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Are European sovereign bond spreads in concordance with macroeconomic variables evolution?

European
sovereign
bond spreads

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Abstract

Purpose – The last great financial crisis which arose in the middle of 2007 in the USA produced contagion effects over others economies. The purpose of this paper is focused on analyzing the evolution of a set of economic variables of 17 European countries since 1991 until 2013. Sovereign bond spreads are also considered to compare the incidence of the financial crisis over the economies considering macroeconomics fundamentals and fixed bonds.

Design/methodology/approach – Self-organizing maps (SOMs) are used to achieve the purpose of the research. With this methodology, it is possible to analyze the evolution of the macroeconomic fundamentals of each country, obtaining particular and general conclusions according to the position of each country in the SOM. Moreover, the countries are compared between them and with its respective sovereign bond spreads level for each year of analysis.

Findings – The impact of the crisis is different between the countries was analyzed. Belonging to the European Monetary Union is an interesting characteristic of some of the most affect economies.

Research limitations/implications – This research presents wide implications for the economies to control the most vulnerable economic variables in front of financial crisis to prevent the contagion effect. The inclusion of more economic variables and countries could enhance the study.

Originality/value – This research analyzes the relationship between macroeconomic variables and sovereign bond spreads using an infrequent methodology. The results obtained are valuable because they highlight how the present crisis has differently affected the European countries.

Keywords Financial crisis, Economic variables, Self-Organizing maps, Sovereign bond spreads

Paper type Research paper



1. Introduction

The 2008 financial crisis, originated in the USA, and reached different countries. Many economic variables changed their tendencies and some sovereign bond spreads in European countries increased. The global financial crisis modifies investors' perception of risk and the diversification of investment portfolios propagates market risks, which are more than

enough important reasons to study financial crisis consequences, contagion effects and bond spreads determinants.

Considering the contagion definition of [Eichengreen *et al.* \(1996\)](#), the contagion effect is a situation in which it is known that there is a crisis in one place and it increases the chances that it may occur in another country. Other authors ([Kaminsky *et al.*, 2002](#); [Basu, 2002](#)) specify the concept and the phenomenon that, for reasons not so obvious in time such as currency devaluation or the announcement of default of sovereign debt obligations, trigger a series of immediate and subsequent events among countries in the same region and, in some cases, beyond a certain region.

Since the middle of June 2007, fear and uncertainty in financial markets expanded by increasing the default of subprime mortgages in the USA. Early indications of the crisis began when two hedge funds of the investment bank Bear Stearns had billions of losses from bad bets on the market for collateralized debt obligations backed by subprime mortgages and for the insolvency declaration of the American Home Mortgage Investment Corporation.

In early August of the same year, there were signs of an international financial crisis. The first symptoms were manifested by difficulties in the mortgage market, especially those of lower credit quality or subprime. The conflict began to affect the prime sector because of the increased rate of the uncollectible of the countrywide funds. The difficulties in the mortgage market moved to the rest of the financial system, leading up to rationing and higher credit costs in other sectors beyond the real estate, especially in the USA and some European countries.

Given the rising cost of borrowing, companies and financial agents were forced to rethink their decisions and investment plans. This atmosphere generated greater risk aversion among investors and increased volatility. This situation, which is moving from one stage of liquidity to one of insolvency, is what allows us to speak of a crisis in the financial system. [Caceres *et al.* \(2010\)](#) analyzed the effect of the financial crisis over the European financial markets by considering a number of factors such as the global risk aversion degree, the contagion effect, the specific fundamentals of countries and the swap spreads evolution. They highlight the contagion effect and the effect of the flight to quality that occurred in the strongest financial markets.

In the same line of study, [Attinasi *et al.* \(2009\)](#) find that sovereign bond yield spreads in the euro area include a country's credit risk and liquidity risk, as well as higher international risk aversion. Higher expected financial deficits and/or higher expected government debt relative to Germany have contributed to higher government bond yield spreads in the euro area over the period of 2007-2009. Since that time, some European countries suffered different consequences in their economies and financial system because of the contagion effect. [Merigó *et al.* \(2016\)](#) consider that an economic crisis can be defined as a scenario where a region's economic condition is considered to show lower than desired or negative growth. This situation is usually reflected by the poor evolution of the gross domestic product (GDP) for at least six months. The last financial crisis has severely affected this indicator.

So, the aim of this paper is to analyze the evolution and coincidences during the period of study of a set of economic variables from 17 European countries. The interval under analysis covers important economic events, such as the introduction of the euro currency and the inception of the last great financial crisis in 2007-2008. Moreover, the obtained results are compared with sovereign bond spreads evolution to contrast the contagion effect of the financial crisis under different aspects: macroeconomic variables and sovereign bond spreads.

