

[DOI: 10.20472/EFC.2018.010.041](https://doi.org/10.20472/EFC.2018.010.041)

**EMÍLIA ZIMKOVÁ**

Matej Bel University in Banská Bystrica, Faculty of Economics, Slovak Republic

**VLASTIMIL FARKAŠOVSKÝ**

Matej Bel University in Banská Bystrica, Faculty of Economics, Slovak Republic

**ĽUBOMIR PINTER**

Matej Bel University in Banská Bystrica, Faculty of Economics, Slovak Republic

**JAROSŁAW SZOSTAK**

WSB University in Chorzow, Poland

**KRZYSZTOF KOJ**

WSB University in Chorzow, Poland

## **A DYNAMIC HIERARCHICAL CLUSTER ANALYSIS OF ECONOMIC PERFORMANCE AND PERCEPTIONS OF THE EURO ACROSS EU COUNTRIES**

### **Abstract:**

One of the crucial benefits of EU membership, inscribed in Art. 3(3) of the Treaty on the European Union, should be economic and social cohesion. Ample empirical studies have examined EU countries' performance in terms of nominal convergence, real convergence, and convergence of business and financial cycles. Twenty years after the inception of the Economic and Monetary Union, economic cohesion clearly is not a reality, while widening real income gaps threaten social cohesion, too. The paper aims to highlight the heterogeneity and dynamics of changes in economic performance and perceptions of the euro across Europe – two factors arguably having a tremendous impact on the success of the European project. To this end, series of data spanning 2008 through 2017 were explored using hierarchical cluster analysis.

### **Keywords:**

Economic and Monetary Union, economic performance, convergence criteria, euro adoption, euro perception, dynamic hierarchical cluster analysis

**JEL Classification:** E52, E62, E50

## 1. Introduction

The euro area, drawing on the concept of optimum currency area proposed by Robert Mundell (1961), has brought its members multiple benefits while not wholly immunizing them from either cyclical or noncyclical turbulences affecting financial markets and, consequently, real economies. One of the promises and crucial benefits of EU membership, inscribed in Art. 3(3) of the Treaty on the European Union, is economic and social cohesion. Empirical studies have thoroughly examined EU countries' performance in terms of (i) nominal convergence (interest and inflation rates), (ii) real convergence (income levels and productivity), and (iii) convergence of business cycles and financial cycles. From these it is clear that even now, ten years after the inception of the Economic and Monetary Union, economic cohesion has not become a reality, while widening real income gaps threaten social cohesion, too. Beyond economic and social cohesion, perceptions of the euro represent another factor that may have a tremendous impact on the sustainability of the European project.

The divide between Eurozone members and non-Eurozone states clearly intersects that between countries that could be seen as having fundamentally sound economies and those that could not. In like manner, membership in the European Monetary Union (EMU) does not seem to be the key variable that differentiates between the countries that suffered the most from the 2007-08 financial crunch, or the ensuing sovereign debt crisis, and those that did not experience major difficulties. A disconcerting question hence arises why some non-performing economies have become part of the European Monetary Union whereas some highly-performing ones have not. Explanations can be sought e.g. in national inferiority complexes, in the European identity issue and the "return to Europe" narrative, in societies' approach to the symbolic value of their national currencies, in the euroskepticism of political elites, or in overtly economic factors (Dandashly, Verdun 2015).

The paper aims to highlight the heterogeneity and dynamics of changes in economic performance as well as in perceptions of the euro across European countries in an attempt to contribute to the understanding of their relevance to euro adoption strategies. To this end, series of data sourced from the European Commission (Eurobarometer reports), the European Central Bank, and the Eurostat, for the euro area as well as for non-euro area states, were examined using dynamic hierarchical cluster analysis. The data cover the years 2008 through 2017 – a time span that makes it possible to identify trends and, in particular, capture the effect of the 2007-08 financial crunch and the aftermath of the ensuing sovereign debt crisis on specific countries.

The methodology of hierarchical cluster analysis is discussed in more depth in the following section. Section three describes the research findings, while section four places these findings in the context of insights provided by other theoretical perspectives, such as those offered by Dandashly, Verdun (2015), trying to explore their implications for specific countries' strategies toward the adoption of the common currency. Finally, tentative conclusions are offered.

