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Sovereign default and macroeconomic tipping points

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Abstract

This paper examines the impact of macroeconomic fundamentals on the probability of sovereign default and the probability of exit from default while allowing explicitly for model uncertainty. Model uncertainty is addressed by employing Bayesian model-averaging techniques, averaging over a very large number of different empirical models that each endeavour to explain entry to and exit from periods of sovereign default for defaulting countries over the period 1975 to 2010. Default probabilities are estimated and then used to price sovereign bond spreads. Key findings are: (i) large budget deficits and high interest payments on external debt represent key macroeconomic tipping points for sovereign default; (ii) for exiting periods of default, reducing public debt matters most. These results are robust to both narrow and wide definitions of sovereign default and, due to use of model-averaging techniques, robust to model uncertainty.

Keywords: Sovereign default, risk, model uncertainty.
JEL Classification: E62, F34, G12, G13, G15.

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Non-technical summary

While debt crises and defaults by sovereign states have been occurring for centuries, the prospect of a mature economy defaulting on its sovereign debts has in recent decades been variously neglected, ignored, assumed negligible or considered simply not possible by politicians, academics, bankers and financial experts. To some extent this is understandable (though not excusable). Before Greece in 2012, the last sovereign default of a major European country was Germany in 1948.[1] Memories, especially in finance, are short. But with Europe currently in crisis and risk-aversion around the world escalating higher it is important for policymakers to be able to gauge which countries are vulnerable to sovereign default and why. Econometric models that offer predictive power are essential not just to aid crisis management but also to inform national and supranational macroprudential policy in aiming to prevent, or at least reduce vulnerability to, future defaults.

This paper examines the extent to which variation in a country's macroeconomic characteristics can help predict that country's probability both of defaulting on its sovereign debts and of exiting a period of sovereign default. Main findings are threefold: (i) large budget deficits and high interest payments on external debt represent key macroeconomic tipping points into sovereign default; (ii) for exiting periods of default, reducing public debt matters most; (iii) the default content of sovereign bond spreads increases with the probability of default.

Perhaps the most important of these results is the finding that *fiscal* health is key to both default and exit from default: fiscal illiquidity in the form of a large general government budget deficit is a common tipping point for default while fiscal solvency, in the form of a smaller government debt burden, is key for exiting default. These findings are new in the sense that while many theoretical models stress a role for fiscal variables in the determination of sovereign default, no empirical studies, as far as the author is aware, stress a similar importance.

Another important conclusion is that in terms of the macroeconomic *tipping points* of sovereign default what matters most is not solvency but liquidity. More precisely, while measures of external and fiscal solvency may offer important signalling information on the susceptibility of a country to default, the regularity and anticipatory strength of these signals are inconsistent and more consistent signals, in terms of one-year-ahead predictive power, are offered by flow variables: the budget deficit and interest payments on external debt.

[1] Russia defaulted on its domestic debt and declared a 90-day moratorium on payments by commercial banks to foreign creditors in 1998.

1 Introduction

This paper examines the extent to which variation in a country's macroeconomic characteristics can explain that country's probability both of defaulting on its sovereign debts and of exiting a period of sovereign default. Eighteen macroeconomic characteristics are considered for a pooled database that includes 32 defaulting countries over the period 1975 to 2010. Results are robust to discrepancies in the dating of past episodes of sovereign default and, due to use of Bayesian model-averaging techniques, robust to model uncertainty.

While debt crises and defaults by sovereign states have been occurring for centuries, the prospect of a mature economy defaulting on its sovereign debts has in recent decades been variously neglected, ignored, assumed negligible or considered simply not possible by politicians, academics, bankers and financial experts. To some extent this is understandable (though not excusable). Before Greece in 2012, the last sovereign default of a major European country was Germany in 1948.[2] Memories, especially in finance, are short. But with Europe currently in crisis and risk-aversion around the world escalating higher it is important for policymakers to be able to gauge which countries are vulnerable to sovereign default and why. Econometric models that offer predictive power are essential not just to aid crisis management but also to inform national and supranational macroprudential policy in aiming to prevent, or at least reduce vulnerability to, future defaults.

Current wisdom on what causes sovereign states to default on their external obligations draws on two strands of research: (i) empirical studies of the determinants of sovereign default and (ii) theoretical models. Theoretical models of sovereign default suggest a broad range of influencing factors such as reputational (Eaton and Gersovitz, 1981; Grossman and Huyck, 1988), global (Guimaraes, 2008), fiscal (Hatchondo et al., 2012), cyclical (Arellano, 2008; Kovrijnykh and Szentes, 2007; Mendoza and Yue, 2011), political (Cuadra and Sapriza, 2008; Foley-Fisher, 2012), and internal in the sense that governments may face an incentive to default if they are unable, due to inadequate bankruptcy legislation, to lay claim to the assets of domestic, private-sector borrowers who default on their own debts (Arellano and Kocherlakota, 2008).

Empirical studies, meanwhile, come to conclusions that can be equally diverse and difficult to interpret. While Kraay and Nehru (2006), for instance, find that those macroeconomic characteristics with the biggest impact on the probability of sovereign default are external liquidity, external solvency and GDP growth, Tomz and Wright (2007) find that growth is not that important—countries have defaulted when output was relatively low but some have also defaulted when their domestic economies were healthy. Detragiache and Spilimbergo (2001) find that external solvency, liquidity, overvaluation and openness are important. Manasse et al. (2003) and Manasse and Roubini (2009), meanwhile, find a wide range of factors have important conditional effects on sovereign debt crises including short-term external debt, interest payments on external debt, the current-account balance, reserves growth, the US Treasury bill rate, real GDP growth, inflation, the exchange rate, openness and the number of years before a presidential election. Bandiera et al. (2010) find that just one macroeconomic factor, the level of indebtedness, is required for adequate

[2]Russia defaulted on its domestic debt and declared a 90-day moratorium on payments by commercial banks to foreign creditors in 1998.

predictive power of default. Catao and Sutton (2002) and Hilscher and Nosbusch (2010) provide evidence suggesting that macroeconomic volatility is the biggest determinant of default while Reinhart and Rogoff (2010) suggest that other significant determinants may include default history (a country that has defaulted recently will be more likely to default again) and the global capital cycle.

That empirical studies offer such an unhelpful surfeit of suggested and sometimes conflicting determinants of sovereign default may be due to a number of factors. First, common determinants may simply not exist. That is, perhaps there are no common, consistent determinants of sovereign default, just a complex array of changing and highly conditional circumstances that can, sometimes, cause a country to default on its sovereign bonds (Manasse and Roubini, 2009). Second, perhaps different empirical studies come to different conclusions about the determinants of default because they are not attempting to explain the same thing: some studies seek to explain sovereign *default* (Hilscher and Nosbusch, 2010), some sovereign debt *crises* (Manasse et al., 2003), and some periods of sovereign debt *distress* (Kraay and Nehru, 2006). These events can be quantitatively and temporally different, so it is not surprising that conclusions can be inconsistent. Third, the findings of empirical studies may conflict due to *model uncertainty*. That is, results may differ because different researchers are attempting to explain sovereign default using different sets of explanatory variables, some common, some not, and most representing at best only a fraction of the total number of potential explanatory factors. Each researcher specifies just one set of explanatory variables (or in the jargon, just one *model*). Uncertainty surrounding model specification is, as a consequence, ignored, and results will be incorrect because they underestimate uncertainty about the quantities of interest (Raftery, 1995).

This paper addresses directly both model uncertainty and the issue of sensitivity to the definition of default. Definitional sensitivity is tackled by focusing firmly on sovereign default rather than episodes of arbitrarily-defined crisis or distress. Further, results are tested for their robustness to multiple definitions of default, from narrow definitions used by credit-rating agencies to the broader definitions used in academic research. Model uncertainty, meanwhile, is addressed by employing *Bayesian model averaging*.