The methodology applied is self-organizing maps (SOMs) that are unsupervised neural networks with competitive learning. In this work, SOMs are used to group patterns, defined

as country-year, according to the similarity within their macroeconomic fundamentals. Through these groups, the relationship between the variables selected and the sovereign bond spreads will be analyzed.

This paper contributes to the financial literature in different aspects. First, the empirical analysis is expanded through the inclusion of several economic variables and it is applied in a novel methodology in this field. Moreover, the results are compared with the sovereign bond spreads of each country during the period of 15 years and for the 17 European countries under study. This process allows to identify key variables sensitive to the financial crisis contagion effect. Second, it is possible to recognize the incidence of the euro currency over the economic evolution of the countries of the sample. Third, the methodology applied is novel in this context and endeavors to the goal of the research. Fourth, the paper analyzes the European market, where the most visible effects have taken place. The paper is organized as follows. Section 2 presents a brief review of the literature on sovereign bond spreads and the incidence of the last financial crisis over European economies. Section 3 introduces SOMs, as the main methodology of the analysis. Section 4 describes the data used in the study. Section 5 sets out the empirical results. Finally, Section 6 contains the main conclusions.

2. Literature review

A wide and interesting literature about the analysis of sovereign bond spreads has emerged since the last financial crisis. However, some important studies date back to the period prior to the onset of financial turmoil.

Numerous articles (Codogno *et al.*, 2003; Geyer *et al.*, 2004; Bernoth *et al.*, 2004; Attinasi *et al.*, 2009; Barrios *et al.*, 2009; Bernoth and Erdogan, 2012; Manganelli and Wolswijk, 2009; Klepsch and Wollmershäuser, 2011; among others) deal with the three main determinants of the sovereign bond spreads in the euro area. The first of these determinants is the credit risk, which includes default risk, downgrade risk and credit spread risk. During the crisis, debt and deficit indicators have increased. Governments have had greater difficulties in coping with higher debt and deficit. As a consequence, the market's perception of default changed which led to a decrease in the rating qualification of these economies and an increase in the credit spread risk.

The second determinant is the liquidity risk. A liquid market allows investors to make decisions at any time, so the number of financial operations should be considered to determine the size and depth of the market and the liquidity premium level. Furthermore, if transaction costs are high, investors will demand a higher yield. The liquidity risk and the credit risk are interconnected (Barrios *et al.*, 2009; Arghyrou and Kontonikas, 2011). On the one hand, if a government increases its bonds supply, the pressure on the liquidity premium decreases. On the other hand, a high supply is associated with an increase in public debt and deficit, which increases the credit risk premium. Caceres *et al.* (2010) consider that high yields of sovereign assets should be accompanied by increases in interest rates in the rest of the economy, affecting both consumption and investment decisions. On the fiscal side, high yields of government debt imply high debt service costs and therefore increase the cost of financing, creating debt rollover risks and economic losses.

Finally, the third determinant of sovereign bond spreads is the risk aversion. Bond spreads are affected by the amount of risk that investors are willing to take when they invest in financial markets. Hence, an increase in the risk perception of an economy will increase its bond spread. Furthermore, according to Barrios *et al.* (2009), the combination of high risk aversion and large current account deficits tends to magnify the incidence of deteriorated public finances on government bond yield spreads.

Moreover, a common and prevailing view of the literature on euro area government bond indices is that spreads are driven by a common global factor (Codogno *et al.*, 2003; Geyer *et al.*, 2004; Barrios *et al.*, 2009; Manganelli and Wolswijk, 2009; Sgherri and Zoli, 2009) represented by international factors such as risk perception.

Bernoth and Erdogan (2012) state that not only the variation in macroeconomic fundamentals but also the variation in credit risk over time should be considered. They estimate time-varying coefficients in an additive nonparametric fixed-effects panel model framework and conclude that bond yield differentials are significantly affected by international and country-specific risk factors such as liquidity and the default risk premium.

Otero-González *et al.* (2016) analyze the effect of financial innovation on European banks' risk during the period of the inception of the last financial crisis. Their results suggest that the amplified use of securitization and certain credit derivative uses have negative effects on European banks' financial stability.

The impact of the financial crisis deeply affected bond markets. During periods of instability, investors increase their risk aversion and change their portfolio to more liquid and higher-quality assets. These two effects are known as "flight-to-liquidity" and "flight-to-quality" (Vayanos, 2004; Beber *et al.*, 2009).

Therefore, the study of the main determinants of spreads is relevant to policymakers given that they are important indicators of fiscal vulnerabilities, and the price of risk represents the cost of the service debt.

3. Methodology

Kohonen (1982, 1989) developed an artificial neural network known as the SOM. The SOMs are unsupervised neural networks with competitive learning. They have two layers of neurons with feed-forward connections between them. The input layer has n neurons (or units), with n being the number of variables that are used to describe the input data. The output layer has m neurons that form a two-dimensional map, with lateral and auto-recurrent connections that facilitate the competition process.

