Professor Alexandra HOROBET, PhD
Faculty of International Business and Economics
The Bucharest Academy of Economic Studies
E-mail: alexandra.horobet@rei.ase.ro
Lucian BELASCU, PhD
University Lucian Blaga of Sibiu
Irina IONITA, MA
Faculty of International Business and Economics
The Bucharest Academy of Economic Studies
Anca-Teodora Serban - OPRESCU, PhD
Faculty of International Business and Economics
The Bucharest Academy of Economic Studies

A NEURAL NETWORKS PERSPECTIVE ON THE FINANCIAL INTEGRATION OF EUROPEAN CAPITAL MARKETS

Abstract*. We use a Self-organization Map algorithm (SOM) to investigate the changes in the level of EU capital markets' integration before and after the recent financial and sovereign debt inter-twinned crises, based on data on capital market features for all 27 EU countries, collected from various databases, such as ECB, EUROSTAT, OECD and WFE. A number of indicators that reflect the level of capital market development and its level of openness is taken into account for each country, on an annual basis, in order to have a proper view on capital markets' features both from the perspective of market performance and market development. We find that the European capital markets form a rather heterogeneous structure, with a number of stable clusters that move towards more homogeneity – formed of mature capital markets in the EU, and with other smaller clusters, which typically include the emerging markets in the EU, which seem to be less integrated with the other EU capital markets.*
Keywords: *Capital markets, financial integration, cluster analysis, Self-organization map, neural networks.*

JEL Classification F36, D53

1. Introduction

In the aftermath of the financial crisis that emerged in 2007 and of the sovereign debt crisis that erupted in 2010, a valid concern of policymakers in Europe should refer to the impact of these crises on the level of capital markets, given the benefits of a high level of integration for capital market development, particularly for the likely candidate countries for Euro adoption. The aim of our paper resides in investigating the evolution of capital market integration in the European Union after 2000, with a special apprehension on the changes that the recent financial crises might have induced.

The measurement of financial integration has been performed in the past by using various instruments, which can be divided in three broad categories, following Baele et al. (2004): price-based measures, news-based measures and quantity-based measures. Price-based measures take into account the discrepancies between prices or asset returns due to assets' geographical location, which may be considered as a direct test on the law of one price that should prevail in the case of total financial integration. The literature based on this research direction used asset pricing models to explore potential differences in systematic risk factors or other asset attributes [see the studies of Bekaert and Harvey (1995), Chen and Knez (1995), Hardouvelis et al. (1999) and Dewachter and Smedts (2007)]. The European Central Bank also uses an indicator based on prices, the cross-sectional dispersion of interest rates spread, to measure financial integration in the euro-area (see the European Central Bank "Financial Integration in Europe" report, published annually). The news-based measures are used with the goal of differentiating the effect of new information arrival from other frictions that may exist in markets. If markets are financially integrated at the global level, then news in the form of economic information of domestic or regional nature should have no significant impact on prices, while information of global nature should be relevant important for assets' prices. In this framework, the level of systematic risk should be the same across assets and countries if financial integration is complete; if not, financial integration is not complete and local information influences assets' prices and returns. The favourite methodological tools employed to test financial integration level based on this type of measures are vector auto-regression models (VAR), Granger causality tests and cointegration, able to better model market co-movements than the traditional correlation tool, but with rather mixed results [see the research of Jeon and Chiang (1991), Chan et al. (1992), Arshanapalli and Doukas (1993) and, more recently, Chen et al. (2002]. The quantity-based measures investigate the effects of frictions faced by demand for and supply of investment opportunities, using statistics on the ease of market access across countries, for example from the perspective of cross-border lending or listings. A favourite tool in this category have been statistics on international holdings of institutional investors, aimed at uncovering the level of home-bias in their portfolios – since total financial integration assumes that portfolios are fully internationally diversified, the higher the degree of home-bias, the lower the level of integration is [see, for example, the studies of Pastor (2000), De Santis and Gerard (2006), Baele et al. (2007) and Sercu and Vanpee (2007), among others].

