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# Creating the General Convergence Index (GCI) and using it to rank Convergence Potential in the EU

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# Introduction

- Only the minimum nominal convergence criteria have been regulated thus far. This raises two significant questions:
  - How can aspiring countries to EMU improve their levels of convergence? and
  - How can this level be optimally quantified?
- Determining the optimal moment for joining the EMU is closely related to the analysis of the level of convergence between EU member states and eurozone member states.
- For this reason, we have proposed a classification of EU member states based on their level of convergence, and we found it necessary to create a convergence index that considers nominal, real, and social aspects.

# Literature Review

- As per Ridao-Cano and Bodewig (2018), the convergence process consists of two distinct aspects: the quantitative aspect and the qualitative aspect.
- Bucur and Stangaciu (2015) analyze the level of convergence in the EU, while focusing on the economic and human development aspects.
- Aursulesei (2020), used the convergence index developed by Dulgheriu (2016), and Principal Component Analysis (PCA), and developed a nominal and real convergence index called IACNR.

# GCI – Time baseline and variables

- The parameters were analyzed over a period of 10 years, from 2012 to 2021.
- As Estonia does not have all the yearly data for the long-term interest rate indicator, we decided to study the remaining 26 European countries: Belgium, Bulgaria, Czech Republic, Denmark, Germany, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, and Sweden.

# GCI – Time baseline and variables

- The indicators we considered when creating the GCI were:
  1. The Harmonized Index of Consumer Prices (HICP) inflation rate (%)
  2. Budget deficit (% of GDP)
  3. Public debt (% of GDP)
  4. Long-term interest rate (%)
  5. GDP per capita in purchasing power standards (PPS),
  6. Real effective exchange rate based on HICP (3 year % variation),
  7. Unemployment rate (% of total labor force),
  8. Small and medium-sized enterprises (SME) productivity (mil. EUR),
  9. Innovation expressed as government expenditure on R&D (EUR per capita),
  10. Poverty risk rate (% of total population),
  11. Tertiary education for the 15-64 age group (% of total population), and
  12. Youth unemployment rate for the 15-24 age group (% of the labor force).

# GCI – MCDM methods used

- Multicriteria decision-making (MCDM) methods are used in decision-making when there are multiple conflicting criteria, such as: selecting the factors that are part of the general convergence index and determining their importance to the subject of interest.

- To evaluate the convergence potential of European countries, it was imperative to assess the impact of each selected indicator on the convergence index, rank the countries, and compare the outcomes obtained using four distinct techniques. To accomplish this, we employed the following multi-criteria data analysis methods:

  – Principal component analysis (PCA),

  – Analytic hierarchy process (AHP),

  – The critical method for weight determination, and

  – The entropy method for weight determination.

# GCI – methods used

- **The principal component analysis (PCA):** The main stages of principal component analysis include standardization or normalization of the initial dataset, calculation of the correlation matrix, eigenvalues and eigenvectors, determination of the influence of each factor on the created index, and selection of the principal components.

Principal Components Analysis
Date: 10/26/22 Time: 14:46
Sample: 1 26
Included observations: 26
Computed using: Ordinary correlations
Extracting 12 of 12 possible components

Eigenvalues: (Sum = 12, Average = 1)

| Number | Value | Difference | Proportion | Cumulative Value | Cumulative Proportion |
|---|---|---|---|---|---|
| 1 | 5.051704 | 2.757975 | 0.4210 | 5.051704 | 0.4210 |
| 2 | 2.293729 | 1.036099 | 0.1911 | 7.345433 | 0.6121 |
| 3 | 1.257630 | 0.325704 | 0.1048 | 8.603063 | 0.7169 |
| 4 | 0.931926 | 0.048123 | 0.0777 | 9.534990 | 0.7946 |
| 5 | 0.883804 | 0.382631 | 0.0737 | 10.41879 | 0.8682 |
| 6 | 0.501172 | 0.103737 | 0.0418 | 10.91997 | 0.9100 |
| 7 | 0.397436 | 0.127946 | 0.0331 | 11.31740 | 0.9431 |
| 8 | 0.269490 | 0.091088 | 0.0225 | 11.58689 | 0.9656 |
| 9 | 0.178402 | 0.035434 | 0.0149 | 11.76529 | 0.9804 |
| 10 | 0.142967 | 0.082139 | 0.0119 | 11.90826 | 0.9924 |
| 11 | 0.060828 | 0.029916 | 0.0051 | 11.96909 | 0.9974 |
| 12 | 0.030912 | --- | 0.0026 | 12.00000 | 1.0000 |

