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ASSESSMENT OF SMART GROWTH INDICATORS PROGRESS IN EU: COHESION APPROACH

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Abstract. Smart Growth, a concept present since the inception of the European Union, has grown in significance with each subsequent programming period. Eventually, it solidified as a pivotal strategy for Europe2020. Post-2020, it has evolved into the Smart Specialization Strategy (S3) for the period 2021–2027, and discussions now include the S4+ strategy, focusing on smart specialization strategies for sustainable and inclusive growth. This study aims to evaluate the cohesion level of smart growth indicators and their temporal development among EU member states, examining three key indicators: employment, tertiary education, and gross expenses on R&D (GERD) within the timeframe of 2010–2022. The findings reveal a consistent long-term trend of growth in the cohesion level of these indicators among EU member states, indicating a noteworthy convergence. Particularly in employment, the indicators demonstrate striking similarities across all countries, reflecting the highest level of cohesion within the EU. Conversely, in the case of GERD, the most substantial variations among EU countries are observed. These results underscore the success of Smart Growth initiatives in fostering convergence across EU member states, especially in terms of employment. However, challenges persist, particularly in achieving cohesion in research and development investments. Understanding these dynamics is crucial for shaping effective policies to sustain and enhance smart growth strategies in the ever-evolving European landscape.

Keywords: Smart Growth, Smart Specialization, GERD, tertiary education, employment, cohesion, EU.

JEL Classification: A10, C10, O11, O30.

1. Introduction

Smart Growth gained particular relevance after the 2007–2009 Great Recession. The re-covery of almost all EU member state economies was challenging. Countries and regions grew unevenly, leading to increasing disparities. The troubles of problematic regions (mostly in Southern and Eastern Europe) resurfaced. Additionally, productivity gaps with other economically developed countries, such as the USA, began to widen (Rigby et al., 2022; Foray, 2018). In response to these challenges, the European Commission proposed development strategies like Europe 2020 and subsequent ones, which were based on smart, sustainable, and inclusive growth principles (Marrocu et al., 2023; Rigby et al., 2022; Foray, 2018).

To achieve the set aim, development strategies and programs such as the Smart Specialization Strategy (S3), Research and Innovation Strategies for Smart Specialization (RIS3), and Regional Operational Programme 2014–2020 were employed. Smart growth was integrated into the activities of funds like the European Regional Development Fund (ERDF), for which significant amounts of funding were allocated (Antonelli et al., 2023; Marrocu et al., 2023). A notable difference between these strategies and previous ones is the philosophical foundation of S3 and other strategies, which is based on a bottom-up approach. In this approach, local government institutions determine the direction of innovation, sectors, and industrial development (Rigby et al., 2022; Kroll, 2015).

According to Wojnicka-Sycz (2020), it is time to summarize the mid-term results of the mentioned strategies, compare them with the theoretical, fundamental basis. This is necessary to adjust further objectives and identify emerging priority areas. Undoubtedly, reliable indicators and their systems are required for proper evaluation.

It is not surprising that the raised questions are widely examined by scholars from various perspectives and levels. Marrocu et al. (2023) observed that "the current debate, although very intense, has remained mostly

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speculative, with limited evidence-based analysis." Only in recent years scientific papers begin to prevail with more precise, statistics-based assessments. For example, Di Cataldo et al. (2021) and Deegan et al. (2021) examined the results of S3 in some EU regions. Trippl et al. (2020) addressed not only individual regions but also EU member states. Gianelle et al. (2020a) and D'Adda et al. (2020) assessed the situation in Italian and Polish regions. Bellini et al. (2021), Barzotto et al. (2019), and Aranguren et al. (2019) discussed the results of RIS3 implementation mostly concerning lagging regions. Some researchers (Rigby et al., 2022; Balland et al., 2019) attempt to explore the topic at the level of urban areas (cities). Rigby et al. (2022) "examine if diversifying into related and more complex technologies improved the economic performance of urban areas across the EU."

Authors (Whittle & Kogler, 2020; Hidalgo et al., 2018; Kogler et al., 2017) emphasize the importance of relatedness for innovation. It is important to understand in which cases there will be a greater positive impact on the economic development of regions. First, when regions develop existing technologies and industries. Or second, when regions focus more on new, yet undeveloped but promising activities.

