# MACROECONOMIC DETERMINANTS OF SOVEREIGN CREDIT RISK

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**Abstract**

The recent global financial crisis has highlighted the need to understand financial instability in particular the management of credit risk. In this paper we empirically investigate the link between the macroeconomic fundamentals and sovereign credit risk for particular countries in the Euro-zone, namely: France, Germany, Spain and Portugal. The studied sample was affected by disadvantageous economic conditions. Thus, the identification of credit risk determinants is necessary for a better understanding of financial crisis. Using Autoregressive Distributed Lag Modeling, we didn't retain the same macroeconomic factors to explain the risk of default for the selected countries. The retained models, in addition to explaining to which extent credit risk reacts to the changes of the explanatory variables, serve as tools to stress testing. The results, reinforced by back tests, indicate that the creditworthiness of the studied entities depends largely on macroeconomic fundamentals with various elasticities that require a different economic policy for each country. Furthermore, the assessment of the results shows that an increase in debt has opposite effects on the sovereign credit risk which depend on the country's economic situation. Finally, the study finds that the Treasury Bond Yield follows a mean-reverting process with dissimilar speed of return for each country.

**Key words:** Sovereign credit risk, macroeconomic fundamentals, Autoregressive Distributed Lag Modeling, Treasury bond yield.
**JEL Code:** C58, E44, G18.

## Introduction

Credit risk is the possibility to failure in credit payment. When the borrower is a country, this is called sovereign credit risk and it measures the ability and the tenacity of a state to fulfill its obligations. This case has been examined for a long time and has led to several findings like the evaluation systems of the borrower quality by giving a score to individuals and ratings to States. The Basel committee on banking supervision -whose aim is to strengthen the regulation through the Basel accords[1] -tries to improve these latters to adapt them to innovations and movements on the market. Nevertheless, Credit risk models aiming to estimate a borrower default probability are being developed very quickly and widely. Structural, stochastic or econometric models try to predict the probability that a borrower will default on maturity and / or when this event is most likely to occur. This paper attempts to explain what happens in an economy before seeing its risk of bankruptcy increases. As documented in Asghar and Daly 2010 in their research on the United States of America and Australia where the variable used to measure the default risk is the ratio of provisions for risky debt to total debt, there is a negative relationship between the GDP level and the default rate, as well as a positive link between this latter with the debt with more responsiveness of the American economy to macroeconomic shocks. A number of recent studies like Hilscher and Nosbusch have investigated the empirical determinants of Sovereign credit spreads and they found a significant link with the macroeconomic fundamentals. Plank applies a structural model of sovereign credit risk with macroeconomic fundamentals as determinants on a sample of emerging economies. He defines the repayment capacity of a country as the maximum amount of foreign currency available for the payment of external debts. This ability improves with the expectations of future export as well as foreign exchange reserves. However, it is negatively correlated with the present value of future imports, and on the other hand, the model is not validated for Turkey which is the most developed country in the sample. To follow the default probabilities evolutions Otaviano and all, 2012 use ratings provided by rating agencies. The authors confirm that a good rating (i.e. low risk) is associated with a low inflation, high economic growth, unimportant level of debt, significant trade openness, and a low past events of default since 1975. The choice of In-Mee Baek and all, 2005 is rather focused on the bond yield spread as a dependent variable to describe the

[1] http://www.bis.org/bcbs/basel3.htm

evolution of default risk. Their conclusion is that a higher GDP growth, larger foreign reserves, and an appreciation of domestic currency lead to a decrease in the bond yield spread. On the other hand, the more important the inflation is, the higher the bond yield spread is also. After a review of the literature on the different credit risk approaches, we present our modeling, the regression results, recommendations and back testing graphics for each country of the sample.