## 2. Cluster analysis methodology

Cluster analysis is a multivariate method whose objective is to classify objects into groups called clusters. It is a very commonly used statistical method (see e.g. Halkidi et al. 2001; Löster 2017; Řezanková et al. 2013; Sobíšek et al. 2012; Mackovičová et al. 2012).

Cluster analysis looks for similarities in a set of data and attempts to group them into relatively homogeneous clusters (Řezanková et al. 2009; Löster 2016). This can be accomplished by applying a large variety of methods and procedures, most of which are differentiated by the criteria used for linkage (see e.g. Gan et al. 2007; Král' et al. 2009; Řezanková et al. 2011). Literature also typically makes a distinction between traditional methods and new approaches. Traditional, or standard, methods have been thoroughly researched and developed to a point where they can be widely implemented in dedicated software products. The most popular types of hierarchical clustering include the nearest neighbor method, the farthest neighbor method, the average distance method, and the centroid method.

The nearest neighbor method is the oldest and simplest. Under this approach, two objects are searched between which the distance is the shortest, and then a cluster is formed containing these two objects. Another cluster is created by linking the third closest object. The distance between two clusters is defined as the shortest distance between any point in the first cluster and any point in the other cluster (Gan et al. 2007). The farthest neighbor method is based on the reverse of the principle that drives the nearest neighbor method, and its greatest advantage is that it yields small, compact and clearly separated clusters.

Under the average distance method, the criterion for combining clusters is the average distance between all of the objects in one cluster and all of the objects in another. The advantage over the nearest and the farthest neighbor methods is that the outcomes are not influenced by extreme values, because cluster fusions are dependent on all objects.

The centroid method involves a unique criterion for cluster merges. Rather than on inter-cluster distances between objects in data sets, it focuses on distances between cluster centroids, where the centroid is designated as an average of the variables in each cluster. What determines that a pair of clusters will be merged is the minimum distance between their centroids. Thus, under this method, remote objects do not bear significantly on the outcomes.

The median method may be seen as an analog of the centroid method, while it differs in that, instead of the distance between cluster centroids, it uses the distance between the medians of those clusters. The median method hence eliminates the shortcomings of the centroid method by abandoning weights that have to be assigned to dissimilarly sized clusters.

Ward's method, used for data clustering in the research reported in this paper, deploys an original clustering procedure that distinguishes it from methods seeking to optimize distances between clusters. Ward's designed a procedure that minimizes the heterogeneity of clusters, i.e. in forming clusters it aims at maximizing intra-group homogeneity. The measure of cluster homogeneity is called the minimum variance criterion, or Ward's criterion, and is conceived as the intra-group sum of squares of deviations in values from the cluster average. The criterion for linking clusters is founded on the idea that in each clustering step a minimum increment of intra-group variance is pursued. Ward's method is capable of creating clusters of approximately the same size, while small clusters are few or none.

Detailed descriptions of the different methods and formulas used for clustering can be found e.g. in Řezanková et al. (2009), Gan et al. (2007) and Dias (2017).

### 3. Presentation and discussion of the research findings

For the underlying research, data sets acquired from the European Commission (Eurobarometer reports), the European Central Bank, and the Eurostat were arranged in time series spanning 2008 through 2017 and subjected to a normalization step, followed by transformation through a principal component analysis (PCA). Principal component analysis (PCA) is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values assigned to linearly non-correlated variables (termed as principal components).

Subsequently, Ward's minimum variance clustering method was applied on the normalized and PCA-transformed data in an attempt to unveil regularities and heterogeneities in the countries' 2008-2017 trajectories, possibly capturing the effects of the 2007-08 financial crunch and the ensuing sovereign debt. The study encompasses an extended time frame, setting out to track the overall dynamics – hence the designation of dynamic hierarchical cluster analysis.

The analysis involved both EMU member states and non-member states and aimed at clustering those that exhibit similar characteristics in terms of economic performance and societal attitudes toward the adoption of the euro. The countries' economic performance was assessed against the so called Maastricht criteria. Thus, inflation was measured by the harmonized index of consumer prices, while the estimates of long-term interest rates were based on yields from government bonds with a maturity of 10 years. Two other measures – primary balance over gross domestic product and public debt over gross domestic product – were assumed to be indicative of the fiscal performance of respective countries. Most of the relevant data were (inflation, primary balance over gross domestic product, public debt over gross domestic product) sourced from the European Central Bank statistical warehouse, except for interest rates on 10-year government bonds that were acquired from the Eurostat database.

