suits our purpose better than using individual bonds. The EMBI Global, furthermore, controls for floating coupons, principal collateral, rolling interest guarantees, and other unusual features of the bonds, and it is computed for all the main emerging market sovereign issuers, making comparisons easier.

2.2 Institutional Investor's Creditworthiness Index

Institutional Investor's Creditworthiness Index is a survey-based measure of the perceived creditworthiness of a large number of countries.[7] This index has been computed and published twice a year since 1979 in the March and September issues of the Institutional Investor magazine. The survey represents the responses of between 75 and 100 bankers, that are asked to rate each country on a scale of 0 to 100 with regards to what they perceive as the default risk of the country, where 100 represents no risk of default. Institutional Investor then computes the average of these individual ratings weighted by its perception of each bank's credit analysis sophistication and level of global prominence.

The index is, consequently, a measure of the creditworthiness of the individual countries, and in this sense it measures more or less the same thing as the credit ratings of, for example, Standard and Poor's or Moody's. One could argue, that the credit rating agencies are doing a more thorough analysis of the countries than the bank's credit analysts in general, and that the credit ratings, therefore, should be a better measure. We have in this study, nevertheless, decided to use the Institutional Investor's Creditworthiness Index mainly for two reasons. First, this index can be regarded as a continuous variable while the credit ratings assigned by the rating agencies have the

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market capitalisation of the individual issues. See JP Morgan (1999) for a further discussion on how the index is defined.

[7] See also Erb, Harvey and Viskanta (1996).

characteristics of a discreet variable. Second, the Creditworthiness Index changes over time from year to year, while the ratings can remain constant for long periods of time. The Creditworthiness Index, in this sense, contains more detailed information then the credit ratings, even if its quality might not be as good.

2.3 Review of Earlier Studies

In the 1990's international bond issues from developing countries surged dramatically becoming the fastest growing instruments for financing development, while reducing the dependence on syndicated bank loans.[8] However, emerging markets have been an option of investment for centuries; Taylor (2003) examines the history of investment in Latin America since independence. In his paper, he shows that foreign investment in the region has been highly volatile, presenting symptoms of overborrowing, sudden stops, defaults and crises since the beginning. He concludes that Latin America is still much less globalised today than a hundred years ago in capital markets, which is mainly explained by excessive controls, interventions and distortions. Steward (2001) emphasises that by 1920 Moody's provided credit ratings for 50 sovereign borrowers,[9] while between 1930 and 1970 capital controls, wars and domestic regulations almost blocked international bond investment. Fortunately for some and unfortunately for others, reduction in controls, technological development, the creation of international bonds and appearance of the internet have all contributed to the amazing globalisation of the bond market in the last 15 years.

Despite this explosive growth of emerging market debt in the last decade, there have only been few studies of the determinants of emerging market sovereign spreads. Erb, Harvey and Viskanta (1999) explain this lack of academic work because of the short time series that exist, making it very difficult to produce a good evaluation of the characteristics of the market. It is, thus, no wonder that most studies in the area are cross-country analyses

[8] Min (1998).
[9] See also Eichengreen and Portes (1989) for an analysis of the international bond markets in the 1920s, which was the last time bond markets were a leading vehicle for international lending.

and only very few are dedicated to a specific country. However, there is now over a decade of data collected since the surge of the sovereign bond market in the early 1990's, making it easier to empirically test the investment theories that have emerged in emerging markets in the last decade. Erb, Harvey and Viskanta (2000) emphasise that now is a good time for doing research, because the 1990's probably represented a full cycle of sentiment for emerging market bonds. Indeed, from 1991 to 1997 their average return exceeded that of the S&P 500. However, after 1997 a series of severe crises have hit the markets, and several sovereign issuers have defaulted on their outstanding debt.

The study of international sovereign debt can possibly be divided into two main areas, theoretical analysis and empirical research. On the former category many studies apply game theory analysis and optimisation techniques to try to specify the incentives of countries to issue bonds (borrow) and service their debt, as well as the incentives of the investors (lenders) to provide the capital. Eaton and Gersovitz (1981) emphasise that the analysis of financial transactions is made very complicated by the fact that default and bankruptcy are possible strategies. For them, large scale borrowing by foreign governments in international capital markets generates a need to complement the literature of borrowing in domestic markets. The main features, that the international lending models must account for are, that there are no explicit international mechanisms to impede a government from repudiating its debt, and that borrowers can be assumed to be inherently dishonest. They will, consequently, not pay their obligations if it is not to their benefit. Eaton, Gersovitz and Stiglitz (1986) explain why insolvency is neither a sufficient nor necessary condition for the declaration of default, since the debt of a country is usually less than the value of the assets of the government and the nationals of the country. They conclude, that even if moral hazard and adverse selection in lending can explain some behaviours, what is really important in the analysis is to understand incentives. In their 1981 paper, Eaton and Gersovitz model the benefits from defaulting as a borrowing function of the outstanding debt, and the costs as a function of the growth rate volatility inside the country. Allen (1983) tried to model why in credit markets the borrowers can be rationed in the amount they can borrow. His explanation is that in contrast to other markets, the transfer of the good (capital) and the payment take place at

different moments in time. The borrower may, therefore, not pay if the project in which the borrowed money was invested is unsuccessful or if the borrower simply does not wish to make his payments. His conclusion is that contracts are only enforceable if the current payment of the borrower is less than the value of future access to the capital markets, and this condition only binds with credit rationing.

Two of the early panel studies of questions related to the pricing of developing countries' foreign debt, were conducted by Edwards (1983, 1985). In his 1983 work he tried to establish whether the international financial community (at that time international banks) were taking into account the special characteristics of borrowing developing economies when granting loans. He studied the determinants of the spread between the interest rate charged to a country and the London Interbank Borrowing Rate (LIBOR). He used for his analysis pooled data from the Eurocredit markets on 727 public and publically guaranteed loans granted to 19 developing countries between 1976 and 1980. He used a random effects components estimation and found that the spread was determined by the reserves-to-GNP, debt-to-GDP and debt-service ratios, as well as by the propensity to invest. He concluded that the main determinant in the period was the reserves ratio, suggesting that banks might have overlooked other aspects of emerging economies. In his 1985 paper he suggested that, since the bank loan market was much more developed at the time than the bond market, the two might behave differently. However, he found more or less the same determinants when studying the two markets, thus, invalidating some theories of the inability of yield spreads to charge correctly for the risk involved in lending to emerging markets.

Some examples of recent single-country analysis include Budina and Mantchev (2000) who investigated the determinants of the prices of the Bulgarian Brady bond issues of 1994,[10] using monthly data from July 1994 to July 1998 in a cointegration framework. They concluded that, in the long run, gross foreign reserves and exports had a positive effect on bond prices, and the real exchange rate and Mexico's nominal exchange rate

[10] Note that they study the bond prices rather than the spread.

depreciation had a negative effect.[11] Nogués and Grandes (2001) conducted an investigation into the determinants of the spread of Argentina's floating rate bond (FRB);[12] they used monthly data from January 1994 to December 1998 and an estimation technique developed by Pesaran, Shin and Smith (2001) to control for stationarity and to check for the existence of a long-run structural relationship. They concluded that the Mexican crisis, the debt-service-to-export ratio, the GDP growth rate,[13] the fiscal balance and the 30-year US Treasury yield had significant impact on the spread. Rojas and Jaque (2003) studied the determinants of the Chilean sovereign spread using OLS estimation. They used monthly data from April 1999 to July 2002, and found significant impact on the spread of the debt-to-reserves ratio, exports, economic activity, and US interest rates. However, the validity of their results might be questionable, since they didn't account for the fact that the variables they were using are most likely to be non-stationary, thus invalidating the significance of their estimated coefficients.

Some recent works have used cross sectional analysis to control for contagion effects that country studies neglect and to increment the number of observations. The latter allows them to include many potential determinants that are only published on a yearly basis. With the surge in international sovereign lending, the demand for ratings by international agencies has also increased. If the ratings are assumed to properly measure the credit risk, one could expect the determinants of the ratings to be similar to the determinants of the spreads. Cantor and Packer (1996) investigated the determinants of ratings for a cross section of sovereign bonds. They used a linear transformation on the ratings and found with OLS estimations that the per-capita income, GDP growth rate, inflation rate, external debt, economic development and default history all are significant in explaining the ratings of 49 countries in September 1995. A regression of the spreads of the most liquid Eurodollar bonds of 35 countries and eight economic determinants, showed that while the determinants explained about 86 percent of the spread variation, the credit ratings alone could explained as much as 92 percent, implying that ratings appeared to

[11] The Mexican exchange rate was included to investigate whether Mexico's economic crisis of 1995 had any contagion effects, a hypothesis supported by the results.
[12] One of Argentina's Brady bond issues.
[13] The GDP was transformed from quarterly to monthly data using a cubic Spline function.

provide additional information to that contained in macroeconomic country statistics. Afonso (2002) complemented the previous work by not only using the linear transformation of the ratings but also a logistic transformation. He used information from 81 developed and developing countries in year 2000,[14] and with OLS estimations he concluded that GDP per capita, external debt, economic development, GDP growth rate and inflation rate are relevant in determining a country's credit rating. However, he concluded that using the logistic transformation improves the overall adjustment of the model and consequently the predictive power of the determinants, especially for the countries placed at the top end of the rating scale.

