# Empirical analysis of sovereign default risk in the euro area

## دراسة قياسية للمخاطر السيادية في منطقة اليورو

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**Abstract:**
The turbulence that characterized the euro area countries notably the manifestation of sovereign risk which results in the unsustainability of public debt and the increase in the cost of borrowing because of the increase in risk aversion in international markets, inspired us to study determinants that explain the dynamics of sovereign spreads, particularly the increase in the sovereign CDS spread, using an empirical and/or econometric approach. The purpose of this article is to analyze the risk factors which determine the aggravation of the sovereign risk, necessary to know especially in the current unfavorable macroeconomic context which is likely to cause the surge of the public debt of the most vulnerable economies. We will conduct a descriptive analysis on the stylized facts of the manifestation of sovereign default risk by examining the volatility of sovereign bond yields and the widening of sovereign CDS premiums, and an econometric analysis of this risk in order to determine the main factors that explain the resurgence of this risk during the debt crisis in the euro area, using an approach by panel data with the FGLS estimator.

**Keywords:** Sovereign default risk; Sovereign CDS; Panel data; FGLS estimator; Euro area.
**Jel Classification Codes**

**ملخص**
الاضطرابات التي ميزت دول منطقة اليورو ، و مظاهر المخاطر السيادية التي ادت إلى عدم استدامة الدين العام وزيادة تكلفة الاقتراض بسبب زيادة المخاوف من المخاطر في الأسواق الدولية ، ألهمتنا بدراسة المحددات التي تشرح المخاطر السيادية ، ولا سيما الزيادة في تقلب CDS السيادي (مبادلات مخاطر الائتمان) ، باستخدام نهج تجريبي. الغرض من هذا المقال هو تحليل عوامل الخطر التي تحدد تفاقم المخاطر السيادية ، وهو من الضروري معرفته خاصة في

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سياق الاقتصاد الكلي الحالي غير المواتي والارتباك العالمي الناتج عن تباطؤ النمو والذي من المحتمل أن يتسبب في زيادة الدين العام في الدول الأكثر ضعفًا. سنجري تحليلًا وصفيًا لحقائق مظاهر المخاطر السيادية من خلال دراسة تقلب عوائد السندات السيادية وتوسيع أقساط التأمين على الديون السيادية المعروفة بمبادلات مخاطر الائتمان CDS ، و دراسة تحليلية قياسية لهذه المخاطر من أجل تحديد العوامل الرئيسية التي تشرح تفاقم الخطرالسيادي خلال أزمة الديون في منطقة اليورو ، باستخدام طريقة لوحة البيانات مع مقدر FGLS.

**الكلمات المفتاحية:** المخاطر السيادية ؛ مبادلات مخاطر الائتمان ؛ طريقة لوحة البيانات ؛ طريقة التقدير FGLS؛ منطقة اليورو.

**تصنيف JEL:**

## Introduction :

During the last two crises, the member countries of the euro area have demonstrated weaknesses, which has shown and recalled that it was necessary not to neglect the unsustainability of the debt of advanced countries in the same way as that of emerging countries and constantly assess sovereign solvency.

Indeed the sovereign debt crisis in 2010 manifested a surge in sovereign bonds, an increase of the sovereign Credit Default Swaps (CDS) spread and successive downgrades of the sovereign rating by rating agencies especially for vulnerable economies, which indicates deterioration in the credit quality of some euro area member countries. In front of this situation, investors have become more risk averse and attentive to the economic indicators and debt of the countries of this union. This debt weakens the most vulnerable States and whose room for maneuver is limited, in particular the countries known under the name of "PIIGS" (Portugal, Ireland, Italy, Greece, Spain).

The reasons that explain the sovereign default risk are various and can be stimulated by the unsustainability of sovereign debt, a budget deficit, a commercial deficit, systemic crises (banking, stock market, foreign exchange or economic, etc.) lead to a phenomenon of contagion and an increase in international borrowing costs in the capital markets.

The deterioration of public finances and the sovereign insolvency of certain countries in the euro area, leads us to analyze the resurgence of sovereign risk in the member countries of the euro area, some of which showed their vulnerability during the crises of 2007 and sovereign debts in the euro area, which have led to a worsening of the unsustainability of sovereign debt, the risk of exclusion from the financial markets and investor mistrust of sovereign insolvency.

These facts lead us to ask a crucial question around which this work is articulated, namely*:*

*"How was manifested the sovereign default risk in the euro area and what are the causes that explain its resurgence?"*

In this study with econometric approach, we will consider the sovereign CDS spread as a measure of the default risk of a public borrower. This spread plays a major role in determining the default risk and is a pertinent measure of the estimated solvency of investors, as clarified by Barrios et al. (2009), Afonso et al. (2012), De Santis (2012) and Aizenman et al. (2013) who argue in favor of this indicator as a better measure of sovereign risk.