Tables 1, 2, and 3 comprise the data for the EU countries covered by the research, for 2008, 2009, and 2017, respectively, while Figures 1, 2, and 3 offer dendrograms depicting the outcomes of the clustering procedure applied. Shifts in cluster membership indicate how the countries' economic performance and the tide of their public opinion on the euro evolved throughout the period being investigated.

The dendrograms accompanying tables show how the countries were grouped as a result of the clustering procedure applied. Cluster 1, depicted in green in Figure 4, encompasses countries with fairly good economic performance and rather positive attitudes toward the euro. Cluster 2, tinted yellow in Figure 4, comprises countries experiencing minor problems, possibly lagging behind on just one of the indicators. Cluster 3, tinted red in Figure 4, countries whose condition is considerably worse than the average, possibly afflicted by serious difficulties or showing alarming levels in more than a single area.

In 2008, excessive inflation was recorded in Latvia, Lithuania, and Estonia. Interest rates on government bonds with 10-year maturity oscillated from 8.24% for Hungary to 0% for Estonia (Estonia is not running a fiscal deficit, therefore it does not have a need for issuing government debt). The fiscal indicators demonstrate a significant degree of heterogeneity as well: while there was a large surplus over gross domestic product in Ireland (5.68%), large deficit over gross domestic product was seen in e.g. Bulgaria. In 2008, Greece was by far the most indebted

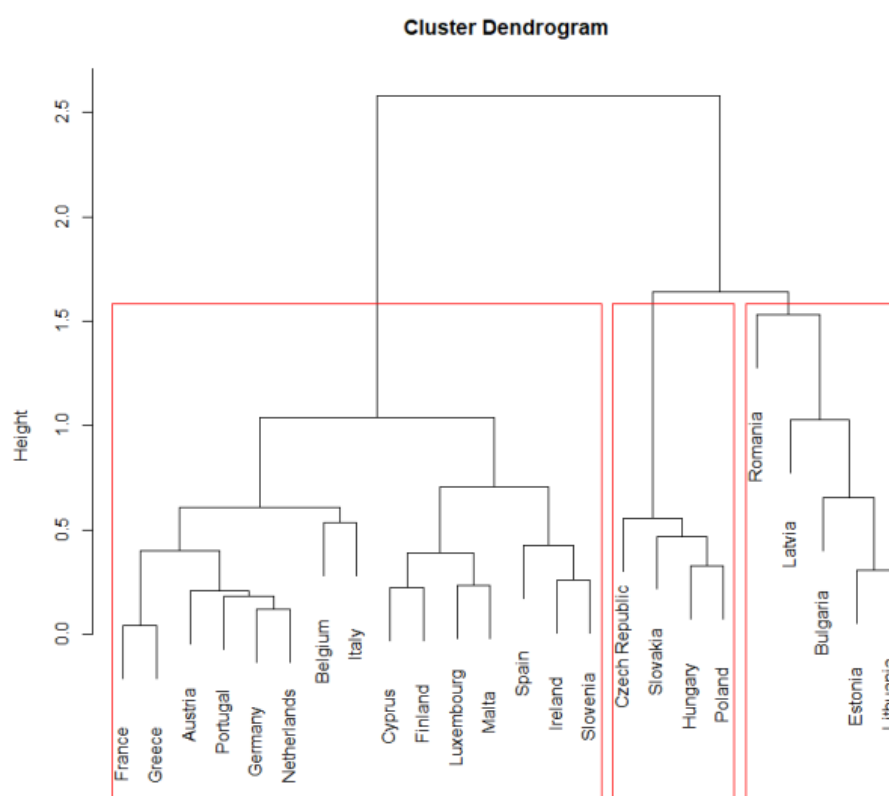
European country, and Estonia was performed the best in terms of debt over gross domestic product. The most favorable attitudes toward the euro were observed in 2008 in Finland, Ireland, and Malta (93%), whereas the least positive perceptions were sustained by Latvia (44%) and the Czech Republic (47%).