SOM are designed to convert high-dimensional data (patterns, or specifically in this work, the value of the main macroeconomic fundamentals of a country in a year) into simple relationships in a similarity graph. In this sense, similar patterns are closer in the map than the more dissimilar ones. For this reason, SOMs are appropriate in complex tasks as clustering problems when there are several variables to take into account and it is important to preserve the relationships of all the data.

The process by which SOMs obtain the feature map is as follows. First, input data are described in terms of vectors of n components. In such a way, it is obtained as a set of P patterns: $x^p = (x_1^p, x_2^p, \dots, x_n^p)$ with $p = 1 [\dots] P$, where x_i^p represents the value of the i -th component for the pattern p . After normalization, all the patterns are introduced into the system.

In each training step, one of the patterns is chosen randomly and it is compared with the weights vectors that form the rows in the matrix $W = (w_{ki})_{k=1, \dots, m; i=1, \dots, n}$ where w_{ki} is the weight associated to the connection between the input neuron i and the output neuron k . The winning neuron (or the best-matching unit) is the unit whose weight vector has the greatest similarity with the pattern. Although different definitions of distance can be used, the most common one is the Euclidean distance. So, the winning unit k^* satisfies:

$$d_{k^*}^p = \min [d_k^p]_{k=1, \dots, m} = \min \left[\sqrt{\sum_{i=1}^n (x_i^p - w_{ki})^2} \right]$$

Once the winning neuron has been found, the weights associated with this neuron and also with its neighborhood area are updated. The new weights are obtained because of the following expression $w_{hi}(t+1) = w_{hi}(t) + \alpha(t) \cdot [x_i^p - w_{hi}(t)]$, where $\alpha(t)$ denotes the learning rate, which has a value between 0 and 1 and decreases with the number of iterations. The neighborhood area of the winning unit is formed by adjacent units in a regular area whose radius goes down with time.

Finally, this process is repeated with the rest of input patterns, and new iterations are carried out until stability in the association between each pattern and the same winning output unit is achieved.

SOM can be applied to a big variety of problems, for example, to pattern recognition, to solve optimization problems, data codification or data grouping. In financial context, SOMs have been successfully used to examine financial crises, to analyze risk of bankruptcy, among other economic events. This type of artificial neural networks has been applied to problems of grouping in financial markets, for example, to analyze temporary effects in stock markets (Sorrosal and Ramirez, 2009) or to improve the classification of mutual funds (Moreno *et al.*, 2006). Related with financial crises, Sarlin and Marghescu (2011) applied the SOM to examine visual predictions of currency crises and concluded that it is a feasible tool whose visual capabilities expedite the understanding of the factors and conditions that contribute to the inception of a currency crisis. Similarly, Fioramanti (2008) applied artificial neural networks, using data since 1980-2004, to predict sovereign debt crisis. Terceño *et al.* (2013) analyze sovereign bond spreads evolution before and after the 2008 financial crisis. du Jardin and Séverin (2011) apply the SOM to improve a model to predict corporate bankruptcy. They also provide a valuable tool for companies seeking to measure their financial condition through the analysis of the trajectories. In a similar way, Chen *et al.* (2013) considered a large number of variables related to the bankruptcy risk of the companies studied, and they concluded that SOM is a useful visual data-mining approach to explore a large amount of data.

In this research, SOMs are used to get patterns defined as country-year into groups according to the similarity within their macroeconomic fundamentals. Through these groups, the relationship between the variables used and the Eurobond spreads will be analyzed. Moreover, the particular characteristics of each group are also evaluated.

4. Data description

The database used to the empirical analysis comprises 17 European countries: European Monetary Union (EMU) countries, except Luxemburg[1] (Austria, Belgium, Finland, France, Germany, Greece[2], Ireland, Italy, The Netherlands, Portugal and Spain) and non-EMU countries[3] (The Czech Republic, Denmark, Hungary, Poland, Sweden and UK). All data are obtained from DataStream, for the period from 1999 to 2013, measured at the end of each year.

The Government Bond Index (GBI) elaborated by JPMorgan is used to calculate sovereign bond spreads. The GBI is made up of fixed-rate bonds and domestic bonds of countries that give international institutional investors an opportunity to invest in liquid debt markets. This means that bonds are stable, active and regularly issued. We select the GBI that represents government bonds with a maturity between 7 and 10 years, with annual frequency. Germany is our benchmark to estimate bond spreads.

There are some exceptions with respect to the period included given the unavailability of data. The time series of Poland and the Czech Republic begins in 2000, the Hungary time series starts in 2003 and the Belgium time series starts in 2001.

The economic variables included in the study were chosen bearing in mind the literature related to the determinants of sovereign bond spreads (Martinez *et al.*, 2013; Min *et al.*, 2003; Gande and Parsley, 2007; Hilscher and Nosbusch, 2010; Baldacci *et al.*, 2011; González

Rozada and Levy-Yeyati, 2008; Arora and Cerisola, 2000; Eichengreen and Mody, 1998). This set of variables and their description and source used for each country are shown in Table I.

