

CONVERGENCE OF EXPENSES ON RESEARCH AND DEVELOPMENT AS A DETERMINANT OF INNOVATIVENESS – COMPARATIVE ANALYSIS

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Purpose: The purpose of this paper is to analyze the economic convergence of expenses on research and development and researching the trends of this convergence in the European Union states with the division into countries that joined the EU before and after 2004.

Design/methodology/approach: The trial was made to research the economic convergence to verify the influence of the factor determining the amount of R&D expenses at the national level the most. The research was conducted for the groups of the European Union states on the data from 2005–2023 from the Eurostat database. The variables were converted according to PPS and given in fixed prices of 2015 in order to avoid wrong conclusions.

Findings: The conducted research showed that the decisive parties wanting to increase their innovativeness have to pay attention to the level of economic growth and a significant role of human resources in creating innovativeness and in obtaining high competitiveness in the market. The periods of convergence (falling, the period of sustainable growth) and divergence can be noticed both in so called ‘old’ and ‘new’ European Union states. However, the pace is different in both groups and when it comes to both changes. It results from the fact that even though the Scandinavian countries lead in the field of innovativeness, the states of South-Eastern Europe are developing faster when it comes to innovativeness. Should such a tendency remain, the situation would be optimistic. In the ‘new’ EU states the average annual rate of GERD convergence towards GDP is 1.9 percentage point higher but calculated per capita is 1.4 p.p. lower. Thus, in the second case, the situation of the states that joined the Union in 2004 is not profitable especially considering the aging of the society.

Research implications: The following analyses should include more affecting the R&D expenses so that it was possible assess the convergence of the tested value in particular states in a more detailed way. The next important suggestion concerning the future analyzes is to extend them not only to the EU member states but it is necessary to use one source of information to provide reliable data.

Practical implications: Paying attention to all the factors affecting the innovativeness may contribute to the changes in companies and thanks to that improve the competitiveness of the whole economies in the international area.

Value: The convergence research affects efficient management in order to make the companies or countries competitive. The continuous raising of the innovativeness level and thanks to it, obtaining high efficiency, is the main source of competitive advantage.

Keywords: convergence, divergence, σ -convergence, absolute β -convergence.

Category of the paper: Research paper.

1. Introduction

The convergence of innovativeness refers to both the phenomenon of convergence process to the balance state as well as to the process of equalizing the development level of various countries (Strahl, 2011). So, talking about the convergence of structures, it is possible to use the term of convergence to almost every situation in which the forces encouraging people or social groups to achieve the common aim occur (Kluth, 2023).

Thus, analyzing the economic growth, the effect of approaching innovativeness levels is considered through the convergence of particular countries. It refers to the process of assimilating the less developed economies of countries (regions) to the more developed economies (Rapacki, Próchniak, 2019) by implementing new technologies, production processes (Hammar, Belarbi, 2021). Thus, it is possible to talk about the convergence of nations among other considering the GDP in the macroeconomic field. It is visible among others in the investments in research and development which are ones of the main factors affecting the management and competitiveness of companies or the support of their R&D activity by the state (Szymański, 2017; Celli, Cerqua, Pellegrini, 2024).

Due to this fact, considering the convergence of R&D expenses in this paper, they were referred not only to the population but also the GDP was used as a measurement factor used most often in the analyses to assess the economic convergence. Undoubtedly, it is connected with the fact of measuring the economy wealth with the use of GDP (Szajt, 2010).

However, the existence of differences between countries, e.g. various level of economic growth, makes it difficult to introduce new technologies and to adapt to common solutions. Nevertheless, it is not impossible to meet some standards, especially that the EU supports the member states actively in the scope of wider political, social and economic integrity, which contributes to the functioning of companies in the dynamically changing surroundings.

So, the fact that the financial means, and in particular possessing them, are undoubtedly the main element affecting the innovative activity especially in small and medium-sized enterprises, causes that the issue should be considered from the economic point of view (Baj, Pietucha, 2006; Ciupek, 2014; Lisowska, 2017; Perez-Alaniz et al., 2022; Ostrowska, Lipska, 2023). The % of GDP spent on R&D may be a significant (deciding) factor supporting the introduction of new solutions, services or products to the market and consequently contributing to the proper management in the companies. As it is widely known, this process is connected with high costs as the existence of a new product in the consumer's awareness needs a wide range of analyses and preparations (Rutkowski, 2021).