The EU has been the subject of study of numerous works in financial integration, given its standing as the best framework for economic integration at the global level. It is widely believed that the introduction of the common currency is the underlying cause of increased financial integration, due to the elimination of currency risk. Yang et al. (2003) show that the emergence of EMU improved integration among member states, while other large EU financial markets such as the UK remained rather isolated. The same result is validated by Hardouvelis et al. (2006), which prove that stock markets in the Eurozone converged due to the alignment of interest rate differentials and inflation differentials to the best performing states, Germany in particular. At the same time, Abad et al. (2009) found out that Eurozone

countries are more vulnerable to EMU risk factors than to world risk factors, while the situation for countries outside the eurozone is reversed. More recent studies confirm that currency stability is an important driver of financial integration. For example, Boubakri & Guillaumin (2011) analyze the level of integration of countries from Central and Eastern Europe (CEE), and they conclude that their integration with Eurozone countries has occurred more slowly, but also that a lower currency risk premium was able to improve the degree of financial integration. Furthermore, they show that although the EU is far from having a homogenous financial market, the integration process is improving. The recent financial crisis and the subsequent sovereign crisis which affected the European markets raised concerns about the efficiency of the EMU and the process of financial integration in Europe. The differences in domestic risk factors, such as market liquidity and default risk, proved that euro markets are not perfect substitutes and have different reactions to crisis emergence (Abad et al. (2009)). Although the current crisis has proven that an increased integration among financial markets enhances the spillover effects of a domestic shock to other countries, the asymmetries between European markets imply that the macroeconomic environment of these countries played a dominant role in the effects of this shock (Lane (2012)).
As it may be observed in previous studies, opinions regarding the integration of financial markets in the EU are far from being homogenous. The selection of countries and of the possible impact factors, as well as the methodologies used, plays a significant role in the research output. Our research proposes a new approach, based on neural networks methodology, which has the capability of offering more insight into the level of homogeneity and heterogeneity of capital markets in the European Union, as a manner of interpreting integration. The paper is organized as follows: Section 2 describes the data and the research methodology; Section 3 presents the main results and Section 4 concludes.

2. Data and research methodology

The data set used in our research addresses the 27 countries that are EU members, as our objective resides in analysing the capital market behaviour of countries that belong to a region where the same rules and development policies are applied. The capital markets of these countries are characterised by two types of indicators: performance indicators and market structure indicators, which reflect both the investors' perception echoed in stock prices and the reforms that each country promoted over the years in terms of capital market development. Overall, a number of eight indicators have been used, with an annual frequency, covering the 2000-2011 timeframe. Data sources are Bloomberg (for performance indicators) and World Bank (for market structure indicators).
In order to build the performance indicators we have used the main stock market indices for each country, with a daily frequency, and we have calculated the following attributes, based on return distributions for each year: (1) Mean to Standard deviation (Mean/SD); this measure is preferred to each of its components due to the lack of homogeneity of EU capital markets; (2) Skewness (Skew); and (3) Excess Kurtosis (Kurt). For what concerns the market performance indicators, we have selected a number of five market attributes, depending strongly on data availability, as follows: (1) the number of listed domestic companies (LISTCO), which includes all local companies listed on each stock market until the end of

the year; (2) the stock market capitalization as percentage of country's GDP (MKCAP%); (3) the stock market capitalization in US dollars (MKCAP); (4) the total value of stocks traded as percentage of country's GDP (VSTTR%) – this is a complementary indicator to the ratio of stock market capitalization to GDP, as it shows whether the capital market size is justified by the transactions' value; and (5) the turnover ratio of stocks traded in percentages (TURNRAT), calculated as the ration between the total value of transactions in a year and the average of market capitalisation over the same period.