Eigenvectors (loadings):

| Variable | PC 1 | PC 2 | PC 3 | PC 4 | PC 5 | PC 6 | PC 7 | PC 8 | PC 9 | PC 10 | PC 11 | PC 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RATA INFLATIEI | -0.214552 | -0.455006 | 0.014443 | -0.030634 | 0.097159 | 0.656511 | -0.313412 | -0.109395 | 0.331316 | 0.032473 | 0.288577 | -0.032349 |
| DEFICIT BUGETAR | -0.351460 | 0.061673 | -0.040903 | 0.311045 | -0.421587 | -0.212786 | 0.361112 | -0.033141 | 0.328467 | 0.253668 | 0.483931 | 0.115367 |
| DATORIA PUBLICA | 0.326911 | 0.228199 | 0.287229 | -0.308779 | 0.190913 | 0.087112 | 0.228390 | 0.442175 | 0.277010 | -0.300221 | 0.437536 | 0.114838 |
| RDOBTL | 0.374345 | -0.085451 | -0.104539 | -0.092611 | -0.324232 | 0.328477 | 0.292004 | 0.265785 | 0.257638 | 0.463723 | -0.426980 | 0.019981 |
| PIBPERCAPITAPPS | -0.265087 | 0.422565 | 0.083187 | 0.114515 | -0.032471 | 0.506237 | 0.094917 | 0.254386 | -0.563095 | 0.197741 | 0.143009 | -0.153144 |
| CSREAL | -0.243113 | -0.168002 | 0.131067 | 0.223923 | 0.744792 | -0.082303 | 0.368909 | 0.134100 | 0.096847 | 0.290231 | -0.176316 | 0.071312 |
| RATA SOMAJ | 0.380547 | 0.246727 | -0.063966 | 0.163178 | 0.205854 | -0.004860 | 0.012185 | -0.341126 | 0.179306 | 0.215500 | 0.210213 | -0.694187 |
| PRODUCTIVIMM | 0.016491 | -0.008478 | 0.837849 | 0.116880 | -0.158541 | -0.160623 | -0.369002 | 0.074926 | 0.059768 | 0.275723 | -0.090481 | -0.059255 |
| INOVARE | -0.278334 | 0.419635 | 0.219565 | 0.050542 | -0.055132 | 0.263403 | 0.205085 | -0.333286 | 0.371992 | -0.394094 | -0.419727 | -0.015958 |
| SARACIE | 0.244448 | -0.104509 | -0.068237 | 0.807748 | -0.048410 | 0.092480 | -0.095680 | 0.326232 | 0.032919 | -0.374530 | -0.065151 | -0.011468 |
| ED TERTIARA | -0.140098 | 0.492576 | -0.341086 | 0.013698 | 0.165546 | -0.085294 | -0.548804 | 0.270664 | 0.346782 | 0.233088 | -0.068155 | 0.181262 |
| TINERET SOMAJ | 0.390030 | 0.180029 | 0.072831 | 0.199123 | 0.123214 | 0.184788 | -0.011332 | -0.474692 | -0.131643 | 0.183615 | 0.140744 | 0.651821 |

Ordinary correlations:

| | RATA INFLATIEI | DEFICIT B... | DATORIA ... | RDOBTL | PIBPERCA... | CSREAL | RATA SOMAJ | PRODUCT... | INOVARE | SARACIE | ED TERTI... | TINERET ... |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RATA INFLATIEI | 1.000000 | | | | | | | | | | | |
| DEFICIT BUGETAR | 0.185698 | 1.000000 | | | | | | | | | | |
| DATORIA PUBLICA | -0.552337 | -0.685383 | 1.000000 | | | | | | | | | |
| RDOBTL | -0.269914 | -0.553464 | 0.561721 | 1.000000 | | | | | | | | |
| PIBPERCAPITAPPS | -0.040705 | 0.506646 | -0.197003 | -0.499645 | 1.000000 | | | | | | | |
| CSREAL | 0.425700 | 0.260321 | -0.347088 | -0.609615 | 0.177793 | 1.000000 | | | | | | |
| RATA SOMAJ | -0.635178 | -0.639510 | 0.685260 | 0.599444 | -0.296615 | -0.405514 | 1.000000 | | | | | |
| PRODUCTIVIMM | -0.016568 | -0.006497 | 0.221989 | -0.082521 | 0.026125 | 0.009695 | -0.049330 | 1.000000 | | | | |
| INOVARE | -0.054720 | 0.576848 | -0.170072 | -0.580879 | 0.809037 | 0.192274 | -0.291875 | 0.145999 | 1.000000 | | | |
| SARACIE | -0.152527 | -0.233224 | 0.133894 | 0.441739 | -0.320381 | -0.154847 | 0.488549 | 0.044402 | -0.422676 | 1.000000 | | |
| ED TERTIARA | -0.302089 | 0.233583 | -0.088082 | -0.390331 | 0.572581 | -0.012520 | 0.055257 | -0.296613 | 0.500729 | -0.228109 | 1.000000 | |
| TINERET SOMAJ | -0.533309 | -0.670636 | 0.670296 | 0.638197 | -0.292010 | -0.434886 | 0.930911 | 0.091226 | -0.308528 | 0.532723 | -0.122315 | 1.000000 |

# GCI – methods used

- **The Analytic Hierarchy Process (AHP)** stages: - comparing pairs of decision alternatives with respect to the chosen criteria to determine a hierarchy based on the criterion, - comparing pairs of decision criteria to determine a relative hierarchy, and - determining the performance matrix and alternative scores using the hierarchies obtained in the previous stages.

| **From σ** | -3.55 | -2.7875 | -2.025 | -1.2625 | -0.5 | 0.5 | 1.2625 | 2.025 | 2.7875 |
|---|---|---|---|---|---|---|---|---|---|
| **To σ** | -2.7875 | -2.025 | -1.2625 | -0.5 | 0.5 | 1.2625 | 2.025 | 2.7875 | 3.55 |
| **Value** | 9 | 7 | 5 | 3 | 1 | 1/3 | 1/5 | 1/7 | 1/9 |
| **Importance** | Extremely | Very strong | Strong | Moderate | Equal | Reciprocal | | | |