# 1 Credit risk approaches

## 1.1 Structural models

In the structural approach, Economic variables of the firms are used as determinants of its potential failure in that an entity is considered in default if it is unable to pay its due. That is to say that the asset value no longer covers the nominal debt beyond. This approach has emerged with Merton model, 1974 where he adapted Black-Scholes-Merton model[2], 1973 on derivates to credit risk. Black, Fischer and John Cox, 1976 have helped to develop this modeling by assuming that default actually can happen before the maturity date. Moody's in its KMV model (Kealhofer, McQuown et Vasicek) uses the structural approach in determining the probability of default risk since 2002, in the extent that failure occurs when the asset value falls below some determined barrier.

## 1.2 Reduced form models

Unlike structural models, reduced form models focus only on the default event but not its causes, since, in this approach this latter is considered as an accident, i.e. a sudden and rare event. This explains its modeling by a Poisson process[3] which is a continuous diffusion model typically used to model rare events. Jarrow and Turnbull, 1995 have developed the first stochastic model in 1995. The Duffie and Singleton model has appeared in 1999.

## 1.3 Econometric models

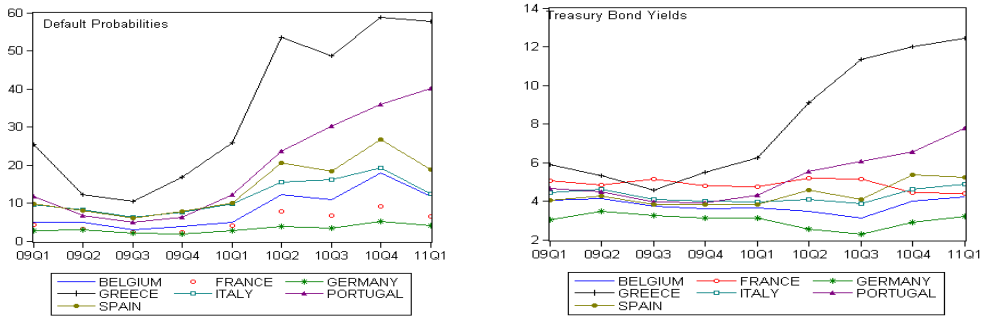
Thomas C. Wilson initiated this approach in 1997, he explains the failure by economic factors including macroeconomic by statistic link. The most used model is Credit Portfolio View, 1998 of Mckinsey[4]. The particularity of this model is that it considers not only specific factors of the studied entity, but also contextual ones.

[2] Black-Scholes-Merton is a mathematical model of market action, in this model; the share price follows a stochastic process. (Fischer Black and Myron Scholes "The pricing of options and corporate Liabilities)
[3] Jean Jacod, "Chaines de Marcov, Processus de Poisson et Applications" 2003-2004
[4] A global management consulting firm among the top five. http://www.mckinsey.com/

## 2. Modeling

The graphs below show default probabilities and bond yield evolutions[5] of a sample of Euro zone countries. They confirm what states the modern portfolio theory that return and risk are inseparable concepts, taking additional risk is only accepted if coupled with a higher Yield. Countries are no exceptions to the rule; the greater the risk that a state will default and finds itself unable to honor its commitments, the more the lenders require higher Treasury bond yield. Indeed, the risk premium is a part of the required return; it represents what claims an investor willing to place his funds in risky assets. The more the risk incurred is, the higher the premium is, which leads the demand of greater yield.

**Fig. 1: Default probabilities and Treasury bond yields**




Source: Author's calculation based on Bond yields and CMA Credit Market Analysis

Graphs comparing the evolutions and trends of the Treasury bond yields and the default probabilities.

### 2.1 Data and model specification:

The chosen dependent variable in this modeling is the Treasury bond yield. This choice is justified by the fact that this variable reflects the sovereign default risk and by data availability. The Reuters EcoWin Economic & Financial database[6] is our main source of data. Selected explanatory variables (In first difference) are:

- Lagged Long-Term Government Bond Yields, 10-Year : LBY
- Long-term interest rate on government bonds : LIRL
- Short term interest rate : LIRS

[5] Traced from default probabilities calculated by CMA Credit Market Analysis Ltd http://www.cmavision.com

[6] The Reuters EcoWin Economic & Financial database consists of global economic and financial data covering more than 100 countries worldwide, as well as aggregates. Data is collected from more than 800 primary sources: national statistical offices, central banks, financial exchanges, private institutes as well as other data sources.

