

Macroeconomic Determinants of Sovereign Credit Risk

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1 Abstract

The recent global financial crisis has highlighted the need to understand financial instability in particular in the context of 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: Belgium, France, Germany, Italy, Spain and Portugal. The studied sample was affected by disadvantageous economic conditions. Thus, the identification of credit risk determinants is crucial and necessary for a better understanding of financial crisis. Using Autoregressive Distributed Lag Modeling (ARDL), we did not 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 var-

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ious 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 depends on the comfort level of 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.

Keywords : Sovereign credit risk, macroeconomic fundamentals, Autoregressive Distributed Lag Modeling, Treasury bond yield.

JEL Classification : C58, E44, G18.

2 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 accords¹ - tries to improve these matters 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 Ali and Kevin Daly 2010[1]² 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

¹<http://www.bis.org/bcbs/basel3.htm>

²Asghar Ali; Kevin Daly, Macroeconomic determinants of credit risk : recent evidence from a cross country study, International review of financial analysis. - Amsterdam [u.a.] : Elsevier, Vol. 19.2010, 3, p. 165-171

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 chocs. A number of recent studies like Jens Hilscher and Yves Nosbusch[11]³ have investigated the empirical determinants of Sovereign credit spreads and they found a significant link with the macroeconomic fundamentals. Thomas J. Plank[12]⁴ 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; Nevertheless, 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 [5]⁵ 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 [2]⁶ is rather focused on the bond yield spread as a dependent variable to describe the 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.

³Jens Hilscher Yves Nosbusch, Determinants of Sovereign Risk: Macroeconomic Fundamentals and the Pricing of Sovereign Debt, *Review of Finance*,(2010) 14 (2): 235-262.

⁴Thomas J. Plank, Do Macro-economic Fundamentals Price Sovereign CDS Spreads of Emerging Economies? Philadelphia, Pa. : Weiss Center for International Financial Research, Wharton School, Univ. of Pennsylvania, june 2010

⁵Otaviano Canuto, Pablo Fonseca P. dos Santos and Paulo C.de Sá Porto, Macroeconomics and Sovereign Risk Ratings, *Journal of International Commerce, Economics and Policy*, Volume 03 (2012) P.1250011-1-1250011-25

⁶In-Mee Baek, Arindam Bandopadhyaya and Chan Du, Determinants of market-assessed sovereign risk: Economic fundamentals or market risk appetite? *Journal of International Money and Finance*24 (2005) 533-548

After a review of the literature on the different credit risk approaches, we present our modeling, the choice of variables, the regression results and the back test graphs for each country of the sample.

3 Credit risk approaches

3.1 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)⁷ where Robert C Merton adapted Black-Scholes-Merton model⁸ on derivatives to credit risk. It has seen many developments especially by Black, Fischer and John Cox [3]⁹. Moody's¹⁰ 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.

3.2 The 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 process¹¹ [9] which is a continuous diffusion model typically

⁷Merton Robert C. "On the Pricing of Corporate Debt: The Risk Structure of Interest Rates", Journal of Finance, Vol. 29, No. 2, (May 1974), pp. 449-470

⁸Black-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")

⁹Black, Fischer and John C. Cox, "Valuing Corporate Securities: Some Effects of Bond Indenture Provisions", Journal of Finance, Vol. 31, No. 2, (May 1976), pp. 351-367

¹⁰A rating agency which provides ratings and Credit Monitor Software that calculates the values of EDF(Expected Default Frequency) by issuer for horizons of 1 to 5 years

¹¹Jean Jacod, "Chaînes de Marcov, Processus de Poisson et Applications" 2003-2004

used to model rare events. Jarrow and Turnbull [10]¹² have developed the first stochastic model in 1995, then Duffie and Singleton model [6]¹³ has appeared in 1999.

