The Competitiveness of the EU Countries: A Multi-dimensional Cluster Analysis Approach

Petr Rozmahel, Ladislava Issever Grochová, and Marek Litzman

1 Introduction

Since the economic downturn in Europe and the rest of the world because of the global economic crisis in 2007/2008, Europe remains caught in lingering stagnation. Consequently, Europe is striving to identify a new strategy for reviving growth. Today's Europe seeks sustainable, smart and inclusive growth that is environmentally friendly. The narrow definition in terms of the percentage change in the GDP is not currently the most important issue in European society. Long-term sustainability and support of knowledge-based economic activity must be considered when designing the strategy for a new growth path in Europe. The new growth strategy should also prevent the exclusion of particular groups in society, ensuring social cohesion and seriously considering the ecological aspects of the strategy. According to the current understanding of economic growth in today's European society, the manner of understanding and measuring economic competitiveness has changed recently. In addition to the changing definition of growth, there is a shift in understanding the terms of national and regional competitiveness and their measurement. As stated in The Europe 2020 Competitiveness Report, Europe should support smart, environmentally sustainable and socially inclusive competitive strategies, an obvious shift from a traditional cost-based approach of measuring competitiveness by productivity and cost indicators. The traditional approach is limited because it excludes measures of a knowledge-based economy or innovation potential and does not allow for an evaluation of countries' competitiveness from a firm-level perspective. Instead, different indices of a country's competitiveness potential are considered by firms when choosing a business location.

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New definitions and new approaches to defining and assessing the competitiveness of EU countries have also been discussed in recent economic literature. Aiginger et al. (2013) redefined the term *competitiveness* to render it more useful for the evaluation of a country's performance and for policy conclusions. These authors sought to establish a definition that is "*adequate if economic policy strives for a new growth path that is more dynamic, socially inclusive and ecologically sustainable*". Accordingly, they defined *competitiveness* as the "*ability of a country (region, location) to deliver the beyond-GDP goals for its citizens*". Following the beyond-GDP literature, the authors then suggested a composite indicator of outcome competitiveness comprising income as well as social and ecological pillars.

A new competitiveness index that captures the dimensions in which politics can influence competitiveness beyond factor price adjustment was proposed by Huemer et al. (2013). These authors criticised the traditional concepts of measuring competitiveness, stating that competitiveness can change not only because of market processes but also because of political decision-making. Because this perspective is not compatible with traditional concepts of competitiveness measuring, the authors constructed a competitiveness measure that is more institutional in nature. Various approaches to defining and measuring national and regional competitiveness are followed by multinational organisations and their institutions such as the World Bank, the Organization for Economic Co-operation and Development (OECD), the European Union and the Asia Pacific Economic Cooperation (APEC). Various types of scoreboards evaluating the knowledge-based economy and innovative activity indicators are applied by those organisations when assessing countries' competitiveness.[1]

Considering the changing concepts of competitiveness in current economic literature, our paper evaluates competitiveness using various approaches to definition and measurement across the EU countries. In particular, three dimensions of competitiveness evaluation were identified and used in the analysis. In the first dimension, the traditional cost-based measures were applied to assess and compare competitiveness and its development over time in the EU countries. The second dimension captures the potential of a country to attract firms to establish and sustain high-skilled enterprises in a country. In this second dimension, two sub-dimensions are used separately to evaluate the potential of a country to attract firms to establish high-skilled businesses and to provide the conditions that will induce such firms to stay. Finally, the third dimension evaluates the innovation potential of a country.

In summary, three research questions were asked for each dimension of the competitiveness evaluation: (1) What are the levels of competitiveness and its development over time in the EU countries from the perspective of traditional cost-based measures? (2) How attractive are the EU countries for firms to establish and sustain high-skilled enterprises? (What non-cost conditions do the EU countries offer to firms to establish and retain competitive high-skilled enterprises?) (3) How

[1] For a summary of competitiveness-measuring methods by selected multi-national organisations, see, e.g., Karahan (2012).

attractive are the EU countries to firms in terms of innovation development potential? (What is the innovation and development potential of the EU countries?)

After the individual countries were analysed and compared in the first cost-based dimension, the individual countries and country-groups with similar competitiveness evaluations from the second and third dimension perspectives were identified. The purpose was to examine whether the evaluation of countries' competitiveness differs according to various perspectives of its definition and measurement. Hence, hypothesising the traditional division among the aforementioned three groups of countries to result from the traditional cost-based competitiveness approach, our paper asks whether such a division differs using the perspectives of doing business and innovation potential indices.

The chapter is structured as follows: The motivation, goals and research questions are explained in the introductory section. The second section describes the empirical strategy and methodology of the analysis. The cost-based competitiveness measures utilised to evaluate the EU countries are applied in the third section. The fourth and fifth sections examine the competitiveness of the EU countries from the firm-level perspective. In those sections, competitiveness is evaluated in terms of the conditions necessary to establish a sustainable high-skilled enterprise and the innovation potential in the EU countries. The sixth section concludes.

2 Empirical Strategy

This chapter applies three dimensions to examine different approaches to evaluating and comparing the competitiveness of the EU countries. The dimensions follow the major research questions examined in the analysis. First, the traditional cost-based approach to measure competitiveness is represented by a composition of the first dimension. The remaining two dimensions focus more on individual firms, evaluating the potential of countries to establish a high-skilled and competitive business. The second dimension includes the competitiveness indicators related to quality of infrastructure and human capital. In addition, this dimension includes various indicators evaluating the environment for doing business in the country—doing-business indicators (sourced from the World Bank Doing Business Database). The third dimension comprises indicators of the innovation potential of the country. The innovation potential is evaluated using the measures of research and development support and outputs, educational attainment, measures of students' and pupils' skills, etc. All indicators used in the analysis are described in Table 1. The final list of indicators described in the table represents the final reduced form of the set because some of the selected competitiveness and innovation indicators were excluded because of multicolinearity problems.

Descriptive comparative analysis is used to evaluate the EU countries using the traditional cost-based competitiveness measures approach. The list of cost-based competitiveness measures comprises indices of labour productivity, nominal unit labour costs and the real effective exchange rate (REER), as reported in Table 1.

Table 1 Indicators in analysed competitiveness dimensions

Variable	Dimension/unit	Source
1. Traditional cost-based competitiveness		
REER	Index 1996 = 100	Eurostat
Labour productivity	Euro/hour	Eurostat
Unit labour cost (modified)	Euro	Eurostat
2a. Infrastructure, human capital		
Students of science and computing	% of tertiary students	Eurostat
Engineering students	% of tertiary students	Eurostat
Internet penetration	%	Eurostat
Airport coverage	Per 1,000 km^2	Eurostat
Railway coverage	Km per 1,000 km^2	Eurostat
Motorway coverage	Km per 1,000 km^2	Eurostat
Learning English at ISCED level 3	% of students	Eurostat
2b. Doing business		
Strength of investor protection	Composite index	Doing business
Paying taxes administration (time)	Hours per year	Doing business
Time to enforce a contract	Hours	Doing business
Costs of enforcing a contract	% of claim	Doing business
3. Innovation potential		
GERD	% of GDP	Eurostat
Citations per document in Scopus	Units	SCImago
Patents per inhabitant	Units	Eurostat
Students 15–19	% of population 15–19	Eurostat
Students 20–24	% of population 20–24	Eurostat
Reading skills	Points	OECD PISA
Persons with upper secondary education	% of population 25+	Eurostat
R&D personnel	% of employees	Eurostat
Government expenditures on education	% of GDP	Eurostat

This portion of the analysis seeks to verify whether a clear division among the core and periphery countries remains. In addition, the relative position of the CEE countries is examined in this dimension.

