Physica A 482 (2017) 108–117

Contents lists available at ScienceDirect

Physica A

journal homepage: www.elsevier.com/locate/physa

Unemployment and sovereign debt crisis in the Eurozone: A *k*-means-*r* analysis

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HIGHLIGHTS

- Debt crisis greatly affected some countries in the Eurozone.
- Recession and unemployment followed the application of corrective measures.
- Increasing separation of affected countries from the euro core.
- Restricted *r*-means is an adequate tool for clustering.

ARTICLE INFO

Article history:
Received 29 July 2016
Received in revised form 13 March 2017
Available online 21 April 2017

Keywords:
Sovereign debt
Crisis
Eurozone
Unemployment
Restricted *k*-means

ABSTRACT

Some southern countries in Europe, together with Ireland, were particularly affected by the sovereign debt crises in the Eurozone and were obliged to implement tough corrective measures which proved to be very recessive in nature. As a result, not only GDP declined but unemployment jumped to very high levels as well.

This paper uses a modified version of *k*-means (restricted *k*-means) to analyze the clustering of the Eurozone countries during the recent sovereign debt crisis, combining monthly data on unemployment and government bond yield rates. Our method shows that the separation of southern Europe from the other Eurozone is not necessarily a good characterization of this area before the crisis but the group of externally assisted countries plus Italy gains consistence as the crisis evolved, although there is no perfect homogeneity in this group, since the problems they faced, the type of response requested, the speed of reaction to the crisis and the lasting effects were not the same for all these countries.

1. Introduction

The financial crisis of 2007–2008 had a large impact in many economies, giving rise to the great recession still evident in a number of countries. In particular in the Eurozone, the sovereign debt crisis emerged from the financial crisis and touched dramatically Greece, Ireland, Portugal and Spain, which were obliged to request external financial assistance when they experienced difficulties to access external financial markets. In order to receive financial assistance from the European Union, the European Central Bank and the IMF (the *troika*), all these four countries had to apply rigorous austerity measures to correct their budgetary imbalances, although the package of measures was not exactly the same for all countries since the problems involved and the nature and gravity of the imbalances diverged from country to country.

As a result of these restrictive policies, economic activity retracted, many companies were closed and unemployment has soared. In Greece, GDP contracted 9.1% in 2011 and 7.3% in 2012 and unemployment jumped from 7.8% in 2008 to 24.5%

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http://dx.doi.org/10.1016/j.physa.2017.04.022
0378-4371/

Table 1
Abbreviation and name of countries in each group.

G1		G2		EU4	
AT	Austria	GR	Greece	GR	Greece
BE	Belgium	IE	Ireland	IE	Ireland
FI	Finland	IT	Italy	PT	Portugal
FR	France	PT	Portugal	ES	Spain
DE	Germany	ES	Spain		
NL	Netherlands				

in 2012 and 27.5% in 2013. In Spain, the evolution of unemployment followed a similar pattern and Ireland and Portugal experienced high rates as well. This had dramatic consequences on the economy, politics and people's lives. And although the debt crisis is now under control or much less severe, unemployment is much more persistent and remains at high levels.

The issue of sovereign debt crisis in the EU and in particular in the euro area has been the subject of analysis in a number of papers in the field of econophysics [1], many of them exploring the topological properties of a given time series with spanning trees. Ref. [2] used minimum spanning trees (MinST) to analyze the sovereign debt crisis in the European Union (EU) while in [3] maximum spanning trees were employed to investigate the same issue in the euro area. Ref. [4] studied the debt burden in GDP during 2000–2011 in the EU with MinST and the network structure of debt-to-GDP in Europe for the period 2000–2014 was analyzed in [5]. Other techniques have been used to analyze the euro area crisis as well [6,7] and several methods of econophysics have been applied in different areas, including the efficiency of sovereign bond markets [8] and the network analysis of currencies [9].

In this paper we combine the analysis of the sovereign debt crisis with the evolution of the "real" economy, represented by the important variable of unemployment. We present and apply a new algorithm derived from k-means in order to group the Eurozone countries into two distinct clusters. The availability of data imposed the selection of only eleven countries, listed as G1 (the Eurozone countries more resilient to the crisis) and G2 (the assisted EU4 members plus Italy) in Table 1. Italy is here included in G2 since it has been associated with the other countries in this group, although the debt crisis was more contained in Italy.

In the rest of the paper, Section 2 presents the data used and the methodology and Section 3 explores the main results. The relevant conclusions are presented in Section 4.

2. Data and methods

Data

We use monthly data for the years 2008 through 2014, covering a total of 84 months. Each observation is referenced by a system coding of 6 digits, the first identifying the year and the last 2 referencing the month. For example, 200 803 stands for March-2008. Unemployment rates come from Eurostat and yield rates are for 10-year government bonds, collected from Thomson Reuters Datastream.

In order to simplify the presentation of results we define the following groups of countries:

Methodology. The k-means-$r(6, \mathrm{GR}+4)$ algorithm.

Consider EU11, the set of eleven countries of the Eurozone identified in Table 1 as G1 and G2. We can now partition this set into two groups: one with Greece plus the other 4 countries close to Greece (Cluster2) according to a given criterion and the group (Cluster1) with the other six countries, which remain far apart from Greece. To select the elements of each group in a given period (month) we use an optimization procedure implemented by the following algorithm.

1. Starting with EU10 (G1 + G2 minus Greece), find each (distinct) partition of six (Cluster1) and four (Cluster02) countries obtained from EU10. We have 210 possible partitions. Join Greece to Cluster02 to obtain Cluster2.
2. For each partition
   (a) Compute the centroids C1 and C2 of Cluster1 and Cluster2, respectively. For each cluster i, $(i = 1, 2)$, these centroids are simply $[\bar{y}_i\ \bar{u}_i]'$, the means, over the members of the cluster, of yield and unemployment rates.
   (b) Obtain the sum of squared Euclidean distances between each country and the corresponding centroid, that is, $\sum_{i=1}^{2}\sum_{j=1}^{n_i}\left[\left(y_{ij}-\bar{y}_i\right)^2+\left(u_{ij}-\bar{u}_i\right)^2\right]$. The use of the sum of squared Euclidean distance within clusters is a common practice in many clustering algorithms, but we could have used other criterion, or distance.
3. Select the partition, that is, Cluster1 and Cluster2, corresponding to the minimum sum of squared distances from those 210 cases analyzed in step 2.

This modification of the k-means algorithm enables us to incorporate additional information in the process of cluster selection. During the sovereign crisis we have two distinct groups of countries: those strongly affected by the sovereign debt crisis and needing external assistance and those that were not in this situation. Clearly, Greece belongs to the first group and accordingly, we want to partition the EU11 into two groups: one with Greece and countries with similar problems and the other with those countries in the opposite side. The algorithm should be able to give meaningful partitions with the assisted countries in one cluster during the sovereign debt crisis, but there is no particular reason to obtain the same