The research methodology proposed in our research is based on a Self-organizing Map (SOM) algorithm proposed by Kohonen (2011), which belongs to a class of neural networks trained to organize data so that unknown patterns may be discovered, thus leading to results that cannot be attained by more traditional clustering methods such as Statistical Cluster Analysis (SCA) and Principal Components Analysis (PCA). Although useful for data classification, SCA and PCA are deficient for the uncovering of potential non-linear links between data series, but SOM is a method that is able to overcome these deficiencies. SOM is a type of neural network that uses an unsupervised training algorithm that organises results in a topological representation of the underlying data. The neural network rearranges a set of input vectors for each case (in our framework, each country) on a bi-dimensional grid, and countries are grouped around a number of nodes or neurons. Each neuron has a specific topological position, given by particular dimensions. There are two layers of information processing within the SOM: the entry layer, which includes the elements in the input vectors, and the output layer, where the processing units are connected to the entry layer. SOM is different compared to other neural networks because it does not contain any hidden layer of neurons. Each unit (country) on the topological map is characterised by an n-dimensional vector (where n is the number of variables), and a synaptic weight corresponds to each dimension. Briefly, when an input vector is presented to the network, the distances between the new vector and the output units are calculated, based on Euclidian distances, which we have considered as appropriated given the continuous nature of our data. Thus, the steps that lead to data training are as follows: (1) the grid dimensions (height and width) are established, and their multiplication will give the maximum number of neurons in the grid; (2) randomly, the algorithm selects a vector from the input data and presents it to the created network; (3) each of the neurons is examined in order to calculate which of them has a close weight to the input vector, and the most fit alternative bears the name of "winning neuron"; (4) the neighbourhood radius of the winning neuron – the similar neurons to the input vectors, but with a lower level of similarity compared to the winning neuron – is calculated; (5) the weight of each neuron found in the vicinity of the winning neuron is adjusted so that is resembles the input vector; the closer this neuron is to the winning neuron, the higher the changes in its weight; (6) starting with the second step, the process becomes iterative, for all the input vectors (in our case, for the vector represented by each of the 27 countries), until each vector is associated to a winning neuron. One of the difficulties in applying the SOM algorithm comes from the fact that the user needs to decide a priori the number of processing units in the output layer, based in the shape and size of the desired topological map, which implies a "trial and error" approach aimed at ascertaining the grid's height and width and, implicitly, the number of neurons.

Before the application of SOM we have standardized all variables, using their average and standard deviation across countries, for each year. This is a necessary step, given the fact that there is a distinct possibility that variables that have high values for some indicators to impact to a large extent the clustering process, compared to the remaining values, thus leading to an erroneous placement of countries in clusters.

Our study observes the countries' position in clusters for the entire period (2000-2011), but also for two sub-periods – before the emergence of the financial crisis (2000-2007) and during the crisis (2008-2011). Thus we hope to uncover the specific effect that the financial crises might have generated in terms of financial integration for the EU member countries' capital markets. All analysis has been undertaken by using Statistica, the Data Mining module.

3. Results

The use of SOM results in placing each country on a topological map, depending on its position around the winning network neuron, according to the previously described algorithm. Countries' allocation is based on the lowest values of Euclidian distances between each country's input vector and the neuron's weight vectors, distances being represented by the activation indicator (in the following pages used as "Activation", based on the results generated by the algorithm application). After going through the "trial and error" process, we have settled a 2x2 grid dimension (height and width), thus creating at most 4 neurons. When the grid dimensions are increased winning neurons are not created for any of the input vectors, thus leading us to decide on an optimal number of 4 neurons, described by the combinations between the two dimensions as following: neuron 1 (1,1), neuron 2 (1,2), neuron 3 (2,1) and neuron 4 (2,2). Table 1 presents the number of winning positions of each neuron, for each year, the two sub-periods and the entire period in our analysis.

We may observe that the majority of countries entered neuron 1 (1,1) until 2005, while at the end of the period, in 2011, neuron 4 (2,2) was winning twelve times, an reversed situation compared to 2000. This may indicate that many of the countries whose input vector corresponded to the weight of neuron 1 (1,1), at the end of the period they have "migrated" towards neuron 4 (2,2). This is also demonstrated by the analysis over the two sub-periods. In 2000-2007, neuron 1 is the most frequent winner (12), while during 2008-2011 the most frequent winner is neuron 4 (11 times). Still, when the entire period is taken into account, neuron 1 groups the majority of countries. The least frequent winner is neuron 3, in almost every year, including a maximum number of 8 countries in 2002, 2003 and 2006.

