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Optimized spiral spherical self-organizing map approach to sector analysis – The case of banking

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ABSTRACT

The paper presents a comprehensive treatment of the European Union banking sector in the 2000–2011 period. A wide set of economic indicators is used to derive two-level approach: micro and macro topologies. We use the methodology of the optimized spiral spherical self-organizing map, a version of Kohonen's Self-Organizing Maps, which overcomes some of the major deficiencies found in standard methods. In dynamic analysis we recover the path of the integration process itself by calculating the dynamics of the countries around the sphere and by examining the measure of dispersion. The simultaneous comparison of the micro and macro levels provides deeper insights into the banking sector integration process. Both models, the micro and macro, unveil the formation of two banking clusters, which, with the exception for Greece, coincides with a division between new and old member states. Both clusters intensify integration within their cluster.

1. Introduction

An important part of the European integration process includes financial integration, at the forefront of which is the integration of national banking sectors. This process is desirable since the benefits are expected to be numerous. The importance of financial integration and its impacts – among other things – on the effectiveness of financial markets, capital allocation, the transmission mechanism of monetary policy, bank regulation, export and economic growth, are well documented in both literature and economic policy (Adam, Jappelli, Menichini, Padula, & Pagano 2002; Arnaboldi & Casu 2011; Babecký, Komárek, & Komárková 2010; Baele, Ferrando, Hördahl, Krylova, & Monnet, 2004; Baltzer, Cappiello, De Santis, & Manganelli 2008; Barrell, Fic, FitzGerald, Orazgani, & Whitworth 2011; Boot & Thankor 2010; Casu & Girardone 2008; European Commission, 2009; Gropp & Kashyap 2010; Gur 2013; Inklaar, Maudos, de Guevara, & Meesters 2011; Lane 2008a; Lane, 2008b; Manna 2004; Neyapti & Dincer 2014; Schäfer 2009; Weill 2009). Therefore, the relevant research and policy question of the banking sector integration process requires the expert system ability to measure and investigate its progress.

The conventional definition derives from the law of one price on a spatially integrated market (Baele et al., 2004; Bakucs, Bojnec, & Fertő, 2015). This view is also incorporated in the financial integration definition of the European Central Bank (ECB), which has influenced the literature on the banking sector integration (Gropp & Kashyap, 2010). Different approaches to the measurement of this process have been presented in existing literature (e.g. Adam et al., 2002; Gropp & Kashyap, 2010; Sørensen & Gutiérrez, 2006). However, despite the great variety of methodological approaches on this subject, there is no any a sufficiently comprehensive measurement approach for the identification of the integration stage a dynamic analysis. Therefore, our research aims to fill this missing gap in the literature by using a broad set of indicators, both at the macro and micro levels of banking sector integration. The role of the indicators and/or estimation techniques should not be overseen when measuring economic relationships (e.g. Erdal & Yenipazarli, 2013).

The main novelty of the paper is in the proposed micro and macro typologies of the integration level of the banking sector in the European Union (EU-27) member states. We argue that the anticipated view, via a dynamic analysis, might enable economic policy to act proactively and avoid the tendencies of market segmentation, which can derail the progress of the internal banking market integration away from its intended path. As the study

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results in two topologies, micro and macro, this two parallel analysis offers a unique opportunity for analyzing the integration process in different ways. Firstly, we propose to examine the results graphically on a map derived from a projection. Next we propose numerical measures to quantify banking sector integration at the micro and macro levels.

The paper is structured as follows: In the next section we justify the benefits of using the proposed methodological approach. The third and fourth sections introduce the methodology of integration measures, network architecture and learning parameters, respectively. In the fifth section we turn to the presentation of the obtained results of the micro and macro maps and the values of the integration measures. In the sixth section, we examine the insights gained by the research and discuss its relevance for the economic policy of banking sector regulation in the internal market. Finally, section seven concludes the paper.