Min (1998) analysed the economic determinants of yield spreads of US dollar denominated, fixed income securities of emerging markets issued between 1991 and 1995. Assuming a risk-neutral lender and an exponential behaviour of the risk premium, he used 19 variables to try to explain the log of the yield spread. He worked with pooled data to estimate a panel consisting of bonds from 11 countries with 19 regressors; he used OLS and White's heteroscedasticity-consistent standard errors and tried several different specifications of the model. Using *statistical support on F-tests* to exclude some of the variables, he concluded from two different specifications of the original model that his estimations are robust. To analyse whether the volatility of bond spreads is affected by macroeconomic factors a correlation matrix was estimated. His results suggested that cross country differences in bonds spreads are determined by the debt-to-GDP, reserves-to-GDP and debt-service-to-exports ratios, as well as by the import-export growth rates, the inflation rate, the net foreign assets, the terms of trade and the real exchange rate. He concluded that developing economies seeking greater access to international bond markets, should aim to improve their macroeconomic fundamentals.

Eichengreen and Mody (1998), analysed data of almost 1,000 developing country bonds issued between 1991 and 1996 while paying special attention to selection bias.[15] They pointed out that since participation in the bond market has risen over time, OLS estimates

[14] Inflation, GDP growth and budget balance were averages of 1998-2000.
[15] Their main objective was to study the launch spreads and pricing of those bonds.

of the relationship between spreads and country characteristics suffer from selection bias, induced by the fact that the determinants of the price of the issues could also determine the decision to enter the market. They found that the launch spreads depend on the issue size, the credit rating of the issuer, and on the debt-to-GDP and the debt-service-to-exports ratios. Their main conclusion is that changes in market sentiment, not obviously related to fundamentals, have moved the market by large amounts over short periods.

Finally, Goldman Sachs (Ades et. al. (2000)) modelled emerging markets sovereign's fair value spreads as a function of economic variables, analysing monthly data from 15 emerging market economies from January 1996 until May 2000 using a panel data technique.[16] The spread was calculated for one selected bond from each country in the sample, with a maturity between 10 and 20 years. The reason for using monthly data is that the model was developed to value emerging market debt, and it needed to be updated on a monthly basis. As a strategic investment tool, the model was reported to outperform the EMBI Global total-return index. They used the pooled mean group (PMG) estimator, developed by Pesaran, Shin and Smith (1999), and this restricts the long-run elasticities to be identical among countries and allows short-run parameters to vary across individual groups. To avoid excess volatilities in their explanatory variables they only used the permanent components of the data, obtained from the Hodrick-Prescott filter, on their fitting stage. The data was pooled for all countries in the sample and the authors found a number of variables to have a significant impact on the sovereign spread, such as the GDP growth rate, total external amortizations as a ratio of foreign reserves, the external-debt-to-GDP ratio, the fiscal balance, the exports-to-GDP ratio, the real exchange rate misalignment, international interest rates, and the default history of the country.

The results of these works are summarised in tables 2.1 for single-country studies and table 2.2 for cross-country studies. Note that a weakness of the single-country studies is that they exclude variables published only with annual frequency, and some of these might be important determinants of the spread. Table 2.3 summarises the results of the

[16] They used linear interpolation to transform annual and quarterly data to monthly data where needed, which from an econometric standpoint is highly questionable.

studies investigating the determinants of credit ratings. In general, most authors have found that macroeconomic indicators are an important part of the explanation behind cross-country differences in the spreads. However, some of the authors have made strong assumptions, and others have used inappropriate estimation techniques, which might have biased their results. It is interesting that, although most of the works have used the same possible explanatory variables, some obtained up to 12 significant determinants and others only three or four. The objective of our paper is to use a classical panel-data estimation technique to consider all the possible explanatory variables and to avoid unnecessary simplifications or assumptions, in establishing which fundamental variables have played a part in determining the spread on emerging market debt in recent years.

Table 2.1. Single-country studies of the sovereign spread

Country, Regression Technique and Data Sample	Significant explanatory variables
Budina and Manchew (2000)	
Bulgaria Cointegration framework Monthly data from Jul 1994 to Jul 1998	Gross foreign reserves (-) Exports (-) REER (+) Mexico's nominal exchange rate (+)
Nogués and Grandes (2001)	
Argentina Estimation technique: Pesaran et. al. (2001) Monthly data from Jan 1994 to Dec 1998	EMBI total-return index Mexico (-) External debt service/Exports (+) GDP growth rate (-) Fiscal balance (-) 30-year US Treasury yield (-)
Rojas and Jaque (2003)	
Chile OLS regression technique Monthly data from Apr 1999 to Jul 2002	Short-term debt/Reserves (+) Total external debt/Reserves (+) Exports (-) Economic activity (-) US Federal Funds rate (+)

Note: Budina and Mantchev (2000) use the bond price rather than the spread as the dependent variable. They concluded that, in the long run, gross foreign reserves and exports had a positive effect on bond prices, and the real exchange rate and Mexico's nominal exchange rate depreciation had a negative effect. We have in this table switched the signs on the explanatory variables, to make them comparable to the other studies. If a variable has a positive impact on the bond price, it has a negative impact on the spread, and vice versa.

Table 2.2. Cross-country studies of the sovereign spread

Regression Technique and Data Sample	Significant explanatory variables
Goldman Sachs (Ades et. al. (2000))	
Panel data technique 15 emerging market sovereign issuers Monthly data from Jan 1996 to May 2000	GDP growth rate (-) Total external amortizations/Reserves (+) Total external debt/GDP (+) Fiscal balance/GDP (-) Exports/GDP (-) REER misalignment (+) LIBOR (+) Default history (+)
Eichengreen and Mody (1998)	
OLS regression on pooled data Issue spread, 998 emerging market bonds Both corporate and sovereign issues Period: 1991-1996	Issue size (-) Private placement (+) Credit worthiness (Institutional Investor) (-) Debt/GDP (+) Debt service/Exports (+)
Min (1998)	
OLS regression on pooled data Dummy variable model Issue spread, 505 emerging market bonds Both corporate and sovereign issues Period: 1991-1995	Private issuer (+) Total external debt/GDP (+) Foreign reserves/GDP (-) Debt service/Exports (+) Growth rate of imports (+) Growth rate of exports (-) Net foreign assets (-) CPI inflation rate (+) Terms-of-trade index (-) Nominal exchange rate adjusted by CPI (+) Maturity (-) Issue size (-)
Edward (1983)	
Panel data technique Random effects components, pooled data Loans granted to 19 developing countries Public and publically guaranteed loans Eurocredit Market 1976-1980	Reserves/GNP (-) Debt/GNP (+) Debt service/Exports (+) Investment/GNP

Table 2.3. Cross-country studies of the determinants of credit ratings

Regression Technique and Data Sample	Significant explanatory variables
Cantor and Packer (1996)	
OLS regression on pooled data 35 developed and developing countries Data as of 29 Sep 1995	GDP per capita (+) GDP growth rate (+) Inflation rate (-) External debt (-) Economic development (+) Default history (-)
Afonso (2002)	
OLS regression on pooled data Linear and logistic transformation of credit ratings 81 developed and developing countries Data as of June 2001	GDP per capita (+) GDP growth rate (+) Inflation rate (-) External debt/Exports (-) Economic development (+) Default history (-)

Note: Both these studies investigate the determinants of the credit ratings. The parameter estimates will, therefore, have the opposite sign of the determinants of the spread. If a variable has a positive impact on the credit rating, it should have a negative impact on the spread and vice versa. Both studies, furthermore, use the credit ratings of Standard & Poor's and Moody's.

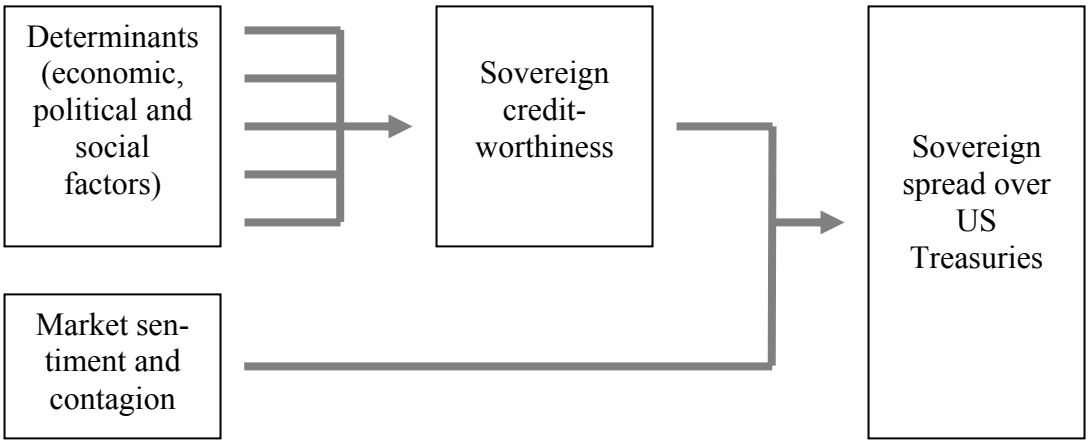
3 Determinants and Theoretical Relationships

The sovereign creditworthiness and the sovereign spread was defined and discussed in the previous chapter. We here continue by analysing the relationship between the two and their underlying determinants. This relationship is examined in section 3.1, while section 3.2 identifies a number of potential economic determinants of the two.

