Determinants of Default Risk in the Eurozone: A Bayesian Approach

Abstract

We analyze the determinants of default risk of EMU member states applying Bayesian Model Averaging (BMA). We use government bond yield spreads as risk indicators and consider annual panel data from 1999-2009. BMA is well-suited in cases of small samples and high model uncertainty, as it seems to be the case for default risk in the Eurozone since the literature reports heterogeneous results with respect to significant explanatory variables. We test a number of variables reported to be significant in the literature and find that the most likely risk drivers are government debt to GDP, budget balance and terms of trade.

Keywords: Default Risk in the Eurozone and EMU Countries, Bayesian Model Averaging, Bond Yields

1 Introduction

During the recent economic crisis several member states of the EMU faced financial turmoil and difficulties in making debt service payments, some even were close to default, which could only be prevented by the help of other EU member states. This badly influenced not only the afflicted economies, but also other countries (for example because of rescue payments) and additionally even called the survival of the EMU into question. Understanding the basic reasons for the problems of some countries is, thus, of crucial importance, especially since a number of problems still remain unsolved. So, there is still the danger that other states will be hit, which leads to the question of whether the rescue package is large enough or whether additional payments will be required in the future. In addition, it is very unclear what will happen when the rescue package comes to an end or in which way and by which amounts it should be prolongated.

The present paper deals with these issues by analyzing empirically the determinants of the default risk of EMU member states in the years of its existence using bond yield spreads (to German bond yields) observed on secondary bond markets as indicator for default risk. The use of spreads enables us to exclude changes in the risk-less interest rate. These yield spreads occur since default risky bonds are traded with a discount that compensates the investors for bearing the default risk. Thus, the yield spreads observed on secondary bond markets reflect an up-to-date risk assessment of investors in the bond markets.

An interesting strand of the literature deals with the analysis of country default risk by regressing potentially explaining variables on bond spreads. The use of yield spreads as an indicator for country default risk has a long history in the literature on analyzing the determinants of country default risk for developing countries. Many papers refer to Edwards (1984) as the first and path breaking paper where yield spreads are used as dependent variable in regressions to identify variables that determine default risk. Edwards (1984) considers data on spreads from bank loans, whereas later papers consider bond data. Edwards (1986), Min (1998), and Eichengreen and Mody (1998) consider primary (market) spreads of several developing countries, i.e. spreads observed when bonds are issued.[1] Kamin and von Kleist (1999) consider secondary market spreads in addition to primary spreads. Later papers focus on secondary market spreads, since these are true market assessments done by a multitude of agents that are supposed to reflect all available information. An early example is Arora and Cerisola (2001), who perform individual regressions for each of the observed countries. Examples for single country studies are Nogues and Grandes (2001), who concentrate on Argentina, and Rojas and Jaque (2003), who consider Chilean data. Cantor and Packer (1996) consider cross-section data for 35 countries. Examples for papers concerned with estimating the economic determinants of default risk in developing countries with panel data are Rowland and Torres (2004), Dailami, Masson and Padou (2005), Baldacci, Gupta and Mati (2008), and Hilscher and Nosbusch (2010).[2]

Whereas the papers mentioned so far exemplify the bulk literature where determinants of default risk for developing countries are estimated using spreads as risk indicators, a number of papers considers the spreads for developed countries, in particular OECD and EU member states. Bernoth, von Hagen and Schuknecht (2006), e.g., provide a detailed literature review for OECD countries in general and Gale and Orszag (2002) for the

[1] The considered sample and results with respect to significant determinants of the papers discussed here are overviewed in Table A-1 and A-2 in the appendix.
[2] Another strand of the literature investigates the period prior to World War I (see, for example, Bordo and Rockoff, 1996, Obstfeld and Taylor, 2003, Meissner, 2005, and Camaron, Gai and Tan, 2006).

US in particular. Examples for other papers dealing with the US are Poterba and Rueben (1999), Gale and Orszag (2004) and Laubach (2003). OECD countries are considered, e.g. in Alesina et al. (1992), who consider a sample of 12 OECD countries and Ardagna, Caselli, and Lane (2004), who consider a panel of 16 countries. A number of papers focuses on EU countries, which are exemplified in the following.

Bernoth, von Hagen and Schuknecht (2006) analyze determinants of bond spread to US or German government bonds for single bond issues denominated in US Dollar or Deutsche Mark respectively Euro that were issued between 1993 and 2005 by 14 European central governments. Debt to GDP, deficit to GDP and debt service to revenues are found to be significantly positively related to spreads in several specifications. The same holds true for the maturity of the bond issue and corporate spreads, whereas a liquidity indicator, an EMU dummy and the US rate have a significant negative relation to spreads. Schuknecht, von Hagen and Wolswijk (2009) consider spreads for sub-national governments in Germany, Spain and Canada in addition to those of central governments of 13 European countries for the time from 1991-2005. They find that a higher public debt ratio and a more negative budget balance increase the default risk reflected by bond spreads. In a later study that includes data observed during the subprime crisis Schuknecht, von Hagen and Wolswijk (2010) confirm these results, yet bond spreads react more sensitively to a deterioration of public finances.