Table 1. SOM: Frequency of countries' positioning in the neurons

Year	Frequency				Year	Frequency			
	1 (1,1)	2 (1,2)	3 (2,1)	4 (2,2)		1 (1,1)	2 (1,2)	3 (2,1)	4 (2,2)
2000	14	5	3	5	2008	10	7	5	5
2001	12	7	3	5	2009	8	11	6	2
2002	10	7	8	2	2010	10	4	6	7
2003	10	3	8	6	2011	4	8	3	12
2004	10	7	4	6	2000-2007	12	5	6	4
2005	9	8	1	9	2008-2011	9	6	1	11
2006	8	4	8	7	2000-2011	11	7	3	6
2007	6	8	5	8					

Source: Authors' calculations

In what follows we discuss the structure of each neuron for the overall period and the two sub-periods, as well as countries' transitions among neurons from the first to the second sub-period. The results obtained after training data were represented graphically, on topological maps, having as coordinates the neuron number (neuron ID) and the Euclidian distance that allowed the neuron to become a winner (activation). Table 2 presents the synthetic results, as values in the table indicate the neuron identification number (from 1 to 4).

Table 2. SOM: „Winning neurons" for each country, 2000-2011

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2000-2007	2008-2011	2000-2011
AUT	1	1	1	1	1	4	1	4	4	2	4	4	1	4	1
BEL	1	3	3	2	3	4	4	4	4	2	4	3	3	4	4
BUL	1	1	1	1	1	1	2	3	1	1	1	4	1	1	1
CYP	4	4	3	1	1	1	1	3	1	1	1	4	3	1	4
CZR	1	1	1	1	4	4	1	1	3	2	1	4	1	4	1
DEN	4	4	3	4	4	4	4	4	4	2	2	3	4	4	3
EST	1	1	1	1	1	1	2	1	1	1	1	4	1	1	1
FIN	2	2	2	3	2	2	3	2	2	2	2	2	2	4	2
FRA	4	2	2	3	2	2	3	2	2	3	3	2	4	2	2
GER	4	2	2	3	2	2	3	2	2	3	3	2	4	2	2
GRE	3	4	3	4	3	4	4	4	1	2	4	4	3	4	4
HUN	3	1	1	4	4	4	4	4	3	2	4	4	1	4	3
IRL	1	3	3	4	3	4	1	4	4	2	4	4	3	4	4
ITA	4	4	3	3	4	2	3	2	3	2	4	2	4	4	3
LAT	1	1	1	2	1	1	1	4	1	1	1	4	1	1	1
LIT	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1
LUX	1	3	3	4	3	1	1	3	1	4	2	3	3	3	4
MAL	1	1	4	2	1	1	1	1	1	1	1	1	1	1	1
NET	2	2	2	3	2	2	3	2	2	3	3	2	2	2	2
POL	1	1	1	1	4	4	4	4	4	2	2	4	1	4	1
POR	3	4	3	4	4	4	2	1	3	2	4	4	3	4	4
ROM	1	1	4	1	1	3	4	3	1	4	1	4	1	1	1
SVK	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1
SLO	1	1	1	1	1	1	2	3	1	1	1	1	1	1	1
SPA	2	2	2	3	2	2	3	2	2	3	3	2	2	2	2
SWE	2	2	2	3	2	2	3	2	2	3	3	2	2	2	2
UK	2	2	2	3	2	2	3	2	2	3	3	2	2	2	2

Source: Authors' calculations

We see that United Kingdom, Spain, Sweden, the Netherlands and Finland belong to the same group, in their case the winning neuron being neuron 2, with some countries transiting towards neuron 3, except for 2009 and 2010. France and Germany also join these countries, although they are less homogeneous compared to the first group of countries. This may be explained by the countries' geographical proximity, but also by the diversity of economic connexions between them, as well as by investors' perceptions on the two countries' similar level of capital market development. Another homogeneous groups of countries is formed of the Baltic countries (Latvia, Lithuania and Estonia), joined by Malta and a few CEE countries (Slovenia, Slovakia and Bulgaria), which suggests a cluster created due to capital markets' resemblances, as well as a geographical-based financial integration. The winning neuron for these countries was neuron 1. From the same geographical area comes Romania, also placed in neuron 1 for both sub-periods, but the country's position was rather changing over the years, with many migrations between neurons.