Considering all the data available, there are a total of 247 patterns. Each pattern represents a country in a particular year. They are defined as vectors of six components or variables. The first variable is the unemployment rate. The second is the annual profitability of the most representative equity index in each country, calculated as the difference between the price index in two consecutive years divided by the price in the initial year. The third component is the percentage of the general government gross debt over the GDP. In the fourth place, is the level of inflation. The fifth variable is the relative increment of GDP (at current prices). The last component is the percentage of change of international reserves.

The SOM network is implemented in Matlab using the toolbox developed by the Laboratory of Information and Computer Science in the Helsinki University of Technology.

The input layer of the SOM has six units. Each contains the value of one of the variables that defines the patterns. Table II shows the correlation matrix between the values of these variables for all the analyzed patterns.

As could be appreciated in the Table II there are not high values of correlations. Therefore, the use of all variables for grouping purposes through SOM is justified.

Once the toolbox of Matlab for SOM implementation has been applied, a map of 12 rows and 7 columns (this dimension has been automatically determined by the program, through the number of input data) is obtained. In this map, patterns (country-year) are placed according to the similarity between their components. In this way, if two patterns are close in the map means that these countries (in the corresponding year) had a similar economic situation, because all the economic variables considered took similar values in both patterns. When the distance between two patterns increases, their economic situation is more different.

SOM can be used for grouping patterns. In this study, the number of groups has been reduced until five to establish groups with economic fundamentals that are significantly different between them, but, at the same time, it is guaranteed that the patterns inside each group are the most homogeneous. The group maps are detailed in the next section.

5. Results

This section shows the results obtained by considering all the economic variables for the whole period of analysis. Figure 1 shows the location of the patterns of non-EMU countries in the Kohonen map and the five groups that are formed. Similarly, Figure 2 shows the location of the patterns of the EMU countries. The division between countries is done to facilitate the interpretation of the results. Each pattern has named with two letters that identify the country and two numbers corresponding to the year (Austria: OE, Belgium: BG, Finland: FN, France: FR, Germany: BD, Greece: GR, Ireland: IR, Italy: IT, The Netherlands: NL, Portugal: PT, Spain: ES, the Czech Republic: CZ, Denmark: DK, Hungary: HN, Poland: PO, Sweden: SD and United Kingdom: UK).

To understand the economic situation of each pattern in function of its position in the map, it is necessary to know the value of each variable in each area. This information is shown in Figure 3, through the values represented by colors in the numerical scale on the right of each map. In all cases, the dark blue color indicates the minimum values of each variable, while the red one indicates the highest values.

Nonetheless, it is important to note that the best expected value for some variables is clearly the opposite for others. For example, the best situation for a country is represented by lower levels of unemployment, of public debt over GDP and of inflation, so considering the scale colors, the best situation is represented by blue. But, on the other side, for stock market

Variable	Description	Source
Unemployment rate	The unemployment rate is the number of unemployed persons as a percentage of the labor force based upon the definition of the International Labor Office. The labor force includes the total number of people employed and unemployed. Unemployed persons comprise persons aged 15 to 74 who: are without work during the reference week; are available to start work within the next two weeks; and have been actively seeking work in the past four weeks or have already found a job to start within the next three months. The data are three-yearly moving averages, i.e. the data for year Y are the arithmetic average of data for years Y, Y-1 and Y-2	Eurostat
Stock Market Index	For each country, the more representative equity index is considered, i.e.: Austria: WIENER BOERSE INDEX (WBI) Belgium: BEL 20 Czech Republic: PRAGUE SE PX Denmark: OMX COPENHAGEN (OMXC20) Finland: OMX HELSINKI (OMXH) France: FRANCE CAC 40 Germany: DAXINDEX Greece: FTSE/ATHEX LARGE CAP Hungary: BUDAPEST (BUX) Ireland: IRELAND SE OVERALL (ISEQ) Italy: FTSE MIB INDEX Netherlands: AEX XBEAR Poland: WARSAW SWIG80 Portugal: PORTUGAL PSI-20 Spain: IBEX 35 Sweden: OMX STOCKHOLM 30 (OMXS30) United Kingdom: FTSE 100	Thomson Reuters; DataStream

(continued)

Table I.