Due to the fact that the expenses on research and development play one of the most important roles in creating innovativeness and innovations, and that the EU supports economic convergence through various instruments, the question arises about the existence of connections of the expenses on research and development in the states that belonged to the Union before and after 2004 in respect to the mean of the given group of the EU states.

The answer to this question is aimed to help verify the following research hypothesis: The results of the research of convergence of expenses on research and development constitute a reference point to building greater competitiveness between 'old' and 'new' EU member states and it may support to manage the means assigned on innovations in particular countries.

Taking the above into consideration, the purpose of this paper is to assess the convergence of expenses on research and development as an external economic factor affecting the innovativeness.

Thus, this paper constitutes an attempt to satisfy the purpose and is the contribution to paying attention to the consistence of expenses assigned on research and development as a factor deciding about the competitiveness of companies in the international markets indirectly.

2. Method

In the long-run all countries pursue to achieve the common level of sustainable growth (Ciołek, 2003). Taking it into consideration, it is possible to state that with the time the economies with the similar level of income per capita show the tendencies to achieve the similar status at the domestic level or at the level of companies.

The information about the R&D expenses and the GDP, which affect the considered determinant of innovativeness and the management of companies significantly, were used to assess the situation in the analyzed EU states.

Due to the fact that the author's interests are focused on the economic convergence in the EU, the σ -convergence and unconditional β -convergence were tested in this paper as a necessary condition but insufficient for σ -convergence (Wójcik, 2018). It was assumed that the tested countries pursue to equalize the level of their economic growth among others by decreasing the differences among them concerning the expenses on research and development.

The coefficient of variation or its logarithm were used to assess σ -convergence (Rosiek, 2011). Thanks to this coefficient, it is possible to test how e.g. the levels and relations of R&D expenses change in particular countries towards the mean for the analyzed group of countries. Lower values of the measures of dispersion of the data i.e. logarithms of the coefficient of variation for countries show the greater connection of the tested values confirming the existence of the convergence phenomenon. Moreover, the analysis of variance of data going through two points was performed during testing the σ -convergence. It was performed by raising a hypothesis $H_0: \sigma_{2005}^2 = \sigma_{2023}^2$ towards $H_1: \sigma_{2005}^2 > \sigma_{2023}^2$. The verification of H_0 was conducted with the use of the test:

$$F = \frac{s_{2005}^2}{s_{2023}^2} \quad (1)$$

where:

s_{2005}^2 – variance of R&D expenses indicated for group i for 2005,

s_{2023}^2 – variance of R&D expenses indicated for group i for 2023.

The rejection of H_0 for the benefit of H_1 means the confirmation that the convergence effect exists, i.e. the phenomenon in which the variation of a given value decreases in a tested group with the time.

Whereas, the concept based on the assumption that all the analyzed countries pursue to the same status of development (balance) was used to test the existence of the absolute β - convergence which exists in the case of the decrease in discrepancies concerning the income per capita. The model of this convergence was created as follows:

$$\frac{1}{T}(\ln WBR_{iK} - \ln WBR_{i0}) = \alpha + \beta \ln WBR_{i0} + \varepsilon_{it} \quad (2)$$

where:

$\ln WBR_{iK}$ – \ln of R&D expenses in country i in the final year,

$\ln WBR_{i0}$ – \ln of R&D expenses in country i in the beginning year,

α – constant term,

β – structural parameter used to determine the pace of convergence (π): $\beta = (-1 + \exp(-\pi T))/T$,

ε_{it} – random component,

T – number of years for which the growth rate is calculated,

$(\ln WBR_{iK} - \ln WBR_{i0})/T$ – the mean annual growth rate of R&D expenses in country i in time K .

The negative value of β parameter means the existence of convergence, the positive value higher than one, the value of this parameter is equal to the existence of the divergence phenomenon.

The data from the EUROSTAT database were used in the analyses and the time series coming from one source were used to avoid the differences in the method of data collection in the paper. The sample covered the years 2005-2023 and among others the GRETl package was used during the analyses.

3. Results

Analyzing the convergence, the R&D expenses calculated per capita (in euro according to PPS) and measured as a % of Gross Domestic Product were tested in the research. The author divided the Union states depending on the moment of joining the EU in order to achieve the aim.

The results for sigma (σ) convergence are presented in the charts below showing the shaping of the ln of coefficients of variations in years 2005-2023.