Thus, this article aims to present the stylized facts of manifestation of the soverign risk in the euro area during sovereign debt crisis and to identify the determinants that explain the manifestation of sovereign risk, particularly through the dynamics of sovereign CDS spreads in euro area member countries. The factors risk that will be analyzed are related to common risk which reflects the perception of the risk of the investors which results in the volatility of the stock markets, liquidity risk in the bond markets, and idiosyncratic risk which results in the state of macroeconomic fundamentals.

In order to exploit the two sources of variation in statistical information: temporal and individual, we will use the panel data method for to identify the main risk factors that have an impact on sovereign CDS spreads.

To achieve this objective and respond to the problem posed, this article will be divided into three parts. In the first point, we will review the literature relating to the various conceptions of sovereign default risk. The second point will present the descriptive analysis on sovereign risk by highlighting stylized facts on the manifestation of sovereign default risk in the euro area. Finally, the last point will focus on the empirical/econometric analysis in which we will present our sample and the period of our study, then, we will introduce the explanatory variables of the dynamics of the sovereign CDS spreads at maturity 10 years selected, and finally, we will examine the results of the regressions of our model, with the FGLS estimator, highlighting the main causes of the volatility of sovereign CDS spreads.

## 1. Literature review on the conceptions of sovereign default risk:

Generally, the sovereign default risk is defined by the probability that a state which has issued a loan is unable to meet its commitments to regularly repay the interest and/or principal of its debt. This risk presents a measure of the capacity, but also of the willingness of a state to repay all of

its debt when due, because the latter may decide not to repay its debts even if it has the resources necessary to do so.

The rise in sovereign risk therefore means that the probability of default by a sovereign state increases. Of course, most of the time, this default event does not occur, the State in question continues to honor its commitments and if it is forced to pay more interest on its debt, it can also try to undertake reforms to limit its deficit. The rise in default risk therefore simply reflects the deterioration perceived by the market in the credit quality of a sovereign issuer.

In this sense, the rating agency Standard and Poor's (S&P) defines sovereign default, on the one hand, as the inability to pay creditors or as a failure to pay the principal or interest owed by the sovereign debtor to at maturity, and on the other hand, as a debt restructuring which consists of an exchange of debt instruments (loans or bonds) on less favorable terms than those previously stipulated in the agreement.

Allegret (2015) clarified in his study that the authors Eaton and Gersovitz (1981) go in the same direction by specifying that the default is linked to the unwillingness or the inability of the debtor to recover the amount of the debt (or interest payment) as originally agreed. Indeed, an episode of sovereign default can be perceived by these factors:

- a sovereign debtor does not pay the first payments (interest or principal payments) due beyond the grace period (during the month in which the default is noted);
- a severe deterioration in the solvency of a sovereign debtor leads to the degradation of its sovereign rating by rating agencies to the grade of SD or selective default;
- a public announcement of default of the payments (voluntary or involuntary) due by the sovereign debtor.

The finding of the episode of default can therefore be very short or relatively long on the time scale, depending on the country and the amount of the debt due.

Several studies, notably Maillard (2013), Sturzenegger and Zettelmeyer (2006), Caen (2014), etc., attest that the most common causes of a sovereign default, materialized following a high level of debt, are following:

- A deterioration in terms of trade;
- A recession in developed countries or funders;
- An increase in international borrowing costs (due, for example, to the tightening of monetary policy in creditor countries);
- The adoption of an inappropriate macroeconomic policies resulting vulnerabilities and leading to lower GDP growth;

- A systemic crisis causing a contagion phenomenon;
- Political and institutional instability.

Generally, according to Brière and Chancari (2004), this risk describes the way in which economic agents perceive the risk and react when faced with a risky situation.