3.3 Econometric models

Thomas C. Wilson [14] initiated this approach in 1997, he explains the failure by economic factors including macroeconomic by statistic link. The most used model is CreditPortfolioView¹⁴ of Mckinsey¹⁵ (1997). The particularity of this model is that it considers not only specific factors of the considered entity, but also contextual ones.

4 Modeling

The graphs below show default probabilities and bond yield evolutions¹⁶ of a sample 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.

¹²Robert A. Jarrow; Stuart M. Turnbull: Pricing Derivatives on Financial Securities Subject to Credit Risk, *The Journal of Finance*, Vol. 50, No. 1. (Mar., 1995), pp. 53-85

¹³Darrel Duffie, Kenneth J. Singleton : Modeling Term Structures of Defaultable Bonds, *The Review of Financial Studies*, Volume 12 Issue 4 (1999), 687 - 720

¹⁴Thomas C. Wilson: Portfolio Credit Risk, *FRBNY ECONOMIC POLICY REVIEW*, Vol. 4, No. 3, OCTOBER 1998

¹⁵A global management consulting firm among the top five. <http://www.mckinsey.com/>

¹⁶traced from default probabilities calculated by CMA Credit Market Analysis Ltd <http://www.cmavision.com>

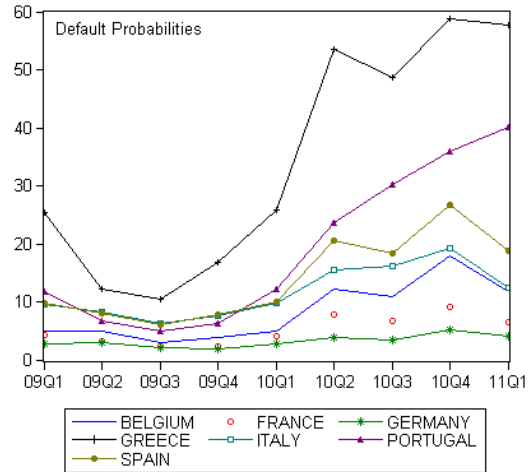


Figure 1: Default Probabilities

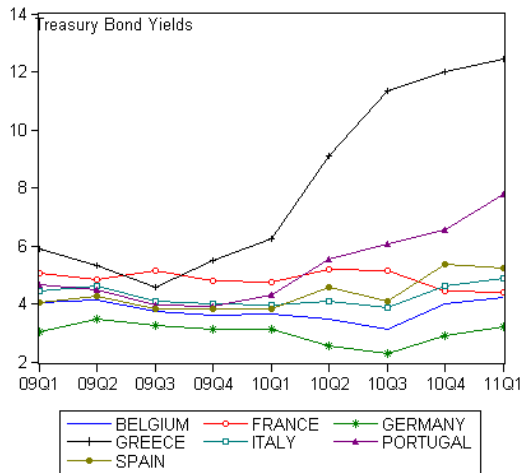


Figure 2: Bond Yield

4.1 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. Selected explanatory variables (In first difference) are:

1. Lagged Bond Yield : LBY
2. Long term interest rate : LIRL
3. Short term interest rate : LIRS
4. Gross fixed capital formation : LGFCF
5. Debt in percentage of GDP : LDEBT
6. Unemployment rate: LCH

For reasons of data availability, estimations are done using quarterly frequency over the 1999-2009 period.

The sample on which we work is: Germany, Belgium, Spain, France, Italy, and Portugal. The unavailability of recent data and the disrupted economic context of the Greece, make it impossible to identify a valid model which has forces us to exclude it from the sample.

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)¹⁷ [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

¹⁷Hendry 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

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

$$Y_t = b_0 + \sum_{i=1}^p b_i Y_{t-i} + \sum_{j=1}^m \sum_{i=0}^{n_j} a_{ji} X_{jt-i} + \epsilon_t$$

The condition $\sum_{i=1}^p b_i < 1$ 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 \mathbf{j} .
- m = The number of selected exogenous variables (Distributed lags).
- n_j = lags of regressor \mathbf{j} .