The aim of this study is to partially address the mentioned questions, assess smart growth indicators and their development among EU member states through the prism of cohesion level. For this purpose, theoretical aspects of smart growth are reviewed, an evaluation system is presented, and the research results are discussed.

The uniqueness of this work compared to other similar studies lies in the facts that: firstly, the cohesion level of whole EU and its member states groups (cluster cohesion) is evaluated instead of individual countries/regions; secondly, a cohesion index is proposed, revealing not only the differences/similarities of individual countries compared with other but also the internal aggregate cohesion level of groups of countries.

Therefore, the structure of the article consists of theoretical, methodological, and analytical blocks. The theoretical analysis reveals the key aspects of the Smart Growth concept and the selection of its measurement indicators. The methodological part presents the research methodology scheme, which includes the selection of the research period, the selection and grouping of research subjects, the determination of research indicators, and the description of their calculation methods. The discussion of the research results follows, based on the structure provided in the methodology. Conclusions summarize the study.

2. Smart Growth concept theoretical background

The concept of Smart Growth is relevant in the European Union (EU) and has been integrated into EU policies and strategies (such as Smart Specialization Strategy (S3), Research and Innovation Strategies for Smart Specialisation (RIS3), Regional Operational Programme 2014–2020, Europe 2020 and etc.) aimed at achieving sustainable and balanced economic, social, and environmental development. The EU's approach to smart growth is part of its broader agenda to encourage smart, sustainable, and inclusive growth.

Researchers (Jamshidi & Barakpour, 2023; Bagheri & Shaykh-Baygloo, 2021; González-López et al., 2019) point some key aspects of the smart growth concept (see Table 1).

Firstly, it is research and development: innovations, scientific researches are seen as necessary drivers of economic growth. One of the EU's development goals is to become leader in technologies and scientific researches. Science and innovations are closely connected with digitalization. As it is principal for boosting competitiveness and economic growth.

Secondly, education and skills: investing in education and skills development is a key component of smart growth. Alongside tertiary educations the EU supports lifelong learning, vocational training, and initiatives to enhance the employability of its workforce.

Thirdly, regional development: the EU supports regional development through various programs, including the Cohesion Policy. This policy aims to reduce economic and social disparities between regions and promote balanced growth across the EU. The essential part of such policy is increasing of employment rate.

Fourthly, all mentioned is strongly linked with entrepreneurship and small businesses: the EU encourages

Table 1. Main aspects of Smart Growth

Key aspect	Main factors	Impact
R&D	Innovations, scientific research, digitalisation, patents and etc.	Booster of competitiveness and driver of economic growth
Education and skills	Tertiary education, lifelong learning, vocational training and etc.	Enhancing of employability of workforce
Regional development	Regional policy, cohesion policy, balanced growth	Reduction of disparities between regions, promotion of balanced growth, increase of employment rate
Entrepreneurship and SME	Support of SME through funding, regulatory simplification	Encouragement of entrepreneurship and support of SME
Green growth	Environmental sustainability, reducing greenhouse gas emission, improving resource usage efficiency	Achieving economic growth through environmental sustainability

entrepreneurship and supports small and medium-sized enterprises (SMEs) through funding, access to finance, and regulatory simplification. The European Small Business Act is an example of EU policy designed to help SMEs thrive.

At last, one of the key aspects of smart policy is green growth: The EU is committed to achieving environmental sustainability while promoting economic growth. While reaching smart economic growth it is mandatory to focus on reducing greenhouse gas emissions, improving resource efficiency, and transitioning to a low-carbon and circular economy.

All mentioned is robustly associated with Smart Specialization concept. Smart specialization is an innovation-driven approach to regional economic development that aims to identify and build on a region's unique strengths, capabilities, and competitive advantages (Wu, 2023; Wojnicka-Sycz, 2020; González-López et al., 2019; Foray, 2018). The concept was introduced by the European Union (EU) as part of its regional development policy to promote sustainable and inclusive growth. The idea is to encourage regions to specialize in specific areas where they have a comparative advantage and can excel, fostering innovation, economic diversification, and competitiveness.