**Table 1: Economic performance and perception of the euro in 2008.**

	<i>HICP</i>	<i>Interest rate</i>	<i>Deficit/HDP</i>	<i>Debt/GDP</i>	<i>Euro perception</i>
Austria	3.2	4.36	1.45	68.70	0.85
Belgium	4.5	4.42	2.86	92.53	0.88
Bulgaria	12	5.38	2.43	13.03	0.58
Cyprus	4.4	4.6	3.49	45.07	0.90
Czech Republic	6.3	4.63	-0.99	28.25	0.47
Estonia	10.6	0	-2.46	4.49	0.49
Finland	3.9	4.29	5.58	32.65	0.93
France	3.2	4.23	-0.45	68.66	0.77
Germany	2.8	3.98	2.50	65.15	0.82
Greece	4.2	4.8	-5.36	109.42	0.77
Hungary	6	8.24	0.37	71.58	0.52
Ireland	3.1	4.53	-5.68	42.41	0.93
Italy	3.5	4.68	2.30	102.40	0.79
Lithuania	11.1	5.61	-2.43	14.56	0.46
Luxembourg	4.1	4.61	3.70	14.91	0.90
Latvia	15.3	6.43	-3.66	18.18	0.44
Malta	4.7	4.81	-0.84	62.61	0.93
Netherlands	2.2	4.23	2.26	54.75	0.82
Poland	4.2	6.07	-1.49	46.29	0.47
Portugal	2.7	4.52	-0.66	71.67	0.82
Romania	7.9	7.7	-4.72	12.42	0.76
Slovenia	5.5	4.61	-0.32	28.46	0.88
Slovakia	3.9	4.72	-1.13	21.80	0.55
Spain	4.1	4.37	-2.87	39.47	0.83

Source: European Central Bank, Eurostat, European Commission.

**Figure 1: Hierarchical clustering of EU countries in 2008: an economic perspective including perception of the euro.**



Source: own.

In 2009, inflation fell throughout the continent, with the highest rate of 5.6% in Romania, and with Ireland plunging into deflation. The highest interest rate (14%) was paid on 10-year government bonds by Lithuania. Nearly all of the countries covered by the study applied stringent fiscal austerity measures that led to more balanced government budgets, with the highest surplus in Ireland (approximating 11.79%) and Greece (10.1%). Despite fiscal improvements, Greece's or Italy's debt further increased – to 126.75% and 112.55%, respectively. The mean perception of the euro went up slightly in 2009 (by 0.02 percentage points, averaging 0.76%), with the most positive attitudes in Slovakia and Ireland. The poorest perception of the euro was, on the other hand, recorded in the Czech Republic (0.41%).

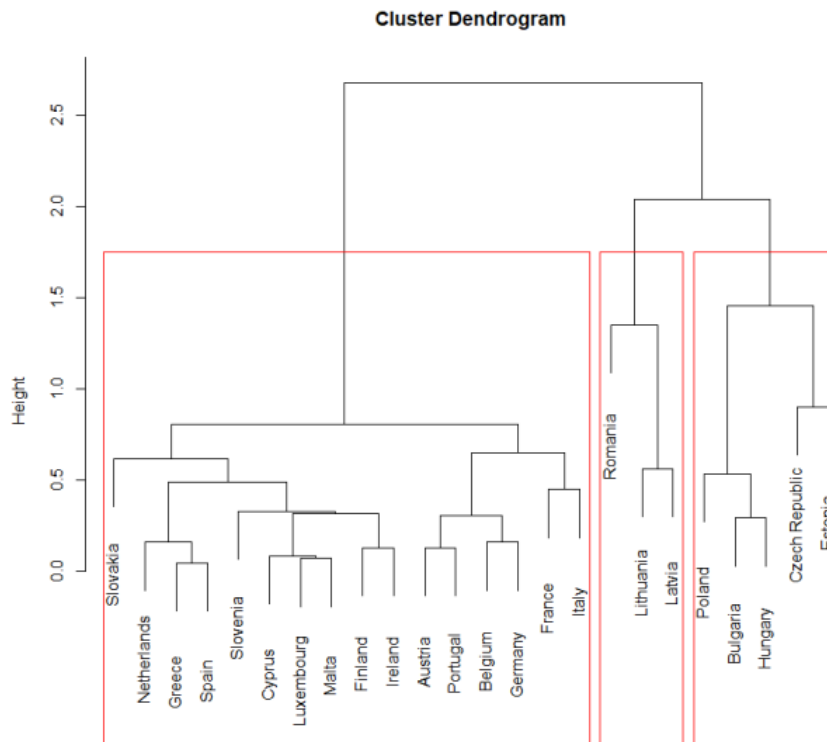
**Table 2: Economic performance and perception of the euro in 2009.**