Whereas the papers mentioned above consider spreads observed for single bond issues, others use data for a benchmark curve, which is related to a fixed maturity. Manganelli and Wolswijk (2007), e.g., use the 10 year maturity of European government bonds and show that spreads are significantly related to ratings and the short-term interest rate. Lemmen and Goodhart (1999) as well as Codogno, Favero and Missale (2003) also apply 10-year bond yield spreads to Germany as dependent variable, which is however corrected by the swap yield in order to account for exchange rate risks. By considering 13 EU member states between 1987 and 1996 Lemmen and Goodhart (1999) find that spreads are positively related to changes in debt to GDP and inflation variability and negatively to inflation and the countries' capacity to raise taxes. Codogno, Favero and Missale (2003) find for 9 EU countries considered in the time 1999-2002 that public debt to GDP as country specific variable significant for country default risk besides international risk factors.

The literature reviewed so far provides interesting insights into the nature und causes of country default risk. However, the results are rather heterogeneous, i.e. different papers identify different variables as main drivers of default risk. This holds true even for the papers that focus on EU countries but is even more pronounced if we consider papers that consider other countries. The fact that there is no consensus about the key determinants of default risk may be seen as indication for high uncertainty about the "true" empirical model.

One appropriate approach to deal with this model uncertainty is Bayesian Model Averaging (BMA). It explicitly accounts for the high model uncertainty by considering (approximately) the whole model space, i.e. any possible combination of regressors out of a given set of potential determinants, whereas in classical statistics the conclusions are based on just one model (or a small sample of models), which implies that information from all other models is neglected. Even if the full model is considered, statistical significance may be neglected by mistake because of the multi-co-linearity problem, which is in particular an issue for small samples as it is the case in the EMU sample. Thus, often only a small set of regressors is tested or smaller models are selected using some heuristics. However, model selection is problematic given the size of the potential model space and, as mentioned, information from most of the models is neglected. Thus, BMA is supposed to provide more solid information about the determinants of growth than classical regressions. BMA is applied successfully to various other topics. Examples are economic growth (see, e.g., Fernandez, Ley and Steel, 2001b, Sala-i-Martin, Doppelhofer and Miller, 2004, Eicher, Papageorgiou and Roehn, 2007, Masanjala and Papageorgiou, 2008), monetary policy (see, e.g., Hineline, 2007, and Milani, 2008), the relationship between consumption and wealth (see, e.g., Koop, Potter and Strachan, 2008), and pricing of stocks (see, e.g., Avramov, 2002, and Cremers, 2002) or hedgefunds (see Vrontos, Vrontos and Giamouridis, 2008) .

We contribute to the literature by applying BMA to the issue of country default risk in the member states of the Eurozone. We test a number of hypothesis on causes of default risk and include related variables reported to be significant in the literature in our analysis. We find that the most likely risk drivers are government debt to GDP, budget balance and terms of trade. For some other variables, as economic growth, export growth, import growth and the US interest rate, there is some likelihood (greater than 10%) to drive default risk. However, for some variables found to be significant in the literature, as interest rate costs, capital formation and inflation, this likelihood is rather low (below 10 %) compared to the variables mentioned above.

In the next section we overview the BMA approach. In Section 3, we formulate the hypothesis with respect to causation of default risk tested in our empirical analysis and discuss the variables used to indicate these hypotheses. Section 4 deals with the setting of our empirical analysis and discusses the results. Section 5 concludes.

2 Bayesian Model Averaging (BMA) in Nutshell

The literature based on a classical regression framework provides interesting results and insights into the causes of default risk. We complement this literature by applying Baysian Model Averaging (BMA). In relation to classical regressions, BMA has some advantages as well as some disadvantages. So, one could state that there is no silver bullet to tackle the issue, but applying BMA enables us to provide additional and in some sense broader information and avoids some drawbacks of classical regressions, which comes at the cost of accepting the assumptions and drawbacks of BMA. To some extent we test the results provided so far since we include various variables which have been included in several papers but haven't been tested jointly.