Variable	Description	Source
General Government Gross Debt, % of GDP	Gross debt consists of all liabilities that require payment or payments of interest and/or principal by the debtor to the creditor at a date or dates in the future. This includes debt liabilities in the form of Special Drawing Rights (SDRs), currency and deposits, debt securities, loans, insurance, pensions and standardized guarantee schemes and other accounts payable. Thus, all liabilities in the GFSM (Government Finance Statistics Manual) 2001 system are debt, except for equity and investment fund shares and financial derivatives and employee stock options GFS Manual used: 2001. General government includes: Central Government, Local Government, Social Security Funds, State Government. Valuation of public debt: Face value Consumer Prices, all terms, Index 2010 = 100	International Monetary Fund
Inflation	Millions of national currencies (including "euro fixed" series for Eurozone countries). Current prices, GDP at market prices In line with the Balance of Payments Manual, methodological requirements and the European Central Bank recommendations on the Euro system reserve assets. The reserve assets must be under the effective control of the Central Bank of each country; and refer to highly liquid, marketable and creditworthy non-euro area currency-denominated claims on non-residents of the euro area as well as gold, SDRs and the reserve positions in the International Monetary Fund of each country. All reversible gold transactions are treated as collateralized loans and recorded accordingly in the national reserves statistics	International Financial Statistics Thomson Reuters; DataStream
GDP and main aggregates		
International Reserves		International Financial Statistics

Note: Own elaboration in base of DataStream database

Variables	Unemployment	Stock market index variation	Public debt/GDP	Inflation	Growth GDP	International reserves (relative variation)
Unemployment	1					
Stock market index variation	0.1140	1				
Public debt/GDP	0.3579	-0.0900	1			
Inflation	0.0028	-0.1069	0.2520	1		
Growth GDP	-0.1145	0.2260	-0.3816	-0.5729	1	
International reserves (relative variation)	0.0072	-0.0201	0.0361	0.1851	-0.3420	1

Table II.
Matrix correlation

indices, GDP growth and international reserves are desirable at a high level; therefore, the best color in the scale for these variables is red.

The main characteristics of each group could be summarized as follows. Group 1 is representative of an economic growth situation but with some imbalance that is shown in a high level of unemployment. Group 2 is the most favorable one in terms of growth and economic balance, although the stock markets behave in a moderate way. In Group Number 3, the economy starts to go down (variation of GDP decays, the percentage of public debt increases), but inflation and unemployment are still medium. Group 4 is characterized by low values of GDP, high levels of inflation and negative profitability in the stock markets. Nevertheless, some positive signals (low levels of unemployment and a low government debt) imply that in this group there are strong countries, able to support the effect of the financial crisis. Finally, Group 5 corresponds to the weakest economic situation and it can be associated with the worst period of the financial crisis.

One of the objectives of this paper is to analyze the evolution of macroeconomic fundamentals of each country according to its position in the Kohonen map. This evolution will be analyzed by using the information of the groups described above.

The Czech Republic and Denmark are predominantly located in Groups 2 and 4, respectively (Figure 1). Unemployment and public debt over GDP do not present great changes during the whole period of analysis given that both groups are characterized by low values in these variables. The stock index, inflation and GDP growth variables show some negative changes since 2008. The only variable that improves its level is the international reserves. This could be a collateral effect of not belonging to the EMU.

Hungary presents similar results. The unemployment rate increased highly since 2008. Similarly, the public debt over GDP corresponding to this country increased notably and Hungary moved from Groups 3 to 4 in 2009. Since 2010, this country moved to Group 5, which implies high level of unemployment rates, inflation and an increase in the public debt over the GDP index. Moreover, Poland presents an improvement since the 2008 financial crisis relative to the unemployment rate. Since that moment, the country moved to Group 4 which indicates lower levels of unemployment. Also, the public debt over GDP enhanced its levels since 2008. The rest of the variables considered, such as inflation, GDP growth and

PO-00,01,04,05,06,07		CZ-03,04,05 HN-05,06 SD-99	DK-00,05			CZ-01 HN-03,04
①	PO-08		DK-06	CZ-06,07	UK-04	CZ-00,02 DK-99 UK-99,00
PO-02,03			②	SD-06,07,10	DK-04 UK-05,06,07	DK-03 HN-07 SD-00 UK-01
			SD-05	SD-04	DK-07	DK-01,02 UK-02,03
					SD-03	SD-02
③						SD-01
			HN-10	DK-10	UK-08	
		HN-08 UK-10	PO-10,11	④		CZ-08,11 DK-08 PO-09,12 SD-08,11
		HN-11		DK-12,13 PO-13	SD-12	DK-11
HN-12	UK-12	HN-13 UK-11,13		CZ-12	CZ-10	CZ-13
⑤					CZ-09 SD-13	
					DK-09 SD-09	HN-09 UK-09

Figure 1.
Kohonen map of
non-EMU countries

international reserves present worst values since the inception of the crisis. The stock index shows a mild progress since the breaking point considered.

With respect to the macroeconomic evolution in Sweden, almost all the variables do not present great changes in their values during the period of analysis. The inflation rate is an exception which shows some increment since 2008.