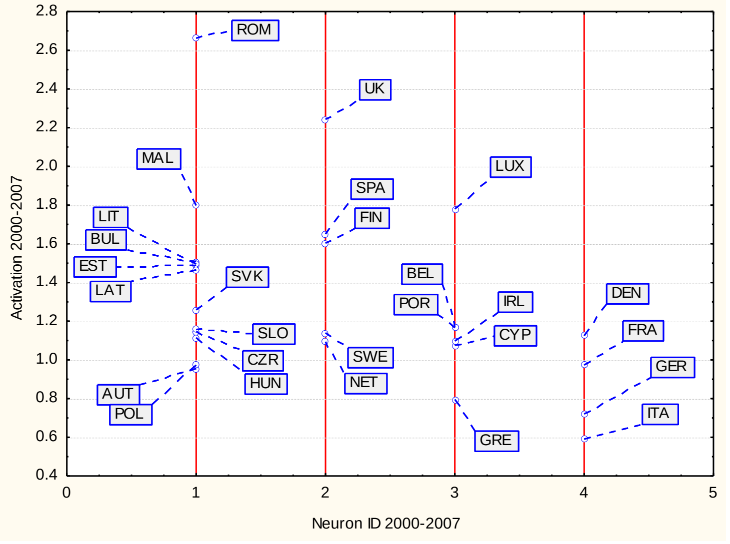
The vast majority of countries modify their position in time, which may be interpreted as a sign that their capital markets develop in a rather similar manner. It is also interesting to note that neuron 2 is populated, almost for the entire period, by the developed capital markets in the EU: United Kingdom, Spain, Sweden, the Netherlands and Finland, and, beginning with 2001, France and Germany also join the neuron (they are closer to the Netherlands and Sweden). Also, Italy joins the same neuron, but only occasionally. This result proves that the Euclidian distances that induce Spain's and United Kingdom's integration into this cluster are higher compared to the remaining countries in the same neuron. Neuron 2 was populated by other countries in 2003, 2006, 2009 and 2010, but the group preserved its structure and countries were included in neuron 3. It is difficult to detect the same patters for the other countries, as they are less homogeneous for what concerns their capital markets.

Figures 1 to 3 present countries' positioning in clusters generated by the winning neuron in the two sub-periods and the overall period. A number of observations are relevant, in our opinion, regarding the 2000-2007 sub-period, based on Figure 1: (1) Five of the mature markets are grouped in neuron 1, as it happened in the majority of years taken separately, thus confirming these countries' high level of capital market integration; (2) Of these countries, closer links seem to exist between Sweden, the Netherlands, Finland and Spain, while United Kingdom joins them at a higher Euclidian distance, a finding somehow justified by the country's biggest capital market in the EU; (3) France and Germany had a different evolution compared to the other mature markets in the EU, although the annual clustering showed similar attributes to the Netherlands and Sweden; (4) Denmark, a developed country but with a less mature capital market compared to France or Germany, belongs to the same cluster as these two countries, that also includes Italy; (5) There is a strong link between Belgium's and Ireland's capital markets, together with Portugal and Cyprus, while Greece and Luxembourg are part of the same cluster but are less integrated with the previously mentioned countries; (6) Neuron 1 includes 12 countries and is the most frequent winning neuron – these 12 countries are highly integrated among themselves, particularly when we refer to Austria and Poland, Hungary, the Czech Republic, Slovenia and Slovakia, and Latvia, Estonia, Bulgaria and Lithuania, joined by Malta, at a relatively high distance; (7) Romania is the only country that joins the group at a much higher distance, although it belongs to this last cluster, and one may easily remark the difference between its capital market and the other capital markets in CEE.