3.1 Relationship between the Creditworthiness and the Spread

Figure 3.1 illustrates a simplified model describing the relationships between the fundamental determinants, the creditworthiness, the market sentiment and the sovereign spread. The creditworthiness of a country should, by definition, reflect the medium to long-term risk that the country will default on its outstanding sovereign debt. This risk depends on a number of economic variables, but also on political and social factors, such as, for example, the stability of the current political system. In this study we will deal only with the economic variables, since political and social factors normally are difficult to quantify.

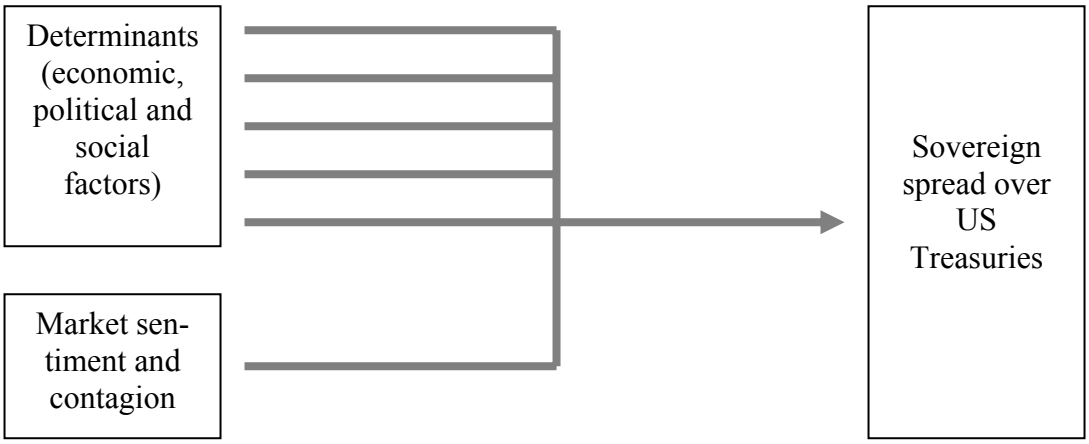
Figure 3.1: Relationships between creditworthiness and spread in a simplified model



The spread between the yield of a particular emerging market sovereign issue and a US Treasury of comparable maturity, relates to the higher yield that investors demand to take on the larger default risk that the emerging market issue carries over the US Treasury. At a certain point in time, two emerging market issues of similar default risk, which implies that the issuers are of similar creditworthiness, should trade at equal spreads over US Treasuries. However, the same issue might trade at different spreads at different points in time, even if the creditworthiness of the issuer remains the same. The spread demanded by investors to take on a certain risk might, consequently, change over time. This is because of changes in what we here refer to as the *market sentiment*, which we define as the compensation demanded by investors on average to take on a unit of risk, and this is directly related to the risk averseness of the investors. Contagion and spill-over also play an important part, in the sense that investors tend to group issuers with similar characteristics together, so that an increase in the spread of one such issuer translates into a spread increase of the others.

If the sovereign creditworthiness in figure 3.1 is omitted, the model simplifies to that illustrated in figure 3.2. The sovereign spread is then directly determined by a number of economic variables together with the market sentiment.

Figure 3.2: Determinants of the spread in a simplified model



3.2 Potential Underlying Determinants

The sovereign creditworthiness, and thereby also the sovereign spread, is determined by a large number of factors. In their statements on rating criteria, the main rating agencies list numerous economic, political and social factors that underlie their sovereign credit ratings.[17] Most of these factors are, however, not quantifiable,[18] and we will, therefore, limit this study to those economic factors that are quantifiable and regularly published, which is in line with most earlier studies.

A number of fundamental economic variables can be envisaged to influence the sovereign creditworthiness and the sovereign spread, and a number of such variables have, indeed, been identified by earlier studies as determinants, as summarised in table 2.1, 2.2 and 2.3 in the previous chapter.[19] Based on these earlier studies as well as on our own intuition, we have identified a number of variables as potential determinants, and we have divided these variables into solvency variables, liquidity variables, variables representing external shocks, and dummy variables.

Solvency Variables

The solvency variables relate to the country's long-term ability to pay its debt. The term *solvency* might be slightly misleading, since insolvency of a sovereign issuer is not a well-defined concept. We have, nevertheless, in line with many other studies decided to use this term, since it is intuitive. Variables belonging to this group include a country's real growth rate, fiscal and current account balances, as well as its stock of external debt.

[17] See Standard & Poor's (2002), Moody's (1991, 1995), and Fitch (2002).
[18] Cantor and Packer (1996), p. 39.
[19] See also Pilbeam (1992), pp. 404ff for a textbook discussion on this subject.

- *Real GDP growth rate:* A high economic growth rate normally generates a stronger fiscal position, and this suggests that the country's debt burden will become easier to service over time.

- *Fiscal balance as a percentage of GDP:* A large fiscal deficit (i.e. a large negative fiscal balance) indicates that the government lacks the ability or the will to increase taxes to cover current expenses including its debt service. A weak fiscal position also implies a higher likelihood that external shocks may generate a default.

- *Current account balance as a percentage of GDP:* A large current account deficit indicates that the economy relies heavily on funds from abroad. Persistent current account deficits generates a growth in foreign indebtedness, which may become unsustainable in the long term.

- *Debt-to-GDP ratio:* The higher the debt burden, the larger the transfer effort the country will need to make over time to service its obligations. A higher debt burden, therefore, corresponds to a higher risk of default. This measure does, however, not say everything about the debt service burden imposed on the country, since this also depends on the maturity structure as well as on the yield of the debt.

- *Debt-to-exports ratio:* Again, the higher the debt burden, the more difficult it will be to service the debt. Exports is, furthermore, a major source of foreign exchange, and countries with large current account receipts are normally less vulnerable to external shocks when it comes to servicing their debt.

Note that to make variables comparables between different countries we normally use the ratio of the variable to the nominal GDP.

Liquidity Variables

The liquidity variables relate to the country's short-term ability to pay its debt. Even if a country has the long-term capability to service its debt, it may lack the necessary funds to service its debt in the short term. The foreign-currency debt has to be serviced out of the international reserves, so the debt service and the international reserves are the two most crucial variables in this category. Exports is another important variable, since exports normally account for a significant part of foreign exchange earnings, and since exports in this sense is a much more stable source of foreign exchange than, for example, foreign

investment flows, which can vary widely from year to year. The debt service is, furthermore, directly dependent on the composition of the debt. A large fraction of short-term debt will increase the current debt service when this debt matures.

We have chosen to include the following liquidity variables in the study:

- *International reserves as a percentage of GDP:* The foreign debt has to be serviced out of the international reserves. For this reason, low reserve levels sharply increase the risk of default.

- *Debt-service-to-GDP ratio:* The debt service is dependent on the level of the debt, but also on its composition and yield. A high debt-service burden indicates that the country might face problems in servicing its obligations. Large amortizations might be difficult to roll over, particularly in times when international risk appetite is low or global liquidity conditions are tight.

- *Debt-service-to-reserves ratio:* Since the foreign debt has to be serviced out of international reserves, the debt-service-to-reserves ratio is a particularly important measure of a country's debt-service capability.

- *Debt-service-to-exports ratio:* As discussed earlier, exports are a major source of foreign exchange, and countries with large exports are normally less vulnerable to external shocks when it comes to servicing their debt.

- *Exports as a percentage of GDP:* Again, large exports normally implies a lower default risk.

- *Short-term-debt-to-reserves ratio:* As discussed earlier, if a country has a large proportion of short-term debt that has to be rolled over, this might generate difficulties, particularly in times of tight global liquidity conditions.

- *Average time to maturity of the debt:* This is another measure of the composition of the debt. A short time to maturity implies a large proportion of short-term debt.

- *Inflation rate:* A high rate of inflation is indicative of structural problems in the government's finances. Many governments have resorted to inflationary finance of the fiscal deficit when they have been unable or unwilling to raise taxes or to cut spendings to bring down the deficit. The rate of inflation can, therefore, be used as a measure of government discipline. Public dissatisfaction with a high inflation rate might, furthermore, generate political instability.