- Gross fixed capital formation , Volume index : LGFCF
- General government consolidated gross debt as a percentage of GDP : LDEBT
- Harmonized unemployment: rate, all persons (all ages): LCH.

For reasons of data availability, estimates are done using quarterly frequency over the 1999-2009 period. The sample on which we work is: Germany, France, Portugal and Spain.

After testing the presence of unit root and the stationarity of the data, the chosen model to explain the link between the Treasury bond yield and the macroeconomic variables is an Autoregressive Distributed Lag Model (ARDL)[7] which is a dynamic model combining distributed lag models and autoregressive ones. In this modeling the regressors may include lagged values of the dependent variable and current and lagged values of one or more explanatory variables. It is a dynamic model since it describes the time path of the dependent variable by its history. In economics, there are not a lot of instantaneous relationships between regressors and dependent variable. The variations of the values taken by the dependent variable are an answer to observed changes in the explanatory variables, but after a time interval. This represents the duration necessary for the new information to be integrated into the replica of the endogenous variable. This duration, also called delay, depends on the speed of response to new information received from different evolutions of explanatory variables. The coefficients corresponding to regressors with the same time index as the dependent variable are called short-term multipliers since they describe an immediate relationship. The sum of the coefficients of the same variables for different periods is the distributed lag multiplier, and it provides us with a full description, or long-term relationship between exogenous and endogenous variables. The general form of an ARDL model:

$$Y_t = b_0 + \sum_{i=1}^{p} b_i Y_{t-i} + \sum_{j=1}^{m} \sum_{i=0}^{n_j} a_{ji} X_{j,t-i} + \varepsilon_t \qquad (1)$$

The condition $\sum_{i=1}^{p} b_i Y_{t-i} < 1$ is regularly imposed in the ARDL literature to ensure that the dependent variable $Y_t$ is stationary. In our modeling:

- $Y$ = Treasury bond yield in first difference.
- $p$ = Lags of dependent variable (autoregressive).
- $X_j$ = The explanatory macroeconomic variable number **j**.
- $m$ = The number of selected exogenous variables (Distributed lags).

[7] Hendry and Pagan and Sargan 1984, Dynamic specification. In Griliches, Z. and M. D. Intriligator ed Handbook of Econometrics, vol.2 Ch.18, Amsterdam, North Holland

- $n_j$ = lags of regressor **j.**

The general form of the model which varies from an economy to another is:

$$LBY_t = c + \sum_{i=1}^{p} b_i LBY_{t-i} + \sum_{i=0}^{n_1} a_{1i} LIRL_{t-i} + \sum_{i=0}^{n_2} a_{2i} LIRS_{t-i} + \sum_{i=0}^{n_3} a_{3i} LGFCF_{t-i} + \sum_{i=0}^{n_4} a_{4i} LCH_{t-i} + \sum_{i=0}^{n_5} a_{5i} LDEBT_{t-i} + \varepsilon_t \quad (2)$$

## 2.2 The regression results

Determined models explain well the evolution of Treasury bond yields and with high adjusted coefficients of determination (Adjusted R²) between 0.84 and 0.94. Unemployment rate was not accepted for any country of the sample. For all regressions were accepted normality of residuals, their homoscedasticity and their non autocorrelation. Results are presented by country. For each one, we expose the estimation equation (i.e. the selected model), interpretations and recommendations. In the Back Testing graphics, we forecast Treasury Bond Yield for 2010, 2011, and 2012 using the chosen model for each country to compare the actual data series to the series obtained by the estimates. This is to check whether the model is able to predict the future evolution of the dependent variable. Test results are attesting to the good predictive power of the models.