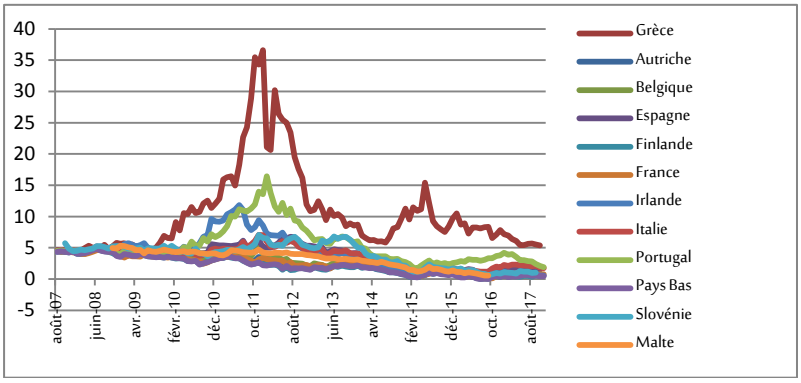
As for the measurement of this risk, sovereign bond investors monitor several types of risk, often grouped into four pillars: economic growth, public finances, external risks, volatility in the financial markets and socio-political stability. Also, the rating of a sovereign bond, resulting from these analyzes, should in theory be a key determinant of the sovereign risk. These indicators have been used in particular in the work of Artus and Rodado (2012), Atchalingam et al. (2012), Castelletti Font and Ben Salem (2017), Houssa (2015), Chebil Mhiri (2016), Mohymont, (2016), Costantini et al. (2014), Afonso et al. (2015).

## 2. Stylized facts on the manifestation of sovereign default risk in the euro area:

After the outbreak of the sovereign debt crisis in the euro area in 2010, the risk of sovereign default in certain countries deemed vulnerable increased and manifested mainly by an increase risk aversion which caused an increase a sovereign bonds spread and risk premiums, in particular the sovereign CDS premiums.

First of all, we observed that the sovereign bond spreads, that is to say the yield gap between government bonds rates in the euro area has reached unmatched levels (unprecedented levels) as shown in Figure (1).

**Figure number (1): Evolution of sovereign bond spreads in member countries of the euro area**




**Source: Constructed from the Eurostat database.**

To analyze the evolution of the sovereign bond spreads in the euro area, we selected the German Bund as a risk-free asset (reference country) from wich we have subtracted the bond yields of other countries members of the zone to calculate the sovereign spread of each one State. Also, we have taken into account the government bond yields with a maturity 10 years which constitutes the benchmark maturity on the public debt market and whose data in our sample are taken from the Eurostat database at one monthly frequency.

If we first consider the case of Greece, the period preceding the first financial shock shows a low amplitude volatility ranging between 3 and 4. It becomes more important to reach a rate of around 6% at the start of October 2008 (remember that this is due to the bankruptcy of Lehman Brothers). This slight volatility is short duration and disappears immediately, due to the interventions carried out by certain States through the implementation of support and recovery plans for the benefit of many financial institutions, which has reassured the markets and reduce general aversion to risk, momentarily.

But this aversion to risk strongly resumes in 2011 and 2012 where volatility caused a surge of Greek spread exceeding 35% at the end of 2011, especially with the announcement of the real level of public balance of Greek which aggravated the situation and whose revelation has fueled investor doubts about Greece creditworthiness. It was also followed by the downgrade of Greece sovereign rating by rating agencies with a negative outlook. However, it should be noted that at the end of 2012, a period of relative stability was observed, during which bond spreads have reduced slightly.

Similar observations can be made for Ireland, Spain, Portugal and Italy whose economy is weakened. The case of Italy, the third largest bond market in the world by size (BIS report, 2011) appears particularly sensitive, as does Portugal, which also reached a peak of volatility exceeding 15% in January 2012, compared with those of other countries of the area, is most important.

These countries known by the acronym "PIIGS" are among the most unstable countries during the crisis that have recorded the highest rate levels since the creation of the Euro, as highlighted by Barclays Bourse.

This situation is explained by the mistrust on the financial market fueled by the difficulties encountered by these countries to achieve budgetary objectives in a recessionary context and which weighed on sovereign spreads. Besides, it was not until the fourth quarter of 2012 that yields returned to their usual level.

These problems, particularly observed in the PIIGS, have raised the existing disparities between the countries of the euro area, in terms of budgetary balance and level of public debt. Indeed, the support measures undertaken for the benefit of the financial system and the revival of growth, have largely contributed to widening the budget deficit and to the increase in the public debt of these countries, hence the amplification of sovereign risk and its contagion to the weakest countries.

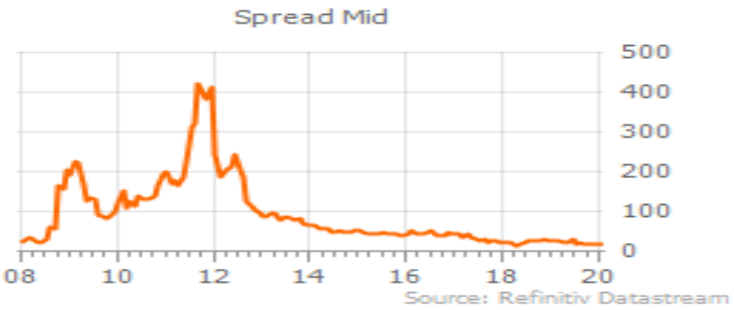
In addition, volatility was less pronounced on the side of the northern countries reputed to be the resilient countries. Austria, Finland, Germany, Belgium and the Netherlands have observed appreciable rates of return with low volatility. The more favorable macroeconomic situation undoubtedly explains a large part of this reaction to the external financial shocks that hit all the countries studied. This finding suggests that macroeconomic characteristics can influence a country ability to absorb the effects of international financial shocks.