The firm-level perspective of countries' competitiveness in establishing and maintaining high-skilled and competitive business is examined by the second and third dimensions. Our approach does not primarily focus on analysing the development of each particular indicator over time. Such a comparative analysis is simply a complementary tool to evaluate the countries. The analysis of the second and third dimensions concentrates more on evaluating the similarity of countries in terms of the entire sets of competitive indicators examined in each dimension. The purpose is to identify the internally homogeneous clusters of EU countries providing similar conditions for firms to start up and sustain competitive and innovative enterprises. We believe that selected indicators in the firm-level dimensions are more indices of long-term success and can say more about a country's future from

the perspective of the current European direction of smart knowledge-based growth. Hence, the multi-dimensional cluster analysis is applied for clusters' identification. The changing clustering structure is compared in the years 2000, 2004, 2008 and 2012. Comparing the identified clustering structures in particular selected years, one may observe changes associated with the integration processes, namely in CEE countries in 2000–2004 and then the early influence of EU membership in 2004–2008. The crisis influence may also be observed in the structure of clusters in 2012.

Considering the application of cluster analysis, similar to Sorensen and Gutierrez (2006) and Rozmahel et al. (2013), we applied the agglomerative Ward method with Euclidean distance to emphasise internal homogeneity and emphasise outliers[2] in the dataset.

Variables were then transformed into an index I representing countries' position relative to the rest of the sample of countries:

$$I_{i,t} = \frac{v_{i,t}}{WAVG(v_t)}, \; if \; values\,(v_{i,t}) > 0 \tag{1}$$

where v represents a respective variable, i stands for a country in the time period t, and $WAVG$ is a weighted average of the particular variable comprising the rest of the EU countries—excluding the *ith* country, weights being *ith* country's GDP. Index I, representing a country's position relative to the rest of the EU when compared to other countries' indices, can be used to describe a contribution of a country to the level of heterogeneity within the EU and thus provide information on the integration process in the EU.

All indices were normalised:

$$N_{i,t} = \frac{I_{i,t} - MIN(I_T)}{MAX(I_T) - MIN(I_T)}, \tag{2}$$

where I is a value of the index in time period t. MAX(I_T) / MIN(I_T) represents a maximal/minimal value of the index during the entire time period T.

The two approaches to examining the dynamics of clustering in the EU from the perspective of both dimensions were applied in the analysis. The first approach compares the structures of internally homogeneous country-clusters in the years of 2000, 2004, 2008 and 2012 as mentioned above. In that approach, the clusters were identified as results of the analysis. Comparing the structures, one may question whether there is also a clear division between the core, periphery and CEE countries using the firm-level perspective of countries' attractiveness to establishing and retaining competitive business there.

[2] For example, Artis and Zhang (2001), Boreiko (2003), Camacho et al. (2006, 2008), Song and Wang (2009) or Quah and Crowley (2010) applied the cluster analysis to identify the clusters of countries using various dimensions capturing measures of economic and institutional performance.

The second approach of dynamics measurement allows presenting some evidence of convergence between the core, periphery and CEE countries considering both firm-level dimensions. This method is based on analysing the average distance within clusters over time. Contrary to the previous method, the clusters of countries are established before (ex-ante) the analysis. The clusters of core countries, the core enlarged by periphery countries (core + periphery), the core enlarged by the CEE countries (core + CEEC) and finally the cluster of the entire EU are set to examine the effect of the cluster's enlargement. Assuming the core as a benchmark for a semi-ideal competitiveness cluster from both dimensions' perspectives, the analysis shows whether the internal homogeneity increases in the cluster after its enlargement or whether the opposite occurs. The decreasing measures of inner average distance within clusters refer to increasing homogeneity, implying the convergence of countries within clusters. Increasing average distance within clusters denotes divergence. Using this analysis, one may also identify and compare the potential contribution of the periphery or CEE countries (or both) to the changing heterogeneity when joining the core cluster.

Concerning the ex-ante proposed clusters, the core involves Austria, Belgium, Germany, Finland, France, Netherlands, Sweden and United Kingdom; periphery countries include Portugal, Italy, Greece, Spain and Ireland. Finally, CEECs are the Czech Republic, Hungary, Poland, Slovenia, Slovakia, the Baltic countries Estonia, Latvia and Lithuania, and Bulgaria and Romania as new member countries.

3 Data

The three-dimensional approach represents three different views of competitiveness in the analysis. The list of indicators in all dimensions is described in Table 1. The set of indicators in each area corresponds to the character of each dimension, which can also be justified by a particular research question.

First, the analysis asks how the EU countries are competitive from a traditional, cost-based perspective. This represents a rather macroeconomic view. In the analysis, the real effective exchange rate deflated by the consumer price index (as a measure of inflation) was applied. The increasing value of the index over time denotes the loss of a country's price competitiveness relative to other trading partners. However, such a simple interpretation of the index may be a bit spurious because the increase in the index may also be a result of the price convergence. If this occurs because of positive growth differential, implying real appreciation of assets in the converging country, the rising REER may be considered a natural effect of the convergence. This may be the case of the CEE countries catching up to the rest of the EU after 2004. The real labour productivity (Euro per hour worked) and nominal unit labour cost index (ULC) are two other measures of the first dimension. The ULC index was modified by multiplying by employee compensation to identify the labour cost indicator expressed in the Euro per unit. Such a

measure allows better comparability with the real productivity measure. The Eurostat was the source of data for this dimension.

The selection of competitiveness indicators in the second and third dimensions is designed to reflect the firm-level view when assessing countries' attractiveness for establishing and retaining competitive business. Considering competitive businesses, the analysis focuses on enterprises demanding high-skilled and well-educated labour. In addition, the conditions for using the results of research and development and exploiting the innovation potential of countries are examined by those dimensions. Finally, the infrastructure quality in a country is also considered an important factor for firms when choosing a business location. The second dimension thus examines indicators describing the attractiveness of a country for establishing and sustaining high-skilled business. The third dimension focuses on evaluating the innovation potential of countries. The indicators of the second dimension should provide some evidence of the quality of the infrastructure and human capital in the country, indicating how friendly the environment is to business. Hence, the second dimension focuses on production of high-skilled products and services. The third dimension focuses on innovation and further development of innovative products and services. Thus, some measures of educational attainment, student skills, research results, and research and development support are included in the third dimension's indicator list. The analysis focuses primarily on identification of clusters of countries showing similar levels of indicators in each dimension. This chapter simply asks the following questions: Which are the attractive country-clusters in the EU for highly innovative firms? What do these countries have in common from the firm-level competitiveness perspective? Are these clusters identical to the clusters resulting from the traditional cost-based macroeconomics approach? A brief analytical comparison of particular selected indicators of chosen EU countries from each dimension complements the cluster analysis in the chapter.