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

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

4.2 The regression results

Determined models explain well the evolution of Treasury bond yields and with high coefficients of determination adjusted (Adjusted- R^2) between 0.84 and 0.94. 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 Belgium

$$LBY_t = -0.385 * LBY_{t-1} + 1.229 * LIRL_t - 0.0195 * LGFCF_{t-2} + 0.0957 * LIRS_{t-3}$$

The coefficient associated to the lagged explained variable is negative, which means that treasury bond yield fit from period to another. An increase in gross fixed capital formation leads to lower Belgian treasury bond yield thanks to additional incomes caused by rising investments which reduces the risk of default. The short term interest rate affects treasury bond yield, an increase of the first stimulates investment, promotes growth and causes more inflation. The Belgian short term interest rate is positively correlated with the treasury bond yield, ie for Belgium, the adverse impact of inflation outweighs the growth, indeed, pronounced inflation causes uncertainty and impoverishes agents by reducing their purchasing power.

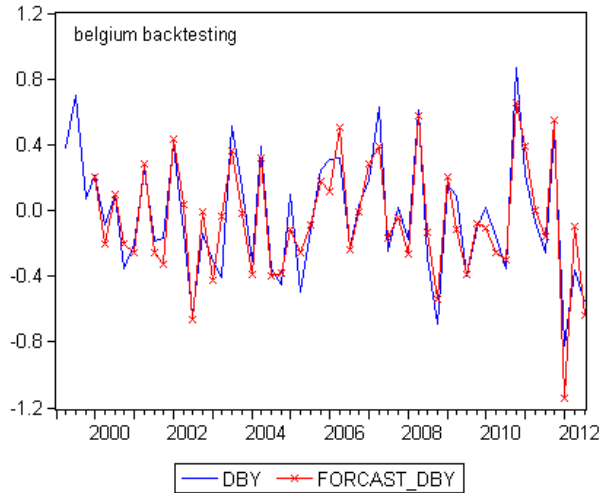


Figure 3: Back test of the Belgian model

Recommendations: Belgian agents must be motivated to invest in sustainable production assets (tangible and intangible). This is more cost effective and improves thereafter profitability and revenue for the economy. A policy of fiscal stimulus can be used to achieve this aim. Besides, an expansionary monetary policy could be advantageous to the Belgian economy. An approach to monetary policy based on controlling inflation may be beneficial.

Results of ARDL regressions for France

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

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*.

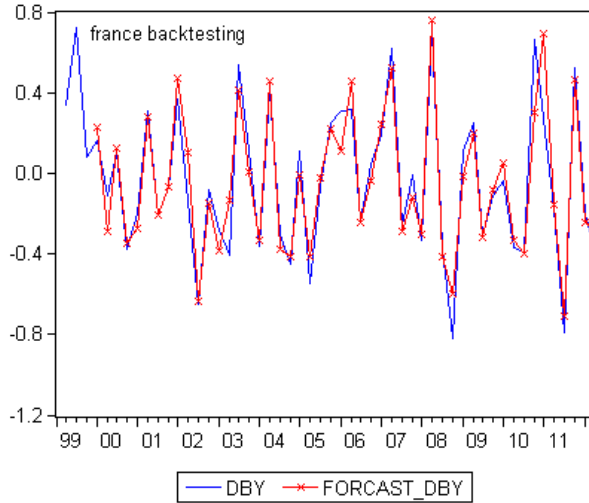


Figure 4: Back test of the French model

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

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

The adjustment of the evolution of Treasury bond yield from one period to another is more important for Germany than in Belgium or 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 vari-

able to explain German Treasury bond yields is the ratio of debt to GDP, it 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.