Bayesian model averaging is a technique used to take account of uncertainty about the correct specification of a model and to ensure that this uncertainty is incorporated into any inferences made about the quantities of interest, which are, here, the macroeconomic determinants of sovereign default. Given that different researchers have used a variety of different sets of explanatory variables (models) to arrive at estimates of the determinants of sovereign default, model uncertainty is a problem. Bayesian model averaging, at its simplest, is a way of accounting for model uncertainty by averaging results from all conceivable models—that is, from all possible combinations of the potential explanatory variables—and weighting those results according to a Bayesian updating rule.[3] The advantage of Bayesian model averaging is that it allows us to determine quickly which models (sets of explanatory variables) possess high likelihoods. Final estimates incorporate information from all models but the impact of information provided by models with low likelihoods shrinks towards zero due to the Bayesian model weights. Raftery (1995) offers a seminal discussion of Bayesian model averaging as a statistical device while Fernandez et al. (2001) present the

[3]For an introduction to Bayesian probability and Bayesian econometrics see Koop (2003).

first application of the technique in the field of economics.

This paper is closest in terms of method to the model-averaging approach used by Bandiera et al. (2010) and, for its analysis of the default content of sovereign bond spreads, draws on the work of Hilscher and Nosbusch (2010). In terms of intent, this paper endeavours to act as a counterpoint to the work of Manasse and Roubini (2009) who focus on the conditionality of the determinants of sovereign default. This paper focuses not on conditionality but on finding what few common, consistent determinants can found to exist: in short, the focus is on common macroeconomic *tipping points*.

The key contributions of this paper to the existing literature can be summarised as follows. First, the focus is on sovereign default rather than, as in most research, general sovereign distress. Second, given this focus on sovereign default, allowance is made for rival definitions of default and discrepancies in the dating of default. Third, this paper assesses the macroeconomic determinants of *exit* from default. Fourth, explicit allowance is made for model uncertainty and, over and above the approach taken to model uncertainty by Bandiera et al. (2010), this paper provides visual representations of posterior distributions for coefficient estimates, summary results for those models with the highest posterior model probabilities and a performance comparison with classical estimation techniques.

Main findings are threefold: (i) large budget deficits and high interest payments on external debt represent key macroeconomic tipping points into sovereign default; (ii) for exiting periods of default, reducing public debt matters most; (iii) the default content of sovereign bond spreads increases with the probability of default, in line with the results of (Hilscher and Nosbusch, 2010).

Perhaps the most important of these results is the finding that fiscal health is key to both default and exit from default: fiscal illiquidity in the form of a large general government budget deficit is a common tipping point for default while fiscal solvency, in the form of a smaller government debt burden, is key for exiting default. These findings are new in the sense that while many theoretical models stress a role for fiscal variables in the determination of sovereign default (Hatchondo et al., 2012), no empirical studies, as far as the author is aware, stress a similar importance.

Another important conclusion is that in terms of the macroeconomic *tipping points* of sovereign default what matters most is not solvency but liquidity. More precisely, while measures of external and fiscal solvency may offer important signalling information on the susceptibility of a country to default, the regularity and anticipatory strength of these signals are inconsistent and more consistent signals, in terms of one-year-ahead predictive power, are offered by flow variables: the budget deficit and interest payments on external debt.[4]

The rest of this paper is organised as follows. Section 2 discusses the estimation approach. Section 3 explains the data while Section 4 presents the results. Section 5 offers some conclusions.

[4]Indeed, many sovereign defaulters in the past defaulted at relatively low levels of external debt, not least Pakistan (1980, 1998), Mexico (1982), Argentina (1982, 2001), Peru (1976, 1983), Turkey (1978, 1982), Ukraine (1998, 2000), Dominican Republic (1975, 1981), Paraguay (1986, 2003), Venezuela (1983), South Africa (1989, 1993), Russia (1998) and Uruguay (1983).

2 Method

This section discusses the issue of model uncertainty and outlines the use of Bayesian model averaging as a means of accounting for model uncertainty in estimation and inference.

Uncertainty about model specification can be high in economic research. The correct specification is rarely apparent. Which explanatory variables should be included in the specification? Which variables should be excluded? Classical statistical methods offer little guidance on how to deal with this uncertainty and, as a consequence, researchers tend to opt for a single set of preferred explanatory variables guided mostly by strong priors and pre-ordained research agendas, producing results that are fragile, vulnerable to incorrect inference (coefficient estimates in effect assume the data favour just one set of explanatory variables) and that by design understate the uncertainty surrounding the estimated effects of the included variables (Leamer, 1978). In short, ignoring model uncertainty amounts to ignoring potentially important information embedded in other plausible specifications.[5]

Empirical studies of sovereign default are far from immune to model uncertainty. Numerous rival models have been proposed.[6] Bayesian model averaging offers a way of dealing with model uncertainty in a manner that is transparent in terms of assumptions, efficient in the sense that it uses information provided by all conceivable models, and correct in as much as it generates standard errors that account explicitly for uncertainty about the correct model. Bayesian model averaging allows us to assess the robustness of results to alternative specifications by calculating *posterior* distributions for all coefficients over all rival models. A posterior distribution summarises current knowledge of all uncertain quantities and is the mathematical product of a *prior*, which reflects our uncertainty about all quantities before viewing the data, and a *likelihood*, which indicates how well each model explains the data (Koop, 2003).

Consider, for instance, a linear model, with dependent variable Y, an n by p matrix X containing p independent variables, coefficients β and a normal, independent and identically distributed error term ε with variance σ^2 such that

$$Y = X\beta + \varepsilon \qquad \varepsilon \sim N(0, \sigma^2 I) \tag{1}$$

Difficulties arise when there are many alternative variables to include in X. Which set of variables $X_\gamma \in \{X\}$ should be included? Which should be excluded? We may be uncertain about which is the correct model of all the $q = 2^p$ model specifications present in the model space $M = \{M_1, M_2, \ldots M_q\}$. Drawing inference from a single linear model that includes all independent variables p will be inefficient (or simply not feasible if the number of observations is too few). Bayesian model averaging deals with the problem of model uncertainty by estimating models for all possible combinations of X. Results are effectively a weighted average of all models. Given that X contains p variables, this means estimating 2^p models with the model weights given by posterior model probabilities.

[5] Within the classical statistical framework, stepwise variable selection is sometimes undertaken to determine the best model, but this approach is now generally understood to lead to a downward bias in estimated standard errors, an upward bias in the R-square measure of model fit, and incorrect probability values (Harrell, 2001).

[6] For a survey of the literature see Panizza et al. (2009).

If we let D represent the data y and X then the the posterior distribution for any coefficient β_h, given the data D, is given by

$$p(\beta_h|\ D) = \sum_{\gamma=1}^{q} p(\beta_h|\ M_\gamma, D)p(M_\gamma|\ D) \tag{2}$$

The posterior distribution for β_h is therefore an average of the posterior distributions for each β_h for each considered model M_γ, weighted by the posterior *model* probability of each respective model. That is, for any given model, Bayesian model averaging uses that model's posterior probability, $p(M_\gamma|\ D)$, to weight the coefficient estimated by that model.

The posterior *model* probability $p(M_\gamma|D)$ is the posterior probability that M_γ is the correct model given that one of the models considered is correct, and can be shown, using Bayes' Theorem, to be equal to the prior model probability $p(M_\gamma)$ multiplied by the ratio of the marginal likelihood of model M_γ to the sum of the marginal likelihoods for all models, such that

$$\begin{aligned} p(M_\gamma|\ D) &= p(M_\gamma)\frac{p(D|\ M_\gamma)}{p(D)} \\ &= p(M_\gamma)\frac{p(D|\ M_\gamma)}{\sum_{\iota=1}^{q} p(D|\ M_\iota)p(M_\iota)} \end{aligned} \tag{3}$$

where the marginal likelihood $p(D|\ M_\gamma)$ is obtained by integrating over the unknown parameters, expressed formally as

$$\begin{aligned} p(D|\ M_\gamma) &= \int (\text{prior x likelihood}) d\beta^\gamma \\ &= \int p(\beta^\gamma|M_\gamma)p(D|\ \beta^\gamma, M_\gamma) \end{aligned} \tag{4}$$

In Eqn.4, β^γ is the vector of coefficients in model M_γ and $p(D|\ \beta^\gamma, M_\gamma)$ is the likelihood of β^γ under model M_γ.

The marginal likelihood $p(D|M_\gamma)$ is calculated using a Bayesian information criterion approximation

$$\begin{aligned} 2\log p(D|\ M_\gamma) &\approx 2\log p(D|\ \hat{\beta}^\gamma) - d_\gamma \log(n) \\ &= -\,\text{BIC}_\gamma \end{aligned} \tag{5}$$

where $d_\gamma = dim(\beta^\gamma)$ is the number of independent parameters in M_γ, and $\hat{\beta}_\gamma$ is the maximum likelihood estimator. Hoeting et al. (1999) offer computational details and further discussion on Bayesian model averaging.