	<i>HICP</i>	<i>Interest rate</i>	<i>Deficit/HDP</i>	<i>Debt/GDP</i>	<i>Euro perception</i>
Austria	0.4	3.94	-2.19	79.85	0.89
Belgium	0	3.9	-1.56	99.54	0.86
Bulgaria	2.5	7.22	-3.33	13.69	0.60
Cyprus	0.2	4.6	-3.12	53.81	0.89
Czech Republic	0.6	4.84	-4.22	33.56	0.41
Estonia	0.2	0	-1.99	7.04	0.50
Finland	1.6	3.74	-1.20	41.70	0.94
France	0.1	3.65	-4.77	82.93	0.79
Germany	0.2	3.22	-0.60	72.58	0.84
Greece	1.3	5.17	-10.10	126.74	0.82
Hungary	4	9.12	-0.05	77.84	0.55
Ireland	-1.7	5.23	-11.79	61.54	0.95

Italy	0.8	4.31	-0.83	112.55	0.72
Lithuania	4.2	14	-7.87	27.95	0.51
Luxembourg	0	4.23	-0.27	15.73	0.90
Latvia	3.3	12.36	-7.61	35.79	0.54
Malta	1.8	4.54	0.03	67.65	0.89
Netherlands	1	3.69	-3.41	56.80	0.84
Poland	4	6.12	-4.80	49.43	0.49
Portugal	-0.9	4.21	-6.83	83.61	0.87
Romania	5.6	9.69	-7.72	22.08	0.75
Slovenia	0.8	4.38	-4.53	36.29	0.90
Slovakia	0.9	4.71	-6.37	34.64	0.95
Spain	-0.2	3.98	-9.25	52.78	0.83

Source: European Central Bank, Eurostat, European Commission.

**Figure 2: Hierarchical clustering of EU countries in 2009: an economic perspective including perception of the euro.**



Source: own.

It is interesting to note that 2008, barely before the upshot of the unfolding financial crisis became visible and prior to Slovakia’s EMU accession, saw the Visegrad (V4) countries, i.e. the Czech Republic, Hungary, Poland, and Slovakia, in the same cluster grouping countries with either mediocre economic performance or unfavorable perceptions of the common currency. 2009 marked a split among the Visegrad group with Slovakia, now a member of the Eurozone, moving to the top-performing cluster, characterized by sound economic performance and prevalent positive perceptions of the euro, and the other V4 countries persisting with less privileged company. Clearly, Slovakia benefitted from the shield against global financial turmoil that the common currency provided while at the same time being able to retain a positive attitude toward the euro.