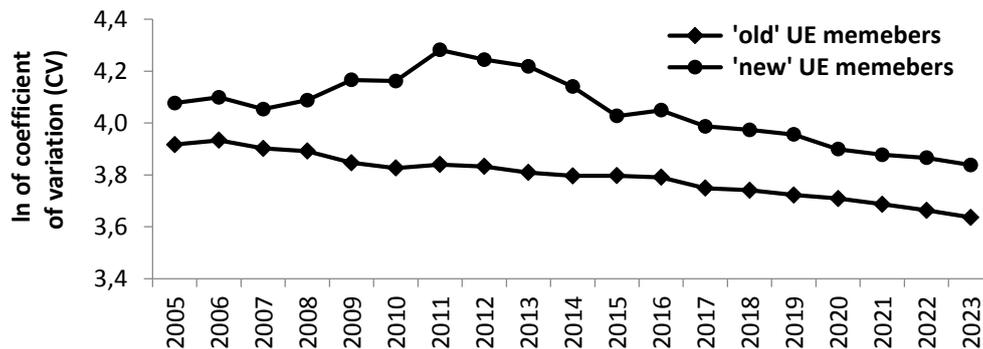


Figure 1. The values of ln of coefficients of variation for research and development expenses for the analyzed groups of the EU states in the mean of these countries (per capita, PPS).

Source: own study based on Eurostat.

Analyzing figure 1, both the periods of convergence as well as divergence were noticed. The phenomenon of convergence between so called 'old' and 'new' EU member states is visible in the case of GERD per capita in years 2005-2006, 2011-2015 and since 2016, whereas the phenomenon of divergence in the period 2007-2011 and 2015-2016. However, considering the whole period of the research, the percentage of the standard deviation in the means of the tested groups of the EU states decreased. Nevertheless, it is slight and amounts to about 0.26 percentage point. Examining the GERD of particular countries, we notice that it is possible to talk about the biggest share of the mean differentiation in the case of Poland (59%), Croatia (49.9%) and Bulgaria (47.2%), whereas the lowest indicator was noticed in Luxembourg (6.84%), Finland (10.4%) and France (12.8%). When it comes to the average pace of changes, the highest value of the geometric mean was observed in Poland (111.1%), Bulgaria (109.1%) and Romania (108.5%) and the lowest in Finland (101.9%), France (102.5%) and Sweden (102.7%).

A bit different situation can be seen in the figure in which GERD was compared to GDP, thus to the relations which the companies consider while taking strategic innovative decisions.

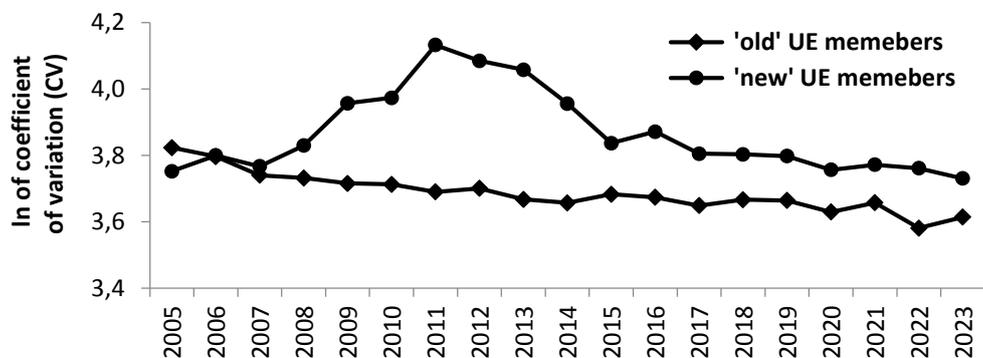


Figure 2. The values of ln of coefficients of variation for research and development expenses for the analyzed groups of the EU states in the mean of these countries (the GDP percentage).

Source: own study based on Eurostat.

On the basis of the information presented in figure 2, it is also impossible to talk only about convergence or divergence. The convergence was observed in two periods: 2005-2006, 2012-2021 and from 2022 to 2023. In the other years, the divergence is visible in both groups. It is possible to notice the fall in \ln of CV in both groups in the tested period but in the case of the states belonging to the EU before 2004 this fall was bigger by about 20.6%. Considering the difference between these measurements in the whole period, it is possible to state that it shaped on average at the level of 3.7 \ln and it was for the benefit of the countries in the Southern and Eastern Europe. Whereas, in 2023 the percentage of the standard variation in the mean of a given group amounted to 12.3% being also more beneficial for these countries. Considering the relative measurement of differentiation in a given group of the EU, its highest value was in Greece (35.8%), Poland (33.3%) and Cyprus (23.9%) and the lowest in France (3.2%), Denmark (7.2%) and Spain (7.5%). However, the order of countries is different when it comes to the average rate of changes. Here the highest value of the geometric mean was observed in Greece (105.3%), Portugal (104.5%) and Slovakia (104.1%) and the lowest in Finland (96.6%), Luxembourg (97.6%) and Sweden (100.4%).