2.1 Modelling probabilities

It remains necessary to specify an appropriate functional form for the desired probabilistic model of sovereign default. This section discusses the implementation of Bayesian model

averaging in the context of this paper's primary aim of assessing the macroeconomic determinants of sovereign default.

Using past annual data on sovereign defaults the conditional probability of a country defaulting in the subsequent year is estimated using a logistic model of default in the spirit of Shumway (2001) with model averaging employed to account for model uncertainty. The unit of observation is a country-year with parameters estimated using the pooled country-year observations.

Let $y_{i,t+1}$ be a binary variable indicating whether country i defaults on its sovereign debts in year $t+1$, in which case $y_{i,t+1} = 1$, or whether it does not default, in which case $y_{i,t+1} = 0$. Also let X be all variables proposed as having significant explanatory power over y, with $X_\gamma \in \{X\}$ representing any subset of regressors (that is, representing any nested *model*). Then a probabilistic model of sovereign default can be represented as

$$p(y = 1|X_\gamma) = F(X_\gamma \beta) \tag{6}$$

where F can be any probability function determined by a distributional assumption on the error term. Here it is assumed to be the logistic function.

Bayesian model averaged parameter estimates are obtained within the logisic framework using Eqn.2 with parameter estimates being averaged over all 2^p models. Priors for parameters and models are set to be flat—alternatively termed *equiproportional*—in the sense that they allocate equal weight to all rival parameters and models.

Computationally the implementation of Bayesian model averaging involves overcoming two burdensome calculations (Hoeting et al., 1999). First is the computation of marginal likelihoods for all models in Eqn.4. Second, averaging needs to be done over all models where the number of models may be very large—thirty predictors, for instance, corresponds to one billion possible models (2^{30}). Here, Bayesian model averaging is undertaken using the programming environment, *R*. Marginal likelihoods are approximated using a Bayesian information criterion (Raftery, 2005) while summation over all models is approximated by finding the best models using the *leaps and bounds algorithm* (Raftery, 1995). Models that are less likely *a posteriori* than the best model are excluded.

3 Data

This section presents an overview of the data, describing the dataset of default episodes and macroeconomic data.

In order to assess the power of macroeconomic characteristics in explaining sovereign default a dataset is assembled covering the years 1975 to 2010 for 32 countries. Table 1 lists all defaulting countries in the sample. For these defaulting countries and for non-defaulting countries this paper compiles also, for the sample period 1975 to 2010, various measures of macroeconomic health that can be usefully classified into five groups:

Domestic: Country-specific measures of *domestic* macroeconomic health include GDP per capita, real GDP growth, real GDP per capita growth, inflation, broad money, private sector credit, the government budget balance and public debt. *External*: Country-specific measures of *external* economic health include the current-

Table 1: Defaulting countries included in sample

Africa	**Asia**	**Europe**	**Americas**
Cote D'Ivoire	Indonesia	Bulgaria	Argentina
Ethiopia	Jordan	Moldova	Bolivia
Ghana	Myanmar	Poland	Chile
Kenya	Pakistan	Romania	Dominica
Morocco	Philippines	Russia	Dominican Republic
Seychelles	Turkey	Slovenia	Honduras
South Africa		Ukraine	Mexico
			Panama
			Paraguay
			Peru
			Uruguay
			Venezuela

Notes: Table lists those countries included in the sample that have defaulted on their sovereign debts at some point during the period 1975 to 2010. Refer to the text for the definition of sovereign default.

account balance, terms of trade, nominal exchange rate and real effective exchange rate. *Global*: The global economic environment is represented by the US default yield spread (the spread between corporate bonds with a Moodys credit rating of Baa and Aaa), the US 10-year Treasury bond yield, the price of gold and the difference between the interest rates on US interbank loans and on US Treasury bills (the TED spread). *External Debt*: Gross external debt, interest payments on external debt, total external debt service, short-term debt and effective interest rate on external debt are included to account for the country-specific characteristics of external indebtedness. *Willingness to pay*: Openness, measured as total trade (Bulow and Rogoff, 1988), and years since default (Reinhart and Rogoff, 2004) are included in order to capture willingness to pay.

Macroeconomic data include author calculations but are drawn otherwise from a range of public data sources. Appendix Table 7 and Appendix Table 8 offer notes and information on sources while Table 2 lists those macroeconomic variables included in the sample and also provides summary statistics for the year preceding default and all other years. In order to ensure that outliers do not have a misrepresentative influence on results, data are winsorized. That is, values beyond the fifth and ninety-fifth percentiles are replaced with the fifth and ninety-fifth percentile values.

3.1 Definition of default

This section discusses the need to ensure robustness of results by allowing for rival definitions of default and discrepancies in the dating of default.

The identification of episodes of sovereign default is not uncomplicated. How,

Table 2: Summary statistics for years preceding default and all other years

	No default next year			Default next year		
Variable	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Years since default	737	7.0	3.6	45	7.2	3.5
Total exports plus total imports (% of GDP)	737	58.9	30.6	45	54.6	32.3
Current account (% of GDP)	737	-2.7	4.8	45	-3.1	5.2
GDP per capita (US$)	737	2,642	2,357	45	2,086	2,012
Gross external debt (% of GDP)	737	117.0	175.6	45	130.5	193.6
Private sector credit (% of GDP)	737	31.8	20.9	45	31.3	22.1
Interest payments on external debt (% of GDP)	737	2.5	1.6	45	3.5	1.9
Total external debt service (% of GDP)	737	6.5	3.4	45	7.7	3.5
Short-term debt (% of total external debt)	737	14.9	9.4	45	15.0	9.7
Broad money (% of GDP)	737	40.5	21.8	45	39.3	21.5
Public debt (% of GDP)	737	59.1	32.3	45	67.4	34.3
Terms of trade, index (2000=100)	737	108.2	28.8	45	112.4	38.6
Real effective exchange rate (1997=100)	737	108	38	45	120	47
Budget balance (% of GDP)	737	-2.7	3.1	45	-4.7	3.2
Effective interest rate on external debt (%)	737	4.7	2.6	45	5.5	3.3
Inflation, consumer prices (%)	737	21.4	27.4	45	19.2	23.5
GDP, growth (%)	737	3.6	4.2	45	1.9	4.2
GDP per capita, growth (%)	737	2.0	4.3	45	0.2	4.2
Global						
US default yield spread	737	1.0	0.4	45	1.2	0.5
Global liquidity (TED spread)	737	0.7	0.7	45	1.2	1.1
Global interest rates (US 10-year Treasury)	737	6.9	2.5	45	8.9	3.2
Gold price	737	404.7	141.5	45	404.4	112.7

Notes: Table reports summary statistics for defaulting countries in the year prior to default and all other years. Data are winsorized at the fifth and ninety-fifth percentile values. Years since default counts the number of years since the last year in which the country was in default. It is capped at 10 and is equal to zero if the country is in default. Trade is total exports plus total imports. GDP per capita is measured in US dollars. US Treasury bond yields are measured in percentage points. The price of gold is in US dollars per troy ounce.

exactly, do we define *default*? A refusal by a sovereign to pay coupon payments to holders of the debt it has issued would seem to qualify as a default. But what about a restructuring of sovereign debt that bondholders accept voluntarily? What if a sovereign were to lapse temporarily into arrears on its debts? What if it simply rescheduled its coupon payments?