The Bayesian approach interprets the concept of probability as a measure of the state of knowledge. Thereby it is acknowledged that there exists uncertainty about the 'true' empirical model, whereby the term model refers to a possible combination of variables determining the dependent variable. In a linear regression framework as given by equation (1) with a given set of k variables that are potentially determinants of the dependent variable 2^k different combinations, i.e. models, are possible. BMA determines the most likely models by considering the whole model space, given by all possible combination of potential determinants of the dependent variable. What is more, it helps to identify the variables which are most likely to determine the dependent variable by estimating the probability of inclusion (in the true model) for each regressor.

One could argue that this problem could be solved by simply estimating the full model containing all possible independent variables. However, in the application of regression models often the problem arises that the results are not robust to alternative model specifications. This means deleting (or including) specific variables turns others to be significant (insignificant), an issue related to co-linearity between the regressors. This is a severe problem, in particular, if the sample is small and the number of observations is low compared to the number of regressors. Researches following a non Bayesian approach deal with this problem by applying several schemes for model selection (see Sala-i-Martin, 1997). These approaches have rather weak statistical foundation since the classical frequent econometrics does not treat models itself as uncertain.

The BMA approach, by contrast, is more comprehensive since information from the entire model space is included in the model selection procedure, which has a sound statistical foundation. Instead of a single model, a ranking of the best models is provided. It depends on the posterior probability of each model, i.e. the probability that a model with given specifications fits the data the best.

Based on the probability of inclusion (in the true model) the importance of single regressors can be evaluated and ranked as well. Here a second major advantage of BMA applies: The information about single regressors is based on information about the entire model space in contrast to the results for one single model considered in frequent statistics. Thus, instead of the measures used in classical statistics, alternative measures are used to judge the quality of a regressor. In particular, we consider the (marginal posterior) probability of inclusion. Its calculation and the BMA methodology is explained in more detail in the following.

We consider the following OLS setting:[3]

[3] Our description of BMA is oriented on Fernandez, Ley and Steel (2001b).

$$y = \alpha\iota + X_j\beta_j + \sigma\varepsilon, \tag{1}$$

where y denotes the vector of the observations of the dependent variable, α the regression constant (multiplied with a vector of ones ι) and X the n x k matrix of the k independent variables, $\beta_j \in \Re^{k_j} (0 \leq k_j \leq k)$ denotes the regression coefficients and $\sigma \in \Re_+$ is a scale parameter. The vector of the residuals, ε, is assumed to have a multivariate normal distribution, with mean μ and covariance matrix Σ. Alternatively to the full model, which includes all possible candidate variables, equation (1) can also used to describe regressions for any subset j of all k potential explaining variables that are taken into consideration. For *k* candidate independent variables 2^k models can be formulated.

The Bayesian view of probability as a measure of the state of knowledge implies a step wise updating of the probability measures in Bayesian techniques. In each step a-priori information is included in the estimation. Also the application of BMA requires the specification of prior distributions. This can be seen as point of criticism for several reasons. Of course, the assumptions concerning the prior distribution influence the outcome of the estimation which means that the results do not follow solely from the data.[4] In addition such prior information must be available, which often is not the case.

However, even if no a-priori information is available or the researcher does not want to include a-priori information, BMA can be applied. In this case, so-called non informative priors have to be used. In this paper, we adopt a prior structure developed by Fernandez, Ley

[4] For further discussion of the impact of prior distributions on the outcomes see Kass and Raftery (1995), and George (1999).

and Steel (FLS henceforth) (2001a).[5] Here a g-prior (proposed by Zellner, 1986) structure is used, which can be represented by the product of

$$p(\alpha, \sigma) \propto \sigma^{-1} \tag{2}$$

and

$$p(\beta_j \mid \alpha, \sigma, M_j) = f_N^{k_j}(\beta_j \mid 0, \sigma^2 (gX_j^{'} X_j)^{-1}). \tag{3}$$

is used. $f_N^q(w \mid m, V)$ represents the density function of a *q*-dimensional Gaussian distribution of *w*, with mean *m* and covariance matrix *V*, and M_j is the model with a subset of *j* regressors. Since the mean is assumed to be zero we include no a-priori information regarding the sign of the considered explaining variables, i.e. whether the direction of influence is positive or negative. By performing empirical simulations regarding the choice of *g* in Equation (3), FLS (2001a) find that assuming $g = 1/\max\{n, k^2\}$ yields robust results.

We also have to specify a-priori information about the probability of inclusion which is related to the a-priori distribution over the model space:

$$P(M_j) = p_j,\ j = 1,...,2^k, with \quad p_j > 0 \qquad \text{and} \qquad \sum_{j=1}^{2^k} p_j = 1 \tag{4}$$

[5] See also FLS 2001b for a detailed discussion of the influence of their non informative priors on the results.