When we refer to the 2008-2011 sub-period, the graph in Figure 2 allows the following observations: (1) Mature markets remain in the same group, thus confirming their high level of integration, even during more turbulent times; France and Germany have similar evolutions, joining the cluster at near distances, while Finland left the cluster; United Kingdom and, to some extent, Spain, join the neuron at a higher Euclidian distance; (2) The remaining countries are almost equally divided between neurons 1 and 4, as follows: we observe a pronounced similarity between Latvia, Slovenia, Malta, Bulgaria, Cyprus, Estonia and Romania (interesting, in turbulent times Romania becomes closer integrated with the other countries), while Slovakia is more isolated in the region; there is the group of more developed markets, but whose capital markets have smaller sizes – Austria, Belgium, Denmark and Finland – or that have been more affected by the sovereign debt crisis – Ireland, Portugal, Italy and

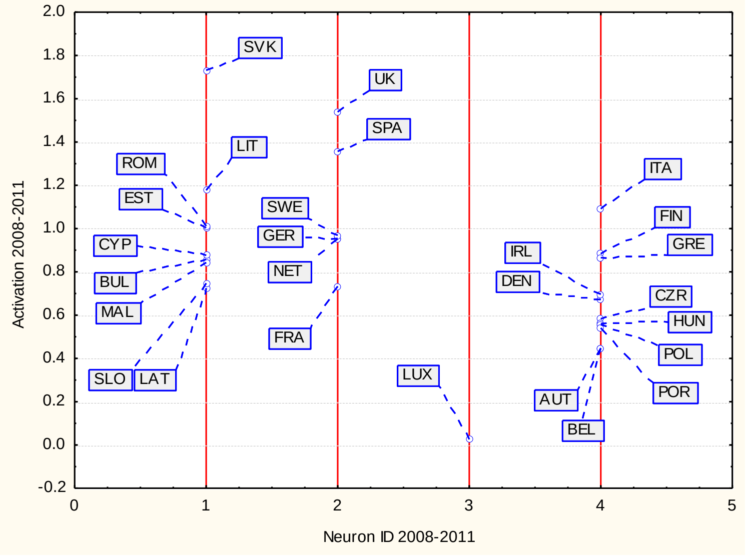
Greece -, joined by a number of CEE markets that are more developed compared to the remaining countries in the region – Poland, Hungary and Czech Republic; (3) Luxembourg is an isolated country, its capital market attributes being different compared to the other; a possible explanation may reside from the fact that although the country is highly developed from an economic and financial perspective, the indicators used in our study place it in the region of less developed countries based on the country's dimension.

