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Determinants of Sovereign Risk: Macroeconomic Fundamentals and the Pricing of Sovereign Debt*

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Abstract. This paper investigates the effects of macroeconomic fundamentals on emerging market sovereign credit spreads. We find that the volatility of terms of trade in particular has a statistically and economically significant effect on spreads. This is robust to instrumenting terms of trade with a country-specific commodity price index. Our measures of country fundamentals have substantial explanatory power, even controlling for global factors and credit ratings. We also estimate default probabilities in a hazard model and find that model implied spreads capture a significant part of the variation in observed spreads out-of-sample. The fit is better for lower credit quality borrowers.

JEL Classification: F34, G12, G13, G15

1. Introduction

There is tremendous variation in the interest rates emerging market governments pay on their external debt. This is true both across countries and over time. A common measure of a country's borrowing cost in international capital markets is its yield spread, which is defined as the difference between the interest rate the government pays on its external U.S. dollar denominated debt and the rate offered by the U.S. Treasury on debt of comparable maturity.

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In this paper we consider to what extent macroeconomic fundamentals can explain variation in sovereign yield spreads. We focus in particular on the explanatory power of the volatility of fundamentals. From a theoretical perspective, the volatility of fundamentals should matter for the pricing of defaultable debt, just as the level of these fundamentals does. All else equal, a country with more volatile fundamentals is more likely to experience a severe weakening of fundamentals which may force it into default. This risk should be reflected in a higher yield spread on its bonds.[1] While this idea is well understood in theory, it has been largely ignored by the empirical literature on sovereign debt, which has tended to focus on level variables.[2] In contrast, we include both the level and the volatility of macroeconomic fundamentals in our empirical analysis.

There are two main parts to the paper. In the first part, we analyze the effect of country-specific fundamentals and global factors on sovereign debt prices for a set of 31 emerging market countries from 1994 to 2007. We measure yield spreads on external U.S. dollar denominated debt using data from J.P. Morgan's Emerging Market Bond Index (EMBI). In the second part, we examine the effect of these macroeconomic variables on the probability of default, using data from 1970 to 2007. We also relate out-of-sample fitted default probabilities to observed spreads.

We find that macroeconomic fundamentals have statistically and economically significant effects on spreads. We focus in particular on terms of trade, which measure the price of a country's exports relative to its imports. As noted by Bulow and Rogoff (1989), changes in a country's terms of trade affect its ability to generate dollar revenue from exports and therefore its ability to make payments on its external dollar denominated debt. The volatility of terms of trade also matters for the overall economy: terms of trade volatility is important for explaining output variability at business cycle frequencies (Mendoza, 1995) and has negative effects on long run growth (Mendoza, 1997). We find that spreads indeed tend to be higher for countries that have recently experienced adverse terms of trade shocks, while countries that have seen their terms of trade improve tend to have lower spreads. We also find that the volatility of terms of trade has a highly significant effect on spreads, both statistically and economically.

One concern is that the terms of trade could be partly endogenous. In order to address this issue, we construct a country-specific commodity price index. Our index includes only major commodity prices traded in world markets and we weight these prices by country-specific export shares. We believe that this index is plausibly

[1] In particular, this intuition holds in Merton's (1974) seminal model of risky corporate debt.

[2] Exceptions are Edwards (1984), who includes variability of reserves and finds that it is insignificant, Westphalen (2001), who finds some limited effect of changes in local stock market volatility on changes in short term debt prices, and Garcia and Rigobon (2005), who find that risk-based measures of debt sustainability are closely related to spreads in the case of Brazil. In the corporate bond context, Campbell and Taksler (2003) find a strong empirical link between equity volatility and yield spreads.

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exogenous (Chen and Rogoff, 2003) and use it as an instrumental variable for terms of trade. The instrumentation does not lead to a significant change in the coefficients on our main variables or the overall regression fit.

We also examine the relative importance of country-specific and global factors. A number of papers have emphasized the importance of global factors for emerging markets: Calvo et al. (1993), and more recently Calvo (2002), Herrera and Perry (2002), Grandes (2003), Diaz Weigel and Gemmill (2006), García-Herrero and Ortiz (2006), Longstaff et al. (2007), and González-Rozada and Levy Yeyati (2008). In order to control for global factors, we include the implied volatility of the S&P500 index (VIX), the U.S. default yield spread, the 10-year U.S. Treasury yield, and the difference between the 3-month Libor rate and the 3-month Treasury rate (TED spread). We find that global factors are indeed important. In particular, the coefficient on the VIX index is positive and significant, which is consistent with Pan and Singleton (2008) who find that the VIX is statistically significant in explaining credit default swap (CDS) spreads of Mexico, Turkey, and Korea. Nevertheless, we find that country-specific fundamentals have substantial explanatory power, even after controlling for global factors.

Our measures of country-specific fundamentals also add explanatory power relative to credit ratings, which are often used as a summary measure of credit quality (e.g. Cantor and Packer, 1996; Kamin and von Kleist, 1999; González-Rozada and Levy Yeyati, 2008; Powell and Martinez, 2008). Including our country-specific variables leads to a substantial increase in adjusted R^2 compared to a regression that only includes global variables and credit ratings and the coefficients on our country-specific variables remain significant when we include ratings.

Finally, we note that, even after accounting for macroeconomic fundamentals, spreads are higher for countries that have recently emerged from default. This is consistent with Reinhart et al. (2003), who find that a key predictor of future default is a country's history of default. Some countries seem to behave like "serial defaulters" in a way that cannot fully be accounted for by macroeconomic fundamentals.

In the second part of the paper, we estimate default probabilities and use fitted probabilities to price debt. This allows us to directly determine the extent to which fundamentals affect spreads through their effect on default probabilities. Using data on country defaults, we estimate the conditional probability of default over the next period in a reduced form logit model following the approach proposed by Shumway (2001) in the context of predicting corporate bankruptcy. We find that the volatility of terms of trade is an important predictor of default, in line with its effect on spreads. We then use estimated default probabilities to calculate out-of-sample predicted spreads and find that predicted spreads can account for a substantial share of the variation in observed spreads. Our methododolgy in this part of the paper is related in spirit to the approach of Garcia and Rigobon (2005). These authors propose a risk-based model of debt sustainability that takes into account

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the stochastic nature of a country's debt accumulation equation. This allows them to infer the probability that debt to GDP exceeds a given threshold. They show that these model implied probabilities are closely related to EMBI spreads in the case of Brazil. Calvo and Mendoza (1996) present related evidence in the context of the Mexican crisis of 1994–95.[3]

When we group bond spread observations into quintiles by their estimated default probability we find that predicted spreads are smaller than actual spreads for all the groups,[4] but that the proportion of the spread explained by the default prediction model increases significantly with the probability of default. Huang and Huang (2003) find a similar pattern when calibrating structural form models to U.S. corporate bond prices.

This paper adds to the large literature on the empirical determinants of sovereign yield spreads. The literature varies widely in choice of variables and methodology. Some papers concentrate on reduced form regressions of spreads on explanatory variables. Examples of this line of research include Edwards (1986), Eichengreen and Mody (1998), Min (1998), Beck (2001), and Ferrucci (2003), among others. These authors explore a large set of macroeconomic variables to explain spreads. As already mentioned, we pay special attention to measures of volatility which are largely absent from this literature.

Duffie et al. (2003) develop a flexible reduced form model of sovereign yield spreads. They estimate their model using weekly data on Russian dollar-denominated debt and U.S. swap yields between 1994 and 1998. Pan and Singleton (2008) explore the term structure of CDS spreads for Mexico, Turkey, and Korea from 2001 to 2006 and consider the risk-neutral credit event intensities and loss rates that best describe the CDS data. While these studies relate spreads implied by a reduced from pricing model to political factors, foreign currency reserves, oil prices, and VIX, macroeconomic fundamentals do not directly enter the estimation of the pricing model. In contrast, our focus is to explore directly the extent to which variation in macroeconomic fundamentals determines spreads and default probabilities across countries and over time.