A natural choice in this respect seems to be the uniform distribution over the model space. To put it simple, the a-priori probability of including a potential candidate variable in the model is 50%. This means, we assume the same probability for inclusion as for exclusion and we assume to be equally uncertain about the inclusion of any of the potential explaining variables.

The assessment of a specific quantity of interest, lets say a potential regressor, in the BMA approach is based on the general idea that information of all possible models is considered by averaging the results obtained for specific models with a posterior probability greater than zero. Thereby, these model probabilities are used as weights. The following formula is used:

$$P_{\Delta|y} = \sum_{j=1}^{2^k} P_{\Delta|y,M_j} P(M_j \mid y) \tag{5}$$

The probability, $P_{\Delta|y}$, of a certain quantity, Δ, let's say some regressor out of the set of potential regressors, results from calculating the weighted average of the specific likelihoods of inclusion, $P_{\Delta|y,M_j}$, in each of the 2^k potential models, M_j, given the specific model and the data. As weights, we use the posterior probabilities, $P(M_j \mid y)$, of the considered models, M_j, given the data. This model probability follows from dividing the likelihood of this specific model by the sum of the likelihood of all models in the model space:

$$P(M_j \mid y) = \frac{\ell_y(M_j)\, p_j}{\sum_{h=1}^{2^k} \ell(M_h)\, p_h}, \tag{6}$$

where $\ell_y(M_j)$ is the marginal likelihood of model M_j, which follows by:

$$\ell_y(M_j) = \int p(y \mid \alpha, \beta_j, \sigma, M_j)\, p(\alpha, \sigma)\, p(\beta_j \mid \alpha, \sigma, M_j)\, d\alpha\, d\beta_j\, d\sigma\,. \tag{7}$$

Here, $p(y \mid \alpha, \beta_j, \sigma, M_j)$ represents the probability of the model described in (1), and $p(\alpha, \sigma)$ and $p(\beta_j \mid \alpha, \sigma, M_j)$ are the priors described in (2) and (3) respectively.

In applying BMA we estimate any possible model, and calculate, on the one hand, the corresponding likelihood values and, on the other, the probability values of each regressor that is part of the model. In a second step, we assess the “quality” of each model, i.e. estimate the model probability according to equation (6). In the third step, we estimate the posterior probability of each regressor using equation (5).

In a similar way, one can infer information on other quantities of interest. The average value of the regression coefficient β_i related to a regressor, x_i, for example, can be calculated by averaging all coefficients estimated for specific models and using the respective model probabilities as weights. The sign of the average regressor is of special interest since it hints the direction of influence.

Even with modern computers, it is hard or even impossible to estimate all 2^k potential models if the number of regressors is large. Thus, in practical applications the model space is searched approximately. We do this by applying the MC^3-Sampler (Markov Chain Monte Carlo Model Composition) of Madigan and York (1995).

3 Hypotheses und Variables

In this section, we discuss our hypotheses on determinants of country default risk and the variables used to test the significance of these hypotheses in the case of the considered EMU member states in recent years. The considered hypotheses and the variables used may be seen as overlap of findings in the literature, i.e. we include variables that were found to be significant in a number of papers.

An important determinant of default risk found to be significant in several important studies is the countries' *budget balance in relation to GDP*. It plays the most prominent role (mostly in terms of deficit to GDP) in the public discussion (together with the debt level in relation to GDP) and is even named in the Maastricht treaty as important stability criterion that EMU countries are required to fulfill. A negative budget balance (deficit) leads to higher default risk, e.g., since it points to problems in financing the government's budget by taxes, which in turn may result from a weak tax system or a weak state of the economy.

Another important variable found to be significant in a multitude of papers and also named in the Maastricht treaty as stability criterion is *total government debt to GDP*. This variable reflects the hypothesis that higher indebtedness increases *ceteris paribus* the default risk. This results from the fact that for higher indebtedness the country has to spend more funds for debt servicing. For higher debt service payments the requirements on ability and willingness to pay are higher, and thus a default is more likely.

Besides the total amount of outstanding debt also the interest rate costs may influence default risk, for which we use the *average interest rate* paid on all outstanding debt as indicator. This average interest rate results from the contractual conditions (loan interest and coupon payments) when debt, i.e. loans or bonds, are issued, which is not to be confused with the bond yields observed on secondary markets. Higher interest rate costs are supposed to lead to higher default risk, since it makes debt service more costly and increases the burden of the debt for the economy.