Credit-rating agencies, such as Standard and Poor's, Moody's and Fitch Ratings, take a relatively narrow view when categorising episodes of default. Standard and Poor's, for instance, defines default as the failure to meet a principal or interest payment on the due date contained in the original terms of a debt issue. More specifically:

> Standard & Poor's defines default as the failure to meet a principal or interest payment on the due date contained in the original terms of a debt issue. Questions can arise, however, when applying this definition in different situations and to different types of sovereign obligations. Standard & Poor's considers a sovereign to be in default under any of the following circumstances: (i) For local- and foreign-currency bonds, notes, and bills issued by the central government and held outside the public sector of the country, a sovereign default occurs when the central government either fails to pay scheduled debt service on the due date or tenders an exchange offer of new debt with less-favorable terms than the original issue. (ii) For local currency issued by the central bank, a sovereign default takes place when notes are converted into a new currency of less-than-equivalent face value. For private-sector bank loans incurred by the central government, a sovereign default occurs when the central government either fails to pay scheduled debt service on the due date or negotiates with the bank creditors a rescheduling of principal or interest at less-favorable terms than in the original loan. (Standard and Poors, 2010)

It is useful to ask whether this definition of default is unhelpfully *narrow*? More specifically, do narrow definitions of sovereign default fail to account for a lot of de-facto defaults? There is some justification for thinking so. Perhaps the narrowest definition of default is the legal definition that holds within a debt contract. As highlighted by Miller et al. (2006), modern bonds typically include a range of contractual provisions regarding grace periods and cross-default conditions which allow the fiscal agent for the bond, or alternatively the creditors holding the bond, to *declare* when a bond is in default. However, defaults do not always come with a declaration of default. Creditors may fail to give a declaration even when provisions in the bond contracts have not been met.[7] Also, a bond may be restructured in advance of a missed payment, avoiding legal default but still reducing the value of the bond to its holders (Das et al., 2012).

Understandably, therefore, some researchers use a wider definition of default to gauge whether a sovereign state is making good on its debt obligations. Some, such as Detragiache and Spilimbergo (2001), Kraay and Nehru (2006) and Manasse et al.

[7]During the Latin American sovereign debt crises of the 1980s creditor banks were reluctant to declare a default because of concerns about prudential requirements for write-downs. Miller et al. (2006) offer further discussion.

(2003), leave behind the concept of default altogether and study periods of variously-defined *crisis* or *distress* which may, or may not, include episodes of default. The study of sovereign crises is of course a legitimate academic pursuit but it is the intention of this paper to concentrate, explicitly, on sovereign *defaults*.

For completeness this paper assesses the macroeconomic determinants of (i) sovereign default, (ii) sovereign debt restructurings and (iii) external sovereign debt crises. Sovereign default is defined according to Standard and Poor's as outlined above. Sovereign debt restructurings are defined according to Cruces and Trebesch (2011) while external sovereign debt crises are defined in line with Reinhart and Rogoff (2010). See Appendix A.1 for full definitions.

4 Results

This section presents results from an empirical assessment of the macroeconomic determinants of sovereign default, restructuring and crisis using Bayesian model averaging to account for model uncertainty. Estimated default probabilities are used to calculate predicted sovereign bond yields. Predicted yields are then compared with actual yields. Results are also presented from an examination of the macroeconomic determinants of exit from sovereign default.

4.1 Results: default, restructuring, crisis

This section assesses the macroeconomic determinants of sovereign default where default, in the base dataset, is defined according to Standard and Poors (2010). The base dataset contains information on 18 macroeconomic characteristics for 32 countries covering the period 1975 to 2010. Frequency of the data is annual. Default years account for 6% of the observations. With 18 potential explanatory variables there are more than two-hundred-and-sixty thousand possible models (2^{18}).

Table 3 outlines results from the application of Bayesian model averaging to the determinants of sovereign default. The column headed *Post Prob* shows the posterior probability that the variable is in the model. The column headed *Post Mean* shows the estimated posterior mean and the column headed *Post St Dev* shows the estimated posterior standard deviation for each variable. The subsequent columns show parameter estimates for the five models with the highest posterior model probabilities together with the number of variables they include, their associated Bayesian information criterion and their posterior probabilities.

Bayesian model averaging suggests that the most likely model of sovereign default, with the highest posterior probability of being the correct model among all alternatives, is Model 1 (which explains 29% of the total model posterior probability). This model also has the lowest Bayesian information criterion. Model 1 implies that periods of sovereign default can be adequately explained by an intercept and variation

Table 3: Bayesian model averaging the macroeconomic determinants of sovereign default

	Post. Prob (%)	Post. Mean	Post. St. Dev	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	100.0	-4.13	0.56	-4.20	-3.54	-4.86	-4.26	-4.10
Years since default	3.6	0.00	0.01	.	.	.	.	.
Total trade (%)	3.0	0.00	0.00	.	.	.	.	.
Current account (%)	2.5	0.00	0.01	.	.	.	.	.
GDP per capita (US$)	3.1	0.00	0.00	.	.	.	.	.
Gross external debt (%)	2.1	0.00	0.00	.	.	.	.	.
Private sector credit (%)	2.6	0.00	0.00	.	.	.	.	.
Int. payments on ext. debt (%)	79.0	0.23	0.14	0.27	.	0.28	.	0.28
External debt service (%)	6.4	0.00	0.03	.	.	.	.	.
Short-term debt (%)	2.3	0.00	0.00	.	.	.	.	.
Broad money (%)	2.8	0.00	0.00	.	.	.	.	.
Public debt (%)	2.5	0.00	0.00	.	.	.	.	.
Terms of trade, index	2.3	0.00	0.00	.	.	.	.	.
Effective ex. rate	11.8	0.00	0.00	.	.	0.01	.	.
Budget balance (%)	88.9	-0.15	0.07	-0.16	-0.20	-0.15	-0.20	-0.18
Int. rate on ext. debt (%)	12.0	0.01	0.04	.	.	.	0.14	.
Inflation (%)	8.7	0.00	0.00	.	.	.	.	-0.01
GDP, growth (%)	8.8	-0.01	0.02	.	.	.	.	.
GDP per capita, growth (%)	6.0	0.00	0.02	.	.	.	.	.
Number of variables				2	1	3	2	3
Bayesian information criterion				-4,872	-4,869	-4,868	-4,868	-4,868
Posterior model probability				0.294	0.055	0.042	0.034	0.033

Notes: Table shows estimation results for Bayesian model averaging over 2^{18} models of sovereign default (18 independent variables). The dependent variable is equal to one if the sovereign state defaults in the subsequent year and equal to zero otherwise. The column headed *Post Prob (%)* shows the posterior probability that the variable is in the model. The column headed *Post Mean* shows the estimated posterior mean and the column headed *Post St Dev* shows the estimated posterior standard deviation for each variable. The subsequent columns show parameter estimates for the best five models, together with the number of variables they include, their associated Bayesian information criterion and their posterior model probabilities. Here the best five models have a cumulative posterior probability of 0.49.

in just two macroeconomic characteristics: interest payments on external debt (as a share of GDP) and the budget balance (as a share of GDP).

Coefficient posterior probability estimates indicate a probability of 89% that the effect of the budget balance on sovereign default is *not zero*. This suggests that variation in the budget balance has significant explanatory power even when we allow for model uncertainty. Recall that posterior means (*Post Mean*), standard deviations (*Post St Dev*) and posterior effect probabilities (*Post Prob (%)*) for each variable incorporate model uncertainty directly. For instance, the averaged posterior distribution associated with the budget balance has 11% of its mass at zero. This has the effect of shrinking the coefficient estimate towards zero and also increases the standard deviation to account for model uncertainty.