| Tara | Rata inflatiei | Deficit bugetar | Datoria publica | RdobTL | PIB per capita PPS | CS real | Rata somajului | Productiv. IMM | Inovare | Saracie | Educatie tertiara | Somaj tineri |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BELGIA | 0.020 | 0.021 | 0.017 | 0.049 | 0.023 | 0.031 | 0.042 | 0.047 | 0.022 | 0.038 | 0.015 | 0.033 |
| BULGARIA | 0.051 | 0.063 | 0.080 | 0.034 | 0.074 | 0.042 | 0.031 | 0.045 | 0.062 | 0.011 | 0.048 | 0.031 |
| REPUBLICA CE | 0.012 | 0.052 | 0.060 | 0.046 | 0.045 | 0.037 | 0.070 | 0.043 | 0.048 | 0.118 | 0.066 | 0.063 |
| DANEMARCA | 0.058 | 0.086 | 0.058 | 0.059 | 0.018 | 0.029 | 0.051 | 0.025 | 0.008 | 0.069 | 0.020 | 0.060 |
| GERMANIA | 0.025 | 0.106 | 0.033 | 0.064 | 0.020 | 0.067 | 0.075 | 0.015 | 0.012 | 0.033 | 0.044 | 0.090 |
| IRLANDA | 0.073 | 0.026 | 0.025 | 0.045 | 0.010 | 0.009 | 0.031 | 0.045 | 0.035 | 0.037 | 0.009 | 0.035 |
| GRECIA | 0.129 | 0.011 | 0.006 | 0.005 | 0.052 | 0.007 | 0.005 | 0.047 | 0.048 | 0.013 | 0.038 | 0.006 |
| SPANIA | 0.049 | 0.006 | 0.017 | 0.031 | 0.045 | 0.047 | 0.006 | 0.042 | 0.043 | 0.011 | 0.016 | 0.007 |
| FRANTA | 0.040 | 0.012 | 0.019 | 0.053 | 0.028 | 0.060 | 0.026 | 0.030 | 0.023 | 0.052 | 0.020 | 0.027 |
| CROATIA | 0.040 | 0.023 | 0.028 | 0.019 | 0.058 | 0.032 | 0.017 | 0.043 | 0.051 | 0.015 | 0.074 | 0.013 |
| ITALIA | 0.049 | 0.017 | 0.009 | 0.026 | 0.036 | 0.047 | 0.020 | 0.005 | 0.040 | 0.014 | 0.097 | 0.011 |
| CIPRU | 0.105 | 0.025 | 0.019 | 0.015 | 0.047 | 0.015 | 0.020 | 0.047 | 0.051 | 0.038 | 0.011 | 0.021 |
| LETONIA | 0.025 | 0.045 | 0.058 | 0.046 | 0.055 | 0.060 | 0.026 | 0.047 | 0.059 | 0.011 | 0.026 | 0.044 |
| LITUANIA | 0.014 | 0.057 | 0.058 | 0.046 | 0.050 | 0.022 | 0.031 | 0.047 | 0.054 | 0.012 | 0.015 | 0.048 |
| LUXEMBOURG | 0.025 | 0.069 | 0.080 | 0.059 | 0.005 | 0.045 | 0.058 | 0.047 | 0.007 | 0.030 | 0.011 | 0.041 |
| UNGARIA | 0.007 | 0.021 | 0.029 | 0.013 | 0.052 | 0.007 | 0.058 | 0.047 | 0.054 | 0.052 | 0.059 | 0.048 |
| MALTA | 0.031 | 0.048 | 0.043 | 0.042 | 0.039 | 0.056 | 0.064 | 0.047 | 0.054 | 0.030 | 0.052 | 0.067 |
| TARILE DE JOS | 0.021 | 0.057 | 0.043 | 0.056 | 0.018 | 0.049 | 0.051 | 0.011 | 0.016 | 0.069 | 0.019 | 0.063 |
| AUSTRIA | 0.016 | 0.034 | 0.024 | 0.055 | 0.020 | 0.020 | 0.058 | 0.043 | 0.015 | 0.047 | 0.034 | 0.073 |
| POLONIA | 0.017 | 0.026 | 0.046 | 0.018 | 0.052 | 0.032 | 0.051 | 0.015 | 0.054 | 0.033 | 0.039 | 0.044 |
| PORTUGALIA | 0.058 | 0.017 | 0.011 | 0.017 | 0.050 | 0.045 | 0.021 | 0.045 | 0.051 | 0.023 | 0.057 | 0.017 |
| ROMANIA | 0.009 | 0.018 | 0.058 | 0.010 | 0.058 | 0.045 | 0.043 | 0.042 | 0.062 | 0.008 | 0.109 | 0.023 |
| SLOVENIA | 0.040 | 0.014 | 0.032 | 0.031 | 0.047 | 0.056 | 0.042 | 0.047 | 0.051 | 0.059 | 0.030 | 0.049 |
| SLOVACIA | 0.021 | 0.022 | 0.044 | 0.048 | 0.052 | 0.042 | 0.026 | 0.047 | 0.051 | 0.069 | 0.066 | 0.024 |
| FINLANDA | 0.032 | 0.037 | 0.043 | 0.056 | 0.025 | 0.089 | 0.038 | 0.043 | 0.012 | 0.073 | 0.013 | 0.031 |
| SUEDIA | 0.033 | 0.086 | 0.058 | 0.055 | 0.020 | 0.011 | 0.040 | 0.042 | 0.012 | 0.033 | 0.013 | 0.031 |
| **CI** | 0.009 | 0.007 | 0.011 | 0.001 | 0.003 | 0.006 | 0.007 | 0.013 | 0.005 | 0.003 | 0.006 | 0.010 |
| **CR** | 0.005 | 0.004 | 0.006 | 0.000 | 0.002 | 0.004 | 0.004 | 0.008 | 0.003 | 0.002 | 0.003 | 0.006 |

# GCI – methods used

- **Criteria Importance Through Intercriteria Correlation (CRITIC) Method:** the critical method presents numerous advantages in the decision-making process, as it can be used to determine weights in the absence of decision makers and can be successfully applied in a wide range of fields, such as: - pharmaceutical industry (Diajoulaki et al.), - water resources management (Yilmaz and Harmancioglu), - national savings (Aznar Bellver et al.), - logistics (Cakir and Percin).
- **Entropy Weight Method (EWM):** The main advantage of the entropy method is that it avoids human interference in determining the weight of the indicators, resulting in a high degree of objectivity. The EWM measures the value of dispersion in the decision-making process, meaning the higher the degree of dispersion, the greater the degree of differentiation and the more information can be obtained.