The content of the second dimension is internally divided into two subgroups of indicators. The first subgroup concentrates on assessing the quality of human capital and infrastructure in a country. The second dimension includes indicators evaluating how convenient the business environment is for doing business from a long-term perspective. In other words, the second dimension evaluates the institutional aspects of the business environment of the country. Both subgroups are associated with common research. In the first subgroup of indicators, the quality of human capital is approximated by the indices of educational attainment in terms of the study focus on a tertiary level. In particular, percentages of tertiary students (ISCED 5–6) by field of education (science, mathematics and computing) and tertiary students (ISCED 5–6) by field of education (engineering, manufacturing, and construction) and finally a share of students learning English at ISCED level 3 (upper secondary education) as a percentage of total students at this level were applied in this dimension. The measure of Internet penetration as a percentage of households with Internet access and the measure of transport infrastructure capturing airport, railway and motorway coverage were used to check the infrastructure quality in the country. The data in this subgroup of indicators were provided by

Eurostat. The second subgroup includes the indicators evaluating the institutional environment in the country, sourced from the World Bank Doing Business Database. Our indicator list of this sub-dimension begins with a composite indicator measuring the strength of minority shareholder protection against directors' misuse of corporate assets for personal gain. This indicator is estimated as a simple average of three institutional indices capturing the extent of disclosure (of related-party transaction), director liability and ease of shareholder suits (access to internal corporate documents, access to documents, information during trial, etc.). The tax paying administration indicator, representing the second measure in this sub-dimension, measures the time in hours per year spent addressing the administrative agenda to comply with the three major taxes in a country: profit taxes, consumption taxes and labour taxes, with mandatory contributions. In particular, this indicator counts hours spent collecting information and computing the tax payable, completing the tax return forms, filing with the proper agencies, arranging payment or withholding and preparing separate mandatory tax accounting books. The time spent enforcing a contract represents a measure evaluating the efficiency of the judicial system in a country. This indicator is measured as the number of days required to resolve a commercial sales dispute in the courts. This indicator covers the time required to file and serve the case, the time for the trial and obtaining judgement and the time required to enforce the judgement. Finally, the costs of enforcing the contracts measured as a percentage of claim covers the average attorney fees, court costs and enforcement costs.

The third dimension evaluates the innovation potential of a country that may be applicable in business. This dimension covers the results of research and development represented by measures of citations per document in the Scopus database and patents per inhabitant in a country. The Eurostat and SCImago databases were the sources of these data. Similarly, the indicator of reading skills among students provided by PISA OECD (Programme for the International Student Assessment) was evaluated in the analysis. According to the Programme, students with good reading skills are more likely to continue and complete higher education. These students are also less likely to receive long-term social benefits. The students-to-population ratios (%) in three age groups above 19 are also covered in the third dimension. Regarding the meaning of the education attainment indicators in the third dimension, we hypothesise that a high proportion of students, namely at the tertiary level, combined with high measurements of research and development results (patents, citations) and reading skills implies a high innovation potential in the country. From this point of view, the innovation potential dimension naturally includes the indices of government support of education and research and development measured as expenses-to-GDP ratio. Finally, the percentage of employees in research and development sectors is used in the final dimension.

The second and third dimensions include various measures of educational attainment for several reasons. The second dimension focuses more on a description of actual potential to employ university students in the areas of engineering, science and computing. These students are promptly accessible for newly as well as previously established firms focusing on high-skilled labour production and

services. For the same reason, the second dimension includes the percentage of students learning English to satisfy the needs of small international start-ups and firms as well as supranational companies. The third dimension concentrates more on future innovation and the research potential of countries in terms of educational attainment. Hence, this dimension captures indices of what shares of society in particular age groups (15–19, 20–24, 25+) are actively studying. The analysis assumes that higher proportions of university and post-university students imply greater potential for quality research, development and innovation in a country.

4 The Competitiveness of the EU Countries: Traditional Cost-Based Approach

Using traditional cost-based productivity measures clarifies the gap between the core of the Euro area and the CEE or periphery countries. Figure 1 (left) compares the actual real labour productivity of selected CEE countries measured in EUR per hour with the average of the EU 27 and EU 15 in 2012. The measure of nominal unit labour costs (ULC) presented in Fig. 1 (right) was modified. The ULC index was multiplied by the measure of compensation of employees sourced from Eurostat to determine the labour cost indicator expressed in Euro per unit.

Ireland and Italy overreach the nominal EU average labour costs. This creates relative disadvantages in cost-based competitiveness for these countries compared with the rest of the sample. Conversely, higher labour costs should force these countries to focus on improving the quality of their production. The Visegrad countries comprising the Czech Republic, Hungary, Poland and Slovakia show comparable levels of unit labour costs, placing them in a relatively homogeneous cluster from this perspective within the entire country sample. Slovenia shows the highest level of convergence among CEECs towards the old EU countries. Apart

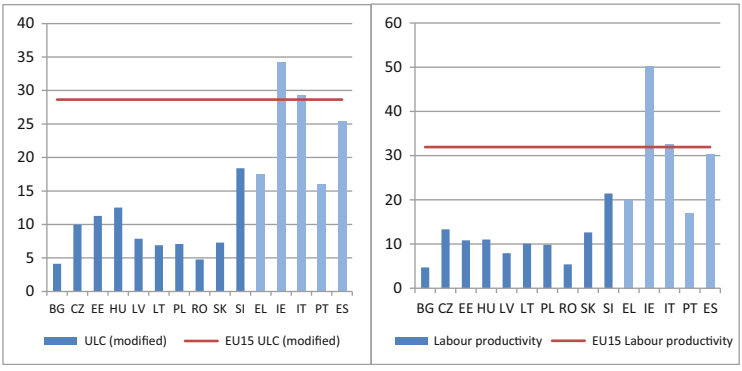

Fig. 1 Labour productivity in the CEECs compared with the EU and EUR averages; Nominal unit labour costs modified by the compensation of employees (EUR per unit), 2012 (Eurostat)

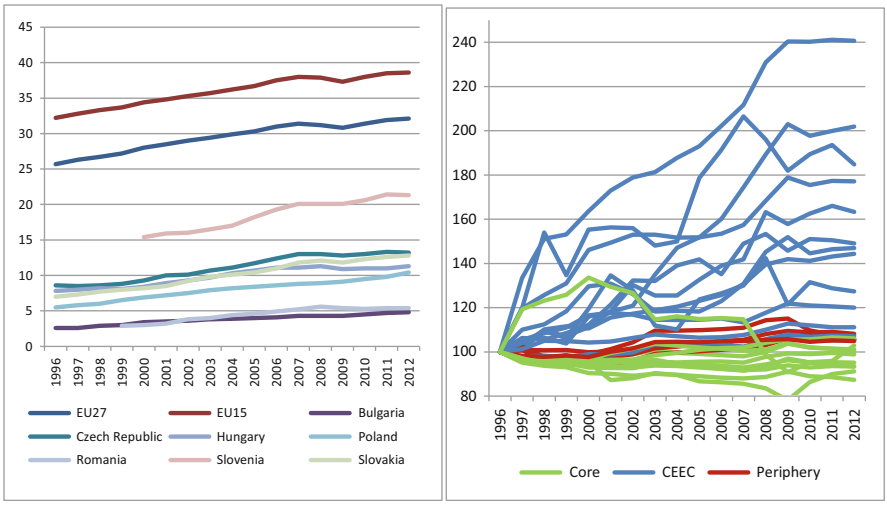

Fig. 2 Labour productivity in CEE countries and the EU and EUR averages (EUR/hour, left part), Real effective exchange rate in the EU core, periphery and CEE countries (deflated with CPI, 1996 = 100) (Eurostat)

from Slovenia, all CEE countries reached lower labour productivity than the EU periphery countries in 2012. In addition, a significant gap remains between the labour productivity in CEECs and the EU average. Similar to the measure of unit labour costs, Bulgaria and Romania show the lowest levels of labour productivity among the CEE countries. Portugal is lagging behind the rest of the old EU countries and shows nearly comparable results to the leading countries of the Visegrad group.