Most of researchers (Marrocu et al., 2023; Wojnicka-Sycz, 2020; González-López et al., 2019; Foray, 2018; Radosevic et al., 2018; Uyarra et al., 2018; McCann & Ortega-Argile, 2016; Kroll, 2015) agree that the main idea behind Smart Specialization Strategy (S3) is that regions should focus their efforts and resources on areas where they are most likely to succeed in creating products that can compete internationally (see Table 2). This specialization can be in different areas like science, technology, or innovation. The basic idea of S3 is that regions can't be good at everything, so they should concentrate on what they are best at and try to come up with new products or ideas in those areas. This approach helps regions diversify their economy by combining their local knowledge and resources in innovative ways.

Criticism was not long in coming. The main threats of Smart Specialisation Strategy (S3) can be summarized in some main groups (Gianelle et al., 2020b; Aranguren et al., 2019; Hassink & Gong, 2019; Foray, 2019; Pugh, 2018).

Table 2. Main advantages and disadvantages of Smart Specialization Strategy

Main advantages
– creates products that can compete internationally; – covers different areas as science, technology, innovations; – concentrates on what regions are best at; – diversifies region's economy by combining local knowledge and resources in innovative way
Main risks
– risk of inefficient implementation; – challenge in diversifying region's economy due to smaller sets of capabilities; – mismatched sectoral focus

There are concerns about the risks of inefficient implementation, especially in peripheral regions facing additional developmental constraints. This suggests that the strategy may not be adequately tailored to address the specific challenges faced by these regions. It is linked with doubts about the flexibility of the S3 policy to operate across the diverse institutional environments found in EU regions. This lack of adaptability could hinder the strategy's effectiveness in addressing regional economic needs and constraints.

Less developed economies may face challenges in diversifying their economies due to having smaller sets of capabilities. This limitation can restrict their options for related diversification, potentially hindering their economic growth and development under the S3 strategy.

Mismatched sectoral focus as many regions are observed to distribute S3 funds across industries with only tangential evidence of building new growth trajectories. This suggests a potential mismatch between the chosen sectors and the regions' existing capabilities or competitive advantages, which could undermine the strategy's success in fostering economic transformation.

While smart growth and smart specialization have some differences in primary focuses, there are overlapping elements. Both concepts may involve considerations for environmental sustainability, community engagement, and economic development.

In strategic EU documents (e.g., Europe 2020, S3, RIS3, etc.) and reports, there is no prepared and final list of Smart Growth measurement indicators. Summarizing the indicators and their systems used in scientific literature, several commonly occurring indicators can be distinguished: R&D expenditures (usually through Gross Expenses for R&D – GERD), knowledge (e.g., tertiary education level), and employment (especially employment in Smart Specialization industries).

The most important and frequently mentioned by researchers indicator is R&D expenditures. There is little doubt about the positive impact of this indicator on the economic growth of a country or region, especially in the context of Smart Growth. Wojnicka-Sycz (2020), Benner (2019), and Cohen (2019) acknowledge that the concepts of Smart Growth and Smart Specialization are inconceivable without innovations, which are a serious stimulus for economic growth. Frank et al. (2019), and Müller et al. (2018) emphasize that innovations, digitalization, and the automatization of manufacturing (and other processes) promote collaboration and flexibility among individual companies and sectors. This leads to high productivity and cost optimization, which in turn promotes competitiveness in both local and international markets and leads to overall economic growth. Wang (2023) and Coman et al. (2022) additionally mention that innovations are important not only for economic growth but also for adequate living standards.

Uhlbach et al. (2022), Balland et al. (2019), and Hidalgo et al. (2018) reveal the positive impact of R&D through the prism of relatedness. It is situation when new specializations emerge not out of necessity (consumers' needs) but from existing specializations and infrastructure in the region. Such relationships, through multiply effect, can provide greater stimulus for the emergence of new specializations and provide faster regional growth.