Related to the incidence of the crisis in UK, it is possible to appreciate some changes in the unemployment rate, which increased its levels since 2009. In the same way, the values of the public debt index and the inflation rate increased in a moderate form. On the other hand, the stock market index and the GDP growth were lightly down since the turmoil.

In Austria (Figure 2), no important changes are observed in any of the variables analyzed. The unemployment rate has been low during the entire period of analysis and the rest of variables took similar values since the start of the study. The inflation rate is perhaps the

	FN-00		NL-99	IR-03,04	NL-00,01	PT-00
	ES-06		PT-99	IR-05	IR-99,02	IR-00,01
①	ES-05		IR-06			
GR-00	FN-99		FN-04	FN-07		②
ES-99,00,01,02	FR-00			NL-06		
	ES-03,04			ES-07		
	FR-99	FN-05,06		NL-07		NL-02
	BD-99					PT-01,02
GR-99,01,03,04,05		FR-03,05	FN10	PT-04	OE-00	NL-03
IT-99		BD-03,04,05,06	PT-05,06,07		NL-04,05	
BG-03,04	BG-05,06	BD-07	OE-03,04	OE-99,01,02		FN-01,02,03
GR-06			③			FR-01,02
IT-04						BD-00,01,02
						PT-03
BG-01,02	IT-05,06	FR-04,07		OE-05,06	NL-08	FR-08
GR-02,07				NL-10		BD-08
IT-00,01,02						
IT-03	BG-07	FR-06	FN-11		FN-08	OE-08
	IT-07	BD-10				ES-08
						IR-07
BG-08	BG-11	BG-10		④		OE-07,11
FR-11	IT-08	FR-10				FN-12
GR-08		BD-11				
IT-09,11,12	IT-10	BG-12,13	BD-12,13	OE-09,10,12,13	NL-11	NL-12
			PT-08	FN-13		
				NL-13		
GR-10,11	IT-13	FR-13	FR-12			
PT-11,12						
IR-10,11						
GR-12,13	PT-13	ES-11	BG-09	BD-09		FN-09
ES-12,13	ES-10	⑤	FR-09	ES-09		NL-09
IR-12,13			GR-09	IR-09		PT-09
			PT-10			IR-08

Figure 2.
Kohonen map of EMU
countries

more atypical one, given that since 2005, it shows high standards. The Netherlands and also Finland (to a lesser extent) show similar results to Austria, the first with no specific changes in its indicators (only is present in Groups 2 and 4) and Finland with the exception of the small public debt levels during the years of study. Belgium displays a worse behavior, besides its public debt index being high throughout the period of analysis and the decrease in the GDP growth since 2009. Moreover, some economic variables as unemployment rate, public debt and inflation got worse since 2009. In these years, the country was found in Group 5. In Germany, as it was expected, the contagion effect of the turmoil had no consequences over all its macroeconomic indicators. The inflation rate is the only variable modified since 2010. The great change during the period of analysis has been during the inception of the euro. The patterns moved from Groups 2 to 3 in 2003 and remain in it until

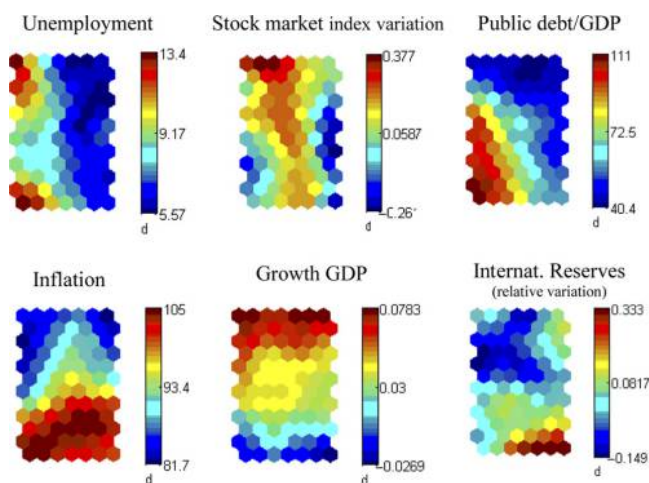


Figure 3.
Component maps

2007. Due to the inception of the crisis, the patterns corresponding to this country were located in Group 4.

In France, the financial crisis effects are manifested through the evolution of some economic variables such as the unemployment rate and the GDP growth which have deteriorated since 2007. The inflation rate has also increased since 2007. The stock market index and the public debt over GDP slowly changed their tendencies to a worse situation. Nonetheless, the international reserves grew during the last years of the study.

On the contrary, in Ireland, Spain, Portugal, Italy and Greece, the spillover of the financial crisis produced some structural problems. The unemployment rate, the stock market index, public debt over GDP, inflation and GDP growth have been negatively affected by the contagion effect of the crisis, some of them since 2007 and another since 2008 or 2009. Since 2008, most of the patterns corresponding to these countries belong to Group 5. A specific detail from the variables evolution could be appreciated in Figure 2. International reserves rates rarely behave in all the countries analyzed given that their levels increased in some of them and were maintained in the others. The evolution of these countries since 2008 is homogeneous, and have moved from Group 2 to 4 and 5 progressively.