**Results of ARDL regressions for France**

$$LBY_t = -0.39 * LBY_{t-1} + 1.33 * LIRL_t + 0.04 * LGFCF_{t-2} - 0.0379 * LGFCF_{t-3} + 0.25 * DUM0401 - 0.0069 \quad (3)$$

Changes in French Treasury bond yields are negatively correlated with its lag of a period which must be due to the effects of expectations that lead to the reduction of misalignments. The factor of risk aversion that is related to the GFCF can intervene. In France it outweighs the benefits of increased investment in the economy. When risk aversion is high, which is due to the involvement of France relative to other members of the euro area, the increase in investment is associated with a higher risk premium which increases the LBY.

Recommendations: France can take more benefit of increased investment by trying to reassure investors. These can be given consistent guarantees that are aligned with their overall objectives. It would also be interesting that France operates a policy of fiscal stimulus in particular by reducing the level of taxation.

**Results of ARDL regressions for Germany**

$$LBY_t = -0.42 * LBY_{t-1} + 1.439 * LIRL_t + 0.043 * LDEBT_t - 0.037 * LDEBT_{t-1} + 0.248 * DUM0401 \quad (4)$$

The adjustment of the evolution of Treasury bond yield from one period to another is more important for Germany than in France. The coefficient associated to the lagged dependent variable is still negative but larger. Thus, the return to the general trend is faster.

The other held variable to explain German Treasury bond yields is the ratio of debt to GDP; it overall varies in the same direction as the endogenous variable. In fact, the more a country is indebted, the more impressive the refunds to be completed are.

Recommendations: Germany sees its risk of becoming insolvent increasing when its debt rises due to higher reimbursements. It had better lower its debt to reduce its risk of defaulting on its commitments. Germany should look for other sources of funding; this can be done by increasing self-financing.

**Results of ARDL regressions for Portugal**

$$LBY_t = -0.357 * LBY_{t-1} + 1.42 * LIRL_t + 0.037 * LDEBT_{t-2} - 0.054 * LDEBT_{t-3} + 0.28 * DUM0105 + 0.0043 \quad (5)$$

Like the other countries, a part of the evolution of the Portuguese Treasury bond yields is explained by adjustment from his past. In Portugal there is a negative relationship between the global level of debt and the evolution of default risk, this can be explained as Grossman and all argue that the debt can improve managerial efficiency which leads to risk reduction.

Recommendations: The Portuguese economy could enhance its creditworthiness by increasing its indebtedness (without this being unsustainable).

**Results of ARDL regressions for Spain**

$$LBY_t = -0.64 * LBY_{t-1} + 1.4 * LIRL_t + 0.48 * LIRL_{t-1} - 0.059 * LDEBT_{t-2} + 0.034 * LGFCF_t - 0.037 * LGFCF_{t-2} - 0.32 * LIRS_{t-1} + 0.15 * LIRS_{t-2} - 0.24 * DUM0102 - 0.018 \quad (6)$$