Table1: Description of Variables

No.	Variable	Definition	Source
0	Bond yield spread (dependent variable)	Redemption yield on sovereign bonds of the considered country minus redemption yield on German sovereign bonds, both taken from the yield curve for a fixed 10-year maturity	DATASTREAM
1	Budget balance to GDP	Budget Balance to GDP	Economist Intelligence Unit
2	Total government debt to GDP growth	Total government debt as percentage of GDP (annual growth)	IMF World Economic Outlook
3	Average interest rate	Interest as percent of gross public debt of preceding year	Annual Macroeconomic Database of the European Commission
4	GDP growth	Real GDP at 2005 prices (annual growth)	OECD Economic Outlook
5	Imports growth	Imports (CIF) in US Dollar (annual growth)	IMF International Financial Statistics
6	Exports growth	Imports (FOB) in US Dollar (annual growth)	IMF International Financial Statistics
7	Terms of Trade growth	Terms of Trade Index (1990 = 100) (annual growth)	Economist Intelligence Unit
8	Inflation	Inflation as annual change in CPI	IMF World Economic Outlook
9	Inflation variation	Instantaneous volatility, i.e. quadratic deviation of inflation from long-term (10 year) mean	Own calculations based on IMF World Economic Outlook
10	Capital formation	Gross fixed capital formation divided by GDP	Annual Macroeconomic Database of the European Commission
11	US interest rate	Bond yield from US treasury yield curve for one-year maturity	DATASTREAM

Whereas the variables related to the debt situation describe the (payment) obligations the government has to fulfill, in addition the governments ability to meet these obligations is of crucial importance. With respect to the government's ability to meet debt service requirements, several hypothesis and variables are to be named. First, the overall state of the economy may be important. The most important indicator used here is the *growth of GDP*, which is supposed to have a negative influence on default risk. For growing economies it is c.p. easier to fulfill given payment obligations. Already, early theoretical contributions on the sustainability of countries' debt (see, e.g., Domar, 1944, 1950) point to the relation between the growth rate of GDP and growth rate of debt. It is stated, e.g., that from a theoretical point of view the burden of the debt, even if the debt is ever growing, is not problematic as long as the debt grows more slowly than the GDP.

Besides the overall state of the economy also the external sector is found to be significant in several studies. To capture this issue we include the *growth of exports and growth of imports*. These variables may influence the default risk in several ways. Higher exports are supposed to lead to lower default risk, in particular, because it helps to collect funds for debt servicing and – more general – because it may serve as indication for a high competitiveness of the economy. Higher imports may have the opposite influence. Thus, we would expect a negative sign for exports and a positive sign for imports. However, exports and imports also indicate the openness of the economy: higher imports *and* higher exports point to a more open country. With respect to openness, however, two competing explanations are thinkable, which leads to opposite directions of influence. The first approach is related to the issue of unwillingness to pay, which is an important issue in countries' default risk, since enforcement problems play an important role if sovereign states are borrowers (see Eaton, Gersovitz and Stiglitz, 1986, or Eaton and Fernandez, 1995). According to the willingess-to-pay-literature, countries which do not fulfil their payment obligations are "punished" by disruptions of trade (which gives an explanation why countries pay their debt at all). More open countries suffer more from these punishments and, hence, are rather willing to pay. Thus, based on this theory, not only the sign for exports but also the sign for imports is supposed to be negative since a higher degree of openness (higher exports *and* imports) implies a lower default risk. However, higher openness may also result in higher default risk since more open countries are more prone to variations and shocks in the world economy. Hence, they suffer more from economic crisis in the rest of the world, which in turn increases their default risk in crisis times. This second hypothesis on openness implies a higher default risk for higher exports and higher imports, i.e. a positive sign for both.

A third variable related to the external sector that we use in the analysis is the *change in the terms of trade index.* An increase (decrease) of the terms of trade means that (average) export prices in relation to (average) import prices increase (decrease). A change in terms of trade may result from a change in the exchange rate, on the one hand, and from a change of market prices paid for goods and services, on the other. Since all EMU countries, which constitute our sample, use the Euro as domestic currency differences between countries solely result from the latter. An increase of terms of trade may decrease default risk since it favours the economy and makes it easier to collect funds for debt servicing. This holds true especially if the increase results from changes in market prices. If an increase in terms of trade results, by contrast, from an increase in the exchange rate it may lead to a loss in competitiveness and, hence, to a higher default risk.

Although all EMU member states face the same monetary policy made by the European Central Bank (ECB), *the inflation* shows considerable differences. Inflation influences economic activity in several ways and may have an influence on default risk. In fact, inflation was found to be a significant determinant of default risk in several studies. In the case of EMU member states the influence of inflation on the economy may be even more important since it may be hard(er) for governments to deal with inflation and achieve the optimal level of inflation without independent monetary policy, whereby one size (monetary policy/interest rate) usually does not fit all (countries). On the other hand, for some countries usually troubled with high inflation in the past it may be easier to achieve low inflation rates being member of a monetary union. Besides inflation, we include *variation of inflation*, which was also found to be important in the literature (see, e.g., Lemmen and Goodhart, 1999). A high variation of inflation imposes additional costs and disruptions on the economy and makes debt service more difficult.