**Table 3: Economic performance and perception of the euro in 2017.**

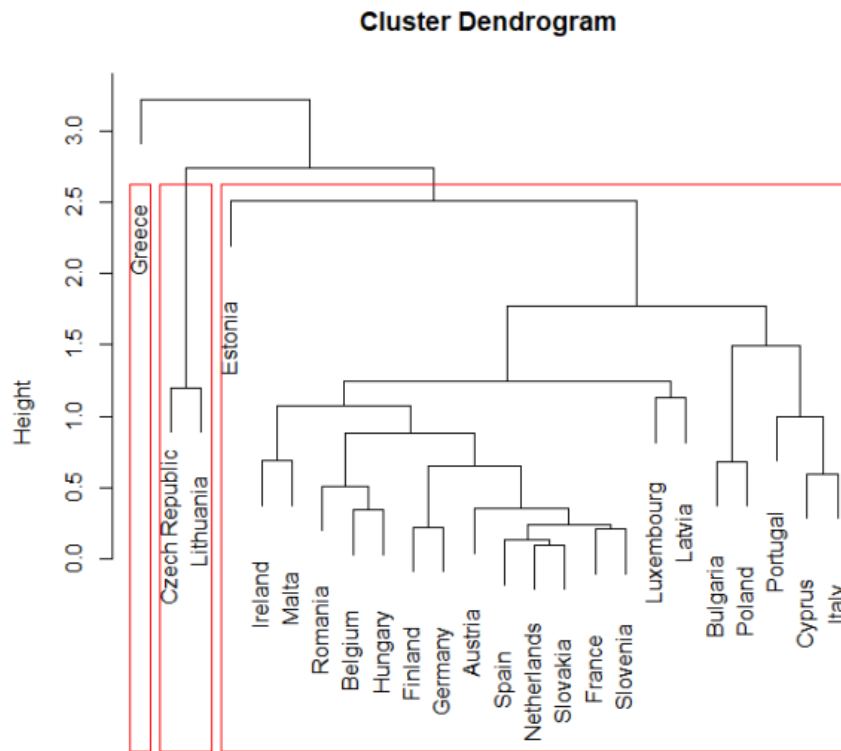
	<i>HICP</i>	<i>Interest rate</i>	<i>Deficit/HDP</i>	<i>Debt/GDP</i>	<i>Euro perception</i>
Austria	2.2	0.58	1.13	78.41	0.74
Belgium	2.2	0.72	1.43	103.12	0.64
Bulgaria	1.2	1.6	1.73	25.41	0.53
Cyprus	0.7	2.62	4.97	97.45	0.59
Czech Republic	2.4	0.98	2.34	34.60	0.29
Estonia	3.7	0	-0.25	8.98	0.85
Finland	0.8	0.55	0.41	61.42	0.84
France	1.2	0.81	-0.83	96.98	0.72
Germany	1.7	0.32	2.31	64.13	0.83
Greece	1.1	5.98	3.98	178.58	0.66
Hungary	2.4	2.96	0.84	73.58	0.59
Ireland	0.3	0.8	1.62	67.97	0.90
Italy	1.3	2.11	1.51	131.81	0.53
Lithuania	3.7	0.31	1.65	39.73	0.43
Luxembourg	2.1	0.54	1.86	22.95	0.85
Latvia	2.9	0.83	0.45	40.15	0.68
Malta	1.3	1.28	5.79	50.80	0.80
Netherlands	1.3	0.52	2.05	56.75	0.75
Poland	1.6	3.42	-0.09	50.62	0.44
Portugal	1.6	3.05	0.92	125.68	0.70
Romania	1.1	3.96	-1.58	35.04	0.68
Slovenia	1.6	0.96	2.51	50.86	0.72
Slovakia	1.4	0.92	0.36	73.62	0.76
Spain	2	1.56	-0.55	98.34	0.74

Source: European Central Bank, Eurostat, European Commission.

At the end of 2017, a decade after the inception of the Eurozone, economic performance was still largely heterogeneous. Inflation rates remained steady and low, with the lowest in Ireland (0.3%) and the highest rate in Lithuania (3.7%). The largest interest rate was paid on governmental bonds by the Greek taxpayer (5.98%). Some countries tried to consolidate their fiscal policy and experienced primary surplus over gross domestic product (Estonia, France, Poland, Romania, Spain). Indebtedness deteriorated in 2017 in all of Europe, exceeding 100% of GDP in Greece (178.58%), Italy (131.81%), Portugal (125.68%), and Belgium (103.12%). Attitudes toward the euro were even more divergent than ever before, and suffered an overall decline. The most positive attitude to the euro was seen in Ireland (0.90%), the least – in the Czech Republic.



**Figure 3. Hierarchical clustering of EU countries in 2017: an economic perspective including perceptions on the euro**



Source: own.

Figure 4 takes a dynamic perspective to illustrate all of the changes in the clustering of EU countries that took place between 2008 and 2017. In interpreting the results, most attention was given to countries that experienced most significant fluctuations, moving between clusters, with a special focus on euro non-adopters (Bulgaria, the Czech Republic, Poland) and countries that adopted the euro during the period under examination (Cyprus, Estonia, Latvia, Lithuania, Slovakia).

**Figure 4: Changes in the clustering of EU countries between 2008 and 2017: a dynamic perspective covering economic performance alongside perception of the euro.**

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Greece	Green	Green	Green	Red	Red	Red	Red	Red	Red	Red
Latvia	Red	Red	Red	Green	Green	Green	Green	Green	Green	Green
Lithuania	Red	Red	Green	Green	Green	Green	Green	Green	Yellow	Yellow
Romania	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green
Bulgaria	Red	Yellow	Green	Green	Green	Green	Red	Green	Yellow	Green
Cyprus	Green	Green	Green	Green	Green	Green	Red	Green	Green	Green
Estonia	Red	Yellow	Green	Green	Green	Green	Green	Green	Green	Green
Portugal	Green	Green	Green	Green	Green	Green	Red	Green	Yellow	Green
Ireland	Green	Green	Yellow	Red	Green	Green	Green	Green	Green	Green
Czech Republic	Yellow	Yellow	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Hungary	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Yellow	Green
Poland	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Yellow	Green



some cases, with e.g. Estonians, Slovaks, Latvians and Lithuanians being less concerned about abandoning their short-lived national currencies than e.g. Czechs or Poles who have had their korunas and zlotys for more than a century.