There is also a large literature on predicting banking and currency crises and sovereign defaults using macroeconomic fundamentals.[5] Again, the focus of these

[3] In the literature on corporate default risk, the link between default probabilities and spreads has been explored by a number of papers, e.g. Anderson and Sundaresan (1996), Huang and Huang (2003), and Berndt et al. (2005).

[4] This is not surprising given that we only model the default component of the spread. We discuss other spread components in Section 4.

[5] Early contributions to this literature include Hajivassiliou (1987, 1994). Berg et al. (2000), Kaminsky and Reinhart (1999), and Goldstein et al. (2000) have concentrated on constructing what they refer to as "early warning systems." Berg et al. (2005) provide an overview of this line of research.

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studies is on level variables, rather than volatility. There are some exceptions: Catão and Sutton (2002) and Catão and Kapur (2006) predict sovereign default in a hazard model using a similar setup to the one used in the second part of this paper. They identify volatility of terms of trade as an important predictor of default.

The remainder of the paper is organized as follows. Section 2 describes the data. Section 3 describes the results from using fundamentals to explain spreads in a regression framework. In Section 4 we turn to default prediction and compare out-of-sample predicted spreads to observed spreads. Section 5 concludes.

2. Choice of Variables and Data Description

Our empirical investigation concentrates on explaining variation in sovereign external debt prices across countries and over time. We restrict ourselves to dollar-denominated debt instruments issued or guaranteed by emerging market governments.[6] Our measure of the yield spread over U.S. Treasuries is J.P. Morgan's Emerging Markets Bond Index Global (EMBI Global). This series consists of daily data starting in January of 1994 and covers a sample of 32 emerging market countries.[7] It includes Brady bonds, loans, and Eurobonds with an average maturity of 12 years and verifiable prices. We discuss inclusion requirements in more detail in the appendix.

Table I lists the set of countries with available EMBI spread data and groups countries into regions. The largest regional group is made up of countries in Latin America with 12 countries. The data set also includes 5 countries in Africa, 6 in Eastern Europe and a total of 9 in the Middle East and Asia. The spread data begin in 1994, but not all countries have data going back that far. We report the first year of available spread data for each country. By 1996, nearly half of the eventual set of countries have available data and since 1998 J.P. Morgan has been constructing series for close to two thirds of the countries.

There is tremendous variation in spreads both across countries and over time. Table I reports median EMBI spreads from 1998 to 2007 ranging from 62 basis points (Hungary) to 2666 basis points (Côte d'Ivoire).[8] Figure 1 plots the weighted average EMBI spread.

We begin our investigation of spread determinants by considering some suggestive global evidence that terms of trade are an important determinant of sovereign

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[6] In contrast, the yield on local currency debt tends to be driven mainly by local inflation risk.

[7] The final spread regression sample contains only 31 countries; due to missing macroeconomic data Nigeria is not included. However, Nigeria is included in the longer default prediction sample (Section 4).

[8] The large variation in spreads is driven partly by observations of countries in default, e.g. Argentina, Nigeria, and Côte d'Ivoire. Exluding these, the highest two median spreads are equal to 1305 and 565 basis points.

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Table I. Summary statistics by country

The table presents statistics by country. EMBI refers to J.P. Morgan's Emerging Market Bond Index Global (EMBI). The spread is measured in basis points over U.S. Treasuries. We report the first year for which EMBI data is available and the median end-of-year spread between 1998 and 2007. Volatility of terms of trade is the median standard deviation of the percent change in terms of trade calculated using annual data and a rolling ten year backward-looking window. Number of defaults is the number of times a country has gone into default over the next year. Debt/GDP is the median level of external debt divided by GDP. These three colums are for the sample period 1970 to 2007. Export groups are for 2000–2001 (UNCTAD).

	Country	Country code	Start of EMBI series	EMBI spread	Volatility of terms of trade	Number of defaults	Debt/GDP	Top two exports (SITC group) and their percentage of total exports
Latin America	Argentina	ARG	1994	707	9.2	2	42.4	Crude petroleum (10%), feeding stuff for animals (10%)
	Brazil	BRA	1994	565	9.5	1	33.1	Aircraft (6%), iron ore and concentrates (5%)
	Chile	CHI	1999	143	9.6	1	46.4	Copper (27%), base metals ores (13%)
	Colombia	COL	1997	436	10.0	0	32.7	Crude petroleum (26%), coffee and substitutes (8%)
	Dominican Rep.	DMR	2001	447	0.9	1	29.4	Men's outwear non-knit (17%), under garments knitted (13%)
	Ecuador	EQU	1995	824	12.4	3	60.9	Crude petroleum (41%), fruit, nuts, fresh, dried (18%)
	El Salvador	ESD	2002	238	13.6	0	30.5	Coffee and substitutes (16%), paper and paperboard, cut (6%)
	Mexico	MEX	1994	310	7.8	1	31.7	Passenger motor vehicles, exc. bus (10%), crude petroleum (8%)
	Panama	PAN	1996	346	2.3	1	77.6	Fish, fresh, chilled, frozen (20%), fruit, nuts, fresh, dried (20%)
	Peru	PER	1997	435	14.5	4	52.3	Gold, non-monetary (17%), feeding stuff for animals (13%)
	Uruguay	URU	2001	308	8.4	4	34.7	Meat, fresh, chilled, frozen (16%), leather (10%)
	Venezuela	VEN	1994	601	21.8	3	40.3	Crude petroleum (59%), petroleum products, refined (25%)
Africa	Côte d'Ivoire	CDI	1998	2666	19.7	2	108.0	Cocoa (28%), petroleum products, refined (18%)
	Morocco	MOR	1997	429	7.3	2	55.6	Women's outwear non-knit (11%), men's outwear non-knit (8%)
	Nigeria	NIG	1994	1061	26.3	1	52.3	Crude petroleum (99.6%)
	South Africa	SAF	1994	236	5.4	3	16.9	Pearl, prec., semi-prec. stones (13%), special transactions (12%)
	Tunisia	TUN	2002	118	4.8	0	56.2	Men's outwear non-knit (17%), women's outwear non-knit (10%)
Eastern Europe	Bulgaria	BUL	1994	285	5.3	1	66.0	Petroleum products, refined (11%), copper (7%)
	Croatia	CRO	1996	353	1.5	1	59.3	Ships, boats etc. (15%), petroleum products, refined (8%)
	Hungary	HUN	1999	62	2.9	0	58.7	Int. combust. piston engines (9%), automatic data proc. eq. (7%)
	Poland	PLD	1994	165	3.9	1	39.0	Furniture and parts thereof (7%), ships, boats etc. (4%)
	Russia	RUS	1997	450	13.1	2	41.6	Crude petroleum (24%), gas, natural and manufactured (17%)
	Ukraine	UKR	2000	290	12.1	1	36.9	Iron, steel primary forms (13%), iron, steel shapes etc. (8%)
Southeast Asia	China	CHN	1994	98	2.6	0	12.8	Telecom equip., parts, acces. (5%), automatic data proc. eq. (5%)
	Malaysia	MAL	1996	178	7.0	0	38.9	Transistors, valves etc. (19%), office, adp. mach. parts (12%)
	Philippines	PHI	1997	435	7.6	1	62.4	Transistors, valves etc. (42%), automatic data proc. eq. (13%)
	South Korea	SKO	1994	168	3.6	0	34.6	Transistors, valves etc. (12%), passgr. motor vehicl. exc. bus (7%)
	Thailand	THA	1997	128	7.6	0	34.1	Office, adp. mach. parts (9%), transistors, valves etc. (8%)
Middle East & South Asia	Egypt	EGY	2001	131	9.6	1	40.5	Petroleum products, refined (39%), crude petroleum (10%)
	Lebanon	LEB	1998	369	3.8	0	28.1	Gold, silver ware, jewelry (9%), gold, non-monetary (7%)
	Pakistan	PAK	2001	339	11.7	1	43.9	Textile articles (16%), textile yarn (12%)
	Turkey	TUR	1996	379	5.0	2	34.8	Outer garments knit non-elastic (6%), under garments knitted (6%)