Moreover, comparing the information included in both figures, it should be noticed that the values of R&D expenses vary from the mean in the tested groups much more in the case of expenses calculated per capita in the states belonging to the EU from 2004 in the whole tested period. Even though it is possible to observe the advantage of 'old' countries in comparison to the 'new' ones only in 2005 when it comes to R&D expenses in % of GDP, it could have been assumed due to the possibilities of development including economic and historical conditions, which is usually connected with other ways of management. However, independently of shaping the expenses, it is possible to state that there is a decreasing tendency in the whole analyzed period. Four trend functions were assessed in order to present this direction of changes. The first two indicate the changes of the tested expenses measured in euro per capita, PPS, the other two the average periodic rate of changes also calculated as the percentage of GDP. Thus, functions (3) and (5) refer to the countries belonging to the EU before 2004 and (4) and (6) to countries joining the structures of the Union from 2004:

$$\hat{y}_1 = 0,513 - 0,007 \cdot t \quad (3)$$

$$\hat{y}_2 = 0,674 - 0,009 \cdot t \quad (4)$$

$$\hat{y}_3 = 0,438 - 0,004 \cdot t \quad (5)$$

$$\hat{y}_4 = 0,516 - 0,003 \cdot t \quad (6)$$

where:

y_i – coefficients of variation GERD for the group i of the EU states in the period 2005-2023,

$i = 1, \dots, 4$.

The negative value of the coefficient with the time variable shows the decreasing differentiation of the taken factor in the whole period, which confirms the direction of changes.

Moreover, while analyzing test (1), for $\alpha=0,20$ test F shows that there are no reasons to reject H_0 for the benefit of H_1 in the case of the GDP percentage assigned for R&D expenses but it should be rejected for GERD per capita. It confirms the existence of convergence in years 2005-2023 in respect to the expenses assigned on R&D (per capita, PPS) and when it comes to the tested expenses as % of GDP, it should be talked about the partial divergence and more precisely about the lack of reasons to state that the convergence does not occur in the whole period.

Considering the data presented in figures 1 and 2, it is difficult to indicate clearly for which of the groups presented in them the rate of convergence is higher. However, the unconditional convergence was assessed for both presented groups to specify this rate. The results of the β -convergence analysis show that at the estimation of absolute convergence coefficients β in model (2) are negative and statistically significant in all cases (Table 1).

Table 1.

Estimate of parameters in model (2)

UE members	GERD per capita			GERD as %GDP		
	β	Parameter error	P-value	β	Parameter error	P-value
old EU states	-0.021	0.006	0.003	-0.021	0.008	0,019
new EU states	-0.015	0.006	0.038	-0.003	0.003	0.194

Source: own work based on the GRETL program.

On the basis of the values of coefficients β it is possible to state that the convergence of R&D expenses given in euro per capita, PPS was the same as in the case of these expenses measured as % GDP – about 2.5% in the ‘old’ countries. However, in the new EU states the average annual rate of convergence was different and amounted to 1.1% (per capita) and 4.4% (share in %GDP).

4. Discussion

The convergence of innovativeness may be considered as the ability to create, initiate and absorb the innovations (Bal-Domańska, 2011), regarded as a significant factor affecting the challenges of sustainable growth most often (Azmat et al., 2023). Thus, considering the innovation convergence process is to understand in which scope the new solutions which affect various aspects of social, technological and economic life are introduced. Although each innovation disturbs the current situation in the company, the introduction of a new solution contributes to the increase in competitiveness of small and medium-size enterprises highly (Klimek, 2015), which affects their management and in particular taking strategic decisions.

Considering the convergence from the economic point of view, it can be confirmed that the undoubtedly different level of economic growth can be observed in each country, which makes it more difficult to manage at the mezzo and macro-level. These differences cause that

the research should be focused on the convergence of R&D expenses between countries, i.e. the means playing a significant role at innovativeness (Beizitere, Brence, Sloka, 2020). However, meeting some standards in this scope is difficult despite active support of the Member States by the EU when it comes to stronger economic integration (Kusideł, 2013; Campos, Coricelli, Moretti, 2019; Hecke, Cunj, 2023). In consequence, being by the Union so called 'convergence machine' (Nagy, Šiljak, 2022) may be regarded as complicated but not impossible. In other words, the actions taken by the EU contribute strongly to the GERD convergence measured in % of GDP as this relation is one of the main factors showing the economic condition and innovativeness of the countries (Gürler, 2022).