Figure 2 reveals the apparent division among the core, periphery and CEE countries. The development of labour productivity measured in EUR per working hour in the left section of Fig. 2 shows no remarkable signs of convergence among the three sub-groups of countries mentioned above. In addition, there is an obvious trend in the real effective exchange rate (REER) appreciation in the CEE countries in general as shown in the right portion of the figure. A rationale for the appreciation tendency, particularly over 1996–2008/2009 in the CEEC, may be the growth differentials and maintaining price stability in those countries. The real convergence of the CEE countries in terms of GDP per capita towards the rest of the EU over the analysed period pushes up prices in the catching-up economies, which implies nominal convergence. Regarding the efforts of CEE countries to keep the price stability in accordance with the Maastricht criteria, the exchange rate appreciation is the only remaining channel of the convergence. Hence the countries appreciated mostly during the period of positive growth differentials up to the point of the global crisis in 2008. Since then, the appreciation tendency diminishes as shown by the REER development after 2008.

5 The New Competitiveness Evaluation Concept: Do the EU Countries Have the Potential to Be Competitive from the Perspective of the New Growth Path Strategy for Europe? Do They Differ?

Having observed relatively clear divisions among core, periphery and CEEC countries using the cost-based macroeconomic indicators in the first dimension, one might ask whether this rather narrow approach represents a complex evaluation of competitiveness. Answering such a question can include the effects of on-going real and price convergence processes among the catching-up countries towards the EU and Euro area average that may play a role in explaining the rising values of the REER for the CEE countries. The remaining gaps among price levels, cost-of-living standards, different life expectations and other various aspects across the EU countries should also be considered. In addition, the diminishing role of the cost-based output indicators in the beyond-GDP literature should be mentioned. Recalling the current discussions regarding the changing perceptions of growth among European academics and policy-makers and stressing the role of a knowledge-based economy and societal and environmental issues, one should ask about the future perspective of such an approach on competitiveness evaluation.

The role of medium and small enterprises focusing on high-tech, high-skilled and highly competitive businesses with high innovation potential is stressed in the EU strategic documents on the new growth path in Europe, leading to the question of whether the EU countries provide interesting conditions for such businesses. In today's globalised world, there is nothing easier than to move even high-skilled production to low-cost countries such as India, Brazil or China. Are the EU countries competitive in providing appropriate conditions for establishing and running highly competitive businesses? Do the EU countries and their populations have a high enough innovation and development potential to attract firms and start-ups for highly competitive businesses? These questions should be answered to evaluate the competitiveness and the potential to be competitive from the perspective of the current new growth path strategy in Europe. These approaches to competitiveness evaluation may focus more on the input indices whereas the traditional cost-based method includes the output measures (such as various forms of labour productivity indices); however, the effect of globalisation renders Europe basically uncompetitive in a low-cost manner compared with large, emerging economies such as China or India. Another argument for the suggested change in measuring competitiveness is that in addition to current competitiveness evaluation, the new method also captures indices of the future potential of a country to be competitive from a long-term perspective. This is because of the inclusion of human capital quality indices involving the educational attainment and skills of

the people, the infrastructure of the economy and research and development support and results.

5.1 *How Attractive Are the EU Countries to Firms to Establish and Retain Highly Competitive Businesses?*

5.1.1 Infrastructure and Human Capital Quality

Assessing human capital quality from an internationally competitive firm-level perspective, the ability of prospective employees to communicate in English and possess competitive knowledge and skills in competitive branches in selected periphery and CEE countries is compared with the EU15 average. The results of the comparison in 2012 depicted in Fig. 3 provide evidence of a high proportion of English-learning students at the upper secondary level in the majority of CEE and periphery countries. The majority reach or even surpass the EU15 average. Hungary, Bulgaria, and Cyprus from the CEE country-group and Greece and Portugal from the periphery countries do not reach the EU15 average. Portugal and Hungary especially fall behind. Malta can be considered a special case in this evaluation because the majority of its citizens speak English for historical reasons.[3] Unlike learning English, the majority of the CEE countries have a smaller proportion of students studying the sciences and computing than the EU15 average of 11 %. Only the Czech Republic and Estonia reach this level. Other CEE countries vary around the level of 5–6 % of students in this area and do not approach the EU15 average

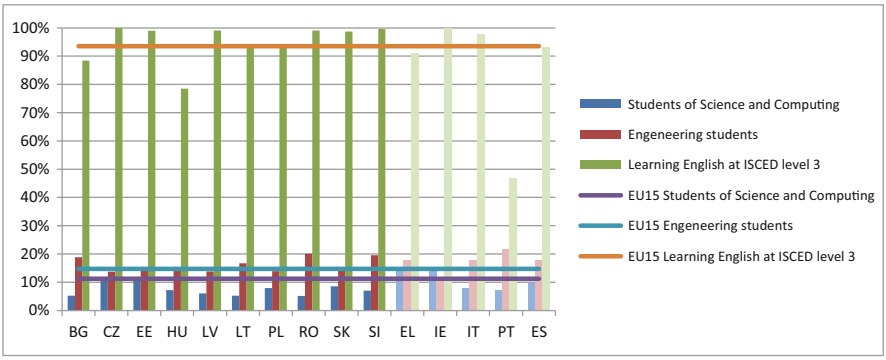

Fig. 3 Percentage of students studying science, computing, engineering (% of tertiary students) and English (% of students at ISCED level 3—upper secondary education) compared with EU 15 averages, 2012 (Eurostat)

[3] Malta was a British Colony until its independence in 1964 and became an independent republic in 1974. Malta remains a member of the Commonwealth of Nations.

level. In engineering, the situation is much more balanced because nearly all countries of the CEE and periphery groups reach or approach the EU15 average of 15 % of the total student population at ISCED levels 5 and 6 (tertiary students up to a bachelor's level). The high percentage of engineering students in CEE countries may be attributed to the fact that engineering branches were strongly favoured and supported by the ruling communist establishment in the past era of centrally planned economies in CEECs whereas the social sciences were neglected during those times. There are a surprisingly low number of engineering students in Ireland (Fig. 3).

Situated in the heart of Europe, the Czech Republic is considered a transportation hub for passengers as well as cargo, having the highest railway density among the analysed countries. Other CEE countries also significantly surpass the EU15 average. As opposed to railway transportation, the CEE countries suffer from low coverage by motorways. Slovenia is the exception, showing high coverage by railways, motorways, and airports. Apart from Italy, the periphery countries also show minimal values of coverage by railways. The airport coverage indicator should be interpreted carefully. The extremely small countries with a small total area (measured, e.g., by km^2) generally have at least an airport in their capital. Thus, they show high values of airport coverage. This occurred with Malta and Cyprus, causing these two countries to significantly exceed the EU15 average.[4] Greece shows notably high values of airport coverage mostly because of newly built airports financed by ESF funds. Omitting any exceptional cases, the simplified comparison indicates generally lower coverage by airports in the CEE countries than in the periphery countries. These results are alarming, especially for large countries such as Poland, Bulgaria and Romania. These countries jointly report low coverage by motorways and airports, which indicates disadvantages, especially for passenger traffic. In addition, some regions in smaller countries such as the Czech Republic, Slovakia or Hungary may be served by nearby airports in other countries (such as Vienna for those CEECs mentioned above), which is not a solution for large internal regions in larger countries (Fig. 4).

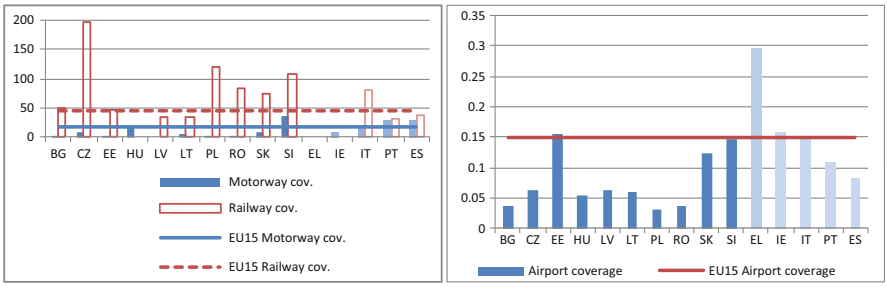

Fig. 4 Motorway, railway (km per 1,000 km^2) and airport (with more than 15,000 passengers per year) coverage (per 1,000 km^2) compared with EU 15 averages, 2012 (Eurostat)

[4] Being an extreme outlier, Malta was excluded from the picture of airport average.