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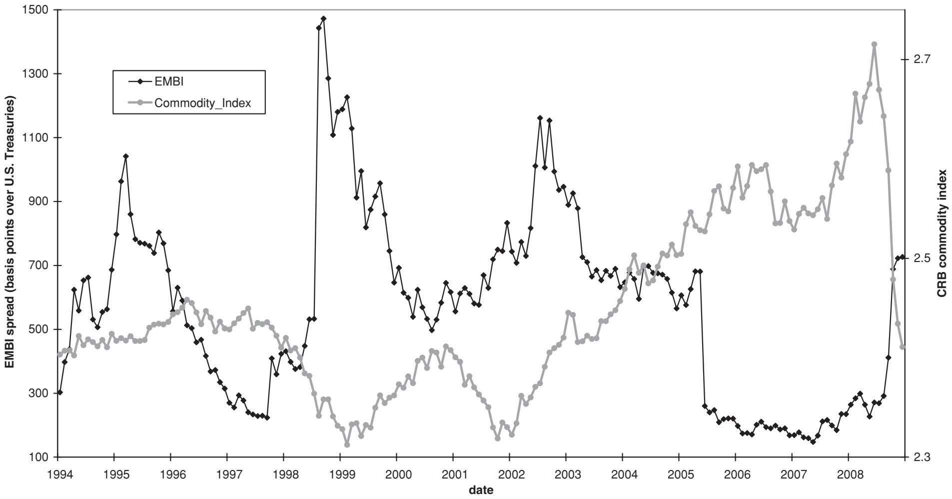

Figure 1. EMBI spreads and Commodity Prices
This figure plots EMBI spread (from J.P. Morgan, monthly spread over U.S. Treasuries), weighted by country external debt, and the CRB commodity price index (in logs).

yield spreads. Since many emerging markets are important commodity exporters, we expect an improvement in the terms of trade and a resulting decline in spreads when commodity prices increase. We plot commodity prices as measured by the Commodity Research Bureau (CRB) commodity index in Figure 1 and find that commodity prices and spreads in fact exhibit a strong negative correlation of −0.66, which is apparent from the graph.

A natural interpretation is that when commodity prices are high, commodity exporters are more likely to repay their external debt, which reduces the yield spread they face in international capital markets. For example, the substantial increase in commodity prices from 2002 to 2007 was accompanied by significant spread narrowing. However, it is important to note that we cannot readily generalize from this evidence since countries have very different baskets of exports, the top two of which we report in Table I. For example, Venezuela exports mainly oil, while Chile exports copper and other metals. In order to capture these differences we use more detailed country-specific terms of trade data in our subsequent empirical investigation.

2.1 COUNTRY VARIABLES

A country's ability to pay its external debt affects its probability of default and, therefore, the spread it has to pay in international capital markets. In order to analyze spread variation across countries and over time we gather annual cross-country data

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on macroeconomic fundamentals from a variety of sources. We provide details in the appendix.

In our choice of country variables we focus on measures of fundamentals that are likely to be related to the risk of default. We would expect a country's terms of trade, the price of the country's exports relative to its imports, to affect its ability to generate dollar revenue and repay its external debt. The intuition for why this measure is relevant for the pricing of debt is apparent when considering an oil-exporting country. The country generates dollar revenue by exporting oil and spends dollars on imports. If the price of oil rises, the country is in a better position to generate export revenue and repay its dollar-denominated liabilities. Since terms of trade is a relative price series, we measure the country's terms of trade by constructing the percentage change in the terms of trade over the past five years (Change in terms of trade). A positive number means that a country's exports have become more expensive relative to its imports.

Bondholders, however, do not only care about recent changes in the terms of trade but also about the risk of a large adverse shock in the future, say a large decline in the price of oil in our example. As a result, we expect the volatility of terms of trade to be positively correlated with spreads. We calculate the standard deviation of the percentage change in terms of trade (Volatility of terms of trade) over the previous ten years.[9] We graph terms of trade volatility against EMBI spreads for our cross-section of countries in Figure 2, which indeed suggests a positive relationship.[10]

We also include a measure of a country's recent default history. This variable is motivated by the work of Reinhart et al. (2003), who argue that history of default is an important predictor of future default. These authors have constructed annual default indicators for different debt categories for a large sample of countries going back to the early nineteenth century. We use their series for default on total debt, which includes foreign currency bonds and foreign currency bank debt. We count the years since the country's last year in default (Years since last default). We cap the variable at 10 and set it equal to 11 if a country has never defaulted.[11]

We summarize default activity for the set of countries in Table I. There are a total of 40 sovereign default episodes since 1970. A number of countries defaulted

[9] For the few cases where data on terms of trade start later in the sample, we reduce the window size to a minimum of six years.

[10] There is considerable variation in terms of trade volatility across countries. High terms of trade volatility is to a large extent driven by oil prices. Petroleum products are among the top two export categories for the three countries with the highest terms of trade volatilities (Table I). However, our results are robust to excluding countries with more than 20% of their exports concentrated in oil.

[11] If unrestricted, this measure could become very large for countries that continue to stay out of default. We make these adjustments because we expect additional years out of default to have incrementally less importance.

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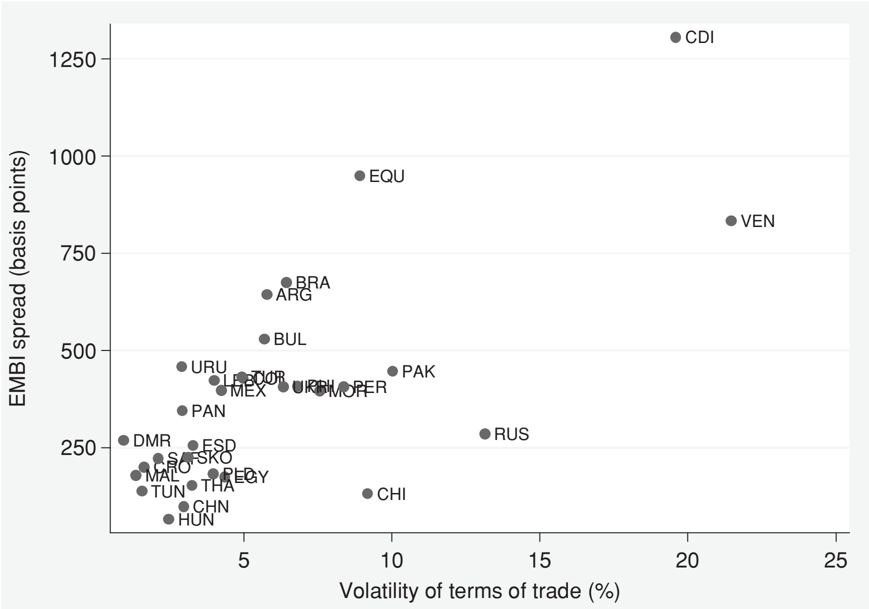

Figure 2. Volatility of terms of trade and EMBI spread
This graph plots mean EMBI spread (from J.P. Morgan, end-of-year spread over U.S. Treasuries) against mean country volatility of terms of trade.

on multiple occasions – Peru and Uruguay each have four defaults – while nine countries did not go into default during this period.

2.2 TERMS OF TRADE AND COMMODITY PRICES

While many of the countries in our data set are large commodity exporters whose export prices are determined in world markets, not all of the countries' exports are concentrated in commodities. It is therefore possible that our measure of terms of trade may be influenced by local factors, raising the concern of endogeneity. In order to address this, we construct country-specific commodity export price indices which we use to instrument for terms of trade in our empirical investigation in Section 3.