The negative impact of R&D and innovation is usually presented through the prism of environmental unsustainability. For example, innovations can promote both production and consumption, which sometimes encourage more active use of non-renewable resources. This is discussed by, for example, Wang (2023) and Assi et al. (2021).

Another important Smart Growth indicator is education (sometimes referred to as knowledge or science). Most authors (e.g., Zafar et al., 2022; Marra & Colantonio, 2021; Kiefer et al., 2019) associate the impact of this indicator on growth with R&D and innovation. The typical logical sequence is as follows: high-level education is necessary for the creation of high-tech products and the emergence of innovations – high-tech products imply increased productivity and cost reduction – growth in productivity is a crucial part of Smart economic growth. In this regard, Wojnicka-Sycz (2020) presents an interesting "sixstuple helix" scheme: "science – business – bridging institutions/knowledge intensive services – administration as well as society and environment".

Some authors (e.g., Yang et al., 2022; Assi et al., 2021; Hsu et al., 2021) highlight the ecological aspect of higher education's influence. Without high-level education and sciences, it is impossible to properly develop eco-compatible technologies, ecological innovations, and nature-oriented products. Moreover, smart, sustainable, and inclusive growth is inconceivable without these advancements.

Another Smart Growth measurement indicator that is less frequently mentioned is employment. For example, Wojnicka-Sycz (2020) uses employment in industries related to Smart Specialization as one of the indicators in her research. Additionally, Kiefer et al. (2019) argue that human intellect, abilities, knowledge, and skills are an integral part of economic development.

In summary, it can be concluded that in EU strategic documents and reports, as well as in the works of many researchers, Smart Growth is associated with several key and commonly mentioned indicators: GERD (Gross Expenditures on R&D), tertiary education level, and employment level. The indicators mentioned serve as the methodological basis for this study.

3. Research methodological framework

The methodology of this study is very similar to that used in the author's other studies related to EU cohesion, its various aspects and measurement. The basis of the methodology (see Figure 1) is the selection of the research period, the selection and grouping of research subjects, the determination of research indicators and the description of their calculation methods.

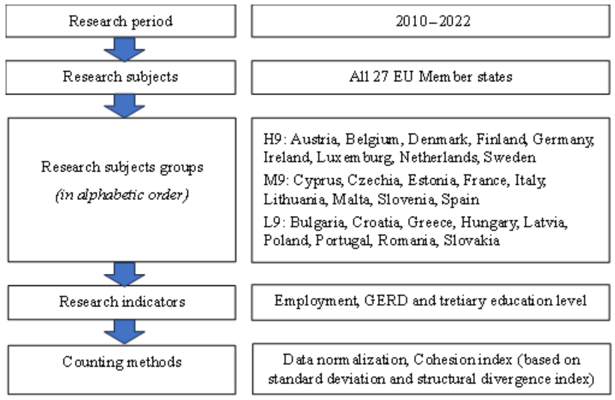

Figure 1. Research characteristics and their meanings

The research aims to cover the longest possible period. However, the statistical data for all subjects under examination are only available from 2010 onward. Prior data is either absent or incomplete. The analysed period covers timeline from 2010 to 2022.

The chosen level of research subjects is all EU member states. Subjects' grouping model is based on multi-speed EU idea. All mentioned 27 EU countries are divided into three groups by their economic development level (GDP per capita (PPP) in comparison with EU average). Grouping was made with statistic data analysis computer program SPSS (v26) using clustering function according year 2022 data.

The first group is highly developed countries (H9): Austria, Belgium, Denmark, Finland, Germany, Ireland, Luxemburg, Netherlands, Sweden, – which GDP per capita is higher than 105% of EU average.

The second group is medium developed countries (M9): Cyprus, Czechia, Estonia, France, Italy, Lithuania, Malta, Slovenia, Spain, – which GDP per capita is between 80% and 105% of EU average.

The third group is less developed countries (L9): Bulgaria, Croatia, Greece, Hungary, Latvia, Poland, Portugal, Romania, Slovakia, – which GDP per capita is under 80% of EU average.