2. Research methods

Using clustering methods to examine the integration has been known in previous literature. An interesting study with hierarchical clustering was presented by Sørensen and Gutiérrez (2006). On the other hand non-standard data mining techniques' are for other banking questions often used in the literature (e.g. Iturriaga & Sanz, 2015; Moro, Cortez, & Rita, 2015; Sundarkumar & Ravi, 2015). However, cluster methods are numerous and differ very much among themselves. In the literature there are studies where Kohonen's Self-Organizing Maps (SOM) were applied to investigate national banking sectors, e.g. for the Russian banking sector, including 1800 banks by Shumsky and Yarovoy (1998). Jagric and Spes (2010) made an attempt at using Kohonen's SOM in the field of cross border banking integration. The results showed that the selected research approach is very promising; however, there were some methodological pitfalls present. An important one comes from the fact that regular Kohonen's SOM is only two-dimensional and may suffer badly from the border effect. To what extent this represents a methodological shortcoming depends on the characteristics of the data. Based on our test results for macro indicators, it appeared to be very important. Although the border effect would seem to be easily overcome with another topological selection, e.g. toroidal, we have decided for the spherical one for the following two reasons: first, the sphere compared to toroid has a greater ability of the interpretation of graphically presented results and second, it enables also better neighborhood widening. Both characteristics seem to be of greater importance for the dynamic analysis of banking sectors, when taking into account that the border effect is not a problem in the chosen version of SOM, the optimized spiral spherical SOM.

2.1. Topology method

In what follows, we looked for a methodological enhancement. Jagric (2013) proposed that due to banking sector data specificities an appropriate method could be what is known as the optimized spiral spherical SOM and gives a detailed discussion of the methodological issues when considering the properties of the banking data and the need of dynamic analysis ability. The method we use in this article was presented by Jagric (2013), while simulations on artificial data were presented by Jagric and Zunko (2013). The paper presents the main findings of the dissertation by Jagric (2014).

The selection of the method for the research of banking sector integration was also motivated by following favorable characteristics of the method: the handling of outliers, suitability for unbalanced panel data, and resilience on problems of multicollinearity. Additionally, the selection was motivated by the following four facts. Firstly, in the literature of financial markets and institution, it is well known that financial data typically does not follow a normal distribution. For the application of the optimized spiral spherical SOM there is no such assumption required. Secondly, the method allows for the identification of nonlinear dependencies among variables. Thirdly, an important advantage of the method is in its robustness. And finally, the optimized spiral spherical SOM does not suffer from the border effect since neurons are distributed on the sphere with the optimized procedure deriving from an initial spiral distribution.

When investigating the state of the banking integration, this can firstly be done for a single year. The self-organizing learning algorithm would order similar banks (in a microeconomic level of the research) or similar banking sectors (in a macroeconomic level of the research) into the same winning neuron or in the neurons topologically nearby. When the input space of the optimized spiral spherical SOM includes indicators for a period of time, say a decade, then a topology enables a dynamic analysis. In our analysis, we would like to achieve the comprehensiveness of the analysis by observing national banking sectors for multiple years, so that the dynamics of the integration process might be discovered.

On the other hand we see that the lack of a study on the banking integration process would also be in a limitation to solely one level: the micro or macro. We therefore use two input spaces, a micro level and a macro level. Since we consequently use the very same estimation procedures, both resulting topologies may be compared and the results can be interpreted simultaneously.

2.2. Integration indicators

The used methodology is suitable for high dimensional input spaces. We use this characteristic as an advantage, since it allows us for the fact that we do not need to eliminate individual indicators. In doing so we do not force the result to come out from a very poor description of the phenomena, *a contrario*, we instead allow for the capture of information hidden in nonlinear and overlapping dependencies of the indicators and the topology of the banking sector. For the macro data basis we use indicators that are conventionally used in literature and some more (see Table 1). We have gathered data for all EU-27 member states (changing composition), for the 2000–2011 period, from the statistical databases of the ECB (2013b), World Bank (2013) and Eurostat (2013).

Borgioli, Gouveia, and Labanca (2013) argue that the financial crisis has thrown into light the meaning of a microeconomic database. In order to capture the characteristics of the banks sufficiently in-depth we need to define the micro input space with a wide list of indicators (see Table 2), starting with financial ratios and financial statement data which have been used in the banking sector analysis literature (e.g. Shumsky & Yarovoy, 1998; Terrones & Vargas, 2013). We gathered the data from the financial statements of commercial banks in their annual reports. Since the banking sector of the EU-27 member states consists of a large number of banks, we defined a sample of banks that would represent the banking sectors.

We followed two criteria when choosing the micro data sample. The first criteria concerned the market share of the bank. According to this criterion, the bank had to belong to the biggest, that its size is among the top 10 banks, at the selected national banking market, as measured in the year 2011. The second criterion was about the presence in the market in the observed time period. Within this criterion, we selected banks that were present in the national market in the same manner, without being merged. In this way we selected for each national market up to 5 banks. We thus included 125 banks in the EU-27 member states. However, the annual data for all 125 banks was collected only for the year 2009, while there the smallest number was collected for the year 2000, namely data