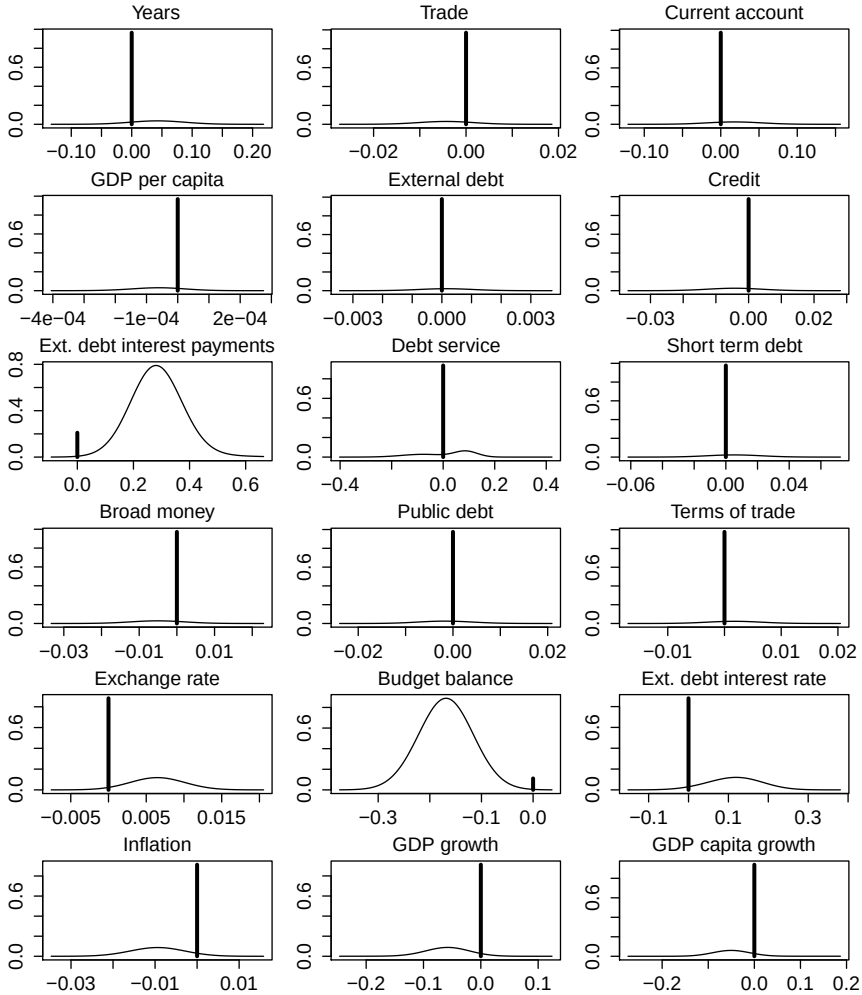
The second-most likely predictor of sovereign default is interest payments on external debt as a per cent of GDP. The posterior probability that interest payments on external debt have a non-zero effect on sovereign default is 79%. The estimated posterior mean is 0.23. If we exponentiate this we get an odds ratio that suggests that with every one-percentage-point increase in interest payments on external debt as a share of GDP, the odds of sovereign default in the subsequent year increase by around 25%. The estimated posterior mean for the budget balance is -0.15. For every one-percentage-point increase in the budget deficit as a share of GDP, the odds of sovereign default increase by 15%.

Posterior effect probabilities for all other variables are very low. For instance, the posterior effect probability for GDP per capita growth is just 6%. Put another way, with 94% of the mass of its posterior distribution at zero, we can say, in the Bayesian framework, that this is in fact evidence *against* GDP per capita growth having a non-zero effect on sovereign default.

Visually these results are displayed in Figure 1, which shows posterior distributions for all coefficients. In each individual plot the length of the vertical line at zero shows the posterior probability that the variable is *not* in the model. Each curve is a model-averaged posterior density of the coefficient given that the variable is in the model, approximated by a finite mixture of normal distributions, one for each model that includes the variable. The density is scaled so that its maximum height is equal to the probability of the variable being in the model. It is clear that the only variables with high posterior probabilities of being present in the true model of sovereign default are the budget balance and the interest burden on external debt.[8]

[8]Hilscher and Nosbusch (2010) find that the volatility of terms of trade has significant one-year-ahead predictive power for episodes of sovereign default. For completeness this paper also tests for significance of volatility of terms of trade but findings offer evidence against an effect. Results are presented in Appendix A.2. A caveat to these results is that, to incorporate the ten-year-lag required for the calculation of volatility, the sample size is necessarily reduced (by almost 20%), with defaults in the new sample accounting for just 3% of observations and the best model, Model 1, accounting for less than 1% of total model posterior probability. Model uncertainty is, in other words, very high.

Figure 1: Posterior distributions for model coefficients



Notes: Figure shows posterior distributions for all coefficients. The length of the vertical line at zero shows the posterior probability that the variable is *not* in the model. Each curve is a model-averaged posterior density of the coefficient given that the variable is in the model, approximated by a finite mixture of normal distributions, one for each model that includes the variable. The density is scaled so that its maximum height is equal to the probability of the variable being in the model. Abbreviations: Years since default (Years), total trade, % of GDP (Trade), current-account balance, % of GDP (Current Account), GDP per capita, gross external debt, % of GDP (External debt), private sector credit, % of GDP (Credit), interest payments on external debt, % of GDP (Ext. debt interest payments), total debt service, % of GDP (Debt service), short-term debt, % of total external debt (Short term debt), broad money, % of GDP (Broad money), terms of trade, index (Terms of trade), real effective exchange rate, index (Exchange rate), general government budget balance % of GDP (Budget balance), effective interest rate on external debt, % (Ext. debt interest rate), consumer-price inflation, % (Inflation), GDP growth, % (GDP growth), GDP per capita growth, (%).

Table 4: Comparing stepwise p-values and posterior effect probabilities

	p-value	Posterior prob. (%)
Dependent variable: default indicator		
Budget balance (% of GDP)	0.001***	88.9
	(0.835)	
GDP, growth (%)	0.025**	8.8
	(0.722)	
GDP per capita, growth (%)	0.064*	6.0
	(1.314)	
Inflation, consumer prices (%)	0.036**	8.7
	(0.986)	
Interest payments on external debt (% of GDP)	0.000***	79.0
	(1.383)	
Real effective exchange rate	0.056*	11.8
	(1.007)	

Notes: Table reports p-values from a stepwise regression (backward selection) of a one-year-ahead default indicator on macroeconomic explanatory variables covering the period 1975 to 2010. Odds ratios are in parentheses. Also reported are posterior effect probabilities from the Bayesian model averaging approach. Data are pooled.

A natural question to ask is how do these results compare with a traditional, frequentist approach? Perhaps the closest frequentist parallel to the Bayesian approach used here is a stepwise regression. Table 4 compares p-values from a stepwise regression with the previously estimated posterior effect probabilities. For the budget balance and interest payments on external debt, the posterior effect probabilities and the p-values agree that there is strong evidence in favour of an effect: $p < 0.01$ and $P(\beta \neq |D) > 75\%$. But for GDP growth, GDP per capita growth, inflation and the real effective exchange rate, conclusions differ. P-values overstate the evidence for an effect. For instance, the p-value for GDP growth suggests its effect is highly significant, yet the posterior effect probability (8.8%) actually indicates evidence *against* an effect.[9] Posterior effect probabilities, in general, imply weaker evidence for effects than p-values, which do not take into account model uncertainty. In fact it has been argued that p-values overstate the evidence of an effect even in the absence of model uncertainty (Berger and Delampady, 1987; Berger and Sellke, 1987). Further doubt over the integrity of the evidence offered by the stepwise regression is raised by the estimated odds ratios. For GDP growth, the estimated odds ratio suggests a *negative* effect on the probability of default—lower growth raises the probability of sovereign default. But for GDP per capita growth, the odds ratio suggests the effect is *positive*.

For completeness, as discussed in Section 3.1, this paper also evaluates the macroeconomic determinants of external sovereign debt crises according to the definition of crisis given by Reinhart and Rogoff (2010) and sovereign debt restructurings accord-

[9]That low posterior effect probabilities can be interpreted as evidence *against* an effect, providing information that p-values cannot offer, is discussed further by Hoeting et al. (1999).

ing to the definitions given by Cruces and Trebesch (2011). Bayesian model averaging is undertaken for a logistic regression of the same set of macroeconomic determinants as above but for two new dependent variables: (i) a binary indicator variable equal to one if a country in the sample enters into a period of external-debt *crisis* in the subsequent year, and zero otherwise; and (ii) a binary indicator equal to one if a country *restructures* its sovereign bonds in the subsequent year and zero otherwise. Results are presented in Appendix Table 10 and Appendix Table 11.

Turning first to sovereign-debt restructuring, interest payments on external debt appear to have a significant effect on the probability of a country restructuring its sovereign debts. The estimated effect is positive and large: a one-percentage-point increase in interest payments on external debt as a per cent of GDP doubles the probability of restructuring. However, once we allow for model uncertainty, all other macroeconomic characteristics, including the budget deficit, show no consistent evidence of having an effect on the probability of restructuring. That restructurings, unlike defaults, are not associated in a systematic manner with budget deficits is perhaps not surprising. In most cases restructurings occur after a default (Das et al., 2012). Many countries are, as a result, able to reduce their budget deficits during the years that elapse after default and prior to restructuring.

Meanwhile, the macroeconomic determinants of an external sovereign debt crisis, as defined by Reinhart and Rogoff (2010), align well with the determinants of default: both the budget balance and interest payments on external debt are primary drivers of crisis (Appendix Table 11). A one-percentage increase in interest payments on external debt as a share of GDP raises the odds of an external sovereign debt crisis in the subsequent year by around 30%. For every one-percentage-point increase in the budget deficit as a share of GDP the odds of sovereign default increase by 12%.