Choice of research indicators was made by Europe 2020 strategy's and Smart Specialization Strategy's (S3) guidelines according to analysis above. There were three main indicators chosen: employment level of population aged 15–64, counted as percentage of total population; gross expenditures on R&D (GERD), counted as percentage of GDP; tertiary or equivalent level education achieved by population aged 24–65, counted as percent of total population.

The methodology for calculating the cohesion index is based on several basic principles, including the normalization of the indicator, the standard deviation and the calculation of the structural divergence index (see Table 3).

Mentioned principles form the basis for the calculation of the aggregate cohesion index, which makes it possible to assess the level of cohesion in states and determine whether it is decreasing or increasing over the analysed period.

Table 3. Research methods

Counting method	Formula and its explanation
Normalization of variable	$V_{norm} = \frac{V_{nom}}{V_{avg}} \cdot 100\%,$ [1] where: V_{norm} – normalized value of the region indicator; V_{nom} – nominal value of the region indicator; V_{avg} – average value of the region indicator.
Standard deviation	$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \overline{x}\right)^2}$, [2] where: s – standard deviation; x_i – the i^{th} value of the indicator; $\overline{y}$ – average value of the indicator; n – number of indicator values.
Structural Divergence Index (SDI)	$SDI_{i,EU} = \sum_{j=1}^{N} abs\left(S_{j,i} - S_{j,EU}\right).$ [3] where: $SDI_{i,EU}$ – the index of the country's structural divergence vis-à-vis the EU; N – number of economic structure elements (sectors) to be analyzed in country i or region; $S_{j,i}$ – the part of element j (sector) of the economic structure of country or region i, calculated in terms of gross value added, in the gross product of country i or region; $S_{j,EU}$ – the part of element j (sector) of the economic structure of an EU country or region, calculated in terms of gross value added, in the gross domestic product of an EU country or region.
Aggregate Cohesion Index (CI)	$CI = 100 - \frac{1}{n}\sum_{i=1}^{n} abs\left(X_i - \overline{X}\right),$ [4] where: CI – level of cohesion for the analyzed indicator (cohesion index); X_i – normalized value of the indicator for the i region; $\overline{X}$ – average value of the country's indicator; n – number of regions.

In total twelve indices were calculated and evaluated in the paper – four indices for each of three indicators.

Cohesion indices (CI) for measuring employment (Em) in all EU member states (EU27) and in three mentioned countries' groups (H9, M9 and L9): CI(Em)-EU27; CI(Em)-H9; CI(Em)-M9 and CI(Em)-L9.

Cohesion indices (CI) for measuring GERD (R&D) in all EU member states (EU27) and in three mentioned countries' groups (H9, M9 and L9): CI(R&D)-EU27; CI(R&D)-H9; CI(R&D)-M9 and CI(R&D)-L9.

Cohesion indices (CI) for measuring tertiary education level (Edu) in all EU member states (EU27) and in three mentioned countries' groups (H9, M9 and L9): CI(Edu)-EU27; CI(Edu)-H9; CI(Edu)-M9 and CI(Edu)-L9.

Thorough implementation of this methodology ensures that the study's findings are robust and furnish valuable insights into the examined subject matter.

4. Research results presentation

The employment growth trend across the EU is clearly evident. The overall employment rate for the 27 EU member states increased from 68.0% in 2013 to 75.4% in 2022. It is important to highlight that in 2022, the overall EU employment level reached the target value of 75.0% set in the Europe2020 strategy for the first time. Additionally, it is encouraging to note that employment has increased in all EU member states. Particularly notable progress has been observed in Hungary, where employment rose from 59.9% in 2010 to 80.3% in 2022. Similarly, in Malta, the indicator increased from 60.2% in 2010 to 79.1%. Estonia and Lithuania share the third and fourth positions in terms of progress in this indicator, with employment increasing by almost 15% during the study period (respectively, from 68.7% to 83.3% in Estonia and from 64.4% to 79.0% in Lithuania).

Furthermore, the disparities between countries noticeably decreased. For instance, in 2013, the highest employment rate was in Sweden at 81.3%, while the lowest was recorded in Greece at just 53.1%. By 2022, the highest employment rate was still in Sweden, at 83.8%, while the lowest increased to 64.9% in Italy. This means that the difference between the extreme points decreased from 28.2% to 18.9%.