We gather data on export quantities from COMTRADE and export prices from Global Financial Data. We then construct an export-weighted price index for each country using time-varying weights. The commodities included in the basket are those for which we are able to match export price and quantity data. Specifically, we include the following commodities (ordered by the mean share in country exports) in the price indices: oil, coffee, textiles, copper, cotton, cocoa, meat, bananas, leather, gold, gas, and silver (SITC codes listed in the appendix). We use these price

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indices to construct the change in export prices and the volatility of export price changes analogous to the change in terms of trade and the volatility of terms of trade discussed above. In the next section we use the commodity price index to instrument for terms of trade. Before doing so we check that price index changes are associated with terms of trade changes. We regress the terms of trade measures on the price index measures and find that, for both measures, the coefficients are statistically significant at the 1% level and the R^2 are close to 0.5.

2.3 GLOBAL AND CONTROL VARIABLES

In order to control for global factors such as changes in aggregate risk aversion, world interest rates, and liquidity, we add four time series variables. We include the VIX index and the U.S. default yield spread, defined as the spread between corporate bonds with a Moody's rating of Baa and Aaa. As a proxy for the world interest rate we include the 10-year U.S. Treasury rate and to capture changes in aggregate liquidity we include the TED spread.

We also examine two additional country-specific variables: external debt to GDP (Debt/GDP) and the ratio of reserves (including gold) to GDP (Reserves/GDP). A number of papers, particularly in the early literature on this topic (e.g. Edwards, 1986), have found a significant positive coefficient on the ratio of debt to GDP in spread regressions. There are two main concerns with these variables. First, they are both potentially endogenous. The dynamics of debt in particular are likely to be endogenous and non-linear (e.g. Favero and Giavazzi, 2002; 2005). A country's GDP may also be affected by its spread (e.g. Uribe and Yue, 2006). Second, neither variable is an ideal measure of sustainability; reserves to GDP in particular is likely to reflect liquidity rather than solvency.[12] We present specifications with and without these variables to check that our results are robust to their inclusion and to make our results more readily comparable to earlier studies.

3. Spreads and Macroeconomic Fundamentals

We now explore how much of the variation in sovereign yield spreads can be explained by macroeconomic fundamentals by running linear regressions of yield spreads on explanatory variables. For each country we construct an annual end-of-year spread series to match the annual frequency of our measures of fundamentals. Our measure of the end-of-year spread is the median daily EMBI spread from J.P. Morgan for the month of December.[13] Since we want to analyze determinants of

[12] We thank an anonymous referee for helpful comments on these variables.

[13] An alternative would be to use the daily spread on the last trading day of the year which would be a more noisy measure. Our results are robust to using this alternative measure.

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Table II. Summary statistics for EMBI spread regression sample

This table reports summary statistics for the spread regression sample (1994–2007). EMBI spread refers to spreads on J.P. Morgan's Emerging Market Bond Index Global. Volatility of terms of trade is the standard deviation of the annual percentage change in terms of trade. It is calculated using annual data from a ten year rolling window. Change in terms of trade is the percentage change in terms of trade over the previous five years. Years since last default counts the number of years since the last year in which the country was in default. It is capped at 10, equal to zero if the country is in default, and set equal to 11 if the country has never defaulted. It is constructed using a default indicator variable from Reinhart et al. (2003). Debt/GDP denotes U.S. dollar denominated debt to GDP; reserves/GDP is the ratio of reserves (incluing gold) to GDP. The sample corresponds to the regression sample used in Table III. p5 and p95 refer to the 5th and 95th percentiles of the distribution respectively.

	EMBI spread	Volatility of terms of trade	Change in terms of trade	Years since last default	Debt/GDP	Reserves/GDP
Mean	376	5.7	3.6	8.6	46.6	18.2
Median	265	4.4	0.2	10.0	44.5	14.8
St. Dev.	328	4.5	21.2	3.4	21.8	13.8
Min	24	0.7	−31.9	1	11.8	1.5
p5	60	1.5	−17.0	1	15.8	5.2
p95	1072	13.6	55.3	11	87.0	45.4
Max	1803	25.5	162.4	11	114.2	84.5
Number of observations: 276						

the risk of sovereign default and its impact on debt prices, we focus on spread observations while the country is not in default.

For an observation to be included in the regression we require that the full set of explanatory variables is available. This leaves us with a regression sample consisting of 276 country-year observations covering 31 countries from 1994 to 2007. We restrict the sample to be the same for different specifications to facilitate comparison of point estimates, significance levels, and adjusted R^2 across specifications. Table II reports summary statistics for the spread regression sample. It is apparent that there is substantial variation in spreads and all of our explanatory variables.

Table III reports results from regressions of spreads on different sets of explanatory variables. We group the explanatory variables into three categories: our main country-specific variables, global time series variables, and control variables. In column (1), we run a baseline regression with country-specific and global variables. Volatility of terms of trade and changes in the terms of trade have the expected sign and are significant at the 1% level: countries with higher terms of trade volatilities and countries which have experienced a deterioration in their terms of trade tend to have higher spreads. The coefficient on the years since last default variable is negative and significant at the 1% level: the closer a country is to its most recent default episode, the higher its spread tends to be. This latter result is consistent

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Table III. Regressions of sovereign spreads on fundamentals

This table reports results from regressions of end-of-year (median December) EMBI spreads (31 countries, 1994–2007) on a set of explanatory variables: macroeconomic variables, time series variables, control variables, and time and regional dummy variables. We only include observations for which a country is not in default. In specifications (2) and (4) we use the volatility and change in the commodity price index to instrument for the volatility and change of terms of trade. Credit ratings are from S&P; we include dummy variables corresponding to letter ratings in columns (8) to (10). *t*-statistics (reported in parentheses) are calculated using standard errors which are robust and clustered by year. ** denotes significant at 1%; * significant at 5%; + significant at 10%.

Regression equation:

$$spread = \alpha + \beta_1 vol\_tot + \beta_2 chg\_tot + \beta_3 ytd + \beta_4 VIX + \beta_5 DEF + \beta_6 r\_10year + \beta_7 TED + \beta_8 \frac{debt}{GDP} + \beta_9 \frac{reserves}{GDP} + dummies + \varepsilon$$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
COUNTRY VARIABLES										
Volatility of terms of trade (vol_tot)	37.18	47.78	36.61	47.02	32.36	33.64			20.21	21.93
	(9.79)**	(7.76)**	(9.90)**	(8.65)**	(8.75)**	(8.81)**			(2.76)*	(3.25)**
Change in terms of trade (chg_tot)	−5.04	−6.26	−4.33	−5.54	−3.86	−3.81			−2.43	−2.28
	(5.54)**	(4.63)**	(5.44)**	(4.52)**	(4.98)**	(4.88)**			(2.21)*	(2.22)*
Years since last default (ytd)	−35.22	−29.62	−25.19	−19.79	−29.34	−17.73			−23.20	−17.95
	(5.71)**	(4.32)**	(3.43)**	(2.50)*	(3.87)**	(3.43)**			(3.65)**	(2.46)*
GLOBAL VARIABLES										
VIX index (VIX)	9.33	9.92	7.66	8.27	7.46		15.24	15.07	11.49	10.31
	(3.12)**	(3.08)**	(2.31)*	(2.37)*	(2.12)+		(3.67)**	(3.63)**	(3.52)**	(3.08)**
Default yield spread (DEF)	0.73	0.58	1.05	0.90	1.07		1.57	1.38	0.95	1.06
	(1.41)	(1.20)	(1.89)+	(1.69)	(1.90)+		(1.65)	(1.51)	(1.43)	(1.65)
Treasury 10-year yield (r_10year)	0.09	0.11	0.16	0.18	0.14		0.68	0.81	0.38	0.39
	(0.42)	(0.59)	(0.76)	(0.95)	(0.67)		(1.79)+	(2.23)*	(1.41)	(1.51)
TED spread (TED)	0.20	0.17	0.66	0.63	0.54		−0.74	−0.81	−0.26	0.07
	(0.33)	(0.29)	(1.09)	(1.04)	(0.87)		(1.11)	(1.20)	(0.42)	(0.12)
CONTROL VARIABLES										
Debt/GDP			4.16	4.09	4.13	4.25				2.50
			(4.71)**	(4.14)**	(4.74)**	(4.74)**				(3.65)**
Reserves/GDP			−4.60	−4.59	−3.35	−2.66				−3.66
			(3.56)**	(3.39)**	(2.83)*	(2.19)*				(3.11)**
Credit rating								X	X	X
Instrument for terms of trade		X		X						
Regional effects					X	X				
Year effects						X				
Number of observations	276	276	276	276	276	276	269	269	269	269
Adjusted R^2	52.8%	51.5%	58.6%	57.3%	61.6%	66.9%	13.2%	52.3%	62.7%	65.1%