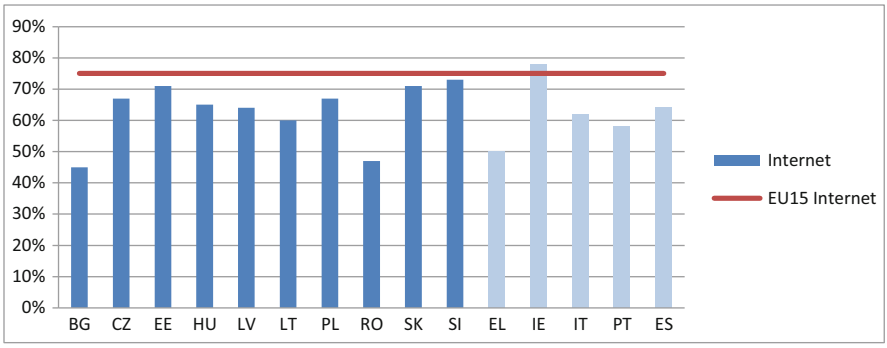

Fig. 5 Households with Internet access (% of households in 2012) (Eurostat)

Considering the levels of educational attainment and infrastructure quality indicators, including also the share of internet penetration (Fig. 5), is it important to note that the indices cannot indicate everything regarding actual competitiveness or the economic performance of analysed countries. The human capital indices are used as a measure of potential for firms when assessing the quality of human resources to be employed in their businesses. Of course, high potential does not guarantee immediate effects on the macroeconomic performance of the countries because there are more factors involved in utilising such potential by internal as well as external firms. Portugal and Spain, with high percentages of unemployed tertiary students (approximately 50 %), may be examples. Although the infrastructure quality indices imply the business potential of a country, the country's usage depends on other factors that are difficult to include in the analysis. For example, institutional support by policy-makers at the national and regional levels comprises subsidies, taxation, employment protection, legislation, etc. These factors also determine the business risk, which firms seriously consider when deciding on an investment location. Nevertheless, the indices used in our analysis represent a potential, which every country has a chance to exploit. In addition, one should not assess the indices separately because they generally relate to one another. Many well-educated engineers with poor communication skills in English are not attractive to investors. Hence, we use the multi-dimensional cluster analysis, which identifies clusters considering a set of related indicators in each dimension.

Figure 6 depicts the changing structures of clusters of EU countries with similar indices of human capital and infrastructure quality in the years 2000, 2004, 2008 and 2012. No stable division is apparent among country clusters similar to those identified as core, periphery and CEE countries with the traditional cost-based competitiveness measures in the analysed years. The formation of two dissected clusters and the two outlying states of Malta and Portugal are observable in the final analysed year. The catching-up CEE countries, including the Czech Republic, Poland and

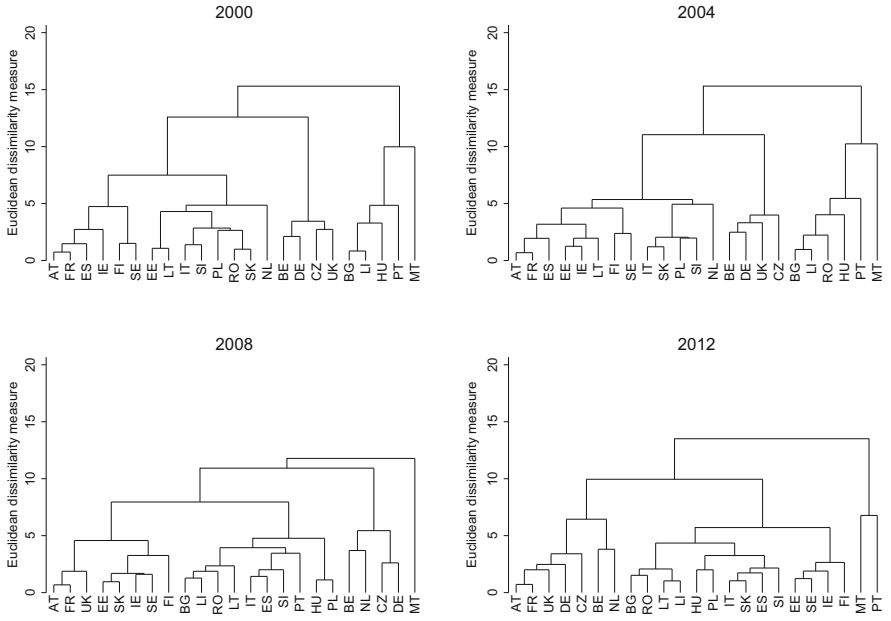

Fig. 6 Clusters of similar EU countries from the perspective of infrastructure and human capital quality (Authors' calculations, Eurostat)

Hungary, complement the EU core countries, Austria, Belgium, France, Germany, Netherlands and United Kingdom, and compose the internally opposite cluster. The opposite cluster comprises Bulgaria, Estonia, Latvia, Lithuania, Romania, Slovenia, and Slovakia, representing the CEECs with Finland, Sweden and the EU periphery countries including Ireland, Italy and Spain. Although one might report these results as a sign of profiling clusters close to the traditional division of the EU countries between the core and the periphery, we must refrain from such an interpretation. The cluster analysis does not seek to assess quality in terms of which cluster is better or more competitive. The analysis is descriptive in nature and enables identification of internally homogenous clusters of countries with similar measures of human capital and infrastructure quality. The analysis did not confirm the dissection of the stable country-group division among core, periphery and new EU countries composing the CEE countries. Regarding the division between the two dissected clusters, which are relatively similar to those of the core and periphery identified by the traditional approach, we do not consider one time period to be sufficient evidence of a country-cluster dominance from the perspective of countries' potential to attract investors to establish and sustain highly competitive business. In the next section, we apply the dynamics analysis to examine the convergence or divergence tendencies among the pre-determined groups of the EU core, periphery and new EU countries.

The distances identified in the cluster analysis are used to examine the convergence among the pre-determined clusters (EU core, periphery and CEE countries). First, the average inner distance for each group is computed and is regarded as a measure of homogeneity. The evolution of average distances of the core, the core

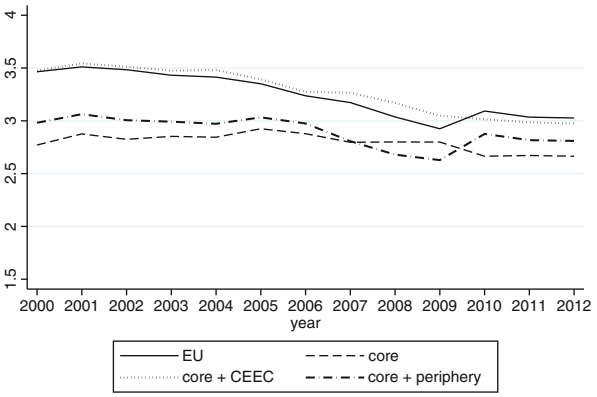

Fig. 7 Competitiveness convergence analysis: development of average distances within selected EU country-clusters from the perspective of infrastructure and human quality from 2000 to 2012 (Authors' calculations, Eurostat)

enlarged by the CEE countries (core + CEEC), the core enlarged by the periphery countries (core + periphery) and the entire EU[5] is then studied. The results of the dynamic analysis are reported in Fig. 7. The average distance among core countries is the lowest and is stable during the entire period, which indicates that this cluster is the most homogeneous, as foreseen. Although the average distance increases when including the periphery in the core cluster, which can be interpreted as a contribution of the periphery countries to heterogeneity, the evolution shows a gradual convergence until 2009, followed by a return to nearly initial values. Despite the greatest contribution to EU heterogeneity, the CEE countries converge steadily towards the core countries over the entire time period analysed and reduce the gap to the periphery contribution to the EU heterogeneity. In addition, internal average distances decrease within the entire EU cluster, implying decreasing heterogeneity in terms of infrastructure and human capital quality measures.