Analysing the cohesion index data for employment (CI(Em)) (see Figure 2), two phenomena are observed: firstly, a very high level of cohesion; secondly, despite the overall convergence occurring across the EU, the processes within the analysed groups differ.

There exists a very high level of cohesion at the EU level regarding employment: the cohesion index CI(Em)-EU27 exceeds 90% throughout the entire analysed period. Despite a slight decrease in cohesion from 2010 to 2013, when the index dropped from 93.1% to 92.2%, cohesion level continued to increase thereafter. By 2022, it reached 94.1%.

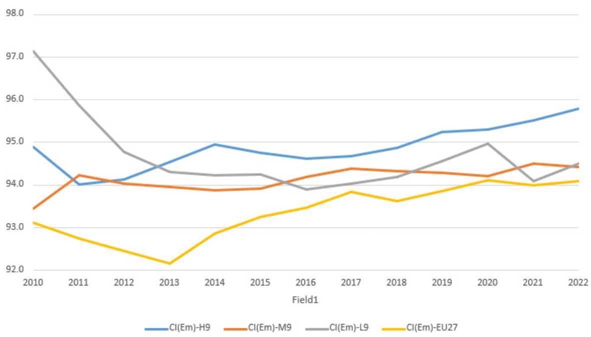

Figure 2. Employment cohesion indices values in EU and its member states groups during 2010–2022 period, in %

When comparing individual country groups (H9, M9, and L9), different (even opposing) trends are observed. Among high developed countries (H9), a clear clustering convergence in employment indicator is noted. The cohesion index (CI(Em)-H9) increased almost consistently throughout the analysed period (except for 2011 and 2016). Its value rose gradually from a minimum of 94.0% in 2011 to 95.8% in 2022. The situation in medium developed countries (M9) can be characterized as relatively stable. Although a modest long-term growth trend is observed in this group, the cohesion index (CI(Em)-M9) mostly fluctuated between 93.9% and 94.4%. In the least developed countries group (L9), the situation leans more towards divergence. Particularly noticeable divergence occurred from 2010 to 2013 when the cohesion index (CI(Em)-L9) sharply decreased from 97.1% in 2010 to 94.3% in 2013. Subsequently, the decrease was less significant, with the index dropping to 93.9% by 2016. After 2016, cohesion levels remained relatively stable, fluctuating between 93.9% and 94.5%.

In summary, the results for employment in the EU appear positive. The differences between member states are small and gradually decreasing. However, there is some concern regarding the slight polarization observed. The cohesion level is highest and continues to increase among more developed countries, while differences between less developed countries are larger and almost unchanged.

Analysis of the second indicator (GERD – gross expenditures on R&D) reveals that R&D expenditures among EU member states are relatively stable – the share of GDP allocated to R&D at the beginning and end of the period is almost the same. In 2010, the distribution ranged from 0.44% in Cyprus to 3.71% in Finland. Meanwhile, in 2021, the distribution ranged from 0.47% in Romania to 3.35% in Sweden. Belgium stood out in this regard, increasing its relative expenditure by 1.16 percentage points (from 2.06% in 2010 to 3.22% in 2021). Significant progress was also noted in Greece (+0.85 percentage points from 0.6% in 2010 to 1.45% in 2021), Poland (+0.72 percentage points from 0.72% in 2010 to 1.44% in 2021), and the Czech Republic (+0.57 percentage points from 1.33% to 2.0%). GERD decreased the most in Finland: from 3.71% in 2010 to 2.99% in 2021.