Variables representing external shocks

This group of variables relates to those that capture external shocks to the economy. The important role played by international interest rates in determining international capital flows to emerging markets has been emphasised by a number of studies.[20] We have, in this category, only chosen to include only one variable:

- *3-months US Treasury Bill rate:* The interest rate yielded by 3-month US Treasury Bills is a liquid US dollar interest rate, and we, therefore, regard it as good proxy for global liquidity conditions. Some other studies have used the London Inter-Bank Offering Rate (LIBOR), but these two rates should be closely correlated, so the choice between the two is of less importance.

Dummy Variables

Theoretical models of creditworthiness or spread determination often include regional or country specific dummy variables, which take the value one if a certain condition is fulfilled and zero otherwise. We have in this study included only one specific dummy variable:

- *Default:* This variable takes the value of one for the years that a country is in structural default on its foreign-currency obligations, and zero otherwise. A default should have a large impact on the spread as well as the creditworthiness of a country. Note, however, that this variable does not make sense in the study of the spread conducted in this paper, since none of the countries studied were in structural default during the period studied; it does, nevertheless, make sense when studying creditworthiness.[21]

[20] See, for example, Arora and Cerisola (2001), Barr and Pesaran (1997), Calvo Leiderman and Reinhart (1993), and Dooley, Fernandez-Arias and Kletzer (1996).

[21] The period used for the spread regressions was 1998 to 2002. For the creditworthiness regression, the default dummy made much more sense, since a number of countries were in structural default during the period studied, 1987 to 2001. The variable also turned up as a significant explanatory variable of the creditworthiness.

4 The Econometric Framework

A panel data framework is used for the empirical analysis in this study. Panel data refers to the pooling of observations on a cross-section of an agent (in this case countries), over several time periods. Following the arguments of Baltagi (1995), we decided to use panel data for our spread analysis for several reasons. First, a panel controls for individual heterogeneity: Our estimations assume that countries are heterogeneous, and it is, therefore, optimal to use panel data estimation, which is able to control for state and time invariant variables. Time series and cross-sectional studies run the risk of obtaining biased results and possibly suffer from serious misspecification if not controlling for this country heterogeneity. Second, panel data estimation gives more information, more variability, less collinearity among variables, more degrees of freedom and more efficiency. In general, time-series studies are plagued with collinearity, and this is corrected in a panel because the cross-section dimension adds more information, which results in more reliable parameter estimates. Variation in the spread could, in fact, be decomposed into variation between groups of countries of different characteristics and variation within groups of countries with similar characteristics, even if we have chosen no to do this in this specific study. Third, panel data are better suited to study the dynamics of adjustment. Cross-sectional distributions that look relatively stable usually hide a lot of changes. Panels are necessary for the estimation of inter-temporal relations, since they relate experiences at different points in time. Fourth, panel data identifies effects that are impossible to detect with only cross-section or time-series data. Let us, for example, assume that we find that reserves could explain 50 percent of the variability of the spread. This could be due to a period of crisis around the world, or because investors typically care about reserves in all situations. The two interpretations have different policy implications and only a panel analysis could discriminate between these possible explanations. Fifth, panel data allows for construction and testing of more complicated models and helps alleviate aggregation bias. Panel data analysis, nevertheless, presents a number of problems, the most important being that most panels suffer from a short time-series dimension. An assumption for the asymptotical arguments to hold completely is that the number of individuals would tend to infinity. This

condition is, of course, impossible to comply with and getting more observations in the cross-section of the time-series dimension usually carries a high cost.[22]

Once a model has been specified, the next question is how to make an efficient estimation of the parameters and how to test hypotheses about them. The model we consider is:

$$Y_{it} = B_{1it} + \sum_{k=2}^{K} B_{kit} X_{kit} + e_{it} \qquad (4.1)$$

where, following Judge et. al. (1985), $i = 1, 2, \ldots, N$ refers to the cross-sectional unit, i.e. the different countries, $t = 1, 2, \ldots, T$ refers to a given time period, and $k = 1, 2, \ldots, K$ refers to the different explanatory variables. Consequently, Y_{it} is the value of the dependant variable, which in this study is the spread or creditworthiness of country i at time t, and X_{kit} is the value of the kth non-stochastic determinant for individual i at time t. The stochastic error term e_{it} is assumed to have zero mean, and constant variance. The response coefficients or parameters B_{kit} are unknown and in the most general case they can vary for different individuals and in different time periods. In general, the estimation technique changes according to the restrictions imposed on the parameters. Judge et. al. mentions five different possibilities: i) all coefficients are constant and the disturbance is assumed to capture differences over time and individuals; ii) slope coefficients are constant and the intercept varies over individuals; iii) slope coefficients are constant and the intercept varies over individuals and time; iv) all coefficients vary over individuals; v) all coefficients vary over time and individuals.

As usual, some statistical tests have been developed to suggest the choice of the best assumptions and thereby to use the correct estimation technique. To choose between a constant or variable intercept, while holding the slope coefficients constant, the Breusch-Pagan test is used. Its null hypothesis is that the individual components do not exist and OLS is the best linear unbiased estimator (BLUE). If the null is rejected, the second question is whether the individual effect is assumed to be fixed or random. If the effects

[22] For additional problems and limitations of panel data analysis see Baltagi (1995).

are fixed, the appropriate estimation is the dummy variable model; if the effects are random then it is better to use the error components model. The dummy variable model is calculated with the within estimator, which captures the variation of the variables within each group or individual. The error components model is a weighted sum of the within and the between estimators, where the latter is intended to capture the variation between individuals. The decision between fixed and random effects is done with the Hausman test, where the null hypothesis is that the effects are random. The fixed effects estimation normally requires too many parameters and the loss of degrees of freedom can be avoided if the effects are assumed to be random. Judge et. al. comments that the choice between the fixed and random assumptions depends on whether or not the individual effect from individual i is correlated with the explanatory variables of individual i, for all i. As expected, if the wrong assumption is made, the estimators will be biased and inconsistent, but if the restrictive distributional assumption of the error components model is correct, using this additional information leads to a more efficient estimator. Baltagi (1995) comments that the fixed effects model is an appropriate specification if the model is taking a specific set of individuals, for example emerging markets, and the random effects model is appropriate if the N individuals are chosen randomly from a large population, for example emerging market economies which have complete macroeconomic datasets and which have not defaulted in the years studied.

Having resolved the problem of the intercept, the next question is to determine whether it is possible that different behaviour of the countries will be reflected not only in a different intercept but also in different slope coefficients. In this case, the constant is treated as another explanatory variable, and the response of the dependent variable to an explanatory variable can, therefore, be different for different individuals, while always being constant over time. When the response coefficients are fixed parameters, the correct estimation is the seemingly unrelated regression (SUR). Otherwise it is better to use the Swamy random coefficient model. To choose between the fixed and random assumption, again it is relevant to determine whether the response parameters are correlated to the explanatory variables. If they are not, the Swamy estimates should be more efficient since this model uses additional information. Pudney (1978) provides a

test with the null hypothesis that the variable coefficients and the explanatory variables are uncorrelated.

Finally, Judge et. al. (1985) emphasises that the decision to choose the appropriate model should be a mix of economic intuition and applying the discussed tests on the dataset. Intuition should determine whether it is likely that the slope coefficients could vary over individuals, and whether this variation is likely to depend on the explanatory variables of the individuals. The tests should be used to back up the intuitive conclusions.

Table 4.1 summarises the different estimation possibilities in a panel data framework.

Table 4.1. Possibilities for the estimation in a panel data framework

Is the different behaviour of the agents only reflected in the intercept?

- Yes – Intercept approach
  - i) No individual effects – OLS
  - ii) Fixed effects – Dummy variable model
  - iii) Random effects – Error components model

- No – Slope approach
  - i) Fixed parameters – SUR
  - ii) Random parameters – Swamy random coefficients model

5 Estimation and Results

After laying out the panel data framework used in the study, this chapter continues by presenting the estimations and the results of the analysis. The data set used is defined in section 5.1, and some specific issues related to the panel data framework are discussed in section 5.2. Sections 5.3 and 5.4 presents the estimations and the results of the spread and the creditworthiness analyses respectively. If the model showed by figure 3.1 in chapter 3 is valid, creditworthiness together with market sentiment should, indeed, explain the sovereign spread, and this is analysed in section 5.5. Finally, section 5.6 discusses some of the limitations of the analysis.

5.1 The Data Set

For the empirical analysis we use annual data in a panel data framework. As a measure of the sovereign spread we use the JP Morgan EMBI[23] Global spread composite for the respective countries. As discussed earlier in section 2.1, this has a number of advantages over other spread measures. In particular it controls for floating coupons, principal collateral, rolling interest guarantees, and other unusual features of the bonds, and it is computed in a similar manner for all the main emerging market sovereign issuers, making comparisons easier. The EMBI Global spread composite is available from December 1997 and onwards, and we will, therefore, study the period 1998 to 2002 using annual period-average data.[24] This is computed as the average of the monthly end-period data for the different years.