Finally, we consider the *capital formation to GDP* as a regressor. By including this variable we aim to test whether the use of funds has an influence on default risk. Higher capital formation is supposed to decrease default risk since it should lead to higher productivity and higher economic growth in the future. Thus, a higher future ability to make debt service payments is to expect which should decrease the default risk.

Besides these country specific variables we include the risk-less *US interest rate*, which is considered in a variety of papers. Its influence is intensively debated in the literature. The US rate reflects the international financing conditions and financing costs and is, thus, supposed to determine default risk. A higher US rate should increase the default risk.

4 Analysing the Determinants of Default Risk by BMA

4.1 The Setting

Our sample comprises the 10 countries that besides Germany and Luxembourg constitute the EMU.[6] Germany is excluded since we use German bond yields to calculate the bond spreads for other countries, whereas Luxembourg is not considered because of lacking data. The observation period starts in 1999 when the EMU was founded and exchange rate risk between the considered countries and Germany disappeared, which means that spreads are not biased by exchange rate risk.[7] The observation period ends in 2009 because of data availability.

We consider annual data since most of the economic data is available in annual frequency. The spreads, by contrast, are available in daily frequency. We calculate average spreads for each year (and country) in the observation period. We relate economic variables (which are end of the year data) to average spread values of the following year. This precludes endogeneity problems since spreads of a specific year are not supposed to influence economic data of the year before. Lagging of data was also used in the literature (see, e.g., Lemmen and Goodhart, 1999). In addition, our results can be used as forecast tool.

We include the 11 variables described in the last section. A detailed description of the data including data source can be found in Table 1. In addition we include country dummies to account for unobserved heterogeneity between countries. Thus, our estimations correspond to fixed effects panel estimation in classical statistics.

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[6] These are Austria, Belgium, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal, and Spain.
[7] For Greece we consider data from 2001 onwards when the country became member of the EMU.

4.2 The Results

We apply BMA to identify the major determinants of default risk using bond spreads as dependent variable. Whereas the main measure to assess the importance in classical statistics is the p-value that describes the significance level for each regressor for the specific model, in BMA the probability of inclusion calculated by equation (5) as described in Section 2 is used to assess the quality of a regressor. As explained this measure combines information obtained by considering the entire model space instead of that from a single model. The probability is the weighted average of probability values (that determine the significance levels) for single model whereby the model probabilities are used as weights. The results are reported in column 2 of Table 2. Similarly, we average the coefficients obtained for a specific regressor in the single models that contain this regressor to obtain an average coefficient. Here especially the sign of the average coefficient is important which gives us the direction of influence. It is reported in column 3 of Table 2.

Our results confirm some important findings of the literature, doubt others and provide mixed evidence to a third group of variables. High likelihood values – clearly above 50% – are obtained for government debt to GDP and budget balance to GDP. The sign of the average coefficient is as expected positive for debt to GDP and negative for the budget balance. A higher debt and a lower budget balance, i.e. a higher deficit (which is mostly observed), increases default risk. This confirms findings of important contributions in the literature (see, e.g., for EU countries Lemmen and Goodhart, 1999, Bernoth, von Hagen and Schuknecht, 2006, Schuknecht, von Hagen and Wolswijk, 2009, 2010) where these variables were also found to be important drivers of default risk and also justifies in some sense their inclusion in the Maastricht treaty.

Table 2: Results - Probability of Inclusion and (Average) Direct of Influence (Sign of the Average Coefficient)

No	Variable	Probability of inclusion	Direction of influence
1	Budget balance to GDP	82.4	-
2	Total government debt to GDP growth	76.4	+
3	Average interest rate	4.6	-
4	GDP growth	12.5	+
5	Imports growth	30.8	-
6	Exports growth	11.1	-
7	Terms of Trade growth	53.7	-
8	Inflation	8.1	-
9	Inflation variation	8.2	+
10	Capital formation	5.6	-
11	US interest rate	15.4	+

A third variable that shows a high probability of inclusion of above 50% is the change in the terms of trade. This variable has not been considered in the revised literature on EU countries, but was found to be significant for developing countries (see, Baldacci, Gupta and Mati, 2008). Our results indicate that this variable seems to be important for EMU countries as well, whereby better terms of trade decrease default risk. Potential reasons are explained in Section 3.