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with the findings of Reinhart et al. (2003).[14] The coefficient on the VIX index is positive and significant at the 1% level; the coefficients on the other time series variables we include are not significant. The regression of spreads on country-specific fundamentals and global factors delivers an adjusted R^2 of 0.53. In contrast, the regression in column (7) which only includes global factors, delivers a substantially lower adjusted R^2 of 0.13. We return to a discussion of global factors in the next subsection.

We draw two main conclusions from these results. First, country-specific fundamentals measured by a country's terms of trade have substantial explanatory power for emerging market sovereign spreads, even after controlling for global factors. Second, the volatility of these fundamentals is important in addition to their level. Moreover the finding that a country-specific measure of terms of trade and the associated volatility go a long way towards explaining emerging market sovereign spreads is plausible on economic grounds given that most of these countries are major commodity exporters.

A natural concern with this first regression is that the terms of trade could be partly endogenous (Chen and Rogoff, 2003). In order to investigate this possibility, we use an instrumental variables approach, instrumenting the terms of trade with our commodity price indices. The idea is to use only major commodity prices traded in world markets and to weight these prices by country-specific export shares. While there may be legitimate concerns about endogeneity for other components of terms of trade, the component related to commodities traded in world markets is plausibly exogenous (Chen and Rogoff, 2003). The results for the instrumental variable regression are reported in column (2). Change in terms of trade, volatility of terms of trade, and years since last default are still significant at the 1% level. The instrumentation leads to a very modest drop in R^2 of around 0.01. The changes in coefficients on these variables are not significant at the 95% confidence level. We interpret the results in column (2) as well as the instrumental variables regression in column (4) for the slightly richer specification discussed in the next paragraph to suggest that endogeneity of terms of trade is not a major issue for our analysis.

Next, we include debt to GDP and reserves to GDP as additional control variables in columns (3) and (4). Many studies have found that debt to GDP has a significant positive coefficient in regressions of spreads on levels of fundamentals (e.g. Edwards, 1986; Eichengreen and Mody, 1998; Min, 1998). We confirm this finding here as well as an intuitive negative coefficient on reserves to GDP.

[14] An important question which we do not address in this paper is what factors aside from macroeconomic fundamentals may cause some countries to be "serial defaulters." The evidence in Kohlscheen (2007) suggests that constitutions are important, in particular whether a country is a parliamentary or presidential democracy.

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Both variables are significant at the 1% confidence level and including them leads to an increase in the adjusted R^2 of around 0.06. However, as noted in Section 2.3, these variables may be endogenous and should therefore be interpreted with caution.

In column (5) of Table III, we investigate regional effects by including regional dummy variables corresponding to the regions in Table I. We find that spread levels are significantly higher in Latin America than in the other regions. Including regional dummies increases the adjusted R^2 by around 0.03; it does not lead to a significant change in any of the coefficients.

In addition to being statistically significant, we find that our explanatory variables are economically significant. We multiply the coefficients from our main specification in column (3) with each variable's in-sample standard deviation. We find that a one standard deviation increase in the volatility of terms of trade is associated with an increase of 164 basis points in the spread. This magnitude underlines the economic importance of the volatility of macroeconomic fundamentals for sovereign spreads. The corresponding effects (in basis points) for the other statistically significant explanatory variables are −92 for change in terms of trade, −85 for years since last default, 45 for the VIX index, 90 for debt to GDP and −63 for reserves to GDP.

In summary, spreads are high for country-year observations where volatility of terms of trade is high, terms of trade have recently deteriorated, the country has recently defaulted, the VIX index is high, the level of debt to GDP is high, or reserves are low.

3.1 GLOBAL FACTORS

We next examine the global time series variables (VIX index, U.S. default yield spread, 10-year U.S. Treasury yield, TED spread) in more detail. Our first main finding is that global factors are indeed important. In column (7) of Table III, we report results from a regression that only includes our four time series variables. Overall, these four variables alone give an adjusted R^2 of 0.13. González-Rozada and Levy Yeyati (2008) show that at higher (monthly or weekly) frequencies, the explanatory power of the U.S. high yield corporate spread and Treasury rate is even higher. Other papers demonstrating the importance of global factors include Eichengreen and Mody (1998), Herrera and Perry (2002), Grandes (2003), Diaz Weigel and Gemmill (2006) and García-Herrero and Ortiz (2006).

The finding that the coefficient on the VIX index is positive and significant at the 1% level is consistent with two recent studies using higher frequency emerging market CDS spread data: Longstaff et al. (2007) find that at higher frequencies there is evidence of comovement in sovereign CDS spreads while Pan and Singleton

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(2008) find that the VIX is statistically significant in explaining CDS spreads of Mexico, Turkey, and Korea.[15]

The finding of a positive coefficient on the 10-year U.S. Treasury yield is consistent with the findings of Arora and Cerisola (2001) and Dailami et al. (2005), among others. Other evidence on the effect of U.S. interest rates in this literature is mixed. For instance, Kamin and von Kleist (1999) could not identify a robust relationship between a number of industrial country interest rates and emerging market spreads. Min (1998) finds a positive but insignificant effect of U.S. interest rates on sovereign credit spreads, while Eichengreen and Mody (2000) report a significant negative effect. More recently, Uribe and Yue (2006) find that an increase in the world interest rate causes a decline in emerging market spreads in the short run followed by an overall increase in spreads in the long run.

More general contagion effects or sudden stops in international capital flows, as in the work of Calvo et al. (1993) and many related papers (e.g. Calvo and Mendoza, 2000; Calvo, 2002; Calvo and Talvi, 2004; Calvo et al., 2006; González-Rozada and Levy Yeyati, 2008) are also likely to be at work. Such effects may not be fully captured by our time series variables. A more flexible way to capture these effects is to include year dummies in the regression. When we replace time series variables with year dummies in column (6), we indeed find that the coefficients on the dummies for the crisis years 1995 and 1998 are positive and significant and those for the four years from 2003 to 2006, a period marked by very low volatility and low yields, are negative and significant. Moreover, comparing the R^2 across columns (5) and (6) shows that including year dummies instead of the time series variables leads to an increase in adjusted R^2 from 0.62 to 0.67. This suggests that there is some comovement not fully captured by our four time series variables.

In addition to demonstrating the importance of global variables, the papers mentioned in this section typically find that local factors have little explanatory power for emerging market sovereign spreads. While global factors are undeniably important, comparing our results in columns (1) and (7) suggests that macroeconomic fundamentals do matter. There are at least three possible reasons for this difference in findings. First, most papers focus on macroeconomic fundamentals other than the terms of trade emphasized by our study. Second, they typically do not include measures of the volatility of these fundamentals, whereas we find that the volatility of terms of trade has substantial explanatory power. The focus on other macroeconomic fundamentals of these studies may be partly driven by data availability. Terms of trade are not available at the monthly or weekly frequencies studied by González-Rozada and Levy Yeyati (2008) and Longstaff et al. (2007), for example. Third, it may be that global factors are particularly important at high

[15] In related work, Berndt et al. (2005) find that the VIX has substantial explanatory power in a high frequency data set of U.S. corporate CDS spreads.