For the study of the determinants of the creditworthiness, we use the Institutional Investor's creditworthiness index, as discussed in section 2.2. Again we decided to base our studies on the period-average data, since this produced a better fit. We compute the

[23] Emerging Market Bond Index.
[24] We also conducted the regressions using end-period data from 1997 to 2002, but the use of period-average data resulted in a better fit.

period average as the average of the March and September value of the creditworthiness index for the different years.[25] The Institutional Investor's creditworthiness index is available since September 1979. However, since many of the explanatory variables are only available from 1987 and onwards for some of the countries in our sample, we are studying the period from 1987 to 2001 when identifying the determinants of the creditworthiness index.

The explanatory variables studied were discussed in section 3.2. Those are listed again in table 5.1 together with their respective sources and their expected sign in the spread regression.[26]

Table 5.2 lists the set of countries used in the study. We have limited this set to those countries included in the EMBI Global composite for the full time period 1998 to 2002. Argentina and Russia were both excluded from the sample studied, since they were in structural default during the time period analysed, which had a large impact on their spread. This is further discussed in the following sections.

[25] As discussed in section 2.2, the creditworthiness index is published bi-annually in the March and September issues of the Institutional Investor magazine.
[26] Note that the signs of the explanatory variables of the creditworthiness model are the opposite of those of the spread model, since a decrease in creditworthiness translates into an increase in the spread.

Table 5.1. Data and data sources

Data Series (unit of measure)	Source	Expected Sign in Spread Regression
Dependent Variables		
EMBI Global country index	JP Morgan	+
Creditworthiness index	Institutional Investor	–
Explanatory Variables		
Real GDP Growth (%)	Calc: Annual change in Real GDP	–
Fiscal balance/GDP (%)	Calc: Fiscal balance / GDP	–
Current account bal/GDP (%)	Calc: Current account * FX / GDP	–
External debt/GDP (%)	Calc: External debt * FX / GDP	+
External debt/Exports (%)	Calc: External debt / Exports	+
CPI Inflation (%)	Calc: Annual change in CPI	+
Reserves/GDP (%)	Calc: Reserves * FX / GDP	–
Debt service/GDP (%)	Calc: Debt service * FX / GDP	+
Debt service/Reserves (%)	Calc: Debt service / Reserves	+
Debt service/Exports (%)	Calc: Debt service / Exports	+
Exports/GDP (%)	Calc: Exports * FX / GDP	–
Short-term debt/Reserves (%)	Calc: Short-term debt / Reserves	+
Maturity of external debt (yrs)	EIU	–
3-month US T-bill rate (%)	IFS	+
Default (dummy)	Standard & Poor's	+
Variables Used to Calculate Explanatory Variables		
Real GDP (index)	IFS and National sources	
GDP (nominal) (nat. currency)	IFS and National sources	
FX (exchange rate)	IFS	
Fiscal balance (nat. currency)	IFS and National sources	
Current account (USD)	IFS	
External debt (USD)	EIU	
Short-term debt (USD)	EIU	
Debt service paid (USD)	EIU	
CPI (consumer price index)	IFS	
Reserves (USD)	IFS	
Exports (USD)	IFS	

Note: IFS refers to *International Financial Statistics* from the International Monetary Fund. EIU refers to the Economist Intelligence Unit.

Table 5.2. Countries included in the study

Country	Included in spread regression	Included in creditworthiness regression
Argentina		
Brazil	●	●
Bulgaria	●	
China	●	●
Colombia	●	●
Croatia	●	
Indonesia		●
Malaysia	●	●
México	●	●
Morocco	●	●
Peru	●	●
Philippines	●	●
Poland	●	●
Russia		
South Africa	●	●
South Korea	●	●
Thailand	●	●
Turkey	●	●
Venezuela	●	●

Note: Argentina and Russia were excluded from the regressions since they both defaulted during the period studied and this had a tremendous impact on the spread of their bonds (this is further discussed in the following sections). Indonesia is not included in the EMBI Global composite and was, therefore excluded from the spread regressions. Data for Bulgaria and Croatia is not readily available for the period 1987 to 2001 used in the creditworthiness regressions. We chose to use a balanced panel and exclude those two countries, rather than using an unbalanced panel and including them.

5.2 The Panel-Data Framework

As discussed in chapter 4, we are using a panel data framework for the empirical analysis. When using such a framework, we first need to decide whether the response coefficients are likely to vary over the different countries studied. If the response coefficients can be assumed to be fixed, we should use the intercept approach. If not, the Swamy approach should be used, as discussed in previous chapter. One important factor to be considered is that neither the spread nor the credit worthiness index is a decision of the individual country. They are imperfect measures of the risks involved in lending to a country and are assigned by the market participants in the case of the spread and more specifically by banks for Institutional Investor's creditworthiness index. When a country intends to borrow money in international markets, investors make evaluations of the fundamentals of the country and they decide how much to charge, banks decide the credit worthiness of the country and rating agencies decide what rating to assign to the country. Even though a specific spread, credit worthiness and rating are assigned to the debt of each individual country, we will assume that the weight of each fundamental should be roughly the same in all countries. That is, if a country defaulted 5 years ago, its debt is charged let us say 100 basis points as a risk premium independently if the defaulting country was Russia, Argentina or Ecuador. The same should hold for the total-debt, debt-service and reserves ratios. Otherwise, investors would have a specific model for pricing the risk of each country, to be able to decide what is the exact risk premium that they should charge to let us say Colombia, when, for example, the debt-to-GDP ratio increases by one percent. Our intuition, consequently, leads us to assume that investors apply the same risk model for all emerging markets, and that they charge approximately the same risk premium to all countries with similar characteristics, when the fundamentals change. However, investors have what JP Morgan calls a *bottom rock spread*, which is a minimum spread that a country's debt should pay in order to cover the investor for the risk of holding such debt. Following this argument, each country will have a structural minimum spread, dependant on its institutions, political regime, economic development, history and social stability. The sovereign spread of a country would not fall below this minimum spread

even if the fundamentals are at their best conceivable level, unless dramatic changes occur in the country, such as, for example, an end to a civil war, democratisation, a fall in corruption, or acceptance to NAFTA or to the European Union. Our intuition, therefore, suggests that, for the empirical analysis of the determinants of the spread and the credit worthiness index, it is best to follow the intercept approach.

We also need to decide whether to use a fixed or random effects model for our estimation, as discussed in the previous chapter. This relates to the question whether, if holding the slopes constant, the intercept should be assumed to be fixed or whether it should be allowed to vary over the different countries. This can be decided using the Breusch-Pagan test and the Hausman test. If the null hypothesis of the Breusch-Pagan test of no specific country effects is rejected, then we proceeded with the Hausman test. If its null hypothesis of random effects is rejected, we decide to use the fixed effects dummy variable model for the estimations.

In the analyses, we used the same variables as candidates to be determinants of both the spread and the creditworthiness index. As discussed in the previous section, we used 15 possible determinants including solvency variables, liquidity variables, indicators of exposure to external shocks and a dummy variable that indicated if a country had defaulted on its debt in the past. An important decision is what variables to include in the individual regressions. Earlier studies are here of little help, since there is no consensus in what determinants to include. As noted before, while some works have concluded that only three or four variables are crucial, others suggest that up to 12 different variables are valid determinants of the risk of a country. Since there is no clear underlying economic model, we decided to implement the empirical approach suggested by Sala-i-Martin's (1997) seminal paper on growth economics and the four million regressions. In his paper the author discusses the problem of identifying relevant determinants when using empirical analysis. His arguments are directly applicable to our study: i) Many studies have tried to identify the *true* model, but since no one knows for sure the *true* regression, each paper typically reports a sample of regressions ran by the researcher with different conclusions; ii) Since most economic theories are not explicit enough, we do not know

exactly how many and which variables to include in the regression; iii) Typically, when one includes variables x_1, x_2 and x_3, the regression is valid, but when variable x_3 is changed for x_4, then the whole regression is ruined; iv) A good theorist could make almost any variable affect the model; v) If there are lots of imperfect measures, no one really knows how to measure what the theory tries to say, and how to choose among the different measures.

Following Sala-i-Martin (1997), we started from a model including a small set of variables, which we had identified as most likely to be determinants of the spread. These were variables which had been found significant by a majority of earlier studies. The basic idea in our paper was to start with a regression than included a liquidity variable, a solvency variable, an indicator of vulnerability to external shocks and the default dummy. We then continued by loosely choosing and trying various additional variables. Those variables that were not significant were excluded from the model and were replaced initially by a variable from the same group. The same procedure was repeated until a robust set of variables had been found. We, finally, tried including additional variables to this preferred set of variables, and after trying to include each of rest of the 15 possible determinants, we concluded whether the set of variables was robust to the inclusion of additional determinants.[27]

This is a systematic and sometimes repetitive procedure, but in the end we wanted avoid a traditional problem in growth economics, where some very interesting results are published, just to be invalidated by a follow-up study a few months later. We have, therefore, invested significant time and effort to assure ourselves that the estimations are made rigorously, following textbook econometrics, as well as investigating whether any chosen set of determinants is robust to the inclusion of any other potential determinant. The only problem is that nothing guarantees that the model is unique, and it is, therefore, possible to arrive at a number of possible combinations of variables that are robust to the inclusion of others.