4.2 Results: exit from default

This section assesses the macroeconomic determinants of exiting a period of sovereign default where periods of default are defined according to Standard and Poors (2010). Exit years account for 17% of all default years in the sample.

Table 5 provides summarystatistics for all years in which a country is defined to be in default and also those years in which a country exited a period of default. Data are winsorized to account for outliers. Results are summarised in Table 6 for Bayesian model averaging over all 2^{18} possible models.

Coefficient posterior probability estimates indicate a probability of 82% that the effect of public debt on the odds of exiting a period of sovereign default is *not zero*. The estimated posterior mean effect is -0.01. Exponentiating this, we get an odds ratio suggesting that with every ten-percentage-point decrease in general government debt as a per cent of GDP, the odds of exiting a period of sovereign default in the subsequent year increase by around 10%. For exiting default, it seems that, based on past the past experience of defaulting countries, what matters is not external debt,

Table 5: Summary statistics for default years and years of exit from default

	In default			Default exit year		
Variable	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Years since default	215	4.2	3.5	44	4.4	3.6
Total exports plus total imports (% of GDP)	215	56.7	33.1	44	58.5	31.9
Current account (% of GDP)	215	-2.0	11.0	44	-0.9	5.6
GDP per capita (US$)	215	1,720	1,616	44	2,369	1,983
Gross external debt (% of GDP)	215	119.8	150.2	44	109.2	182.4
Private sector credit (% of GDP)	215	28.0	19.1	44	30.3	20.9
Interest payments on external debt (% of GDP)	215	2.9	1.9	44	2.6	1.6
Total external debt service (% of GDP)	215	6.4	3.6	44	6.3	3.0
Short-term debt (% of total external debt)	215	13.5	8.5	44	13.3	8.6
Broad money (% of GDP)	215	33.8	19.0	44	39.9	21.1
Public debt (% of GDP)	215	73.2	31.8	44	58.6	31.9
Terms of trade, index (2000=100)	215	107.1	32.6	44	101.7	21.9
Real effective exchange rate (1997=100)	215	101	35	44	104	42
Budget balance (% of GDP)	215	-3.1	3.2	44	-1.6	3.4
Effective interest rate on external debt (%)	215	4.7	2.9	44	5.2	2.5
Inflation, consumer prices (%)	215	29.1	32.0	44	22.5	26.6
GDP, growth (%)	215	2.7	4.7	44	4.1	3.5
GDP per capita, growth (%)	215	0.9	4.7	44	2.5	3.5
Global						
US default yield spread	215	1.1	0.4	44	1.0	0.4
Global liquidity (TED spread)	215	0.8	0.6	44	0.7	0.8
Global interest rates (US 10-year Treasury)	215	8.0	2.4	44	7.2	2.3
Gold price	215	361.6	51.7	44	366.4	58.3

Notes: Table reports summary statistics for all years in which a country is defined to be in default by Standard and Poors (2010) and also those years in which a country exited a period of default. Data are winsorized at the fifth and ninety-fifth percentile values. Years since default counts the number of years since the country entered the period of default. It is capped at 10.

Table 6: Bayesian model averaging the macroeconomic determinants of exiting a period of sovereign default

	Post. Prob (%)	Post. Mean	Post. St. Dev	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	100.0	-1.23	0.69	-1.48	-1.64	-1.05	-1.33	-0.56
Total trade (%)	3.9	0.00	0.00	.	.	.	.	.
Current account (%)	3.1	0.00	0.00	.	.	.	.	.
GDP per capita (US$)	12.5	0.00	0.00	.	.	.	.	.
Gross external debt (%)	3.2	0.00	0.00	.	.	.	.	.
Private sector credit (%)	4.5	0.00	0.00	.	.	.	.	.
Int. payments on ext. debt (%)	3.6	0.00	0.02	.	.	.	.	.
External debt service (%)	3.9	0.00	0.01	.	.	.	.	.
Short-term debt (%)	4.2	0.00	0.01	.	.	.	.	.
Broad money (%)	62.3	0.01	0.01	0.03	0.03	0.02	0.03	.
Terms of trade, index	4.1	0.00	0.00	.	.	.	.	.
Effective ex. rate	3.3	0.00	0.00	.	.	.	.	.
Budget balance (%)	37.6	0.05	0.07	.	.	0.14	0.10	.
Public debt (%)	81.7	-0.01	0.01	-0.02	-0.02	-0.02	-0.02	-0.02
Int. rate on ext. debt (%)	5.3	0.00	0.02	.	.	.	.	.
Inflation (%)	10.9	0.00	0.00	.	.	.	.	.
GDP, growth (%)	24.0	0.02	0.05	.	0.12	.	.	.
GDP per capita, growth (%)	35.6	0.04	0.06	0.12	.	.	0.10	.
Number of variables				3	3	3	4	1
Bayesian information criterion				-1,202	-1,202	-1,201	-1,200	-1,200
Posterior model probability				0.085	0.057	0.042	0.029	0.026

Notes: Table shows estimation results for Bayesian model averaging over 2^{18} models of exit from sovereign default (18 independent variables). The dependent variable is equal to one if the sovereign state exits from a period of default in the subsequent year and equal to zero otherwise. The column headed *Post Prob (%)* shows the posterior probability that the variable is in the model. The column headed *Post Mean* shows the estimated posterior mean and the column headed *Post St Dev* shows the estimated posterior standard deviation for each variable. The subsequent columns show parameter estimates for the best five models, together with the number of variables they include, their associated Bayesian information criterion and their posterior model probabilities. Here the best five models have a cumulative posterior probability of 24%.

but government debt.

4.3 Results: default content of sovereign spreads

This section compares actual sovereign spreads with spreads predicted by fitted default probabilities. The approach here follows that taken by Hilscher and Nosbusch (2010) in their work on sovereign spreads.

Predicted spreads are calculated in a number of steps. First, recovery rates are assumed to be fixed. That is, creditors are assumed to receive a constant proportion of the sovereign bond's principal in the event of a default. The recovery rate is set at 0.6 in line with estimates by Sturzenegger and Zettelmeyer (2005) of average historic experience. The default-implied spread is calculated by discounting the expected payoff at the risk-free rate using estimated default probabilities from Section 4.1. Estimation uses data up to 2000 with the remaining years reserved for fitting out-of-sample default probabilities.

To assess the extent to which predicted spreads based on default probabilities help to explain actual spreads, actual spreads are regressed on predicted spreads and, to control for common shocks, a range of global variables—the US default yield spread, the TED spread, 10-year US Treasury yields and the price of gold. Actual spreads are, in this case, yield spreads on US-dollar-denominated debt using data from JP Morgan's Emerging Market Bond Index (EMBI).

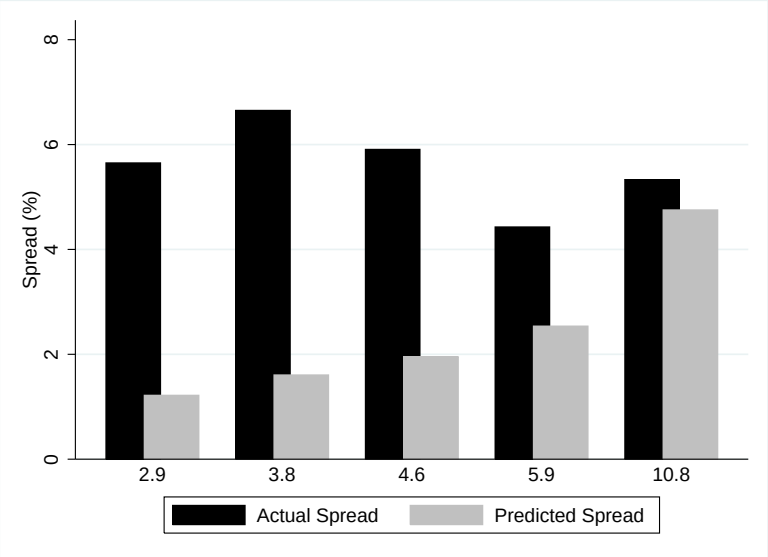
Figure 2 plots actual spreads and predicted spreads by default probability quintiles. Spreads are grouped by their estimated default probabilities, permitting a comparison of average observed and average estimated spreads. There are a number of points to note. First, mirroring the results of Hilscher and Nosbusch (2010), it is found that the default content of high-risk credit is high, but for low-risk credit it is low. This chimes with findings from the corporate-bond market that suggest market spreads often underestimate default risk for low-risk borrowers (Huang and Huang, 2003). Second, *ex ante* we would expect to see actual spreads rise as the default probability quintile increases. But they do not. Actual spreads show no consistent pattern across quintiles. One possible explanation may be that during the period chosen for out-of-sample prediction, 2000 to 2010, bond spreads for emerging-market economies were compressed and credit risk was underestimated, failing to account for the default content of market spreads.