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frequencies, perhaps due to short run changes in aggregate liquidity or uncertainty, while at low frequencies the explanatory power of country-specific macroeconomic fundamentals and their volatility becomes relatively more important.

3.2 CREDIT RATINGS

A number of papers in the literature on emerging market sovereign debt focus on credit ratings. One approach is to take credit ratings as a summary measure of country-specific fundamentals (e.g. Kamin and von Kleist, 1999; González-Rozada and Levy Yeyati, 2008; Powell and Martinez, 2008).[16] A natural question is whether our measures of country-specific fundamentals add explanatory power relative to credit ratings.[17] In order to investigate this, we include ratings dummies constructed using S&P sovereign credit ratings. Comparing the results in columns (8) and (9) of Table III we see that, compared to a regression that just includes time series variables and credit ratings, adding volatility of terms of trade, change in the terms of trade, and years since last default increases the adjusted R^2 from 0.52 to 0.63. In addition, the coefficients on our country-specific variables remain statistically significant when we include ratings. Including debt to GDP and reserves to GDP in column (10) leads to a further increase in adjusted R^2 to 0.65. This increase in explanatory power, and particularly the 0.11 increase in adjusted R^2 from column (8) to column (9), suggests that there is significant additional information in our measures of country-specific fundamentals relative to credit ratings. One potential explanation is that credit rating agencies do not fully take into account the risk associated with terms of trade. This would be consistent with the findings of Cantor and Packer (1996), Afonso et al. (2006), and Powell and Martinez (2008), who study the determinants of sovereign credit ratings.[18]

3.3 ROBUSTNESS

We perform several robustness checks. First, we drop large oil exporting countries from the regression. In particular we drop countries with more than 20% of exports concentrated in crude petroleum and petroleum products. The results are largely unaffected indicating that fluctuations in oil prices are only part of the reason why terms of trade fluctuations impact sovereign spreads. In order to make sure that outliers are not driving some of our results we re-estimate the reduced form regressions

[16] One issue in this context highlighted by González-Rozada and Levy Yeyati (2008) is the potential endogeneity of credit ratings.
[17] The question we are interested in here is to what extent credit ratings explain market prices. A different question is whether credit ratings contain information about future fundamentals not captured by market prices. Cavallo et al. (2008) find that they do.
[18] In addition, Mora (2006) provides evidence of inertia in ratings.

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on winsorized data where we winsorize the explanatory variables at the 5th and 95th percentile levels, replacing values above the 95th percentile of the distribution with the 95th percentile and values below the 5th percentile with the 5th percentile of the distribution. Our main results are unaffected by these changes. Third, we replace the volatility of terms of trade with its one year lag. We also drop observations in years preceding a default. Our results are robust to these changes. Finally, we run our main specification (3) in Table III in first differences as an additional specification check. We find that the magnitudes of the coefficients on country fundamentals are comparable.[19]

4. Default Probabilities and Spreads

In this section we estimate default probabilities directly in a hazard model. We use fitted default probabilities to calculate predicted spreads and compare predicted spreads to observed spreads out-of-sample.

We begin by constructing a measure of default which is equal to one in a given year if the country goes into default over the course of the year (summarized in Table I). Country defaults are rare events. In order to estimate a hazard model, we need a large enough sample with a sufficient number of defaults. We take advantage of the fact that default data are available for a longer period than spread data and extend the sample back to 1970.[20]

We use the same set of explanatory variables as in the reduced form spread regressions measured over the extended sample period of 1970 to 2007. We winsorize the data to ensure that outliers are not driving our results. Conditional on availability of covariates, the sample has 695 country-year observations, including 28 defaults (a little less than 4% of the sample). Table IV presents summary statistics for our explanatory variables. We group observations into two groups: those where the country goes into default over the next year and those observations for which it stays solvent. We calculate statistics for non-default and default observations separately. For each of the explanatory variables the mean and median of the default observations reflect less favorable conditions. Volatility of terms of trade tends to be particularly unfavorable in country-years preceding default: both the mean and median of the default observation sample are about one standard deviation larger than the mean and median for the non-default sample.

[19] The coefficients on the default yield spread and the TED spread remain positive. Consistent with Uribe and Yue (2006), we find that changes in U.S. interest rates are negatively related to contemporaneous changes in spreads (but positively related to future changes in spreads). VIX loses statistical significance.

[20] Although default data extend back farther, terms of trade data are available only from 1960. Since we calculate volatility over a ten year backward looking window the sample with available covariates begins in 1970.

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Table IV. Summary statistics for default prediction

This table reports summary statistics for our set of country variables and control variables for the default prediction sample (1970–2007). We consider the sample for which all variables are available. Variables are winsorized at the 5th and 95th percentile levels. In Panel A we report summary statistics of the group of observations for which the country does not enter default over the following year and in Panel B we report statistics for those observations when the country does enter default over the following year. The sample corresponds to the sample used for logit regressions in Table V.

	Volatility of terms of trade	Change in terms of trade	Years since last default	Debt/GDP	Reserves/GDP
		Panel A: Non-default observations (not in default next period)			
Mean	8.3	0.4	9.5	41.5	12.8
Median	7.3	−0.3	11	39.1	10.3
St. Dev.	5.5	15.9	2.9	19.6	8.4
Min	2.1	−31.6	1	12.4	1.6
Max	23.3	39.1	11	103.3	31.6
Number of observations: 695					
		Panel B: Default observations (in default next period)			
Mean	13.7	−1.1	7.5	57.9	9.3
Median	13.6	−3.5	11	57.4	5.5
St. Dev.	6.3	21.1	4.4	24.7	7.9
Number of observations: 28					

In order to investigate the predictive power of the explanatory variables more formally, we estimate a logit model relating a forward-looking default indicator to explanatory variables. Estimation results for different specifications are reported in Table V. We first consider a specification that includes volatility of terms of trade, the change in the terms of trade, and years since last default. Volatility of terms of trade and years since last default are significant at the 1% level. Next we include debt to GDP and reserves to GDP, which both enter with the expected sign and are significant at the 1% and 5% levels respectively. Volatility of terms of trade and years since last default remain significant at the 1% and 10% levels. Model fit measured by pseudo R^2 improves from 0.13 to 0.20.[21] Following our approach for estimating EMBI spread regressions, we also include two specifications in which we instrument for terms of trade. We find that model fit, coefficient magnitudes, and coefficient significance levels are comparable, except in the case of years since last default, for which the estimated coefficient decreases in magnitude and loses statistical significance. We refer to the model in column (3) as our main specification. It includes the country variables and control variables that correspond

[21] These results are consistent with independent work by Catão and Sutton (2002) and Catão and Kapur (2006) who also investigate empirical determinants of default in a reduced form hazard model setting that is similar to the specification reported in Table V. These authors do not, however, instrument for terms of trade.

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Table V. Reduced form default prediction

This table reports results from logit regressions of a forward looking default indicator on explanatory variables (1970–2007). The default indicator $Y_{i,t+1}$ is equal to one if country i goes into default during the next year $(t+1)$ and zero otherwise. Summary statistics for the sample are reported in Table IV. z-statistics are reported in parentheses. ** denotes significant at 1%; * significant at 5%; $^{+}$ significant at 10%.
Regression equation:

$$P\left(Y_{i,t+1}=1\right)=\left(1+\exp\left(-\alpha-\beta_1 vol\_tot-\beta_2 chg\_tot-\beta_3 ytd-\beta_4\frac{debt}{GDP}-\beta_5\frac{reserves}{GDP}-\varepsilon\right)\right)^{-1}$$

	(1)	(2)	(3)	(4)
Volatility of terms of trade (vol_tot)	0.141	0.138	0.140	0.114
	(4.61)**	(2.67)**	(4.39)**	(1.77)$^{+}$
Change in terms of trade (chg_tot)	−0.006	−0.005	0.010	0.002
	(0.63)	(0.13)	(0.86)	(0.04)
Years since last default (ytd)	−0.155	−0.065	−0.102	−0.017
	(3.19)**	(1.12)	(1.90)$^{+}$	(0.28)
Debt/GDP			0.038	0.033
			(3.73)**	(2.95)**
Reserves/GDP			−0.068	−0.102
			(2.14)*	(2.18)*
Constant	−3.40	−3.69	−4.95	−4.45
	(5.93)**	(4.86)**	(5.04)**	(4.36)**
Instrument for terms of trade		X		X
Number of observations	723	541	723	541
Number of defaults	28	24	28	24
Pseudo R^2	12.8%	11.6%	20.5%	21.7%
Accuracy ratio	76.7%	77.5%	83.3%	84.7%

to the main specification in Table III.[22] To get a sense of economic significance we compute the proportional change of the predicted default probability comparing the case when all explanatory variables are equal to their mean values to the case where we set each variable individually equal to one sample standard deviation above its mean. This leads to an increase in the default probability of 114% for volatility of terms of trade and 110% for debt to GDP and a decrease in default probability of 26% for years since last default and 43% for reserves to GDP.