Overall, we observe two major phases of financial stress which affected the sovereign spreads of the countries of the euro area during the period studied, proof of the manifestation of sovereign risk. The first appeared during the international financial crisis of 2007 with an increase in volatilities, then the markets calmed relatively so that instability resumed in 2010 with the sovereign debt crisis of the euro area where the disturbance reached its peak during the end of 2011 and the year 2012 after the intensification of the crisis and the growing doubts about the ability of European states to repay their debts.

This crisis in the euro area demonstrated the reappearance of global risk, which is confirmed by common movements in the evolution of volatility on sovereign spreads suggesting the presence of an intra-regional contagion effect. However, the markets calmed down after the creation of financial stability mechanisms (European Financial Stability Fund and the European Stability Mechanism) and the interventions of the ECB in reaction to tensions on the financial markets.

After examining the trend in sovereign bond spreads, we should now analyze the evolution of sovereign CDS spreads in order to confirm our observation regarding the strong manifestation of sovereign risk and its contagion in the euro area. Figure (2) shows the evolution of sovereign CDS premiums, reflecting investors perception of sovereign default risk in the euro area.

**Figure number (2): Evolution of sovereign CDS spreads in the euro area**




**Source: Datastream database.**

Analysis of this figure relating to the evolution of sovereign CDS premiums in the euro area reveals once again the differences and similarities between countries in a context of turbulence, declining ratings and uncertainty.

Thus, the countries that appear to be the least affected are the so-called resilient countries where the volatility of CDS premiums has not increased significantly compared to the most vulnerable (PIIGS countries). In fact, the results show that the volatilities in these countries were much higher, reflecting investors' mistrust of their debt sustainability and the doubt about their solvency, pushing speculators to demand more expensive yields and premiums.

As a result, the sovereign bond and related CDS markets have known waves of intense and increasingly widespread pressures, so that volatility has remained high caused by the fear of payments default. However, in recent years (especially since 2015), a recovery has begun to take shape in these two markets.

Now it is necessary to explain the evolution of sovereign spreads during and after the sovereign debt crisis to judge the materialization of sovereign risk. In what follows, we will try to check whether the aggravation of sovereign risk in the euro area is really explained by the various determinants identified in particular in the economic literature, namely: an increase of the aversion risk by investors which results in the

volatility of the financial markets, and the deterioration in the state of fundamentals.

The objective of the next point, therefore, is to highlight relevant empirical evidence on the importance of the impact of common and idiosyncratic risk factors on the resurgence of sovereign default risk.

## 3. Methods and empirical analysis:

This study will use the panel data method to estimate the main determinants of sovereign risk in the euro area. It allows to take into account the dynamics of behaviors and the heterogeneity that can exist between individuals (certain countries members of the euro zone in our case). It also makes it possible to have a large number of observations through the use of the temporal and individual dimension.

### 3.1. Model estimation

Thus, through the fixed and random effects models of the panel data, we will study the relations existing between the CDS spreads and these different explanatory variables.

The model is written as follows:

$$CDS\ Spreads = \alpha i + \beta 1\ Balance + \beta 2\ Debt + \beta 3\ Oblig + \beta 4\ Vstoxx + \beta 5\ Reer + \beta 6\ Prodind + \varepsilon i, t$$

Of which: the variable to be explained is the sperads of the sovereign CDS, the explanatory variables are: Balance that represents the budget balance/GDP, Debt is the level of the public debt/GDP, Oblig is the yield of the sovereign bonds, Vstoxx is the volatility index of the European stock markets, Reer is the real effective exchange rate, Prodind is the growth of industrial production.

Our model takes into account a sample of 11 euro area member countries, namely: Germany, France, Belgium, Finland, the Netherlands, Austria, Ireland, Spain, Italy, Greece, Portugal, with an annual periodicity ranging from 2007 to 2017.

As a result, we will obtain a number of observations of 121 (11 countries X 11 years). This appreciable number of observations makes it possible to guarantee a better accuracy of the estimators, to reduce the risks of multicollinearity and especially to widen the field of investigation.