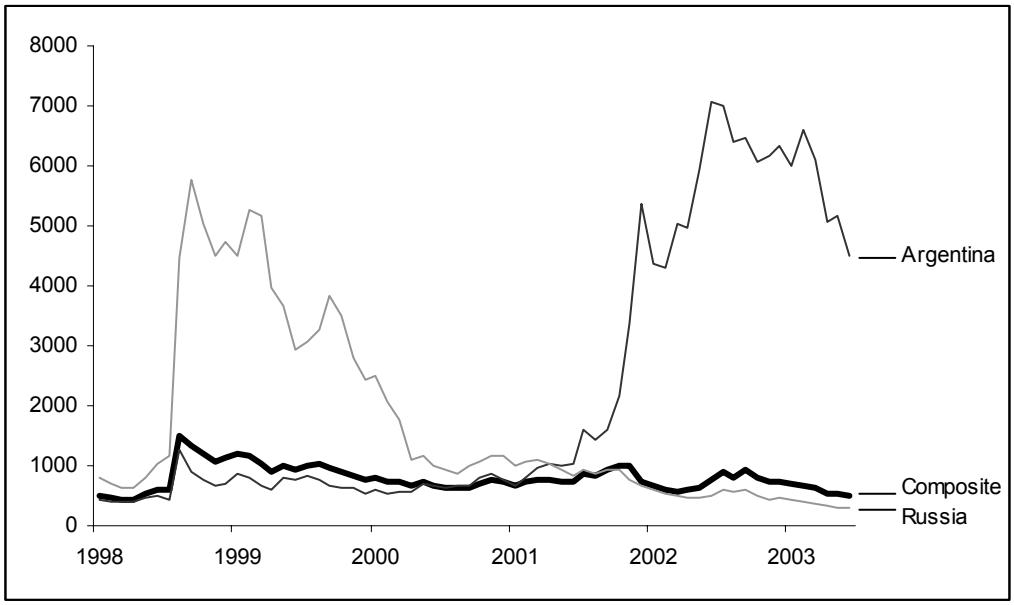
[27] Trying all possible combinations of variables is a practical impossibility, since it would require some 15! = 1,307,674,368,000 regressions.

5.3 Determinants of the Sovereign Spread

For the spread equation, we arrived at two possible models. A complication for these estimations is that we had to choose between using period-average or end-of-period data for the variables. Since we were using yearly data, this could have a significant impact on the results. This choice is not that straight forward. Theory does not suggest the choice of one over the other, and when using panel data estimation techniques, three different R^2 are reported with the regressions. None of these is, however, really informative of the goodness of fit of the model, and in some situations they can even be negative. We, therefore, decided to try in-sample tests and observe the behaviour of the root of the mean square errors (RMSE). The average RMSE of the two models was 507 basis points when using end-of-period data, and 310 basis points when using period-average data. We, thus, decided that using period-average data was the preferred choice. This might also makes sense since period-average data better reflects all that happened throughout the year.

During the period studied, two of the countries in our sample defaulted on their sovereign debt, Russia in 1998, and Argentina in 2001. Figure 5.1 graphs the sovereign spread of these countries against the EMBI Global spread composite for all emerging markets. It is obvious that the spread of these countries were very far above emerging markets in general, which suggests that they should be left out of the sample of countries studied, since they are clear outliers. We also used the RMSE criterion to observe what happened to the estimations when those possible outliers were excluded from the sample. Without the outliers, the average RMSE of the two models was 100 basis points, a much better result than the 310 basis points obtained when including these two countries. We, therefore, decided to exclude Argentina and Russia from the sample.

Figure 5.1. The EMBI Global spread composite versus Russia and Argentina (basis points)



Source: JP Morgan

The two final models resulting from the estimations are reported in table 5.3 and table 5.4. It is obvious that all the parameter estimates are significant at the 5 percent level apart from the debt-to-export ratio in the second model, which is only significant at the 10 percent level. The parameter estimates are, furthermore, all of the expected sign.

Table 5.3a. Spread model I: Random-effects GLS regression

Model	Coefficient	Standard error	z	P > z
Growth	-8.966954	3.781877	-2.37	0.018
Debt/GDP	7.018256	1.81279	3.87	0.000
Exports/GDP	-4.687826	1.839572	-2.55	0.011
Constant	368.2604	109.2957	3.37	0.001

R^2 Within:	0.3062	No of obs:	80
Between:	0.3517	No of groups:	16
Overall:	0.3433	No of periods:	5
		Wald test:	$\chi^2(4) = 35.14$
Corr(u_i, X_{ki}) = 0 for all k (assumed)			Prob > χ^2 = 0.000

Table 5.3b. Spread model I: Breusch-Pagan test for random effects

Variable	Var	SD = sqrt(Var)
EMBI	76606.38	276.78
e	11952.86	109.33
u	35314.35	187.92
H0: Var(u) = 0	$\chi^2(1) = 75.21$	Prob > χ^2 = 0.000

Table 5.3c. Spread model I: Hausman specification test

Model	Fixed effects	Random effects	Difference
Growth	-7.443831	-8.966954	1.523123
Debt/GDP	8.259857	7.018256	1.241601
Exports/GDP	0.011662	-4.687826	4.699488
H0: Difference in coefficients not systematic		$\chi^2(4) = 3.02$	Prob > χ^2 = 0.388

Table 5.4a. Spread model II: Random-effects GLS regression

Model	Coefficient	Standard error	z	P > z
Growth	-11.57583	3.705288	-3.12	0.002
Debt/Exports	72.79330	40.20080	1.81	0.070
Debt service/GDP	16.94199	8.242255	2.06	0.040
Reserves/GDP	-10.51213	4.028258	-2.61	0.009
Costant	453.5380	120.2050	3.77	0.000

R^2 Within:	0.2471	No of obs:	80
Between:	0.5696	No of groups:	16
Overall:	0.5053	No of periods:	5
		Wald test:	$\chi^2(4) = 36.12$
Corr(u_i, X_{ki}) = 0 for all k (assumed)			Prob > χ^2 = 0.000

Table 5.4b. Spread model II: Breusch-Pagan test for random effects

Variable	Var	SD = sqrt(Var)
EMBI	76606.38	276.7786
e	13344.41	115.5180
u	30228.63	173.8338

H0: Var(u) = 0	$\chi^2(1) = 59.47$	Prob > χ^2 = 0.000

Table 5.4c. Spread model II: Hausman specification test

Model	Fixed effects	Random effects	Difference
Growth	-11.83884	-11.57583	-0.26301
Debt/Exports	-1.350828	72.79330	-74.14413
Debt service/GDP	16.04389	16.94199	-0.89810
Reserves/GDP	-11.06733	-10.51213	-0.55520

H0: Difference in coefficients not systematic	$\chi^2(4) = 4.78$	Prob > χ^2 = 0.311

5.4 Determinants of the Creditworthiness

The same procedure was repeated for the estimation of the creditworthiness index, bearing in mind that even though the same determinants are included, their expected signs are the opposite of the ones in the spread regression. This is because, as explained earlier, the creditworthiness index is a measure of the probability of default of a country, which is assigned a grade between zero and a hundred, where a 100 implies zero probability of default. An increase in the creditworthiness, consequently, translates into a decrease in the spread.

Another special feature of the creditworthiness index is that it is a score between zero and a hundred, which violates one of the fundamental assumptions of the panel data estimation framework that the dependent variable has to be continuous and open ended. Even though the creditworthiness index can be regarded as a continuous series, it is limited to the closed range of [0,100]. To overcome this inconvenience, we used the logistic transformation

$$f(x) = \ln\left(\frac{x}{1-x}\right) \tag{5.1}$$

to transform the scores from the closed range, into a continuous number in the range of $[-\infty, \infty]$. This will transform the creditworthiness index (*CWI*) according to

$$LCWI = \ln\left(\frac{CWI}{1-CWI}\right) \tag{5.2}$$

where *LCWI* is the logistically transformed creditworthiness index. This function is useful since it does not alter the underlying relationship between the index and its determinants, which holds because the transformation is continuous and strictly increasing, which can be shown by taking the first derivative of equation (5.1),

$$f'(x) = \frac{1}{x - x^2} > 0 \qquad \text{for} \qquad 0 < x < 1 \tag{5.3}$$

The regressions resulted into two different models and the results are presented in table 5.5 and table 5.6.

The coefficients from the regression do, however, not have a direct interpretation, since the transformation is not linear. We, therefore, used a sensitivity analysis, to try to interpret the possible changes that are predicted by the model to a one-time shock in each of the explanatory variables. As is common, the shocks were calculated to be plus one or minus one standard deviation in each of the variables, with the exception of the default variable.[28] Table 5.7 presents the results of the sensitivity analysis for the first model of the creditworthiness. This model includes the four explanatory variables, growth, debt to GDP, reserves to GDP and default, as shown by table 5.5a. Column *X* indicates the average values of these variables for the time period studied. The average GDP growth was, for example, 4.04 percent during the period. Column σ shows the standard deviation of the variables in the sample.