One more argument might be that it is the degree of euroskepticism in the society as well as in its political elites that explains why some countries have chosen to refrain from joining the Eurozone. Admittedly, one of the prerequisites for successful EMU accession is the presence of independent monetary policy institutions (such as, notably, the central bank) at the national level that are – as long as they can resist political pressures to the contrary – the most natural supporters of the common currency, committed to their mandate of educating the public on its benefits. A stable, independent and compatible institutional framework might well have been what was missing in the Czech Republic or Poland, unlike in Slovakia. After Vladimír Mečiar's term of office as Prime Minister came to an end, Slovakia soon caught up and picked up on its resolve to proceed with tight European integration. Institutional recovery followed, to the effect that the National Bank of Slovakia (Národná banka Slovenska – NBS) could win enough public trust for its president to venture a direct communication to the public announcing a euro adoption plan and elicit a broad consensus around it, then restating it on the eve as well as in the wake of parliamentary elections (Hospodárske Noviny 2006). At the same time, the drive toward the EMU was undermined by the Václav Klaus presidency in the Czech Republic, and by the Kaczyński-led nationalist right-wing movement – whether in opposition or, intermittently, in government – in Poland; it could be argued that these influential political actors not only fostered a negative ideological bias but also stood for a degree of institutional volatility associated with questionable independence of critical institutions, resulting from either deficiencies in checks and balances or from euroskeptical nominees being appointed to key offices. This is very likely the best explanation for the Czech Republic or Poland remaining outside the euro area (Dandashly and Verdun 2015).

In addition, euro non-adoption could be traced back to the structure of a country's economy and its relations with trade partners. For example, both the Czech Republic and Slovakia might be regarded as highly dependent on their automobile sectors. However, this argument does not hold for Poland. If focus is placed on a country's critical export partners, Poland and the Czech Republic could be seen as largely reliant on Germany, while it would not be as true of Slovakia.

It seems that, among all these frameworks for interpreting specific countries' euro (non-)adoption strategies, precedence should be given to the one based on domestic politics and institutional resilience. In some countries, symbolic factors could have also figured much; for example, Slovakia apparently did not feel a need to emphasize national identity but definitely strove to overcome its inferiority complex toward the Czechs (Dandashly and Verdun 2015). The significance of automobile industry for national economy probably played a role, too, albeit a minor one.

## 5. Conclusion

The dynamic hierarchical cluster analyses presented in this paper aimed to highlight heterogeneity in the perceptions of the euro across European countries and to begin exploring its relationships with economic performance, viz. the countries' ability to meet the Maastricht convergence criteria.

The research findings have demonstrated that, on the one hand, there are many states whose strong economic standing has been coupled with positive attitudes toward the common currency while, on the other, an economic downturn need not be associated with unfavorable perceptions of the euro, as indicated by the examples of Greece and, to a lesser degree, Portugal or Spain. At the same time, the analyses singled out a few countries that have not joined the Eurozone although their economic indicators make them eligible or could easily make them so – such as the Czech Republic or Poland.

The fact that reasons for some countries' EMU non-entry remain vague under these analyses suggests they should be sought elsewhere and much beyond an economic cost-benefit analysis. Likely explanations have already been proposed by such authors as Dandashly and Verdun (2015), who considered an array of five such inhibitors and concluded that it is the interplay between the ideological attitudes of key political actors and the economic interests of lobbies and interest groups that has borne the most. What precisely underpins these attitudes, and which factor prevails in driving political elites' motivations, appears less important: whether it is mere tribal pride, sentiment for national currency as an epitome of sovereignty, fear of losing control of monetary policy, or genuine advocacy for import-export relations.

As a result, euro adoption has never really been on the agenda in such countries as Poland or the Czech Republic, with incumbent elites reluctant to address the issue and thwarting attempts to bring it to public debate. By this token, it is small wonder that the tide of public opinion is against the common currency and the country has never set on a path toward euro adoption.

Although a more in-depth treatment of these issues is beyond the scope of this study, it might become the objective of further studies involving political science scholars.

### **Acknowledgment**

The paper was financially supported by the grant scheme VEGA 1/0859/16 “Dynamics of nonlinear economic processes” of the Ministry of Education, Science, Research and Sport of the Slovak Republic.