For the other external variables, export and import growth, the likelihood is about 11 respective 31%, i.e. not negligible but not overwhelming, in particular compared to the variables discussed above. This may result since competing influences neutralize each other. As explained in Section 3, there exist competing theories that imply opposite directions of influence. According to the willingness-to-pay theory the sign for both imports and exports should be positive since higher openness makes the country more vulnerable for negative effects of defaults and, thus, the country rather avoids default as long as possible. If one believes that more open economies are more vulnerable to default risk because the economy is more negatively affected by external shocks and one believes that this influence dominates, one should expect a positive sign for both exports and imports. If, by contrast, the country's ability to collect funds for debt servicing is dominating, higher exports should decrease default risk, whereas higher imports should rather increase it, i.e. the sign for exports is negative, but for imports positive. The sign of the average coefficient is negative for both exports as well as imports, which – carefully – can be interpreted as evidence that the countries' political decisions and potentially resulting (un)-willingness to pay is seen as important for default risk.

Also for economic growth as indicator for the overall state of the economy the likelihood is with values of about 15% not negligible but not overwhelming. As explained above the growth rate of GDP in relation to the growth rate of debt determines the long-run debt burden. But this long-run influence seems to be of rather low importance for default risk in the annual perspective. The burden of debt is also influenced by the interest costs. But for the average interest rate the probability of inclusion is even below 5%, which means that this variable also is rather not important for default risk. Also for capital formation which is supposed to determine the future repayment ability the probability has a low amount of 5.6%. This may also result because the long-run perspective is not important. Another explanation can be that the amount of investments (in relation to GDP) is less important than the quality of investment projects and the reasonable use of funds, which is not measured by this variable. Yet, the most troubled countries in the EMU had high inflow of (cheap) capital in the pre-crisis years which was often not invested very successfully.

For inflation and inflation variation the probability of inclusion is about 8%. This can be seen as evidence that the inflation has rather low importance for default risk in the Eurozone, maybe because the inflation is rather low for all countries in the sample (compared, e.g., to developing countries), which in turn may result from the membership in the EMU. This indicates further that under the viewpoint of (minimizing) default risk, the common monetary policy is rather a minor problem or even positive.

As explained in Section 3, the US rate is used in many papers as indicator financing conditions and financing costs, whereby its influence is debated: some authors find significant influence, whereas other do not. Since the probability of inclusion of about 15% is not very high but also not negligible, we cannot provide convincing evidence to this debate, yet, our results more or less reflect the undecided state of the literature.

As a robustness test we perform the analysis without country dummies, i.e. we use pooled data. The results are displayed in Table A-3 in the appendix. It can be seen that the results are rather robust to this change in the specification. The direction of influence is unchanged for all variables. For the most variables the probability of inclusion is only slightly changed, mostly it is somewhat higher than in the setting that includes country dummies. For budget balance to GDP, terms of trade growth, import growth and inflation variation the probability is increased considerably (more the 10 percentage points). The general results and conclusions with respect to our hypotheses about important determinants are, however, confirmed by running BMA on pooled data without country dummies.

5. Conclusion

Considerable default risk of several EMU member states is an important issue since it causes financial turmoil in the Eurozone, imposes high costs for all member states, and it is even a threat for the future existence of the EMU. An interesting strand of the empirical literature on country default risk analyzes the determinants of country default risk by regressing potentially explaining variables in government bond yield spreads, which serve as risk indicator. These papers provide interesting insights into the nature and causes of country default risk. The results, even for papers that focus on EU countries, are, however, rather heterogeneous, which points to some degree of model uncertainty.

We contribute to this literature by tackling the issue with Bayesian Model Averaging (BMA), which has been already successfully applied on other issues, but not on the question of (EMU) default risk. BMA is an elegant approach to deal with model uncertainty since it uses information from the entire model space and not only a single model (or some selected models), as in classical regressions, to identify the best models and assess the quality of potential regressors. In this sense, it provides additional and broader information. Thus, our paper complements the existing literature by applying BMA.

We confirm some important findings of the literature, doubt others and provide mixed evidence to a third group of variables. We find that the most important drivers of default risk in the Eurozone are government debt to GDP, budget balance to GDP and terms of trade. For economic growth, export growth, import growth and the US interest rate the likelihood is between 10 and 50%, whereas for some variables found to be significant in the literature, as interest rate costs, capital formation and inflation, this likelihood is below 10%.

Our results indicate that the key variables, budget balance (deficit) to GDP and the debt to GDP, that are included in the Maastricht treaty, in fact, are the most important risk drivers of default risk, whereas other, maybe more long-term oriented, variables like capital formation and economic growth and also inflation could not prove to be important. Thus, avoiding defaults – and maybe even the surviving of the EMU – crucially depends on the successful budget consolidation of the member states and the reduction of debt to GDP. The success seems to be partly influenced by favourable conditions in the external sector, in particular, by favourable terms of trade, which seems to be more important than the financing conditions and interest rate costs.