5.1.2 Institutional Environment

Figure 8 shows four indicators from the Doing Business database (see Sect. 2.3 for more information). The first indicator—costs of enforcing a contract—shows that in the majority of CEE countries, enforcing a contract is associated with relatively higher costs than in the EU15 on average. The worst performing country from this perspective is the Czech Republic, followed by Slovakia and Romania. Similar costs to these worst-performing CEE countries can be observed in Italy. Conversely, costs of enforcing a contract are far lower than the EU15 average in Slovenia and Hungary. Similarly, Greece and Portugal showed satisfactory results in this category.

The second indicator, strength of investor protection, is much more balanced than the first indicator, most likely because of the EU legal harmony that partially protects investors. In particular, Slovenia, when compared to the other CEE

[5] Excluding Luxembourg, Cyprus, Croatia, Greece and Denmark because of low data availability.

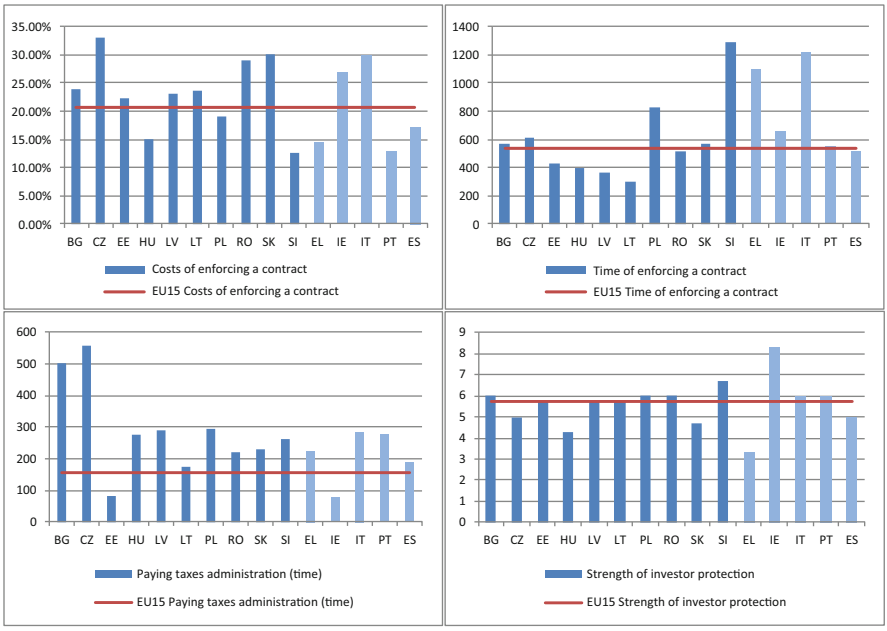

Fig. 8 Institutional environment indicators: cost of enforcing contracts (% of claim), strength of investor protection (composite index), time of enforcing contract (calendar days), paying taxes administration (hours), 2012 (World Bank Doing Business Database)

countries, performed significantly better than the EU15 average. Ireland, a member of periphery group, achieved an even better ranking—high above the "old EU" average. Conversely, Greece, with the worst evaluation in this comparison, is far below the average. The worst performing CEE country, Hungary, was still better than Greece.

The third indicator calculates the time necessary to enforce a reference contract. The fastest in resolving described disputes are the Baltic countries—Latvia and Lithuania, whereas Estonia remains below the EU15 average. The worst situation is in periphery countries, especially in Greece and Italy, in which enforcing a contract may take twice as long as in the EU15 on average and nearly four times longer than in Lithuania.

The fourth indicator describes how long it takes to fulfil all the requirements to pay taxes. Large differences appeared among countries in this category. In Estonia, paying taxes requires only 81 h a year, whereas in the Czech Republic, the same activity requires 556 h. Interesting differences can be observed within some sub-groups of countries. In the Baltic countries, Estonia, as mentioned before, is one of the top countries, Latvia is high above and Lithuania is identical to the EU average. Similarly, the Czech Republic and Slovakia, which shared a common legal system 20 years ago, differ markedly. Paying taxes in Slovakia takes half the time that the same activity takes in the Czech Republic (Fig. 8).

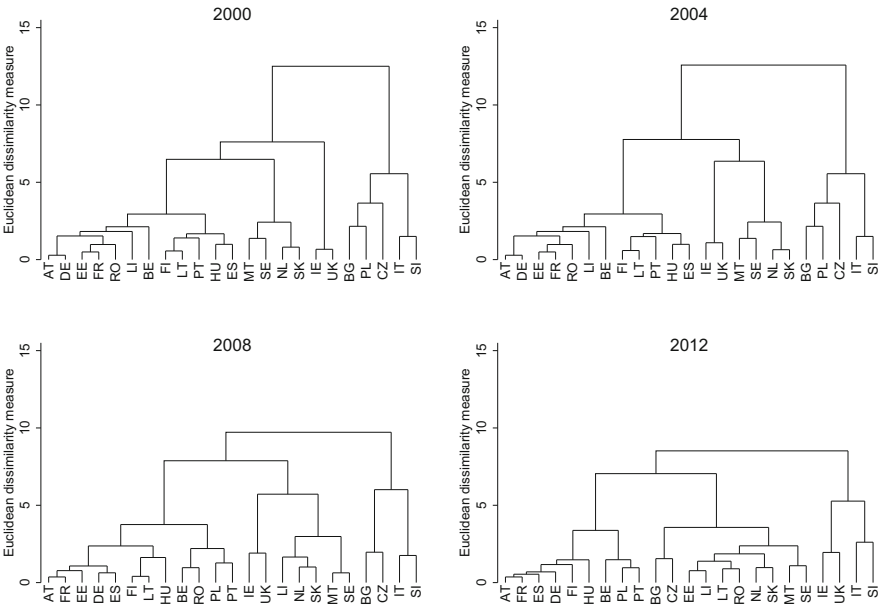

Fig. 9 Clusters of similar EU countries from the perspective of institutional doing-business indicators (Authors' calculations, Eurostat, World Bank's Doing Business Database)

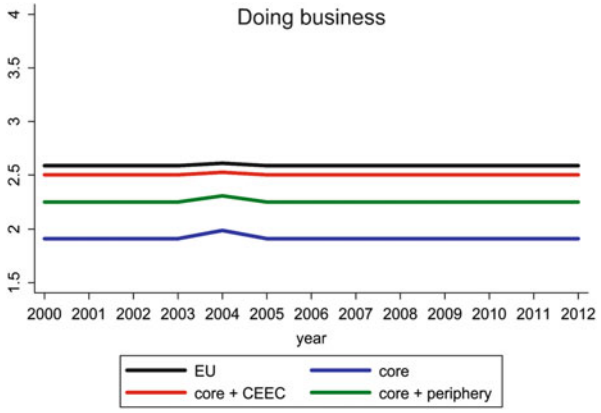

Fig. 10 Competitiveness convergence analysis: development of average distances within selected EU country-clusters from the perspective of institutional doing-business indicators in 2000–2012 (Authors' calculations, Eurostat, World Bank's Doing Business Database)

Institutional indicators examined in cluster analysis remained nearly unchanged during the entire time period. Ireland and the United Kingdom compose a stable group even when moving among clusters. Bulgaria, Poland and the Czech Republic managed to move from the outer cluster that included Italy and Slovenia to the group of the CEE countries. From the institutional perspective, core coutries do not create stable, homogeneous clusters. Core countries tend to form small groups (especially Austria, Germany and France) shared with some periphery and CEE countries (Fig. 9).