Figure 1. Topological map, 2000-2007



Source: Authors' calculations

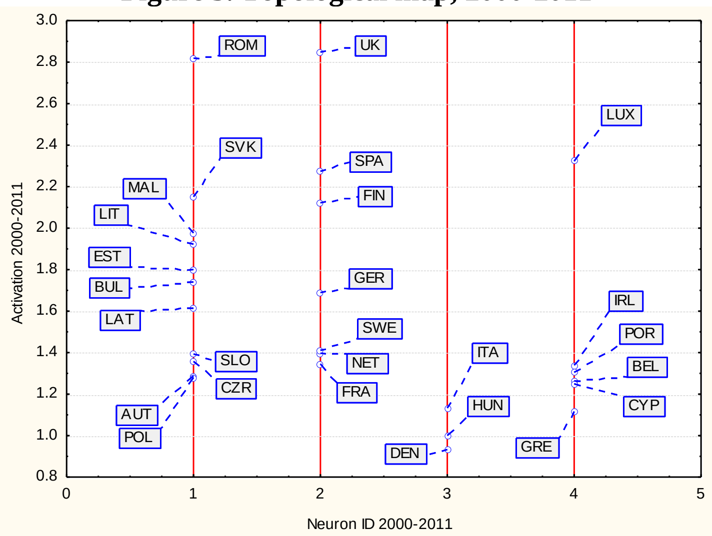
Figure 2. Topological map, 2008-2011



Source: Authors' calculations

Figure 3 presents the topological map for the entire 2000-2011 period, and we may draw the following conclusions based on it: (1) The most developed countries in the EU from an economic point of view are also the ones with the most integrated capital markets: France, the Netherlands, Sweden and Germany, joined by Finland and Spain at a relatively higher distance; (2) The United Kingdom belongs to the this group of integrated countries, but it clusterises to a high distance, thus confirming that the particular features of the British capital market, offered by its status of one of the world' major financial centres; (3) Italy, although one of the first members of the EU and EMU, has a lower level of integration with these markets, but is clusters with Denmark (a developed country from an economic perspective, but with a smaller size of its capital market) and Hungary (one of the more developed countries from CEE); (4) Belgium belongs to the cluster that includes the most hurt countries by the sovereign debt crisis – Ireland, Portugal, Greece and Cyprus -, while Luxembourg is located in the same "winning neuron", but the Euclidian distance is significantly higher (almost double); this result may indicate Luxembourg's particular attributes: a country with a sufficiently high level of development so as to be compared with the other countries from Western Europe, but with a capital market that has a dimension that is closer to the less developed markets, possibly due to its smaller geographical territory; (5) CEE countries form a distinct cluster, with closer links between Austria, Poland, Czech Republic and Slovenia, on one hand (Austria and Poland seem to be the leading countries for the other two, but these two markets are among the vest performing countries in the EU during the financial crisis), and with higher distances from Latvia, Estonia, Lithuania and Malta, and even higher from Bulgaria and Slovenia, on the other hand. In the graphical representation, Romania belongs to this cluster, but it looks rather isolated, thus suggesting that its capital market needs to "catch up" the other markets in the region in terms of development.

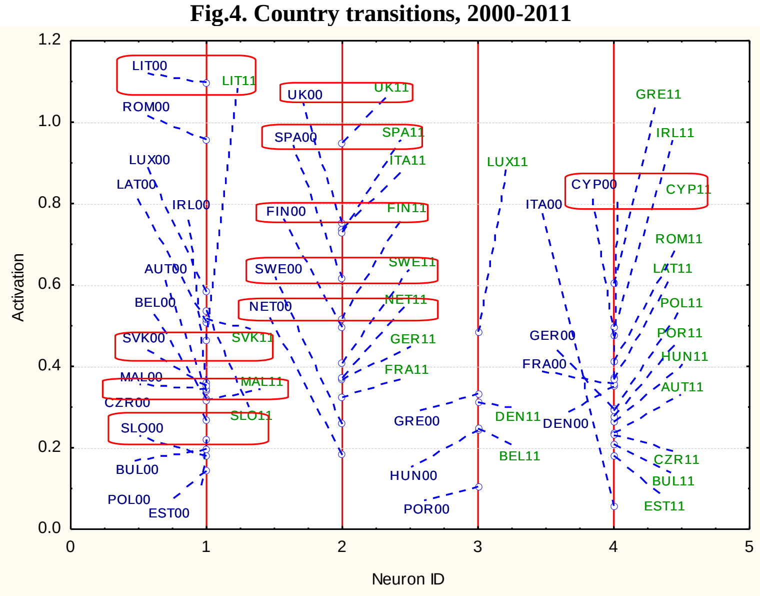
Figure 3. Topological map, 2000-2011



Source: Authors' calculations

It is interesting to examine each country's position in neurons at the beginning and at the end of the period, shown in Figure 4. We have marked the countries that preserve their positions in the same neuron – a total of ten countries. Of these, half are developed markets, stable and well integrated during the time frame of our analysis: the Netherlands, Sweden, Finland, Spain and the United Kingdom. From CEE, Slovenia, Malta, Slovakia and Lithuania have also preserved to a large extent their positions, but with fluctuations regarding the Euclidian distance that includes them in the winning neuron 1. Cyprus also maintained its position in neuron 4. Another notable observation is that most of the countries grouped in neuron 1 in 2000 transited towards neuron 4 in 2011 – many of them are the mature markets from CEE (Austria, Poland, Czech Republic, Hungary and Poland), but also Estonia and Romania. France, Germany, and also Italy moved from neuron 4 to neuron 2 in 2011, joining the developed markets in the EU.