In recent years, a clustering trend has been observed. Since 2016, three groups of countries have emerged: a) countries investing the most in R&D (6 countries), with GERD ranging from 2.81% to 3.35% in 2021 – significantly higher than the EU average; b) countries investing moderately in R&D (4 countries), with GERD ranging from 2.0% to 2.25% in 2021 – around the EU average; and c) countries investing the least in R&D (17 countries), with GERD ranging from 0.47% to 1.75% in 2021 – significantly lower than the EU average. Interestingly, this distribution is not correlated with GDP distribution. Pearson correlation coefficient calculations show that there is no relationship between GERD and GDP values in EU member states. However, there is a

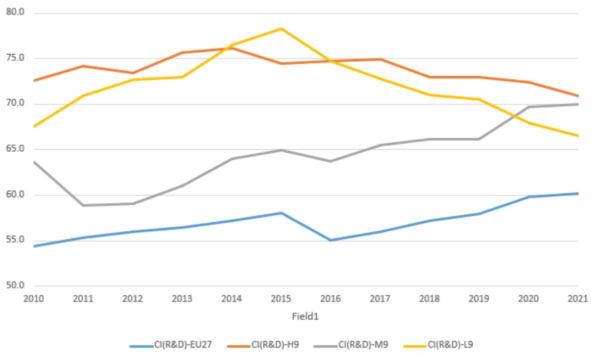

Figure 3. GERD cohesion indices values in EU and its member states groups during 2010–2021 period, in %.

moderately strong correlation between GERD and employment (for example, the Pearson correlation coefficient for 2021 is 0.432, with sig. 0.025; and for 2020 it is 0.421, with sig. 0.029).

Analysis of the GERD cohesion index (CI(R&D)) shows convergence at the EU level. The index (CI(R&D)-EU27) increased throughout the entire study period (except for 2016) from 54.4% in 2010 to 60.2% in 2021 (see Figure 3). While the convergence trend is a positive outcome, it is notable that the cohesion level itself is low – barely 60%. Although differences between countries are decreasing, they are still significant.

Comparing the changes in cohesion indices of country groups (H9, M9, and L9), it is noticeable that until 2015, the cohesion level of all three groups increased. However, after 2015, the trends diverged. The GERD cohesion index of the least developed countries (CI(R&D)-L9) decreased rapidly (from 78.3% in 2015 to 66.5% in 2021) – indicating strong divergence. The GERD cohesion index of the most developed countries (CI(R&D)-H9) decreased more moderately (from 76.1% in 2014 to 71.0% in 2021). This suggests a slight divergence. Meanwhile, the differences between medium developed countries continued to decrease: the CI(R&D)-M9 value increased from 65.0% in 2015 to 70.0% in 2021.

It can be observed that the cohesion levels of all three groups (H9, M9, and L9) are similar (the cohesion index values in 2021 were, respectively, 71.0%, 70.0%, and 66.5%), while the overall EU27 cohesion level is not high (it was only 60.0% in 2021). This once again confirms that three clusters of member states are forming within the EU, whose composition is not dependent on the GDP level (as indicated by the correlation analysis mentioned earlier).

The results of the tertiary education indicator are encouraging. The average value for the EU increased from 32.2% to 42.0% over the analysed period. It is also noteworthy that data for all EU member states showed growth. Austria stood out with particularly high growth rates (+22.4% from 20.7% in 2010 to 43.1% in 2022), followed by Portugal (+18.9% from 25.5% in 2010 to 44.4% in 2022) and Malta (+18.1% from 24.3% in 2010 to 42.4%

in 2022). Additionally, the indicator value increased by more than 10 percentage points in 14 other countries.

While the overall level of tertiary education in the EU is increasing, there is also noticeable growth between the best and the most lagging results. In 2010, the lowest value was observed in Austria and Romania (20.7%), while the highest was in Ireland (49.6%). The difference between them amounted to 28.9%. By 2022, the lowest value remained in Romania (24.7%), while Ireland remained the leading country with 62.3%. Thus, the difference increased to 37.6%.

Despite the growth disparity between extreme values, cohesion index results indicate a convergence trend in the EU (see Figure 4). Cohesion among EU member states increased significantly from 74.0% to 79.6% during the period of 2010–2015. Later, the cohesion level remained relatively stable, fluctuating between 79.6% and 81.3%. This signifies a high level of cohesion.

Analysis of cohesion indices among country groups reveals two important trends: a) first, strong convergence was observed in all groups from 2010 to 2015, but after 2015, the growth of cohesion levels almost halted, with divergence starting from 2018 (except for the M9 country group); b) strong cluster convergence is forming among EU member states, closely related to the level of country development.