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Appendix

Table A-1. Summary of existing literature for developing countries .

Panel A: Studies with primary bond spreads as a dependent variable for developing countries		
Study	Sample	Explanatory variables with significant influence
Edwards (1986)	1976 – 1980 13 countries	Debt to output ratio, Gross investment ratio, Debt service ratio, Maturity
Min (1998)	1991 – 1995 10 countries	Debt Service Ratio, Terms of Trade, Growth rates of exports and imports, Current account balance, Ratio of debt to GDP, Ratio of reserves to GDP
Eichengreen and Mody (1998)	1991 – 1996 55 countries	Ratio of debt to GDP, Debt Service Ratio, Dummy for rescheduling, (10 year) risk-less US interest rate, Private placement, Israel dummy, Supranational, Public or private issuer, Currency (DM/Yen), Latin America dummy, Ratings of Institutional Investor
Kamin and von Kleist (1999)	1991 – 1997	Debt Service Ratio, Ratio of total debt to GDP, Ratio of reserves to imports; Ratings of S&P and Moody's, Maturity, Currency dummy (Yen, Non USD), Time dummies

Panel B: Studies with secondary bond spreads as a dependent variable for developing countries		
Study	Sample	Explanatory variables with significant influence
Cantor and Packer (1996)	September, 29, 1995 45 countries	Ratings (S&P and Moody's), External debt, Stage of economic development (according to IMF classification), Default history
Arora and Cerisola (2001)	1994 – 1999 11 countries	Risk-less interest rates, Debt service ratio, Ratio of total debt to GDP, Ratio of reserves to GDP, Ratio of reserves to imports
Rowland and Torres (2004)	1998 – 2002 16 countries	Economic growth, Ratio of debt to exports, Ratio of debt service to GDP, Ratio of reserves to GDP
Dailami, Masson and Padou (2005)	1991 – 2004 17 countries	Openness, Level of (total) debt, Reserves to GDP, Proportion of short-term debt, Spread of US corporate bonds, Several leading indicators of US interest rates (e.g., Producer prices, Retail sales, Capacity utilization, M2)
Baldacci, Gupta and Mati (2008)	1997 – 2007 30 countries	Fiscal balance, Public investment, Inflation, Political risk index, Reserves, Current account balance, Terms of trade

Table A-2. Summary of existing literature for EU countries

Panel A: Studies with bond spreads (**for single issues**) as a dependent variable for EU countries		
Study	Sample	Explanatory variables with significant influence
Bernoth, von Hagen and Schuknecht (2006)	1993 – 2005 14 EU countries	Debt to GDP, Deficit to GDP, Debt service to revenues, Maturity of the bond issue, Corporate bond spreads, Liquidity of the issue, EMU dummy, Short-term US rate
Schuknecht, von Hagen and Wolswijk (2009)	1991 – 2005 13 EU countries and sub-national governments (regions) of Canada, Spain and Germany	Public debt to GDP, Fiscal balance to GDP, Maturity of the bond issue, US Corporate bond spreads, Liquidity (size) of the issue, Region dummies, Short-term US rate
Schuknecht, von Hagen and Wolswijk (2010)	1991 – 2009 15 EU countries	Central government debt to GDP, Fiscal balance to GDP, Maturity of the bond issue, US Corporate bond spreads, Liquidity (size) of the issue, EMU dummy, Short-term US rate, "Turmoil" dummy, Crisis dummy

Panel B: Studies with bond spreads (**obtained for benchmark curves**) as a dependent variable for EU countries		
Study	Sample	Explanatory variables with significant influence
Lemmen and Goodhart (1999)	1987 - 1996 13 EU countries	Debt to GDP ratio, Capacity to raise taxes, Inflation, Inflation variability
Codogno, Favero and Missale (2003)	1999 – 2002 9 EU countries	Debt to GDP ratio, US swap spread, US corporate bond spread
Manganelli and Wolswijk (2007)	1991 – 2009 15 EU countries	Ratings, Short-term interest rate

Table A-3: Results - Probability of Inclusion and (Average) Direct of Influence (Sign of the Average Coefficient) for BMA without Country Dummies

No	Variable	Probability of inclusion	Direction of influence
1	Budget balance to GDP	99.9	-
2	Total government debt to GDP growth	74.0	+
3	Average interest rate	9.1	-
4	GDP growth	14.3	+
5	Imports growth	49.6	-
6	Exports growth	17.8	-
7	Terms of Trade growth	80.5	-
8	Inflation	10.4	-
9	Inflation variation	18.7	+
10	Capital formation	10.3	-
11	US interest rate	16.1	+