[28] This is a discreet dummy variable, and can, consequently, not have a one-standard-deviation shock.

Table 5.5a. Creditworthiness model I: Random-effects GLS regression

Model	Coefficient	Standard error	z	P > z
Growth	0.009033	0.004639	1.95	0.052
Debt/GDP	-0.007000	0.001666	-4.20	0.000
Reserves/GDP	0.015095	0.003824	4.17	0.000
Default	-0.523790	0.063542	-8.24	0.000
Costant	-0.080388	0.098658	-0.81	0.415

R^2 Within:	0.5042	No of obs:	225
Between:	0.8053	No of groups:	15
Overall:	0.6224	No of periods:	15
		Wald test:	$\chi^2(4) = 239.46$
Corr(u_i, X_{ki}) = 0 for all k (assumed)			Prob > χ^2 = 0.000

Table 5.5b. Creditworthiness model I: Breusch-Pagan test for random effects

Variable	Var	SD = sqrt(Var)
LCWI	0.3892075	0.6238650
e	0.0670159	0.2588742
u	0.0385445	0.1963275

H0: Var(u) = 0	$\chi^2(1) = 261.33$	Prob > χ^2 = 0.000

Table 5.5c. Creditworthiness model I: Hausman specification test

Model	Fixed effects	Random effects	Difference
Growth	0.006023	0.009033	-0.003010
Debt/GDP	-0.006749	-0.007000	0.000252
Reserves/GDP	0.013329	0.015946	-0.002617
Default	-0.496705	-0.523790	0.027086

H0: Difference in coefficients not systematic	$\chi^2(4) = 11.49$	Prob > χ^2 = 0.216

Table 5.6a. Creditworthiness model II: Random-effects GLS regression

Model	Coefficient	Standard error	z	P > z
Growth	0.010888	0.004111	2.65	0.008
Debt/Exports	-0.248450	0.033114	-7.50	0.000
Inflation	-0.000098	0.000032	-3.05	0.002
Default	-0.445703	0.061389	-7.26	0.000
Costant	0.244865	0.077424	3.16	0.002

R^2 Within:	0.5272	No of obs:	225
Between:	0.8045	No of groups:	15
Overall:	0.7057	No of periods:	15
		Wald test:	$\chi^2(4) = 314.55$
Corr(u_i, X_{ki}) = 0 for all k (assumed)			Prob > χ^2 = 0.000

Table 5.6b. Creditworthiness model II: Breusch-Pagan test for random effects

Variable	Var	SD = sqrt(Var)
LCWI	0.3892075	0.6238650
E	0.0637476	0.2524828
u	0.0227084	0.1506931

H0: Var(u) = 0	$\chi^2(1) = 208.83$	Prob > χ^2 = 0.000

Table 5.6c. Creditworthiness model II: Hausman specification test

Model	Fixed effects	Random effects	Difference
Growth	0.008136	0.010888	-0.002753
Debt/Exports	-0.206000	-0.248450	0.042450
Inflation	-0.000103	-0.000978	0.000875
Default	-0.453557	-0.445703	-0.007854

H0: Difference in coefficients not systematic	$\chi^2(4) = 2.63$	Prob > χ^2 = 0.621

Table 5.7. Sensitivity analysis for creditworthiness model I

Variable	X	σ	$X_1 + \sigma$	$X_1 - \sigma$	$X_2 + \sigma$	$X_2 - \sigma$	$X_3 + \sigma$	$X_3 - \sigma$	$X + \sigma$	$X - \sigma$
Growth	4.04	4.87	**8.91**	**-0.83**	4.04	4.04	4.04	4.04	**8.91**	**-0.83**
Debt/GDP	45.78	22.02	45.78	45.78	**67.80**	**23.76**	45.78	45.78	**67.80**	**23.76**
Res/GDP	10.83	7.83	10.83	10.83	10.83	10.83	**18.66**	**3.00**	**18.66**	**3.00**
Default	0.22	0.41	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
LCWI	-0.31		**-0.26**	**-0.35**	**-0.46**	**-0.15**	**-0.18**	**-0.43**	**-0.29**	**-0.32**
- linearised	42.41		**43.49**	**41.34**	**38.70**	**46.22**	**45.49**	**39.40**	**42.77**	**42.06**
- difference			1.08	-1.07	-3.71	3.80	3.07	-3.02	0.36	-0.36

Note: Res/GDP is the reserves-to-GDP ratio. Bold figures indicate a change.

If the explanatory variables for a country took the value of their period averages, the model would predict a logistically transformed credit worthiness index (*LCWI*) of -0.31. Using the inverse logistic transformation,

$$CWI = \frac{100e^{LCWI}}{1+e^{LCWI}} \tag{5.4}$$

this translates into a credit worthiness index (*CWI*) of 42.41.[29] The idea is then to make a one-standard-deviation change in each of the determinants *ceteris paribus,* to establish the impact of such a change. We are, consequently, trying to establish the sensitivity of the model to a one-standard-deviation shock (positive or negative) in one of its determinants. In Table 5.7, X_1 is growth, X_2 is the debt-to-GDP ratio, X_3 is the reserves-to-GDP ratio, and X_4 is the dummy variable of the existence of default in the past. Bold figures indicate the variables that were shocked, and the column $X_1 + \sigma$, therefore, indicates a model with a GDP-growth rate of 8.91 percent, which is one standard deviation higher than the average. The model yields a LCWI of –0.26, which corresponds to a CWI of 43.49. The last row of the column indicates a difference in the CWI of 1.08 due to the increase in the growth variable. This implies, that if a country grew by 8.91 percent instead of 4.04 percent, then the country's creditworthiness index

[29] This is, of course, the average creditworthiness index of the countries in the sample.

would increase by 1.08. This value can be regarded as an approximation of the parameter estimate received in a linear regression.[30]

Table 5.8 presents the results of the sensitivity analysis for the second model of the creditworthiness. This model includes the four explanatory variables, GDP growth, debt to exports, inflation and default, as shown by table 5.5a.

Table 5.8. Sensitivity analysis for creditworthiness model II

Variable	X	σ	$X_1 + \sigma$	$X_1 - \sigma$	$X_2 + \sigma$	$X_2 - \sigma$	$X_3 + \sigma$	$X_3 - \sigma$	$X + \sigma$	$X - \sigma$
Growth	4.04	4.87	**8.91**	**-0.83**	4.04	4.04	4.04	4.04	**8.91**	**-0.83**
Debt/Exp	1.95	1.16	1.95	1.95	**3.12**	**0.79**	1.95	1.95	**3.12**	**0.79**
Inflation	122.2	618.4	122.2	122.2	122.2	122.2	**740.6**	**-496.2**	**740.6**	**-496.2**
Default	0.22	0.41	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
LCWI	-0.31		**-0.25**	**-0.36**	**-0.59**	**-0.02**	**-0.37**	**-0.25**	**-0.60**	**-0.01**
- linearised	42.41		**43.71**	**41.12**	**35.57**	**49.57**	**40.94**	**43.90**	**35.39**	**49.75**
- difference			1.30	-1.29	-6.85	7.15	-1.47	1.48	-7.02	7.34

Note: Debt/Exp is the external-debt-to-exports ratio. Bold figures indicate a change.

5.5 Creditworthiness and the Sovereign Spread

Throughout the paper, we have suggested that the creditworthiness index and the spread should measure approximately the same thing; that is the risk that a country will default in a given time period. In this section we try to model more specifically the relationship between these two variables for a given country.

[30] As expected, the effect of a positive and a negative shock are not equal since the transformation is not linear. However, in most cases the effects are very similar and they only differ in the decimals. Anyway it can be said from the estimations, that the positive effects are bigger than the negative, that is it is easier to improve the score than to worsen it.

Table 5.9. Spread-creditworthiness model: Cross-sectional time-series FGLS regression

Model	Coefficient	Standard error	*z*	P > *z*
CWI	-20.46459	1.878412	-10.89	0.000
EMBIG world	0.4631185	0.066058	7.01	0.000
Costant	1065.854	109.6481	9.72	0.000

Coefficients:	Generalised least squares	No of obs:	128
Panels:	Homoskedastic	No of groups:	16
Correlation:	No autocorrelation	No of periods:	8
Est covariances:	1		
Est coefficients:	3		
		Wald test:	$\chi^2(2) = 186.96$
Log likelihood:	-701.8265		Prob > χ^2 = 0.000

Note: The model uses the individual country spreads as the dependent variable and the creditworthiness index together with the EMBI global composite as explanatory variables. The model, furthermore, uses semi-annual data for four years.

Table 5.9 presents a panel-data regression that uses as the dependant variable the individual country spreads for the 16 countries in our data sample,[31] using end-of-period semi-annual data from 1997 to 2001.[32] The estimation of the panel is done with feasible generalized least squares (FGLS), since the individual country effects make no sense in this setting. In the previous models, we used country characteristics and allowed for specific effects to account for the fact that countries have different structural creditworthiness and conditions, or *bottom rock spreads*. In this case we are already including the creditworthiness of the country as an explanatory variable, so the assumption of no individual effects is made. The other explanatory variable is the EMBI Global emerging markets composite, to try to establish the effects of the global conditions on the individual spreads of the countries. The model used here is,

[31] The country set used was defined in table 5.2. As before, we exclude Argentina and Russia, since these were in structural default during parts of the period studied, and their bonds, therefore, traded at excessive spreads.