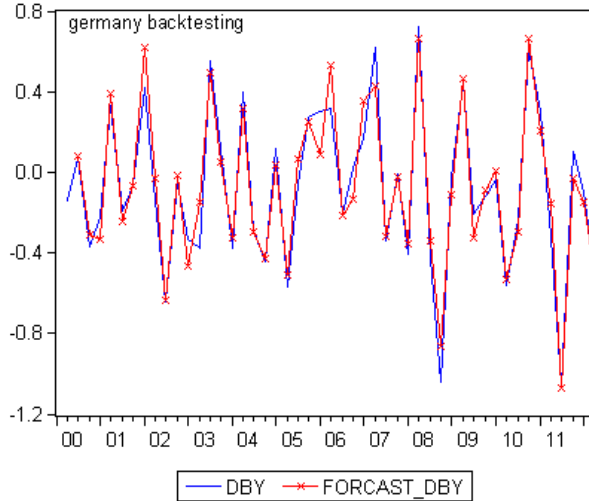


Figure 5: Back test of the German model

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 Italy

$$LBY_t = -0.65*LBY_{t-1} + 1.28*LIRL_t - 0.52*LCH_t + 0.37*LIRL_{t-1} - 0.213*LIRS_{t-1} - 0.0325*LDEBT_{t-1} - 0.0279*LGFCF_{t-3} + 0.139*LIRS_{t-3} - 0.013$$

The adjustment coefficient of the evolution of Treasury bond yields is important for Italy; there is a rapid return to tendency and a prompt reduction of misalignments relative to the general trend of the series.

A rise in fixed investment contributes to the improvement of the economic

situation of the country and reduces the risk that it could default compared to its commitments. The effect of the short term interest rates is spread over two periods; it is generally negatively correlated with the Italian Treasury bond yields. In the case of Italy, an increase in the short term interest rates has a stimulatory effect on investment and growth that outweighs the possible adverse effect of inflation.

In Italy, where there is a negative relationship between the level of debt and the evolution of default risk, this can be explained as Grossman et al [8]¹⁸ argue that the debt can improve managerial efficiency which leads to the reduction the risk.

The unemployment rate, although, negatively correlated with the evolution of the dependent variable, it does not Granger cause it.

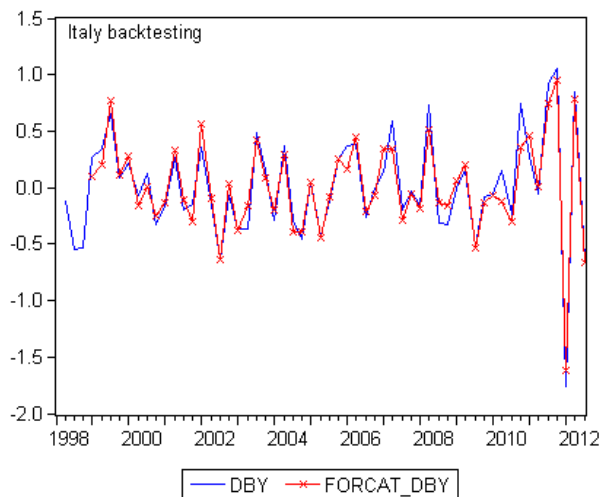


Figure 6: Back test of the Italian model

Recommendations: Besides having to encourage investment in fixed cap-

¹⁸Grossman, Sanford J. and Hart Oliver D. :Vertical Integration and the Distribution of Property Rights. Mimeographed. Chicago: Univ. Chicago,Dept. Econ., 1984.

ital by a policy of fiscal stimulus, the Italian banking and monetary authorities can play an important role opting for a restrictive monetary policy reducing the interest rate to stimulate investment and economic growth. The Italian economy can afford to be more indebted and this is even beneficial since it may improve its solvency.

Results of ARDL regressions for Portugal

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

Like the other countries, a part of the evolution of the Portuguese Treasury bond yields is explained by adjustment from his past.

The debt ratio is moving in the opposite direction as the dependent variable; we are witnessing the same phenomenon observed in Italy (i.e. Managerial efficiency).