### 3.2. Description of the dependent and independent variables

The selected variables are those most commonly used in the literature for the explanation of sovereign spreads. We have chosen a specification consisting of six explanatory variables including macroeconomic and

macro-financial fundamentals (budget balance, public debt, industrial production, real effective exchange rate) and two market variables including "Vstoxx" for risk aversion and bond yield for liquidity risk.

- **The dependent variable:**

For the assessment of the sovereign default risk in our analysis, we selected the sovereign CDS spread with 10 years maturity of euro area member countries. The latter reflects the risk of default as anticipated by the market. Its price includes a premium of risk, liquidity and counterpart that tend to overreact in case of systemic shock. Thus, the sovereign CDS spread play a major role in determining the risk of default and are a good measure of the estimated solvency of investors. The higher the spread, the more doubtful the creditworthiness of the country.

Several authors argue in favor of this indicator as a better measure of sovereign risk including Barrios et al. (2009), Afonso et al. (2012), De Santis (2012) and Aizenman et al. (2013) who also used CDS spreads.

- **The independent variables:**

We selected two market variables, in particular "Vstoxx" which reflects of the common risk is the market volatility index of the Eurostoxx50, an index that includes the 50 largest capitalizations on the euro area financial markets. The Vstoxx reflects the feeling of fear in the market, hence the nickname "the indicator of fear in the euro area". Moreover, the variable "Oblig" is long-term government bond yield, it is representative of the liquidity risk or the phenomenon of "flight to quality" or "flight to liquidity", which designates a situation where investors seek to sell assets perceived as risky and to buy non-risky assets, by seeking liquidity on these safe investments. When the Vstoxx and Oblig variables are high, it means that the market is volatile and that investors will demand higher risk premiums. So we should expect a positive relationship between the evolution of these two variables and the sovereign CDS spread.

In addition, we have chosen macroeconomic fundamentals namely, budget balance and public debt/GDP in order to measure the sustainability of public finances. It reflects risk that the sovereign state cannot honor its commitments because the repayment capacity of a country depends on its ability to generate financial resources to cover the debt service. So, a higher debt should increase the risk of sovereign default, and hence the return demanded by investors. We therefore expect a positive relationship between the public debt/GDP ratio and the CDS spread. Moreover, we expect a negative sign between the budgetary balance/GDP and the sovereign CDS

spread, because an improvement in this balance (i.e. an increase in the surplus or a decrease in the deficit) will lower the CDS spread.

As for the growth of industrial production, it represents the impact of the level of wealth of the countries of the euro zone on the sovereign risk. Thus, an increase or decrease in this variable indicates an increase or decrease in the country's economic performance, which in turn, has an effect on the creditworthiness of a country of these creditors, we expect a negative correlation between this variable and sovereign CDS spread.

And to measure the level of the external competitiveness of the countries of the euro area, we selected the real effective exchange rate (Reer) in order to analyze the possible impact of the macro-financial vulnerability and the external viability on the sovereign CDS spread of the member countries of the euro area. We expect a positive correlation between the Reer and the sovereign of CDS spreads, because a drop in this rate corresponds to an improvement in the country's external competitiveness or price-competitiveness which leads to high production in order to support the increase in exports, which will generate a balance of trade surplus. This will result in a sustained budget balance and debt level due to the large inflows of foreign currency, and therefore lower interest rates on government bonds and less volatile CDS spreads.

It should be noted, in this regard, that the explanatory variables used in this study have also been the subject of previous analyzes. The originality of this article is that it measures sovereign risk by sovereign CDS spreads with an extended time sample over a period of crisis and calm which extends from 2007 to 2017.

The expected signs of their correlation with sovereign CDS spreads are summarized in the following table:

**Table number (1): Presentation of the variables and expected signs**

| | **Designation** | **Data source** | **Expected signs on CDS spreads** |
|---|---|---|---|
| **Dependent variable** | | | |
| **CDS Spreads** | The risk premium of sovereign CDS at maturity 10 years | Datastream | |
| **Independent variables** | | | |
| **Balance** | Budget balance as% of GDP | Eurostat | - |
| **Debt** | Public debt as% of GDP | Eurostat | + |
| **Vstoxx** | Volatility index on the market of Eurostoxx 50 | Investing.com | + |
| **Oblig** | Long-term sovereign bond yield (10 | Eurostat | + |

| | years) | | |
|---|---|---|---|
| **Reer** | Real effective exchange rate | Eurostat | + |
| **Prodind** | The growth of industrial production | Oecd.org | - |

**Source: Designed by ourselves.**

### 3.3. Preliminary testing of the econometric analysis

Before analyzing the results of the regressions, it is important to respect a number of conditions namely: the overall and partial significance of the model, the existence of multicollinearity, heteroscedasticity and autocorrelation which can bias the coefficients data by regressions in panel data. To verify this, the analysis of certain tests of the panel data method is necessary to verify the robustness of the model.