A high level of stability is typical for institutional variables. As Fig. 10 shows, average distances among clusters scarcely change. Thus, no measurable convergence or divergence appears. Core countries are more coherent in the analysis and show more homogeneous institutional environments. Including periphery countries, the level of heterogeneity increases. The greatest distances, however, can be observed within the core + CEEC cluster.

5.2 *What Is the Innovation Potential of the EU Countries?*

Figure 11 shows the levels of scientific achivements in the CEE and periphery countries. Regarding average citations per document published in the Scopus database, all the CEE coutries lie below the EU15 average with one exception—Estonia. This indicates that papers produced in the CEE countries are less likely to be cited than those from the "old EU" countries, suggesting a lower level of research quality in those countries. The quality of papers published by the authors from periphery countries, however, is nearly the EU15 average.

Poorer results for the CEE countries can be observed in patents. All the CEE countries patent their ideas sigificantly less often than the EU15 average. Countries such as Bulgaria, Romania or Lithuania patent several ideas per year, much less than Finland or Sweden, with over 200 patents per inhabitant. Most patent applications were successfull in Slovenia, followed by Estonia. In periphery countries, Ireland and Italy do not perform as well as the EU15 on average; however, the number of succesful patents is higher than in the CEE coutries (Fig. 11).

The proportion of students of the total population between 15 and 19 years shows that nearly all children of this age attend school in the CEECs, exceeding 90 % school attandence with the exception of Bulgaria, Romania and Slovakia. Poorer results were obtained in periphery countries, among which only Ireland was above the 90 % ratio. Portugal and Spain have the same attendance rates as the EU15 average; Italy and Greece fall below the average.

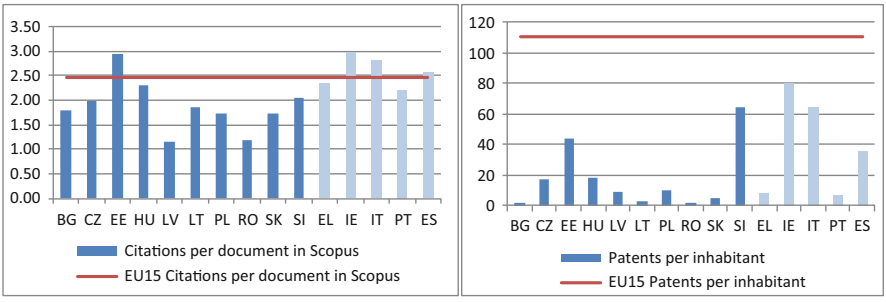

Fig. 11 Citations per document in Scopus database, patents per inhabitant (2012) (SCImago, OECD, Eurostat)

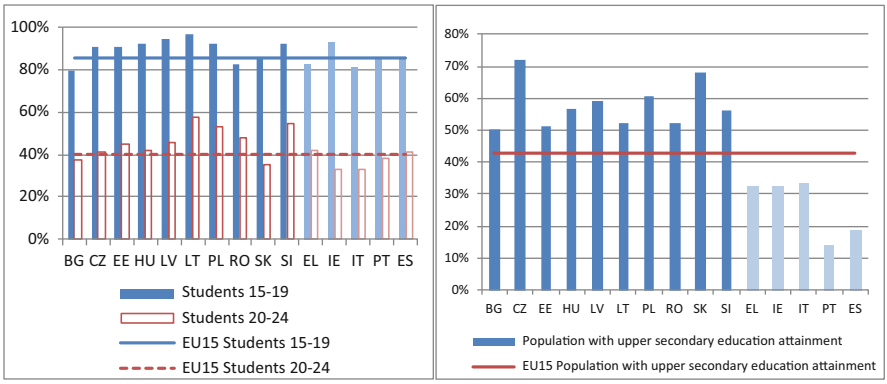

Fig. 12 Percentage of students in the population in the age groups of 15–19, 20–24; Percentage of persons with upper secondary education in the population of 25+, 2012 (Eurostat)

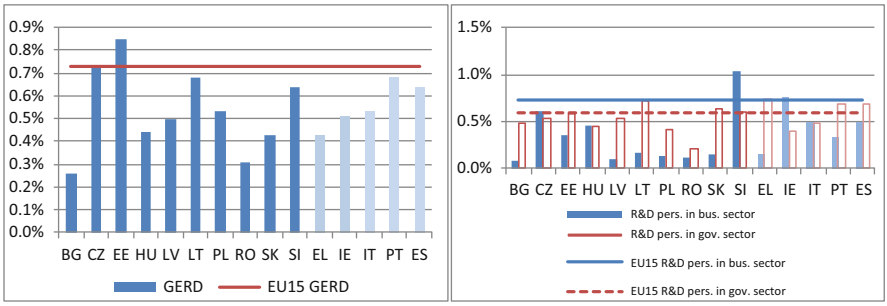

Fig. 13 Total intramural R&D expenditures (GERD)—Government sector + higher education sector, share of R&D personnel in government and higher education sectors in total employment, 2012 (Eurostat)

Results in the older age category, 20–24 years, are similar. A high proportion of chlidren who are in school at this age in CEECs indicates efforts to catch up to the "old EU" countries in the percentage of persons who have achieved a tertiary education in the population. Conversely, periphery countries fall below the EU15 average.

Comparing the percentages of persons attaining upper secondary education shows huge differences among the CEE countries, the EU15 average and periphery countries. The majority of the CEECs are 10 or more percentage points higher in this area. In contrast, all periphery countries are proportionally 10 or more percentage points lower. The Czech Republic and Slovakia show the best ratios in this indicator (Fig. 12).

Resources for research activities are depicted in Fig. 13. Research and development expenditures are measured as a proportion of the GDP. Although the CEECs are generally not able to compete with the EU15, Estonia and the Czech Republic

finance science similarly to the EU15 on average. The lowest percentages of research and development expenditures are in Bulgaria and Romania.

The second chart reveals the weaknesses of the CEE countries in research—the lack of researchers in the business sector. In the EU15, more researchers are employed in the business sector than in the government sector. In the CEECs, the proportion is reversed. Generally, the share of government researchers in the CEECs is quite similar to the EU15 average. Only Slovenia has an above-average share of business researchers. Slovenia, the Czech Republic and Hungary are the only CEE countries in which the ratio of business researchers to government researchers is similar to the EU15 average. Regarding periphery countries, only Ireland has a significantly higher number of research personnel in business than in government sectors. In Greece, the percentage of business researchers is rather low, similar to the poorest performing CEE countries (Fig. 13).

Clustering with respect to innovation potential splits the EU countries into two segments and later into three main clusters. Selected variables divide the EU into periphery, CEECs and core nearly perfectly, especially in 2012. In previous years the clusters differ less. The only persistent cluster is that of the core countries. In the earlier years, periphery countries created one or more smaller clusters with the CEECs but never with the core countries (Fig. 14).