5 Conclusions

This paper attempts to identify the macroeconomic determinants of sovereign default, exit from default, and endeavours to estimate the default content of sovereign spreads.

Main findings are threefold: (i) large budget deficits and high interest payments on external debt represent key macroeconomic tipping points into sovereign default;

Figure 2: Predicted and actual spreads by average default probability



Notes: Figure compares spreads predicted by fitted default probabilities with actual spreads, where actual spreads are spreads over US Treasuries for sovereign debt denominated in US dollars (EMBI spreads). Actual and predicted spreads are ordered along the horizontal axis according to default probability quintiles. The average default probability for each quintile is reported on the horizontal axis.

(ii) for exiting periods of default, reducing government debt matters most; and (iii) the default content of sovereign bond spreads increases with the probability of default.

The finding that fiscal health is important to both default and exiting default is new: fiscal illiquidity in the form of a large general government budget deficit is found to be a common tipping point for default while fiscal solvency, in the form of a smaller government debt burden, is found to be an important predictor of exiting default. While many theoretical models stress a role for fiscal variables in the determination of sovereign default (Hatchondo et al., 2012), this paper is the first, as far as the author is aware, to offer empirical support.

The second key conclusion is that in terms of the macroeconomic *tipping points* of sovereign default what matters most is not solvency but liquidity. That is, the immediate macroeconomic antecedents of default are changes in macroeconomic flows: the budget deficit and interest payments on external debt. Other research has, of course, acknowledged the importance of illiquidity as a trigger of sovereign debt distress (Detragiache, 1996; Chui et al., 2000). Detragiache and Spilimbergo (2001) show that liquidity indicators perform well in explaining debt-servicing difficulties while Reinhart (2002) shows that credit-rating agencies attach little weight to indicators of liquidity despite their reliability as leading indicators of both currency crises and default. While the existing literature recognises the importance of fiscal and external illiquidity as a determinant of default this paper shows that there is still plenty of scope for further research.

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A Appendix

A.1 Definitions: default

Sovereign default: Standard and Poors (2010)
"Standard & Poor's defines default as the failure to meet a principal or interest payment on the due date contained in the original terms of a debt issue. Questions can arise, however, when applying this definition in different situations and to different types of sovereign obligations. Standard & Poor's considers a sovereign to be in default under any of the following circumstances: (i) For local- and foreign-currency bonds, notes, and bills issued by the central government and held outside the public sector of the country, a sovereign default occurs when the central government either fails to pay scheduled debt service on the due date or tenders an exchange offer of new debt with less-favorable terms than the original issue. (ii) For local currency issued by the central bank, a sovereign default takes place when notes are converted into a new currency of less-than-equivalent face value. For private-sector bank loans incurred by the central government, a sovereign default occurs when the central government either fails to pay scheduled debt service on the due date or negotiates with the bank creditors a rescheduling of principal or interest at less-favorable terms than in the original loan."

Sovereign debt restructuring: Cruces and Trebesch (2011)
"To identify relevant events we apply five case selection criteria. First, we focus on sovereign restructurings, defined as restructurings of public or publicly guaranteed debt. We do not take into account private-to-private debt exchanges, even if large-scale workouts of private sector debt were coordinated by the sovereign (eg, Korea 1997, Indonesia 1998). Second, we follow the definition and data of Standard and Poors and include only distressed debt exchanges. Distressed restructurings occur in crisis times and typically imply new instruments with less favorable terms than the original bonds or loans. We therefore disregard market operations that are part of routine liability management, such as voluntary debt swaps. Third, we focus on sovereign debt restructurings with foreign private creditors, thus excluding debt restructurings that predominantly affected domestic creditors and those affecting official creditors, including those negotiated under the chairmanship of the Paris Club. Foreign creditors include foreign commercial banks ("London Club" creditors) as well as foreign bondholders. For recent deals, we follow the categorization into domestic and external debt exchanges of Sturzenegger and Zettelmeyer (2006). Fourth, we restrict the sample to restructurings of medium and long-term debt, thus disregarding deals involving short-term debt only, such as the maintenance of short-term credit lines, 90-day debt rollovers, or cases with short-term maturity extension of less than a year. Finally, we only include restructurings that were actually finalized. We thus drop cases in which an exchange offer or agreement was never implemented, eg due to the

failure of an IMF program or for political reasons."

External sovereign debt crisis: Reinhart and Rogoff (2010)
"A sovereign default is defined as the failure to meet a principal or interest payment on the due date (or within the specified grace period). The episodes also include instances where rescheduled debt is ultimately extinguished in terms less favourable than the original obligation. ... For the period after 1824, the majority of dates come from several Standard and Poor's studies. ... Although external defaults are, by and large, clearly defined and far less contentious than, say, the dates of banking crises (for which the end is often unclear), some judgement calls are still required. In cataloguing the number of times a country has defaulted, we generally categorise any default that occurs two years or less after a previous default as part of the same episode."

A.2 Definitions and further results

Table 7: Macroeconomic variables, units and sources

Variable	Units	Source
Total exports plus total imports	Per cent of GDP	World Bank WDI
Current account balance	Per cent of GDP	World Bank WDI / Economist Intelligence Unit
GDP per capita	US$, current prices	World Bank WDI / Oxford Analytics
Gross external debt	Per cent of GDP	World Bank WDI / Oxford Analytics.
Private sector credit	Per cent of GDP	World Bank WDI / International Financial Statistics
Interest payments on external debt	Per cent of GDP	World Bank WDI / Oxford Economics.
Total external debt service	Per cent of GNI	World Bank WDI / Oxford Economics.
Short-term debt	Per cent of total external debt	World Bank WDI
Broad money	Per cent of GDP	World Bank WDI
Public debt	Per cent of GDP	International Monetary Fund Historical Public Debt Database
Terms of trade, index	Index (2000=100)	World Bank WDI
Exchange rate, US dollars per local currency	Index (1997=100)	International Financial Statistics
Exchange rate, trade weighted	Index (1997=100)	World Bank WDI
Budget balance	Per cent of GDP	Economist Intelligence Unit
Effective interest rate on external debt	Per cent	World Bank WDI
Inflation, consumer prices	Per cent	World Bank WDI
GDP, growth	Per cent	World Bank WDI
GDP per capita, growth	Per cent	World Bank WDI
EMBI spread	Per cent	JP Morgan Markets
US default yield spread	Per cent	Moody's Investors Service
Global liquidity (TED spread)	Per cent	United States Treasury
Global interest rates (US 10-year Treasury)	Per cent	United States Treasury
Gold price	US dollars per troy ounce	London Bullion Market
US 1-year Treasury bill yield	Per cent	US Treasury

Notes: Table lists macroeconomic variables, units and their sources. Sources for certain variables for certain countries may differ. Please contact the author for details.

Table 8: Macroeconomic variables and notes

Variable	**Notes**
Total exports plus total imports	Merchandise trade plus services, divided by the value of GDP, all in current U.S. dollars.
Current account balance	
GDP per capita	
Gross external debt	Total external debt is debt owed to nonresidents repayable in foreign currency, goods, or services.
Private sector credit	Domestic credit to private sector refers to financial resources provided to the private sector that establish a claim for repayment.
Interest payments on external debt	Total interest payments to gross national income.
Total external debt service	Total debt service is the sum of principal repayments and interest.
Short-term debt	External (foreign currency) debt owed to all sectors (ie private and public creditors).
Broad money	
Public debt	Gross general government debt, but for many countries (especially for the period before 1980) only central government data is available.
Terms of trade, index	
Exchange rate, US dollars per local currency	
Exchange rate, trade weighted	Real effective exchange rate is the nominal effective exchange rate divided by a price deflator or index of costs.
Budget balance	General government.
Effective interest rate on external debt	A weighted average of all the different rates payable.
Inflation, consumer prices	Annual
GDP, growth	Annual percentage growth rate of GDP at market prices based on constant local currency.
GDP per capita, growth	Annual
EMBI spread	Annual, end of year spreads
US default yield spread	Default yield spread is defined as the spread between corporate bonds with a Moodys rating of Baa and Aaa.
Global liquidity (TED spread)	Difference between the interest rates for three-month U.S. T-bills and the three-month Eurodollars contract as represented by LIBOR.
Global interest rates (US 10-year Treasury)	
Gold price	US dollars per troy ounce
US 1-year Treasury bill yield	

Notes: Table lists macroeconomic variables and descriptive notes.