In general, related to the EMU countries, they follow similar patterns associated with the inception of the financial crisis. Previous years were in general of high growth (Groups 1 and 2) or moderated growth (Group 3). From the contagion effect of the 2008 financial crisis, almost all of them moved to Groups 4 and 5, although suffering clearly different intensified effects.

In most cases, countries not belonging to the EMU are relatively less affected by the financial crisis. Inside this set of countries, it is possible to distinguish two subgroups: Sweden, Denmark and UK remained jointly in the same groups until 2009. During 2010, these countries recovered their economic situation and moved to different groups. Since that year, Sweden and Denmark move to Group 4 and UK goes to Group 5, which indicates a deeper effect of the contagion over this last country.

To compare earlier results with bond spreads of each country, Table III presents yearly spreads levels, with their respective references to identify the belonging group on the Kohonen Map. Additionally, Table IV summarizes the mean of spreads in each group, distinguishing between EMU countries and non-EMU countries.

C/Y	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
The Czech Republic			2.06	-0.04	-0.49	-0.03	0.50	0.23	-0.22	0.28	1.15	0.60	0.92	1.73	0.67
Denmark	0.12	0.13	0.18	0.04	0.02	-0.09	0.10	-0.01	-0.03	0.10	0.39	0.30	0.19	-0.20	-0.06
Hungary				2.09	3.69	3.66	3.73	3.66	2.95	2.85	5.91	4.73	5.21	8.07	4.95
Poland		3.95	5.87	3.65	0.99	1.91	2.33	1.82	1.25	1.67	2.46	2.91	3.19	4.13	2.45
Sweden	-0.22	0.12	-0.37	0.11	0.13	-0.01	0.26	0.04	-0.14	0.02	-0.55	-0.02	0.41	-0.20	0.38
UK	0.10	0.03	-0.20	-0.13	-0.13	0.20	1.06	0.86	0.89	0.30	0.13	0.68	0.45	0.08	0.45
Austria	-0.30	-0.15	-0.01	-0.10	-0.40	-0.33	0.03	0.00	0.02	0.08	0.72	0.32	0.37	1.18	0.44
Belgium	-0.33	-0.22	0.04	-0.10	-0.31	-0.36	0.02	0.03	0.04	0.14	0.81	0.23	1.02	2.21	0.74
Finland	-0.40	-0.16	-0.07	-0.10	-0.43	-0.44	-0.02	-0.04	-0.01	0.08	0.56	0.18	0.27	0.59	0.18
France	-0.52	-0.28	-0.18	-0.22	-0.40	-0.43	-0.01	0.01	0.03	0.07	0.35	0.15	0.31	1.25	0.57
Germany															
Greece	2.58	0.74	0.31	0.03	-0.22	-0.28	0.14	0.18	0.21	0.27	2.22	2.41	10.09	36.55	39.69
Italy	-0.27	-0.06	0.11	-0.07	-0.28	-0.30	0.07	0.17	0.21	0.23	1.32	0.49	1.75	4.88	3.05
The Netherlands	-0.02	0.06	0.08	0.05	-0.04	-0.09	0.02	-0.01	0.02	0.08	0.56	0.16	0.18	0.43	0.22
Portugal	-0.27	-0.21	0.06	-0.09	-0.32	-0.36	0.02	0.08	0.13	0.18	1.00	0.68	3.68	12.48	5.53
Spain	-0.39	-0.12	-0.02	-0.10	-0.36	-0.41	-0.02	-0.03	0.01	0.09	0.78	0.51	2.47	3.22	3.94
Ireland	-0.39	-1.69	0.25	-0.10	0.74	-0.33	-0.01	-0.08	0.01	0.08	1.20	1.47	5.96	6.52	3.38

Notes: Bond spreads value/SOM group; the cells of this table have been colored according to the group to which the country – year belongs in the Kohonen map; Group 1: yellow; Group 2: Orange; Group 3: Blue; Group 4: Green; Group 5: Pink

Group 1: 0.127	<i>Non-EMU</i>	2.087
	<i>EMU</i>	-0.142
Group 2: 0.973	<i>Non-EMU</i>	0.389
	<i>EMU</i>	-0.135
Group 3: 0.237	<i>Non-EMU</i>	2.754
	<i>EMU</i>	0.021
Group 4: 0.707	<i>Non-EMU</i>	1.104
	<i>EMU</i>	0.352
Group 5: 4.384	<i>Non-EMU</i>	3.202
	<i>EMU</i>	4.587

Table IV.

Mean group spreads

Note: Mean of spreads considering GBI index

As could be observed in Table IV, there are important relations between the economic variables evolution and, consequently, the groups formed by the Kohonen Map, with respect to the sovereign bond spread evolution.