[22] In principle, we could consider additional explanatory variables that predict default in the sample we consider. However, because of the sample size and the rather small number of default observations, we choose only the country variables and control variables included in our main spread regression specification.

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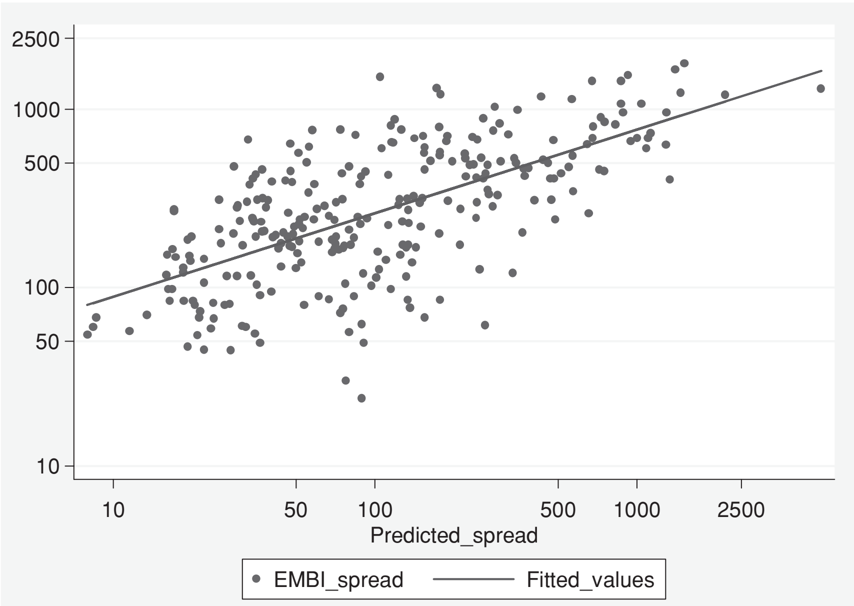

Figure 3. Actual and predicted spreads
This graph plots EMBI spreads (from J.P. Morgan, end-of-year spread over U.S. Treasuries) against out-of-sample predicted spreads using the logit model from Table V to calculate fitted probabilities of default.

4.1 OUT-OF-SAMPLE COMPARISON OF PREDICTED AND EMBI SPREADS

We next calculate predicted spreads using fitted default probabilities from the hazard model and compare these to observed EMBI spreads. We assume that recovery rates are fixed, i.e. that creditors receive a constant fraction of face value in the event of default. We set the fractional recovery rate equal to 0.6 which is broadly in line with the average historical experience (Sturzenegger and Zettelmeyer, 2005).[23] We compute the default component of the spread by discounting the expected payoff at the riskfree rate and calculate predicted spreads using fitted probabilities from our main specification in column (3) of Table V. We estimate the model using data up to 1993 and then calculate fitted default probabilities for the period 1994 to 2007.

We compare out-of-sample predicted spreads to actual spreads and ask how much of the level and variation in EMBI spreads is due to country default probabilities. Figure 3 plots actual against predicted spreads. We notice a strong positive relation which is reflected in a correlation of 0.65.

[23] Panizza et al. (2008) provide a comprehensive discussion of the legal aspects of sovereign debt and default.

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Table VI. Comparing actual and out-of-sample predicted spreads

This table reports results of comparing actual to predicted spreads. Panel A reports summary statistics for EMBI spreads and predicted spreads. The sample corresponds to the spread regression sample of Table III. Panel B reports estimates from regressions of EMBI spreads on predicted spreads. To control for outliers, predicted spreads are winsorized, which results in replacing the two largest and the two smallest spread observations. *t*-statistics (reported in parentheses) are calculated using standard errors which are robust and clustered by year. ** denotes significant at 1%; * significant at 5%; + significant at 10%.

Regression equation (Panel B):

$$spread = \alpha + \beta_1 spread\_pred + \beta_2 VIX + \beta_3 DEF + \beta_4 r\_10year + \beta_5 TED + dummies + \varepsilon$$

Panel A: Summary statistics of predicted spreads and default probabilities

	EMBI spread	Predicted spread
Mean	376	229
Median	265	87
St. Dev.	328	426
p5	60	17
p95	1072	941
Observations: 276		

Panel B: Regression of actual on predicted spreads

	(1)	(2)	(3)	(4)	(5)
Predicted spread (spread_pred)	0.72	0.67			0.41
	(10.70)**	(9.49)**			(4.56)**
GLOBAL VARIABLES					
VIX index (VIX)		10.4	15.2	15.1	12.6
		(2.70)*	(3.67)**	(3.63)**	(3.39)**
Default yield spread (DEF)		1.0	1.6	1.4	1.0
		(1.45)	(1.65)	(1.51)	(1.38)
Treasury 10-year yield (r_10year)		0.31	0.68	0.81	0.56
		(1.32)	(1.79)+	(2.23)*	(2.21)*
TED spread (TED)		0.13	−0.74	−0.81	−0.34
		(0.20)	(1.11)	(1.20)	(0.58)
CONTROL VARIABLES					
Credit rating				X	X
Constant	222.9	−225.4	−379.4	−616.2	−505.6
	(7.18)**	(1.77)+	(1.82)+	(2.87)*	(3.57)**
Number of observations	276	276	269	269	269
Adjusted R^2	44.8%	49.0%	13.2%	52.3%	61.3%

Table VI Panel A reports summary statistics for EMBI spreads and predicted spreads. The sample contains spread observations from 31 countries over the period 1994 to 2007 and corresponds to the regression sample used in Table III. Predicted spreads are smaller than actual spreads: the median predicted spread is equal to

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87 basis points, compared to a median EMBI spread of 265 basis points. This difference reflects non-default spread components, to which we return later in this section.

We check more formally how much of the variation in spreads is explained by variation in default risk by regressing EMBI spreads on predicted spreads and global variables. Predicted spreads have some extreme values. In order to control for outliers we winsorize predicted spreads. As a result of this winsorization the in-sample standard deviation is reduced from 426 to 307 and the kurtosis is reduced from 64 to 9. We report regression results in Table VI Panel B. We first include only predicted spreads. The regression coefficient is 0.72, which is statistically significant at the 1% level; the R^2 is 0.45. This is a surprisingly high level of explanatory power, keeping in mind that our model estimation does not use as inputs any of the observed spreads it is attempting to explain. For comparison, our main specification in Table III explains 62% of the variation.

We next investigate the effect of adding global variables and credit ratings. When we add the four time series variables (column (2)), the VIX index enters with a positive coefficient and is statistically significant while the other time series variables are not significant. Adding global variables increases the adjusted R^2 by 0.04. However, we again find that predicted spreads contain important information not captured by global variables: including only global variables delivers a much lower adjusted R^2 of 0.13 (column (3)). Predicted spreads also contain information relative to credit ratings. Predicted spreads enter significantly when we include them together with credit ratings (column (5)) and increase the adjusted R^2 by 0.09.