First, we begin by analyzing the correlation matrix in order to judge the existence of multicollinearity which is a problem that occurs when the explanatory variables tend to demonstrate and / or measure the same phenomenon, i.e. say whether the selected variables generate a redundant effect or not.

The table 2 represents the correlation matrix that makes it possible to measure the relationship between the dependent variable and explanatory variables and between the explanatory variables themselves, as well as the intensity of the relationship (correlation).

**Table number (2): Correlation Matrix**

| | **CDS Spreads** | **Balance** | **Reer** | **Oblig** | **Debt** | **Vstoxx** | **Prodind** |
|---|---|---|---|---|---|---|---|
| **CDS Spreads** | 1.0000 | | | | | | |
| **Balance** | -0.1320 | 1.0000 | | | | | |
| **Reer** | -0.3402 | -0.0969 | 1.0000 | | | | |
| **Oblig** | 0.5879 | -0,4376 | 0.0719 | 1.0000 | | | |
| **Debt** | 0.5174 | -0,2036 | -0.4968 | 0.3049 | 1.0000 | | |
| **Vstoxx** | 0.0864 | -0.3330 | 0,4473 | 0.2673 | -0.2518 | 1.0000 | |
| **Prodind** | -0.0136 | 0.3433 | -0.0752 | -0.0830 | -0.0115 | -0.0889 | 1.0000 |

**Source: Constructed from database exploitation under Stata 13 software.**

As we can see from this table, there is a relationship between the different variables selected and the correlation between these values is acceptable and the variables are not strongly correlated in our analysis. This indicates the absence of multicollinearity problem.

On the other hand, we must determine whether the data series are stationary, as in the set of empirical analyzes that consider strictly stationary

processes. We will demonstrate stationarity by means of the specified test namely the unit root test, in particular the Levin, Lin & Chu test (LLC).

**Table number (3):The Results of the Unit Root Test (LLC Test)**

| | **Test LLC** | |
|---|---|---|
| | **At the level** | **At first difference** |
| **CDS Spreads** | *0,0172*** | - |
| **Balance** | *0,0024**** | - |
| **Debt** | *0,0000**** | - |
| **Oblig** | *0,1098* | *0,0018**** |
| **Prodind** | *0,0000**** | - |
| **Reer** | *0,0027**** | - |
| **Vstoxx** | *0,0000**** | - |

**Source: Constructed from database exploitation under Stata 13 software**.

NB: If the P-values are less than 0.01; 0.05; This means that the variables are stationary at the 1% ***, 5% **, 10% * threshold, respectively.

Through the stationarity test of LLC, we find that the variables are almost all stationary at level, except for the variable Oblig which becomes stationary at first difference at the threshold of 1%. These results are good quality indicators of our variables and / or our panel.

It should be noted that after verifying stationarity, we continued the classical approach of the panel data method, namely the estimation of regressions with a random and fixed model which showed that the model is generally good with a statistic of Fisher significant at 1% level and a sizable R-squared. However, we cannot validate and present these results insofar as the estimator of the model used has proved to be insufficient because of the presence of heteroscedasticity and/or autocorrelation that we will test in the following points. For this, we use another approach allowing us to find and validate significant results and a robust model, as will be explained below.

Thus, we have analyzed in parallel the existence of the heteroscedasticity phenomenon which reveals whether the error-variance-covariance matrix of the errors are constant or not. In a heteroskedasticity test, the null hypothesis states that all squared regression coefficients are zero, so there is homoscedasticity. The alternative hypothesis states that there is heteroscedasticity. Thus, if the P-value is less than 5%, we reject the null hypothesis, and we can understand that there is presence of heteroscedasticity (Ouellet et al., 2005).

The following table gives the results of the most commonly used heteroscedasticity tests in the panel data, including that of Breusch and Pagan and that of White.

**Table number (4): Heteroscedasticity test in panel data**

| | Breusch-Pagan | White |
|---|---|---|
| Chi2 | 221.16 | 89.54 |
| Probabilité | *0.0000* | *0.0000* |

**Source: Constructed from database exploitation under Stata 13 software.**

These results show the presence of heteroscedasticity in our panel since both tests are significant at the 1% level.

In addition to heteroscedasticity, it is also a tradition to verify the autocorrelation, ie the existence of correlation between the error terms of the panel, by using the Wooldridge test, which reveals in our case the presence of autocorrelation since the probability is less than 5%, as shown in the following table.