The average distance within clusters tends to decline over time, as observed in Fig. 15. The decline is slower in the core countries group. The extended cluster that includes the CEECs, the convergence of core and CEECs, is a result of the

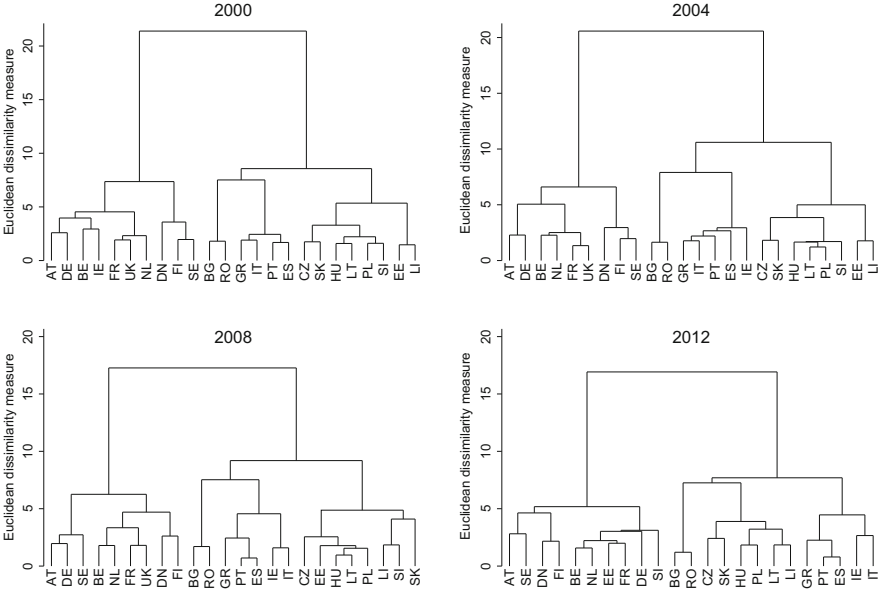

Fig. 14 Clusters of similar EU countries from the perspective of innovation and development potential (Authors' calculations, Eurostat, SCImago, OECD PISA)

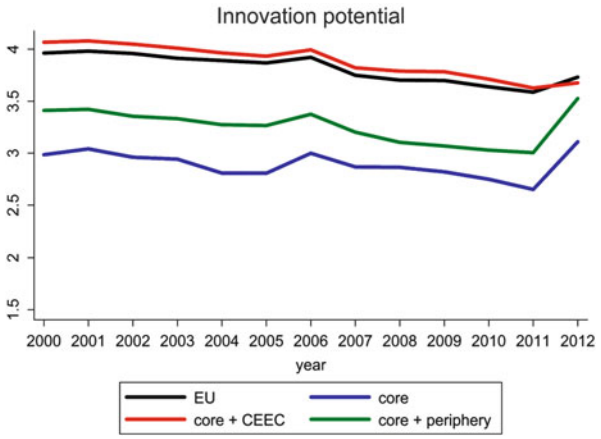

Fig. 15 Competitiveness convergence analysis: development of average distances within selected EU country-clusters from the perspective of innovation and development potential in 2000–2012 (Authors' calculations, Eurostat, World Bank's Doing Business Database)

innovation potential indicators. Heterogeneity in the core and periphery countries is much lower than in the group of core + CEEC, which may be caused by the longer membership of periphery countries in the European Union and "western block". We believe that the increase of divergence observed in 2012 is a temporary phenomenon, partially caused by incomplete data used for this analysis.

6 Conclusions

This chapter attempted to offer some insights into new approaches to understanding, measuring and assessing the competitiveness of the EU countries. The traditional cost-based concept of competitiveness measuring indicated a clear division among the core, periphery and new EU states, mostly the Central and Eastern European countries representing the former centrally planned economies. The alternative approaches, embodied in two alternative dimensions, focused on examining the competitiveness of the EU countries in providing conditions to attract enterprises to establish and maintain high-skilled business. In addition, the innovation potential of countries was assessed to provide some evidence of the prospective competitiveness of countries from the perspective of knowledge-based economy assumptions.

Apart from descriptive statistics assessing selected competitiveness indices, the comparative analysis was the core of research. Using sets of indices, the chapter identified clusters of internally homogeneous country-clusters within the EU and their development over time. In addition, the dynamics analysis was applied to provide some evidence of convergence or divergence tendencies among pre-determined country-clusters of the EU core, periphery and CEE countries from the perspectives of both alternative approaches.

The competitiveness dimension, focused on assessing the infrastructure, human quality and institutional environment, did not confirm the hypothesis of profiling country groups comprising highly competitive and innovative core, the periphery lagging behind and CEE countries composing the rest. The dynamics analysis showed a remarkable convergence trend, especially in CEE countries towards the core of the EU. This may be a positive sign of reducing the gap in the level of attractiveness of the EU countries for enterprises choosing a location for their high-skilled and knowledge-based business. Thus, the EU countries provide relatively comparable conditions for establishing and sustaining high-skilled business.

However, the situation is different for the EU countries' innovation potential. The EU countries differ in terms of institutional as well as private support of research and development. In addition, the effects of research results such as patents and publications differ across the EU. The stable division of two country-groups comprising the EU core countries as the first internally homogeneous cluster and the periphery and the CEE countries as the second group is clearly observable in the dendrograms. The dynamics analysis shows rather slow convergence among the pre-determined countries of core, periphery and CEE countries.

Regarding the policy conclusions, the analysis provided evidence of current EU governments' efforts to attract firms to engage in competitive business in their countries at comparable levels. There are no significant disparities or dissimilarities indicating increasing gaps among countries or stable country-clusters across the EU. This finding is based on infrastructure, human capital and institutional quality indices. However, these conditions may be considered insufficient because the competitiveness advantage is expected to increase with increasing potential to invent and innovate in the future. The current state of innovation potential and innovation's support from both government and private spheres differs across the EU. The gaps among countries and country-clusters appear to be consistent over the analysed period. Thus, the research, development and innovation support should be considered a priority by policy-makers at regional as well as national levels, especially among the EU periphery and CEE countries to take the competitive advantage of specialisation of high-skilled and knowledge-based production and services generating high gross value added.

References

Aiginger K, Bärenthaler-Sieber S, Vogel J (2013) Competitiveness under new perspective. WWWforEurope working papers series, No. 44

Artis M, Zhang W (2001) Core and Periphery in EMU: a cluster analysis. Econ Iss J Art 6:47–58

Boreiko D (2003) EMU and accession countries: fuzzy cluster analysis of membership. Int J Finance 8:309–325

Camacho M, Perez-Quiros G, Saiz L (2006) Are European business cycles close enough to be just one? J Econ Dyn Control 30:1687–1706

Camacho M, Perez-Quiros G, Saiz L (2008) Do European business cycles look like one? J Econ Dyn Control 32:2165–2190

Huemer S, Scheubel B, Walch F (2013) Measuring institutional competitiveness in Europe. CESIFO Econ Stud 59:578–608

Karahan O (2012) Input–output indicators of knowledge-based economy and Turkey. J Bus Econ Finance 1:21–36

Quah CHH, Crowley PM (2010) Monetary integration in East Asia: a hierarchical clustering approach. Int Finance 13:283–309

Rozmahel P, Kouba L, Grochová L, Najman N (2013) Integration of Central and Eastern European countries: increasing EU heterogeneity? WWWforEurope working papers series, no. 9

Song W, Wang W (2009) Asian currency union? An investigation into China's membership with other Asian countries. J Chin Econ Bus Stud 7:457–476

Sorensen CH, Gutierrez JMP (2006) Euro area banking sector integration: using hierarchical cluster analysis techniques. ECB working paper series, No. 627. May 2006

The Europe (2020) Competitiveness report: building a more competitive Europe. World Economic Forum, Genève. 44 p. ISBN-10: 978-92-95044-43-2. Available at http://www.weforum.org/reports/europe-2020-competitiveness-report