We explore if there is variation across different levels of credit risk in the fraction of the spread that is explained by default risk. We group spreads by their estimated default probability and compare average observed and fitted spreads across groups. We choose break points using the distribution of fitted probabilities from the regression sample (1994 to 2007). Figure 4 plots average EMBI spreads and predicted spreads by default probability quintiles. We find that fitted spreads for good credit are much smaller than observed spreads while for poor credit predicted and observed spreads are more similar in magnitude. These findings are consistent with patterns in the corporate bond market. Huang and Huang (2003) show that spreads implied by structural form models are far too low on companies of good credit quality but they are closer to actual spreads for companies of poor credit quality.

Comparing means of observed and model implied spreads in Table VI Panel A or in Figure 4 shows that a large component of the spread is not explained by our model. This finding is not surprising given that we only estimate the default component of the spread. It is related to several studies that investigate non default-risk spread components in the sovereign and corporate bond markets. Hund and Lesmond

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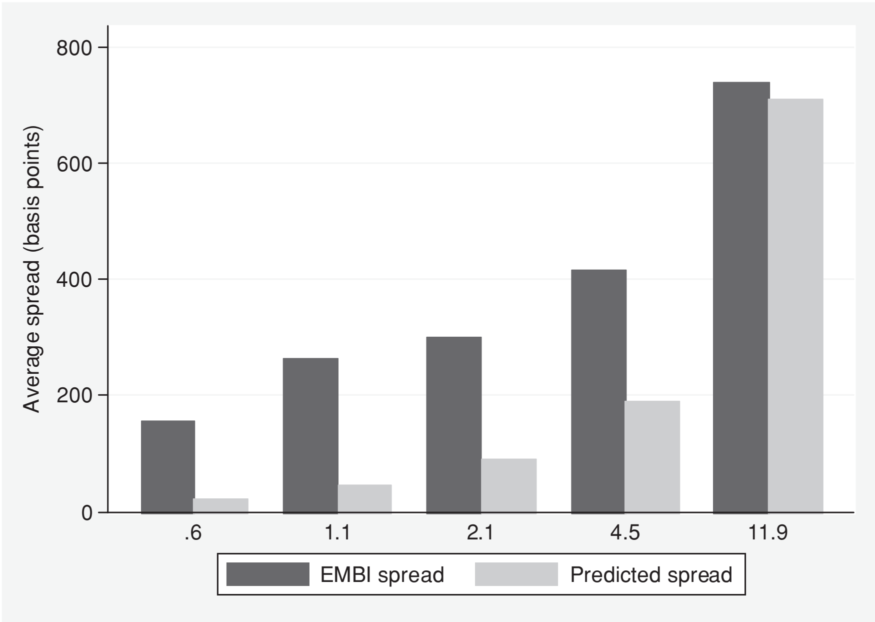

Figure 4. Spreads by average default probability
This graph plots average EMBI spreads (from J.P. Morgan, end-of-year spread over U.S. Treasuries) and predicted spreads by fitted default probability quintiles. We report the average default probability for each quintile on the horizontal axis. The sample used corresponds to that in Table VI.

(2007) provide evidence that a significant part of the spread on emerging market corporate and sovereign debt may be explained by liquidity. Borri and Verdelhan (2008), Martell (2008), Remolana et al. (2008), and Andrade (2009) also investigate non-default risk determinants of spreads in the sovereign bond market.[24]

To summarize, we find that predicted spreads have significant explanatory power for observed sovereign spreads. The default component of spreads explains variation in observed spreads surprisingly well and the fraction of the spread due to default risk is much larger for borrowers of lower credit quality.

[24] For risky corporate bonds, Huang and Huang (2003) find that default risk accounts for only part of the spread. Elton et al. (2001) document important spread components related to liquidity, risk aversion, and taxes. Chen et al. (2007) present evidence that liquidity is priced in U.S. corporate bonds. Longstaff et al. (2005) find that the majority of the U.S. corporate default swap spread is explained by default risk and that the non-default component is time-varying and closely related to measures of liquidity.

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5. Conclusion

In this paper we provide evidence that variation in country fundamentals explains a large share of the variation in emerging market sovereign debt prices for a set of 31 countries over the period 1994 to 2007. In a departure from the existing empirical literature on sovereign debt we pay special attention to the volatility of fundamentals. In particular we find that the volatility of terms of trade is both statistically and economically significant in explaining spread variation. A one standard deviation increase in the volatility of terms of trade is associated with an increase of 164 basis points in spreads, which corresponds to around half of the standard deviation of observed spreads. The explanatory power of changes in terms of trade and volatility of terms of trade is substantial, even after controlling for global factors and sovereign credit ratings. It is robust to instrumenting for terms of trade with commodity price indices.

We also analyze the empirical link between default probabilities and sovereign debt prices. We estimate a hazard model using historical data on measures of fundamentals and default and we find that the volatility of terms of trade is also an important predictor of country default. We calculate spreads implied by our default prediction model and find that the model implied default component of spreads explains a large share of the variation in observed spreads out-of-sample. The model fits better for borrowers of lower credit quality.

The findings in this paper have implications for investors and policymakers. We have identified factors explaining variation in spreads across countries and over time. Countries with larger fluctuations in their terms of trade, possibly due to concentrated exports in commodities with volatile prices, are more susceptible to external shocks. They may find it beneficial to address such risk factors in order to reduce borrowing costs as well as the probability of a crisis or default. In particular, countries could try to explicitly hedge exposures to macroeconomic shocks in international financial markets. Caballero (2003), Shiller (2003), Merton (2005), and a recent report by the Inter-American Development Bank (IDB report, 2006) advocate the use of innovative financial contracts to share these macroeconomic risks more effectively.

Appendix

J.P. Morgan's EMBI includes U.S. dollar denominated Brady bonds, loans, and Eurobonds issued or guaranteed by emerging market governments. Countries need to be classified as low or middle income by the World Bank for the last two years, have restructured debt in the past 10 years, or have restructured debt outstanding. The minimum issue size for a debt instrument is U.S. dollar 500 million, it needs to

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have a maturity greater than 2.5 years, verifiable daily prices and cash flows, and it has to fall under G7 legal jurisdiction.[25]

The Commodity Research Bureau (CRB) commodity index series is from Global Financial Data. According to the CRB, the index includes energy (crude oil, heating oil, natural gas), grains and oilseed (corn, soybeans, wheat), industrials (copper, cotton), livestock (live cattle, live hogs), precious metals (gold, platinum, silver), softs (cocoa, coffee, orange juice, sugar).[26]

We use annual terms of trade data provided by the Development Data Group at the World Bank. Terms of trade indices are constructed as the ratio of an export price index to an import price index. The underlying price and volume indices are compiled by the United Nations Conference on Trade and Development (UNCTAD).

Our measure of government external debt is from the World Bank Global Development Finance data set. GDP data are from the International Monetary Fund World Economic Outlook. Reserves refers to the Total Reserves Including Gold series from the World Development Indicators.

Our commodity price index is constructed using data on export shares from COMTRADE and commodity prices from Global Financial Data. The SITC codes corresponding to the 12 components of our index are oil (33), coffee (071), textiles (65), copper (682), cotton (263), cocoa (072), meat (011), bananas (0573), leather (61), gold (97), gas (34), silver (681). The commodity price change is calculated as the weighted average price change of the 12 price series included in the index, where the weights are the annual export shares for the country.

The 10-year U.S. Treasury yield and the 3-month Treasury Bill rate are from the Federal Reserve Bank of St. Louis. 3-month Libor is from Global Insight. Yields on Aaa and Baa U.S. corporate bonds are from Global Financial Data. The VIX measure of volatility of the S&P500 index is provided by the Chicago Board Options Exchange.

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[25] Source: *Emerging Markets External Debt Handbook for 2002–2003*, J.P. Morgan.

[26] Source: documentation describing CRB Commodity Index in Global Financial Data.

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