For example in Groups 1 and 2, the mean of sovereign bonds spreads is relatively low and those belonging to EMU members are, in general, negative. These results are in concordance with the common characteristics of the patterns of these groups in the Kohonen maps, where the economic variables do not present serious problems.

Greece is an exception in 2000. This country presents a continuous instability since that period, worse during the financial crisis.

Group 2 is extensive and it gathers many countries and years, so there is a great spread dispersion, between 1.06 and -1.685. Nevertheless, there is an interesting aspect to highlight. The 71 per cent of the total of positive spreads are data from non-EMU countries, while EMU countries only represent the 29 per cent. The main reason that justified negative spreads for EMU members, differently than non-EMU countries, is the convergence related with the beginning of the common currency, as data in this group coincide with years after 2002.

Group 3 is formed by countries-years with positive spreads. Nonetheless, the mean of spreads in this group is very low (0.237) and corresponds to moderate growth situations. In this context, some financial problems appear. All values are nearly zero, positives or negatives, except Greece in 1999 that shows a spread level of 2.58.

With respect to Group 4, the mean of spreads is moderate (0.707), but in this case, almost all the variables correspond to the pre-crisis period and positive spreads represent the 90 per cent of the group. Non-EMU countries are the only ones which present negative spreads. This result is a consequence of the homogenization of the Eurozone countries, even in this case when effects are negatives.

Moreover, related to Group 5, the means spreads are elevated, according to the wide variety of countries in this subsample. This group includes countries with high sovereign bonds spreads, such as Greece, Portugal and Ireland, and other countries with lower levels, such as Spain and Italy, but all of them have a deep impact of the financial crisis in common.

6. Conclusions

In this paper, a novel technique in finance is applied, to detect the incidence of the 2008 financial crisis over a set of economic variables of 17 European countries. Moreover, the results are contrasted with yearly sovereign bond spreads and compared with the incidence of the turmoil between EMU members and the rest of European countries.

Using SOMs, different groups formed by homogeneous countries (in different years) according to its economic situation are obtained. Considering the component maps, it is possible to examine the value of each economic variable during the whole period of analysis.

The 2008 financial crisis clearly affected all countries of the sample, although the effect was different between the Eurozone countries and the rest of the European economies. Considering the first subgroup, some of them like Portugal, Italy, Spain, Greece and Ireland were harshly affected. All the economic variables analyzed exacerbated their levels after the inception of the crisis. Moreover, their sovereign bond spreads increased more than the rest of the countries. Hungary shows a similar phenomenon after the crisis and its spreads level increased since 2011, despite it not belonging to the EMU.

Belgium presents similar economic indicators during all periods, although their levels do not reflect good economic conditions. Specifically, the ratio of debt over GDP shows high levels and has increased since the financial crisis. As a consequence, sovereign bond spreads are also elevated.

France has also suffered the financial impact of the crisis, specially related to the rise of sovereign spreads. On the contrary, The Netherlands presents smooth changes in sovereign bond spreads, and also shows small changes in its economic variables.

Moreover, Germany presents some negative economic changes since 2010 to 2011 related to higher debt ratio and inflation level. Austria is clearly not affected by the crisis in any aspect. Specific internal changes can be observed since 2005 until 2013.

With regard to the rest of European countries, the financial crisis impacted in different ways. The Czech Republic, Denmark and Poland present some economic changes since the start of the crisis even though they are not so abrupt. The Czech Republic and Denmark suffered a deterioration of their economic situation since 2008, in concordance with a considerable increase in spreads values. Similarly, Poland also presented worse economic fundamentals one year later.

Sweden and Finland present similar evolution considering bonds spreads despite their economic variables maintained their values. The UK suffered strongly the effects of the crisis, specifically if it compared its bond spread evolution and the value of its macroeconomic variables through the years.

This paper presents an exhaustive analysis relative to the macroeconomic situation of the 17 evaluated European countries during a vast time period, which covers great events such as the introduction of the euro and the financial crisis effect. The results obtained highlight the effect of the common currency and the consequences of affronting the last financial crisis.

For further research, a wider period of time will be included to analyze the progressive recuperation of the European financial markets and their evolution. In this sense, the point of contact between the economics could be appreciated in two ways: considering sovereign bond spreads evolutions and a set of macroeconomic variables. Moreover, a deeper study by considering more economic variables as key indicators of each economy by including all important determinants is interesting.

Notes

1. Whose public debt is negligible.
2. Greece joins UME in January 2001.
3. European countries incorporated later to UME, such as Slovenia (2008); Cyprus and Malta (2009); Slovakia and Estonia (2011); Latvia (2014) and Lithuania (2015), are not considered given the small size of their financial markets. Three non-EMU countries, Bulgaria, Croatia and Romania, have been discarded for the same reason.

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