Fig.4. Country transitions, 2000-2011



Note : Values in blue correspond to 2000, while values in green correspond to 2011.
Source: Authors' calculations

4. Conclusions

Our research investigated the changes in the level of EU capital markets' integration before and after the recent financial and sovereign debt inter-twinned crises, based on data on capital market features for all 27 EU countries, and using a new approach, able to offer a new insight into the process of financial integration in the region. The research methodology is based on a Self-organizing Map (SOM) algorithm, which belongs to a class of neural networks trained to organize data so that unknown patterns may be discovered, thus leading to results that cannot be attained by more traditional clustering methods such as Statistical Cluster Analysis (SCA) and Principal Components Analysis (PCA).

By applying hierarchical clustering an k-means algorithms, our results lead us towards concluding that the European capital markets form a rather heterogeneous structure, with a number of stable clusters that move towards more homogeneity – formed of mature capital markets in the EU, and with other smaller clusters, which typically include the emerging markets in the EU, which seem to be less integrated with the other EU capital markets.

REFERENCES

[1] **Abad, P., Chulia, H., Gomez-Puig, M. (2009),** ***EMU and European Government Bond Market Integration***. *Journal of Banking and Finance*, 34, 2851–2860;

[2] **Arshanapalli, B., Doukas, J. (1993),** ***International Stock Market Linkages: Evidence from the Pre - and post-October 1987 Period***. *Journal of Banking and Finance*, 17, 193–208;

[3] **Baele, L., Ferrando, A., Hördahl, P., Krylova A., Monnet, C. (2004),** ***Measuring Financial Integration in the Euro Area***. *European Central Bank Occasional Paper Series*, 14;

[4] **Bekaert, G., Harvey, C. (1995),** ***Time-varying World Market Integration***. *Journal of Finance*, 50, 403–444;

[5] **Boubakri, S., Guillaumin, C. (2011),** ***Financial Integration and Currency Risk Premium in CEECs: Evidence from ICAM*** . *Emerging Markets Review*, 12, 460–484;

[6] **Chan, C. K., Gup, B. E., Pan, M. S. (1992),** ***An Empirical Analysis of Stock Prices in Major Asian Markets and the US***. *Financial Review*, 27, 289–307;

[7] **Chen, G., Firth, M., Meng Rui, O. (2002),** ***Stock Market Linkages: Evidence from Latin America***. *Journal of Banking & Finance*, 26, 1113-1141;

[8] **Chen, Z., Knez, P. (1995),** ***Measurement of Market Integration and Arbitrage***. *Review of Financial Studies*, 8, 287–325;

[9] **De Santis, R. A., Gerard, B. (2006),** ***Financial Integration, International Portfolio Choice and the European Monetary Union*. ***ECB Working Paper*, 626;

[10] **Dewachter, H, Smedts, K. (2007),** ***Limits to International Arbitrage: An Empirical Evaluation***. *International Journal of Finance and Economics*, 12, 273-285;

[11] **European Central Bank (2005-2012),** ***Financial Integration in Europe*;** Frankfurt am Main: ECB;

[12] **Hardouvelis, G. A., Malliaropulos, D., Priestley, R. (2006),** ***EMU and European Stock Market Integration***. *The Journal of Business*, 79, 365-392;

[13] **Hardouvelis, G., Malliaropoulos, D., Priestley, R. (1999),** ***EMU and European Stock Market Integration***. *CEPR Discussion Paper*, 2124;

[14] **Jeon, B. N., Chiang, T. C. (1991),** ***A System of Stock Prices in World Stock Exchanges: Common Stochastic Trends for 1975–1990*?** *Journal of Economics and Business*, 43, 329–338;

[15] **Kohonen, T. (2001),** ***Self Organization Maps***. New York: *Springer-Verlag;*
[16] **Lane, P. R. (2012),** ***The European Sovereign Debt Crisis***. *Journal of Economic Perspectives*, 26, 49–68;
[17] **Pastor, L. (2000),** ***Portfolio Selection and Asset Pricing Models*** . *Journal of Finance*, 55, 179-223;
[18] **Sercu, P., Van Pée, R. (2007), Estimating** ***the Costs of International Equity Investments*** . *Review of finance*, 12, 587-634;
[19] **Yang, J., Min, I., Li, Q. (2003),** ***European Stock Market Integration: Does EMU Matter****?". Journal of Business Finance & Accounting*, 30, 1256-1276.