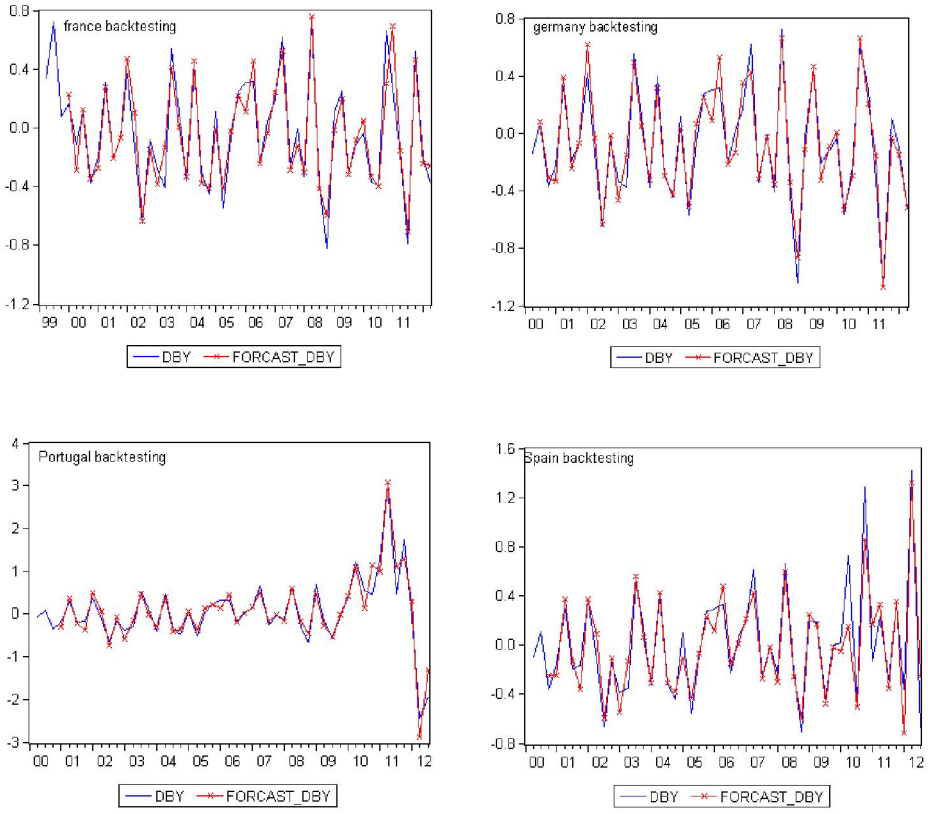
The sign associated to the lagged Treasury bond yields is negative which means that it automatically corrects itself from one period to another. We note that the gross fixed capital formation varies in the opposite direction of the Spanish Treasury bond yields pointing that a more energetic economy with more important investment in fixed capital improves Spain solvency. Debt which improves managerial efficiency and reduces credit risk is also observed in Spain.

Recommendations: For the sake of the Spanish economy, the wisest is to apply an expansionary monetary policy (lowering interest rates) this can also help to achieve the objective of external balance; it is also important to push investments in fixed capital especially by a policy of fiscal stimulus. As for Portugal, improving Spanish repayment capacity could be achieved through contracting on further debt.

### 2.3 Back Tests

Estimates are made until 2009 and we tested the models power of prediction for 2010, 2011 and 2012.

**Fig. 2 Models Back testing**




Source: Author's calculation

## Conclusion:

For all regressions normality of residuals were accepted, their homoscedasticity and their non autocorrelation. The creditworthiness of the sample of countries in the Euro zone depends largely on macroeconomic fundamentals. Determined models explain well the evolution of Treasury bond Yields and with high adjusted coefficient of determination (adjusted-$R^2$) between 0.84 and 0.94. An error correction term is present in each equation; it corresponds to the lagged endogenous variable coefficient. The long-term multipliers, once computed (through the coefficients of the lagged variables), both hypotheses of co-integration and presence of long-term relationships has been tested and accepted. This informs us about the long run equilibrium. In that saying that the obtained relationships between the variables are

still valid and applicable in the long term. The retained models, besides explaining how the Treasury bond yields respond to the increases and decreases of the macroeconomic regressors, they provide a base for scenario analysis to determine the economies reactions to different situations by stress testing. The short-term effects are rare and mainly concern long term interest rates. Its immediate impact is always more important than its long-term impact. The link is obvious and intuitive between these variables, since the latter informs us about the required premium or the expected gain due to the investment in the concerned Treasury securities. The coefficient associated with the lagged dependent variable has a negative sign for all countries indicating that the evolution of Treasury bond yields adjusts itself each period to minimize misalignments. This is usually explained by the effects of expectations. Thereby the Treasury bond yield follows a mean reverting process. Generally, an increase in gross fixed capital formation positively affects the economic situation of a country; it increases investment, revenues and subsequently its solvency. A rising debt increases commitments and the creditor's risk of failure in Germany whose economic situation is sturdier. For Portugal and Spain, the augmentation of the debt raises risk aversion and boosts the managerial efficiency which lowers the credit risk default. The short term interest rate affects the Treasury bond yields through the channel of the economic cycle; an increase in this rate stimulates investment, promotes growth and causes more inflation. Its effect is negative (i.e. positive coefficient associated) if the adverse impact of inflation outweighs the growth and vice versa.

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