During the period of 2010–2015, the cohesion index values of all three examined groups increased: CI(Edu)-H9 from 88.4% to 88.5%; CI(Edu)-M9 from 74.0% to 80.9%; CI(Edu)-L9 from 85.4% to 86.6%. However, after 2015, the trends diverged. In medium developed countries (M9), cohesion levels continued to moderately increase from 80.9% in 2015 to 83.3% in 2022. However, divergence occurred in the other two groups (H9 and L9). In the most developed country group, cohesion levels decreased from 88.5% in 2015 to 86.1% in 2022. In the least developed country group, cohesion levels decreased from 86.6% to 85.0%, respectively.

The cohesion levels of all three groups are similar; for example, in 2022, CI(Edu)-H9 was 86.1%, CI(Edu)-M9 was 83.3%, and CI(Edu)-L9 was 85.0%. Meanwhile, the overall cohesion level of the EU has remained relatively stable recently, indicating ongoing cluster convergence. Furthermore, it is interestingly closely related to the GDP

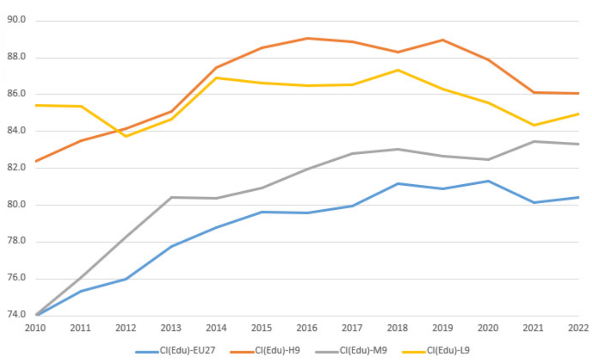

Figure 4. Tertiary education cohesion indices values in EU and its member states groups during 2010–2022 period, in %

level. Correlation analysis shows a strong relationship between the GDP and Tertiary education levels of EU member states. For instance, in 2021, the Pearson correlation coefficient is 0.603 (with sig. <0.001), and in 2020, it is 0.594 (with sig. 0.001).

5. Conclusions

Researchers point some key aspects of the smart growth concept. It is research and development, education and skills, regional development, green growth. All mentioned is strongly linked with entrepreneurship and small businesses. Smart Growth is associated with Smart Specialization concept. Smart specialization idea is to encourage regions to specialize in specific areas where they have a comparative advantage and can excel, fostering innovation, economic diversification, and competitiveness. This approach helps regions diversify their economy by combining their local knowledge and resources in innovative ways. While smart growth and smart specialization have some differences in primary focuses, there are overlapping elements. Both concepts may involve considerations for environmental sustainability, community engagement, and economic development.

In strategic EU documents, there is no final list of Smart Growth measurement indicators. Summarizing the indicators and their systems used in scientific literature, several commonly occurring indicators can be distinguished: R&D expenditures (usually through Gross Expenses for R&D – GERD), knowledge (e.g., tertiary education level), and employment (especially employment in Smart Specialization industries).

The basis of the methodology is the selection of the research period, the selection and grouping of research subjects, the determination of research indicators and the description of their calculation methods. The uniqueness of used method compared to other similar studies lies in the facts that: firstly, the cluster cohesion is evaluated instead of individual countries/regions cohesion; secondly, a cohesion index reveals not the differences/similarities of individual countries compared with others but the internal aggregate cohesion level of groups of countries.

Analysis of the three chosen indicators allows to make some important insights. First, although cohesion level of EU member states is different depending on indicator (e.g., CI(Em) is 94.0%, CI(Edu) equals 80.1% and CI(R&D) reaches 60.2% in year 2021) all of them have tendency to growth. Second, process of clustering of EU member states becomes more and more obvious. Aggregate cohesions of countries groups (divided by economic development level) become more and more similar.

Among EU member states very strong correlation can be noticed between GDP and Tertiary education level indicators (e.g., Pearson correlation coefficient is 0.603 with sig. <0.001 level, in 2021). Also, medium correlation can be pointed between GERD and Employment indicators data (e.g., Pearson correlation coefficient is 0.432 with sig. 0.025 level, in 2021).

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