Table 9: Bayesian model averaging for sovereign default allowing for the volatility of terms of trade

	Post. Prob (%)	Post. Mean	Post. St. Dev	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	100.0	-3.65	0.72	-3.11	-3.81	-2.89	-4.27	-3.95
Years since default	2.2	0.00	0.01	.	.	.	.	.
Total trade (%)	5.6	0.00	0.00	.	.	.	.	.
Current account (%)	4.9	0.00	0.02	.	.	.	.	.
GDP per capita (US$)	3.6	0.00	0.00	.	.	.	.	.
Gross external debt (%)	6.3	0.00	0.00	.	.	.	.	.
Private sector credit (%)	5.5	0.00	0.00	.	.	.	.	.
Int. payments on ext. debt (%)	45.2	0.16	0.20	.	0.33	.	0.38	0.31
External debt service (%)	12.0	0.01	0.05	.	.	.	.	.
Short-term debt (%)	2.6	0.00	0.00	.	.	.	.	.
Broad money (%)	2.7	0.00	0.00	.	.	.	.	.
Public debt (%)	9.2	0.00	0.00	.	.	.	.	.
Terms of trade, index	2.6	0.00	0.00	.	.	.	.	.
Effective ex. rate	2.2	0.00	0.00	.	.	.	.	.
Budget balance (%)	19.1	-0.03	0.06	.	.	.	.	.
Int. rate on ext. debt (%)	4.1	0.00	0.03	.	.	.	.	.
Inflation (%)	4.0	0.00	0.00	.	.	.	.	.
GDP, growth (%)	39.3	-0.05	0.07	.	-0.13	-0.14	.	.
GDP per capita, growth (%)	34.1	-0.05	0.07	-0.15	.	.	.	-0.12
Volatility of terms of trade	2.0	0.00	0.00	.	.	.	.	.
Number of variables				1	2	1	1	2
Bayesian information criterion				-3,801	-3,800	-3,800	-3,800	-3,800
Posterior model probability				0.072	0.065	0.059	0.055	0.05

Notes: Table shows estimation results for Bayesian model averaging over 2^{19} models of sovereign default (19 independent variables). The dependent variable is equal to one if the sovereign state defaults in the subsequent year and equal to zero otherwise. The column headed *Post Prob (%)* shows the posterior probability that the variable is in the model. The column headed *Post Mean* shows the estimated posterior mean and the column headed *Post St Dev* shows the estimated posterior standard deviation for each variable. The subsequent columns show parameter estimates for the best five models, together with the number of variables they include, their associated Bayesian information criterion and their posterior model probabilities.

Table 10: Bayesian model averaging for sovereign debt restructuring

	Post. Prob (%)	Post. Mean	Post. St. Dev	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	100.0	-4.03	0.75	-3.55	-4.07	-4.48	-4.75	-4.17
Years since default	1.9	0.00	0.01	.	.	.	.	.
Total trade (%)	4.8	0.00	0.00	.	.	.	.	.
Current account (%)	7.0	0.00	0.02	.	.	.	.	.
GDP per capita (US$)	6.2	0.00	0.00	.	.	.	.	.
Gross external debt (%)	4.2	0.00	0.00	.	.	.	.	.
Private sector credit (%)	3.5	0.00	0.00	.	.	.	.	.
Int. payments on ext. debt (%)	100.0	0.70	0.23	0.87	0.76	0.84	0.42	0.50
External debt service (%)	68.3	-0.16	0.13	-0.25	-0.22	-0.23	.	.
Short-term debt (%)	5.4	0.00	0.01	.	.	.	.	.
Broad money (%)	7.3	0.00	0.00	.	.	.	.	.
Public debt (%)	2.3	0.00	0.00	.	.	.	.	.
Terms of trade, index	18.7	0.00	0.00	.	.	0.01	.	.
Effective ex. rate	1.9	0.00	0.00	.	.	.	.	.
Budget balance (%)	10.4	-0.01	0.03	.	.	.	.	.
Int. rate on ext. debt (%)	35.5	0.05	0.08	.	0.13	.	0.15	.
Inflation (%)	1.9	0.00	0.00	.	.	.	.	.
GDP, growth (%)	7.8	0.00	0.02	.	.	.	.	.
GDP per capita, growth (%)	5.6	0.00	0.01	.	.	.	.	.
Number of variables				2	3	3	2	1
Bayesian information criterion				-4,843	-4,841	-4,840	-4,839	-4,839
Posterior model probability				0.179	0.067	0.049	0.036	0.035

Notes: Table shows estimation results for Bayesian model averaging over 2^{18} models of sovereign debt restructurings where restructuring is defined according to Cruces and Trebesch (2011). The dependent variable is equal to one if the sovereign state restructures in the subsequent year and equal to zero otherwise. The column headed *Post Prob (%)* shows the posterior probability that the variable is in the model. The column headed *Post Mean* shows the estimated posterior mean and the column headed *Post St Dev* shows the estimated posterior standard deviation for each variable. The subsequent columns show parameter estimates for the best five models, together with the number of variables they include, their associated Bayesian information criterion and their posterior model probabilities.

Table 11: Bayesian model averaging for external sovereign debt crises

	Post. Prob (%)	Post. Mean	Post. St. Dev	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	100.0	-4.51	0.86	-4.22	-5.32	-5.13	-3.56	-4.68
Years since default	40.7	0.05	0.07	.	0.12	0.14	.	0.13
Total trade (%)	3.3	0.00	0.00	.	.	.	.	.
Current account (%)	5.0	0.00	0.01	.	.	.	.	.
GDP per capita (US$)	2.0	0.00	0.00	.	.	.	.	.
Gross external debt (%)	2.2	0.00	0.00	.	.	.	.	.
Private sector credit (%)	2.8	0.00	0.00	.	.	.	.	.
Int. payments on ext. debt (%)	82.7	0.26	0.15	0.27	0.34	0.33	.	0.39
External debt service (%)	6.5	0.00	0.03	.	.	.	.	.
Short-term debt (%)	6.8	0.00	0.01	.	.	.	.	.
Broad money (%)	2.6	0.00	0.00	.	.	.	.	.
Public debt (%)	2.2	0.00	0.00	.	.	.	.	.
Terms of trade, index	4.7	0.00	0.00	.	.	.	.	.
Effective ex. rate	2.9	0.00	0.00	.	.	.	.	.
Budget balance (%)	77.9	-0.13	0.08	-0.16	-0.17	-0.14	-0.19	.
Int. rate on ext. debt (%)	9.1	0.01	0.04	.	.	.	.	.
Inflation (%)	2.2	0.00	0.00	.	.	.	.	.
GDP, growth (%)	24.8	-0.02	0.05	.	.	-0.08	.	-0.11
GDP per capita, growth (%)	12.1	-0.01	0.04	.	.	.	.	.
Number of variables				2	3	4	1	3
Bayesian information criterion				-4,882	-4,881	-4,879	-4,879	-4,879
Posterior model probability				0.146	0.094	0.04	0.032	0.029

Notes: Table shows estimation results for Bayesian model averaging over 2^{18} models of sovereign debt ciris where crisis is defined according to Reinhart and Rogoff (2010). The dependent variable is equal to one if an external sovereign debt crisis occurs in the subsequent year and equal to zero otherwise. The column headed *Post Prob (%)* shows the posterior probability that the variable is in the model. The column headed *Post Mean* shows the estimated posterior mean and the column headed *Post St Dev* shows the estimated posterior standard deviation for each variable. The subsequent columns show parameter estimates for the best five models, together with the number of variables they include, their associated Bayesian information criterion and their posterior model probabilities.