**Table number (5): Autocorrelation test in panel data**

| | Wooldridge |
|---|---|
| F (1, 10) | 1384.092 |
| Prob > F | *0.0000* |

**Source: Constructed from database exploitation under Stata 13 software.**

Therefore, following the existence of heteroscedasticity and autocorrelation in our model, it is important to emphasize that the statistical results (regression results) initially found cannot be verified because the simple model is not valid. The estimators of the classical panel data method no longer provide conclusive coefficients, because the presence of heteroscedasticity or autocorrelation could induce relatively large error terms, which will bias the regression coefficients, and will lead to fallacious P-values, and thus obtain a model with biased estimation. Therefore, it is important to correct this problem before any interpretation or validation of the results or a model.

To remedy this, a new estimation approach is needed and the Feasible Generalized Least Squares (FGLS) estimator should be used as an adjusted generalized least squares panel to consider the presence of heteroscedasticity and autocorrelation.

The estimate with an FGLS model thus makes it possible to overcome these shortcomings and to correct the terms of errors, as stated by the author Hoechle who took over the method of estimation in panel with the help of FGLS under Stata of Kmenta (1986).
We use a special command (xtgls under Stata 13) that allows us to use an autocorrelated and heteroscedastic error structure with panel data because it maps the model to that of generalized least squares.

## 4. Results and discussion: Panel data model with the FGLS estimator

In what follows, we will analyze the results of the regressions with the FGLS estimator to identify the most significant variables that explain the dynamics of sovereign CDS spreads at maturity 10 years in euro area countries.

**Table number (6): Panel regression results with the FGLS estimator**

| Spreads CDS | Coefficients | Standards Errors | P-value |
|---|---|---|---|
| **Balance** | -77.30316 | 36.53836 | *0.034*** |
| **Reer** | -141.2577 | 45.92542 | *0.002**** |
| **Oblig** | 437.1875 | 52.74863 | *0.000**** |
| **Debt** | 14.75707 | 4.933511 | *0.003**** |
| **Prodind** | -5.514607 | 9.891935 | *0.577* |
| **Vstoxx** | 11.93695 | 28.0754 | *0.671* |
| **_cons** | 12692.64 | 4782.162 | *0.008**** |
| **Num of observ** | 121 | | |
| **Wald chi2 (6)** | 144.41 | | |
| **Prob > Chi2** | 0.0000 | | |

**Source: Constructed from database exploitation under Stata 13 software.**

N.B: ***1% significance level, **5% significance level, *10% significance level.

We are interested in the impact of the different common risk, liquidity and systematic risk factors on the spread dynamics of sovereign CDS.
First all, with regard to idiosyncratic risk in each country, the variables relating to the fiscal factor (debt/GDP and balance/GDP) are significantly positive.
For example, if the sign of the ratio budget balance/GDP of a country is negative, the government is in deficit. Specifically, a 1% increase in this deficit would increase the spread by 0.034%, and an increase in public

debt/GDP of 1% increases the spread by 0.003%. This is entirely in line with our expectations. Indeed, when a country's financial and budgetary resources decrease and debt increases, its default risk increases, investors become more suspicious and therefore demand a higher return and the spread increases.

According to our results, the fiscal imbalances of countries deemed to be risky in the euro zone have played an important role in increasing CDS spreads, particularly after the 2007 international financial crisis and the sovereign debt crisis in the euro area. The swelling of these imbalances has, in fact, contributed significantly to the sudden revision of investor expectations.

Concerning the industrial production variable that reflects the economic performance of a country comes out with a negative and not significant coefficient contrary to what we expected, because the countries with a growing production see their spread decrease and it shows that the country is able to repay its debt revenue from this growth.

Therefore, the non-significance of the growth of industrial production in our model is not now in the direction predicted by the theory.

Furthermore, the choice of the real effective exchange rate (Reer) as a possible determinant of variability of the sovereign CDS spread, the regressions reveal in our case that there is certainly a significant impact between the Reer and the spread, but the sign of coefficient of this variable is negative contrary to what we expected. Therefore, the result in our model of this variable relating to external competitiveness does not go in the direction predicted by theory. This can be explained by the strong heterogeneity of our sample, not all individuals have the same economic structures. In fact, according to the "Lowess" test, which makes it possible to observe the distribution of individuals in a curve fitted to a cloud of point, the results revealed a quit important dispersion of countries and some of the extreme values, hence the reason of the sign contrary to expectations.

As for the market variable, on the one hand, the liquidity risk which is represented by the bond yield has a linear relationship with the spread and is significant. This observation suggests that an increase in public borrowing rates implies a phenomenon of flight to assets with low liquidity risk, in this case the German Bund. This reflects a contraction of liquidity in the bond market and thus the manifestation of liquidity risk which causes a surge in sovereign CDS spreads.