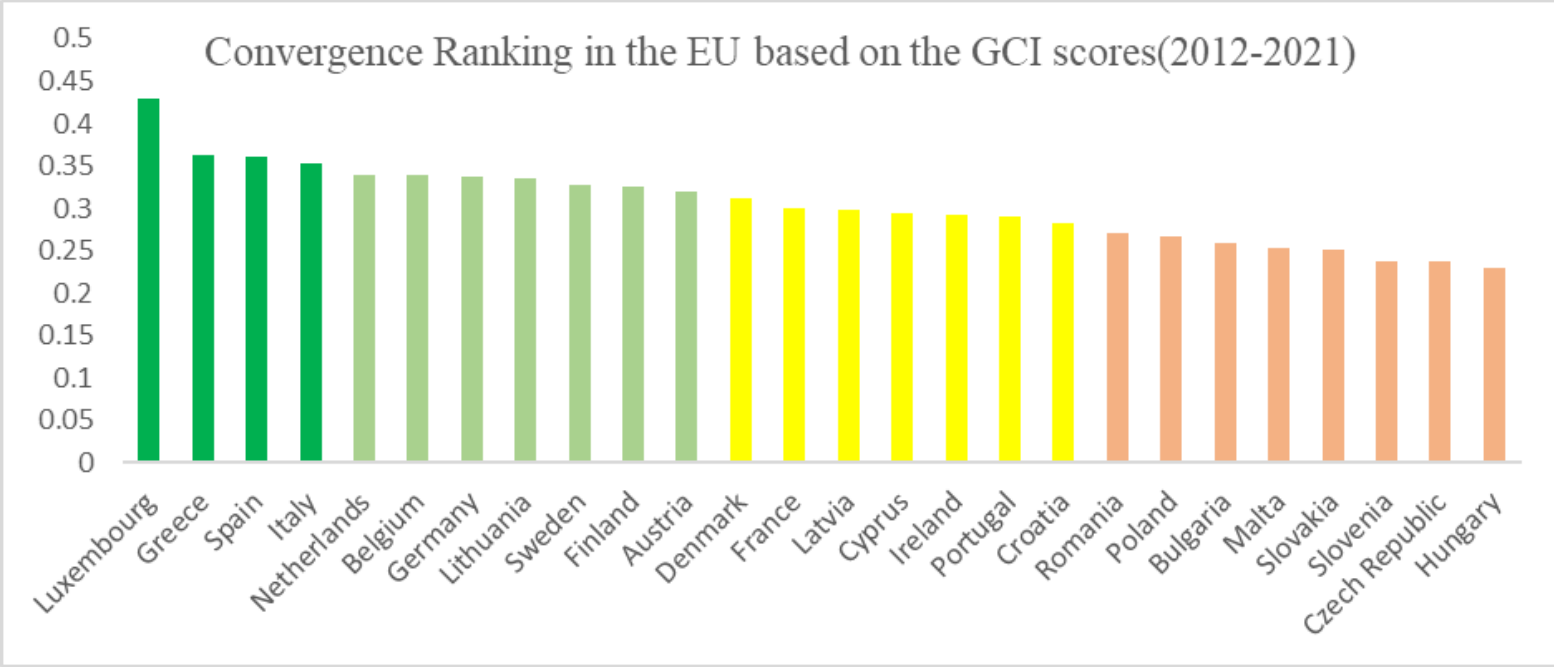
# GCI - Results

| IGC Weights (%) | PCA | CRITIC Method | Entropy Method |
|---|---|---|---|
| HICP Inflation Rate | 8.23 | 8.63 | 10.21 |
| Budget Deficit | 7.39 | 8.54 | 10.25 |
| Public Debt | 8.87 | 7.79 | 9.81 |
| Long-term interest rate | 8.58 | 8.13 | 7.64 |
| GDP per capita PPS | 8.99 | 6.56 | 9.27 |
| Real Exchange Rate | 4.47 | 10.22 | 7.28 |
| Unemployment Rate | 10.19 | 7.47 | 9.12 |
| SME Productivity | 10.28 | 7.20 | 1.72 |
| Innovation | 9.95 | 9.12 | 6.77 |
| Poverty Risk Rate | 3.87 | 8.71 | 9.64 |
| Tertiary Education | 9.32 | 9.63 | 8.05 |
| Youth Unemployment Rate | 9.87 | 8.00 | 10.23 |