### **References**

- CORLISS, D. J. (2012). Dynamically Evolving Systems: Cluster Analysis Using Time. *SAS Global Forum 2012, Statistics and Data Analysis*. Paper 329, 1-9.
- DANDASHLY, A., VERDUN, A. (2015). Boarding the Euro Plane: Euro Adoption in the Czech Republic and Slovakia. *Review of European and Russian Affairs* 9 (2), 2015. ISSN 1718-4835.
- DIAS, J. (2017). Unemployment and sovereign debt crisis in the Eurozone: A k-means-r analysis. *Physica A: Statistical Mechanics and its Applications* 482, 108-117. ISSN 0378-4371.
- GAN, G., MA, Ch., WU, J. (2007). *Data Clustering Theory, Algorithms, and Applications*. Philadelphia: ASA.
- GIANNELLIS, M., KOUKOURITAKIS, M. (2017). Competitiveness divergence in the Eurozone: The need for symmetric adjustment. *Journal of Policy Modeling* 39(5), 942-962. ISSN 0161-8938.
- HALKIDI, M., BATISTAKIS, Y., VAZIRGIANNIS, M. (2001). On Clustering Validation Techniques. *Intelligent Information Systems Journal* 17(2-3), 107-145.

- HOSPODÁRSKE NOVINY (2006). *Guvernér Ivan Šramko: Volby nezmenia proces prijatia eura*. By TASR, posted on March 24, 2006, <https://dennik.hnonline.sk/servisne-prilohy/193644-guvernér-ivan-sramko-volby-nezmenia-proces-prijatia-eura>. Accessed on July 15, 2018
- KRÁL, P., KANDEROVÁ, M., KAŠČÁKOVÁ, A., NEDELOVÁ, G., BOJDOVÁ, V. (2009). *Viacrozmerné štatistické metódy so zameraním na riešenie problémov ekonomickej praxe*. Banská Bystrica: Univerzita Mateja Bela, Ekonomická fakulta, 2009. ISBN 978-80-8083-840-9.
- LÖSTER, T. (2017). Comparison of results of selected clustering methods on real data set. In T. Löster, T. Pavelka (Eds), 11<sup>th</sup> International Days of Statistics and Economics, pp. 886-896. ISBN 978-80-87990-12-4.
- LÖSTER, T. (2016). Determining the optimal number of clusters in cluster analysis. In T. Löster, T. Pavelka (Eds), 10<sup>th</sup> International Days of Statistics and Economics, pp. 1078-1090. ISBN 978-80-87990-10-0.
- MACKOVIČOVÁ, L., STACHOVÁ, M. (2012). Aplikácia vybraných zhlukovacích metód na reálne dáta. *Forum Statisticum Slovaca* 8(5), 92-98. ISSN 1336-7420.
- MUNDELL, R.A. (1961). A Theory of Optimum Currency Areas. *The American Economic Review* 51(4), 657-665.
- ŘEZANKOVÁ, H., LÖSTER, T. (2013). Shlukova analyza domacnosti charakterizovanych kategorialnimi ukazateli. *E + M. Ekonomie a Management* 16(3), 139-147. ISSN 1212-3609.
- ŘEZANKOVÁ, H., LÖSTER, T., HÚSEK, D. (2011). Evaluation of Categorical Data Clustering. In E. Mugellini, P. S. Szczepaniak, M. Ch. Pettenati, M. Sokhn (Eds), *Advances in Intelligent Web Mastering – 3*. Proceedings of the 7<sup>th</sup> Atlantic Web Intelligence Conference, AWIC 2011. Fribourg, Switzerland: University of Applied Sciences of Fribourg, pp. 173-182.
- ŘEZANKOVÁ, H., HÚSEK, D., SNÁŠEL, V. (2009). *Shluková analýza dat*, 2. Praha: Professional Publishing.
- SOBÍŠEK, L., STACHOVÁ, M. (2012). Clustering methods modelling real data. In: J. Fischer (Ed.), *Applications of Mathematics and Statistics in Economy*. Proceedings of the 15<sup>th</sup> International Scientific Conference. Praha: Vysoká škola ekonomická, Nakladatelství Oeconomica, pp. 1-10. ISBN 978-80-245-1905-0.
- TREATY ON EUROPEAN UNION (2007). of The Treaty on European Union and the Treaty on the Functioning of the European Union. Consolidated versions: Official Journal C 326, 26/10/2012.