On the other hand, the regressions reveal that the common or global risk factor represented by the variable Vstoxx has a positive but not significant impact which does not correspond to the previous results, this may be

justified by the frequency of the selected data (annual) unlike other studies that used a monthly frequency where short-term effects are better detected. Thus, the volatility of the stock markets of the main European financial markets, represented by the Vstoxx index, did not have an impact on sovereign CDS spreads in our model. However, this result may be part of some previous studies, as it joins the explanation of the 2011 Deutsche Bundesbank report, which states that spreads are mainly based on fundamentals and cannot be attributed to exaggerated risk aversion.

In general, our model has mostly coefficients with the same signs as our expectations, however, the level of impact varies depending on the type of risk.

Indeed, the result of the regressions with FGLS shows an increase in the importance of fundamentals in the calculation of the spread following the sovereign debt crisis. Investors have become more interested in the state of the fundamentals of the countries such as their debt or budget balance.

In addition, the variable representing the liquidity risk or the safe haven effect in our study seems to be decisive for the calculation of the spreads, which corroborates the results of the previous works. However, the regressions of certain variables, in particular the Vstoxx and the growth of production, do not correspond to expectations.

**Conclusion:**

The significant increase in the debt of certain member countries of the euro zone, well above the 60% ceiling established in the European Stability and Growth Pact, has contributed to a gradual macroeconomic weakening and a decline in the intrinsic resilience of their economy, while the ability to mobilize more public resources to cushion economic and / or financial shocks is eroding.

Indeed, the context of crisis and turbulence that has set in, has fueled the dynamics of sovereign debt and the degraded economic situations of the most vulnerable countries which have given rise of sovereign default risk.

In this article we have attempted to analyze the manifestation and worsening of sovereign risk in the euro area and to empirically identify the risk factors that explain this resurgence.

It appears that the sovereign default risk in the euro area was imminent in certain countries considered vulnerable, which resulted in a surge in the yield on sovereign bonds and volatility in sovereign CDS spreads especially between 2011-2012, which reveal an increase in risk aversion and investor mistrust of the insolvency or inability to repay in some countries.

In addition, the estimation of our model showed the factors which determine sovereign risk, more particularly, the deterioration of the state of macroeconomic fundamentals, namely the variables linked to the budgetary factor which present the non viability of public finances and the unsustainability of public debt. Therefore, the results indicate that investors have become attentive to the development of macroeconomic indicators, especially since the euro area countries are required to respect appreciable levels of debt and budget deficit according to the Maastricht Treaty. On the other hand, the variable relating to the level of wealth notably the growth of industrial production appears not significant in our model, this may be justified by the fact that investors are interested in other indicators to measure wealth or growth in the countries of the euro area.

In addition, the model revealed the significant impact of the liquidity risk on the volatility of sovereign CDS spreads, which means that there was a flight to quality or liquidity phenomenon, and which allows us to clarifying that risk aversion in the bond market pushed investors demanded a higher cost of borrowing for vulnerable countries and higher risk premiums.

However, the impact of our variable Vstoxx relative to common risk on the stock markets is non-linear and not significant contrary to expectations. This can be explained by the fact that our data are annual and therefore the short-term variations have not been captured. We chose to work at the same frequency because most of our data are annual, certainly it generates the limited not being able to analyze the short-term effects on the stock markets but of course the effects in the medium and long term have been well demonstrated with an extended time sample.

The model of panel estimated with the FGLS estimator thus makes it possible to highlight the exposure to the sovereign risk of the so-called "PIIGS" countries, and it could be useful for systematically monitoring sovereign risk, particularly in advanced countries, based on the risk factors identified.

Indeed, this study may have interesting implications for policy makers or for international investors, especially in the current unfavorable macroeconomic context caused in particular by a health crisis with serious consequences for economies most of which observe slower economic growth. Thus, the deterioration of the solvency of countries with low growth prospects becomes an increased risk especially when the level of public debt is high and public spending is increasing globally to cope with lost income from businesses and households, which further accentuates the budgetary deterioration due to the covid-19 pandemic and which will exert more

pressure on sovereign ratings than the global financial crisis of ten years ago possibly.

To this end, policymakers can take into account the various, most significant, determinants of sovereign risk allowing them to put in place effective intervention policies and act directly on these risk factors by implementing adequate measures to limit the effects of the resurgence of sovereign risk and contagion. For investors, taking into account the risk factors that explain sovereign insolvency allows them to reduce exposure to risk in the markets, to anticipate significant losses on their portfolio, and to make consistent forecasts and investment strategies to optimize their profit.

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