# GCI - Ranking of EU member states

| Country | GCI PCA | GCI AHP | GCI Critic | GCI Entropy | AVERAGE | RANK |
|---|---|---|---|---|---|---|
| **Belgium** | 0.358 | 0.123 | 0.438 | 0.436 | 0.339 | **6** |
| **Bulgaria** | 0.227 | 0.140 | 0.324 | 0.340 | 0.258 | **21** |
| **Czech Republic** | 0.237 | 0.129 | 0.295 | 0.289 | 0.237 | **25** |
| **Denmark** | 0.342 | 0.176 | 0.371 | 0.358 | 0.312 | **12** |
| **Germany** | 0.353 | 0.215 | 0.402 | 0.384 | 0.338 | **7** |
| **Ireland** | 0.328 | 0.109 | 0.355 | 0.377 | 0.292 | **16** |
| **Greece** | 0.399 | 0.065 | 0.465 | 0.519 | 0.362 | **2** |
| **Spain** | 0.368 | 0.116 | 0.468 | 0.493 | 0.361 | **3** |
| **France** | 0.317 | 0.137 | 0.372 | 0.371 | 0.299 | **13** |
| **Croatia** | 0.273 | 0.111 | 0.360 | 0.388 | 0.283 | **18** |
| **Italy** | 0.396 | 0.116 | 0.458 | 0.442 | 0.353 | **4** |
| **Cyprus** | 0.316 | 0.106 | 0.369 | 0.387 | 0.295 | **15** |
| **Latvia** | 0.277 | 0.147 | 0.377 | 0.388 | 0.297 | **14** |
| **Lithuania** | 0.328 | 0.135 | 0.439 | 0.443 | 0.336 | **8** |
| **Luxembourg** | 0.467 | 0.174 | 0.538 | 0.542 | 0.430 | **1** |
| **Hungary** | 0.247 | 0.087 | 0.274 | 0.307 | 0.229 | **26** |
| **Malta** | 0.234 | 0.155 | 0.308 | 0.314 | 0.253 | **22** |
| **Netherlands** | 0.381 | 0.163 | 0.422 | 0.391 | 0.339 | **5** |
| **Austria** | 0.345 | 0.124 | 0.412 | 0.401 | 0.320 | **11** |
| **Poland** | 0.283 | 0.116 | 0.336 | 0.333 | 0.267 | **20** |
| **Portugal** | 0.286 | 0.120 | 0.363 | 0.390 | 0.290 | **17** |
| **Romania** | 0.258 | 0.084 | 0.360 | 0.381 | 0.271 | **19** |
| **Slovenia** | 0.238 | 0.133 | 0.289 | 0.292 | 0.238 | **24** |
| **Slovakia** | 0.233 | 0.130 | 0.315 | 0.324 | 0.250 | **23** |
| **Finland** | 0.343 | 0.168 | 0.400 | 0.391 | 0.326 | **10** |
| **Sweden** | 0.347 | 0.163 | 0.394 | 0.403 | 0.327 | **9** |

# GCI scores - Convergence Ranking in the EU




| Legend | |
|---|---|
| | Very high degree of convergence |
| | High degree of convergence |
| | Medium degree of convergence |
| | Low degree of convergence |

# Conclusions

- By analyzing Romania's position in the convergence ranking at the EU level, we can observe that, although it belongs to the group of countries with a low degree of convergence, our country leans towards a medium potential.

- The current position can be improved not only by implementing measures aimed at consolidating the fiscal position and correlating the business cycle, but also by implementing programs that aim to improve social convergence. All three convergence components (nominal, real, and social) must be seen and addressed as a whole, as existing interdependencies cannot be ignored.

- Although the general level of convergence of a country is not a precondition for joining the euro area, its development and expansion depend on and are conditioned by the elimination of disparities among member states.

# Q&A


QUESTION
ANSWER
QUESTION
ANSWER
QUESTION
ANSWER
QUESTION
ANSWER