[32] As discussed earlier, the creditworthiness index is a survey-based index published by the Institutional Investor magazine in March and September each year. We, therefore, used the individual country spreads and the global emerging market composite measure for end-March and end-September for the study.

consequently, that illustrated by figure 3.1 in chapter 3, where the EMBI Global emerging market spread composite is used to represent *market sentiment and contagion*.

The results are conclusive; both explanatory variables have the correct signs and are highly significant. Ignoring the problem of the closed range of the creditworthiness index, which was discussed in section 5.4, we can say that in the period that is being studied, a one point increase in a country's creditworthiness index was reflected, on average, in a reduction of 20 basis points in the country's spread. On the other hand, an increase of 100 basis points in the global composite was reflected on average in an increase of 46 basis points in an individual country's spread.

The literature has long ago discovered this relation; considerable effort has been dedicated to investigate the importance of contagion and spill-over in the markets. In this case, the countries included in the sample show on average that they are very sensitive to the global conditions. This could in part be explained by the fact that investors typically have limited information about emerging markets and they tend to generalise their analysis of some of the countries to all of them. A second explanation that could help us to analyse this result is what the literature refers to as *extreme correlations*. The idea is that in time of crises, the correlations between markets tend to increase. During the period studied, both Russia and Argentina defaulted. Even if this was the reason for excluding them from the sample, investors' worries could have spilled over to the rest of the emerging markets, thus increasing correlations. With this in mind, it is possible to say that a country not only depends on its fundamentals but also on all countries of the emerging market world, a relation that has been increasing in the last two decades with the development of emerging markets and the process of deregulation and opening of economies around the world. In the extreme, we could say that if the creditworthiness of a country remained constant over time, the EMBI Global emerging market composite would be not only a measure of the market sentiment, but also a perfect determinant of the spread.

5.6 Limitations of the Analysis

There are a number of issues relating to panel data analysis that have been outlined in the literature and analysed in other works, and these problems could, indeed, have biased our estimations.

One such issue is that the EMBI Global is a financial time series, and, therefore, it behaves differently from most other types of economic series. In the past years considerable research has been done to try to design financial econometric estimation techniques that take into account the special features of financial series. The panel data framework used in this paper was, on the other hand, developed for macro-econometric analysis, and does not deal with the special financial features, which is a weakness. Among others, Erb, Harvey and Viskanta (1999) comment that, in general, research into the distributional characteristics of emerging market equities has shown significant deviations from normality, and they tend to exhibit skewness and excess kurtosis. They, furthermore, show that from January 1994 to May 1997, the EMBI total-return index had a skewness of -0.7, and the EMBI+ a skewness of -0.06, which is consistent with the high expected returns of investments into emerging market bonds. This implies two different problems for our estimations: On one hand, to take negative skewness investors demand a higher expected return, and on the other, the non-normality implies that the statistical significance of the coefficients, based on *t*-tests may not be relevant since the distributional assumptions of the tests are violated. For our estimation we tested the normality of the EMBI Global spread index from December 1997 to March 2003 with a Jarque-Bera test, and as expected the null hypothesis of normality of the series, was rejected with a P-value of 0.01.[33]

Barbone and Forni (2001) comment that in some series it is possible to find a unit root, since there is a learning process underlying risk premium movements; that is as new information arrives traders update their estimated probabilities of default, thus changing

[33] Skewness was 0.83 and kurtosis was 3.71.

the risk premium that is charged. This means that new information permanently affects the spread and its mean value. Again this poses a potential problem for the estimation, since it is based on the assumption that the variables are stationary.[34] Unfortunately the cointegration framework is not well developed in panel, so better estimations could be achieved in the future, when such a framework has been developed. In our case we ran the Augmented Dickey-Fuller (ADF) unit root test with no drift and no trend, which are plausible assumptions for a spread series; the ADF statistic was -2.92, which should be compared to the MacKinnon 5 percent critical value of -2.91. A similar result was give by the Phillips-Perron test, which yielded a statistic of -2.86 and has a 5 percent critical value of -2.91. We should, therefore, be able to assume that the time series we are using are stationery, even if it is a border case.

We, furthermore, used the Ljung-Box Q-statistics and their P-values, which is testing the null-hypothesis that there is no autocorrelation; the null-hypothesis was rejected, suggesting that there is, indeed, autocorrelation. Based on the autocorrelation function (AC) and the partial autocorrelation function (PAC) and using the Box-Jenkins methodology, it seems plausible that the process is an AR(1).

Finally, most financial series present persistence in the conditional variance, where the occurrence of large residuals is correlated over time. Engle's ARCH modelling takes this into account by assuming that the conditional variance of today's error term, given the previous errors, follows a moving average process. GARCH effects in the panel data framework are still not well developed. It is, nevertheless, likely that in the following years new estimators and test will emerge due to the recent trend of using panel data rather than single time series to test macroeconomic and financial hypotheses.[35]

Besides the particular statistical characteristics of the EMBI Global time series that violate some of the assumptions in our estimations as well as in most of the previous works, market sentiment, changing correlations in times of crises and contagion are also

[34] With non-stationary time series the standard asymptotic theory does not hold and the estimates could be misleading.
[35] See Cemeño and Grier (2001) for testing and estimating GARCH effects in a panel data context.

factors that are present in the EMBI Global series.[36] Barbone and Forni (2001) discuss how investor's decisions are based in their private information on fundamentals, but also on the behaviour of other traders. If fund managers and other investors are concerned about their reputation in the market, mimicking the behaviour of others by ignoring private information might be better than going against the market, since in this case underperforming could be very damaging.

[36] Some works control for some of the problems, but do not consider others.

6 Conclusion

The main objective of this study was to identify the key economic determinants of both the spread of emerging market sovereign bonds over US Treasuries and of the creditworthiness of the issuers. As discussed, the two should be closely related. For the study, we used a panel-data framework and a sample of 16 emerging market sovereign issuers. We used the EMBI Global spread composite for the individual countries as a measure of the sovereign spread, and the Institutional Investor's creditworthiness index to represent the creditworthiness. The spread regressions used time-series data from 1998 to 2002, and the creditworthiness regressions used data from 1987 to 2002. The resulting models are summarised in table 6.1.

Table 6.1. Summary of relevant variables

Model	Growth	Debt / GDP	Reserves / GDP	Debt / Exp	Inflation	Exports / GDP	Debt service / GDP	Default
Spread I	●	●				●		
Spread II	●		●	●			●	
CWI I	●	●	●					●
CWI II	●			●	●			●
Total	4	2	2	2	1	1	1	2

A further objective of the study was to verify the results obtained by a study by Goldman Sachs,[37] and our results do, indeed, differ from theirs. They found global liquidity represented by the London Inter-Bank Offering Rate (LIBOR) to be significant in explaining the spread, as well as the nominal budget balance as a ratio of GDP. We found none of these two variables to significantly influence the spread. Interestingly, hardly any other study has found the budget balance to significantly impact neither the spread nor the credit ratings of the countries. Cantor and Packer (1996) explains this somewhat surprising finding by the fact that fiscal policy might, in fact, in many cases be endogenous; countries trying to improve their credit standings may opt for more conservative fiscal policies.

We also investigated the relationship between the spread, the creditworthiness, and general market sentiment. Our results suggested that the spread is explained both by the creditworthiness, as represented by the creditworthiness index (CWI), and by general market sentiment, as represented by the EMBI Global emerging market spread composite ($EMBIG_{World}$). The regressions yielded a model on the form

$$EMBIG_i = 1066 - 20.46\ CWI_i + 0.463\ EMBIG_{World} \qquad (6.1)$$

where i represents the different countries. All the parameter estimates are significant. This result is supportive of the model discussed in chapter 3, and illustrated by figure 3.1.

As discussed, this type of research has to deal with a lot of different problems that can possibly bias the estimations. Some of these have been corrected in previous studies, while most of them are generally ignored. Our aim was to use text-book econometrics to correct errors ignored by previous works. Even if this study fills a gap in the current literature, considerable research needs to be done in this area in the future when the panel data framework has been further developed to deal with the particular time-series properties of financial data. Future panel-data studies should, particularly, take into account the possibility of an AR process, of GARCH effects and of unit roots.

[37] Ades, Kaune, Leme, Masih and Tenengauzer (2000).

Even if we did not find a unique model, we are pleased with our results. We have shown that fundamentals definitely matter in the determination of the risk premium. The variables included in the models are not unique in determining neither the spread nor the creditworthiness, which is indicative of the complexity of the area. We have, nevertheless, found a number of variables that consistently seem to be associated with the investor's decisions in pricing country risk. Thus, recommendations for emerging market policy makers would be to pay special attention to the indicators that seem to be the most relevant.

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