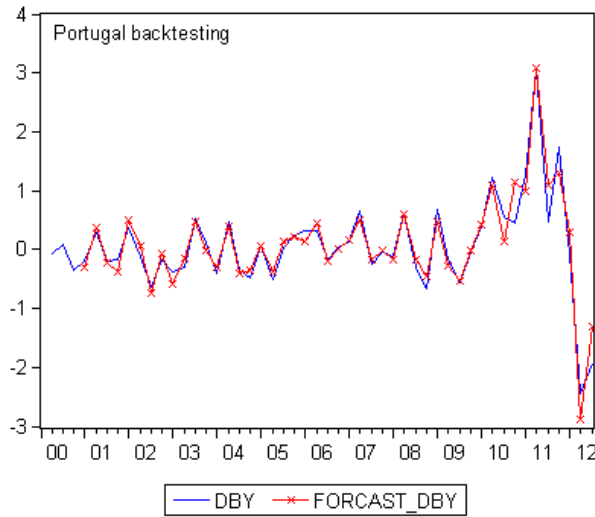


Figure 7: Back test of the Portuguese model

Recommendations: The Portuguese economy could enhance its credit-

worthiness by increasing its indebtedness (without this being unsustainable).

Results of ARDL regressions for Spain

$$\begin{aligned}
 LBY_t = & -0.64 * LBY_{t-1} + 1.4 * LIRL_t + 0.034 * LGFCF_t + 0.48 * LIRL_{t-1} - \\
 & 0.32 * LIRSt - 1 - 0.059 * LDEBT_{t-2} - 0.037 * LGFCF_{t-2} + 0.15 * \\
 & LIRSt - 2 - 0.24 * DUM0102 - 0.018
 \end{aligned}$$

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.

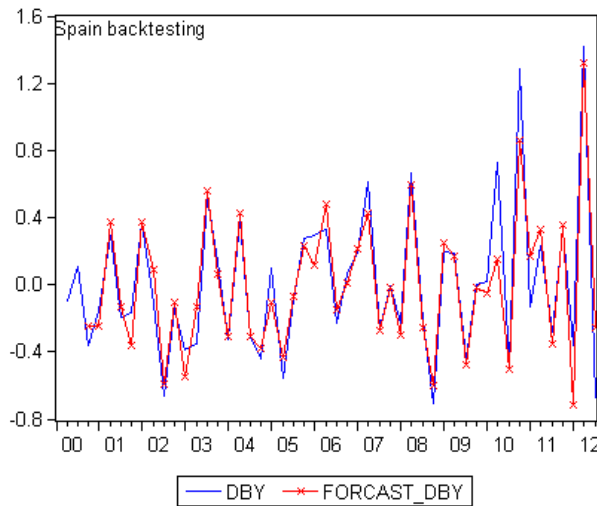


Figure 8: Back test of the Spanish model

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 Italy and Portugal, improving Spanish repayment capacity could be achieved through contracting on further debt.

5 Conclusion

For all regressions normality of residuals were accepted, their homoscedasticity ¹⁹[4]and their non autocorrelation.²⁰ [13]. 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 coefficients of determination adjusted (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 nega-

¹⁹Breusch-Pagan-Godfrey Test, A simple test for heteroscedasticity and random coefficient variation, (with A.R. Pagan). *Econometrica*, 47 (1979) 1287-1294

²⁰Breusch-Godfrey Serial correlation test, BREUSCH, T. S. (1978), Testing for Autocorrelation in Dynamic Linear Models. *Australian Economic Papers* V.17 P.334-355

tive 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. 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 Italy, 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 (ie positive coefficient associated) if the adverse impact of inflation outweighs the growth and vice versa. When the coefficient associated with this variable is negative as for Italy, this is explained by the fact that it is a stimulator of investment and induces production growth and employment and therefore supports the economic growth of a country which reduces the risk of failure.

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