Taking the above into consideration and according to the opinion of some researchers (Stephan, 2012; Etzkowitz, Leydesdorff, 2000; Petersen, Arroyave, Pavlidis, 2023), it is possible to say that the convergence is really complex, especially in the area of innovativeness. They claim that mutual synergies of the industry, research institutions and the government are incredibly important for all actions oriented on innovations and economic growth (Petersen, Arroyave, Pavlidis, 2023). However, it should be noticed that the companies often finance their research and development activity from their own means (Perez-Alaniz, et al., 2022), which is significant in the process of taking management activities. Despite the range of difficulties the companies meet, they depend on the increase in their ability to innovativeness as it is a necessary condition for the company to develop and obtain the competitive advantage at each level (Crossan, Apaydin, 2010; Raymond, St-Pierre, 2010). Moreover, common activities of the companies may contribute to the creation of new solutions among others technological convergence offered to various subjects (Kim, 2017), but it should be remembered that it is necessary to integrate social sciences with the exact sciences (Ashton, et al., 2024). It results from the fact that the human factor plays the main role in creating any innovativeness which plays in companies striving to be competitive. Moreover, in the process of applying for acquiring customers and increasing their market share, the companies are obliged to take sensible financial decisions and to join them with business strategies both in the short and long perspective (Peprah, Ayaa, 2022). It shows that the company should regard the process of innovation management holistically, especially due to the fact that in the case of innovativeness and in particular while launching innovations, it is possible to talk not only about the existence of convergences but also divergence of the aims of countries or companies. So the convergence does not have to be a continuous process and there may occur the periods of stagnation or inhabitation (Berbeka, 2006; Delhey, 2001).

What is more, innovations are a significant factor of sustainable growth in many countries, which forces the companies to discuss the business strategies so that the company was competitive both in the domestic and foreign market.

5. Conclusions

The comparative analysis of convergence of so called 'new' and 'old' EU states presented by the author showed that the decrease in differentiation in time talks about the equalizing of the level of analyzed expenses among the countries. The existence of greater disperse of data in respect to the expenses per capita confirms the existence of greater inequalities in the case of this value. However, presenting the analyzed expenses as % of GDP, although it is used in international comparisons most often, has some limitations. The value of research and development expenses issued by the citizens of a given country is not visible. So the expenses per capita in euro according to PPS may be a better measurement from the convergence point of view as they show the differences in the levels of these expenses in various countries. Furthermore, on the basis of the presented research results, it is possible to state that big in homogeneities in the levels of expenses per capita suggest that this variable may play an important role in the convergence processes. Apart from that, the advantage of the greater R&D expenses differentiation converted per capita in particular countries shows both the stronger position of the EU states in which the GDP in respect to the number of people is greater and also the preferences of the persons interested in new solutions.

As it was shown, the values of the share of the standard deviation in the mean decreases with time in each tested group, which confirms the existence of the convergence phenomenon. However, while assessing the convergence power, it was stated that it was very weak and it is possible to even talk about divergence periods, which confirms various level of economic growth in the countries. Thus, it results from the presented research that the convergence is not an uninterrupted process and the conclusion may be taken that such periods exist as: divergence (2007-2011; 2015-2016), falling convergence or the time of sustainable growth. What is more, it is possible to talk about the inverse convergence in 2006 but only when it comes to the R&D expenses in % GDP. Although the change in the positions of the two groups occurred, it may be caused by the changes in the dynamics of this factor growth/fall.

Despite this, it is possible to state after the convergence analysis that the countries strive to the similar state of GERD in the long term in spite of various beginning conditions and do it with various intensification. Thus, it can be stated that the verification of the innovativeness policy is necessary in all the Union states. The author assesses that it will be a long term process and its results will surely depend on the level of economic growth and demographic changes. Especially that functioning of the companies in the scope of innovativeness depends on the condition of the economy and the politics run by the governments. There are some changes in the approach to the innovative actions in all the countries but they are insufficient, especially in the context of leveling inequalities in assigning R&D expenses and in the way of the activity towards human resources.

However, analyzing the innovativeness, the author claims that the human capital without which the creation of innovative solutions is impossible should be undoubtedly included in future analyzes. Thus, the companies should approach both the technological and social convergence in a more responsible way.

In conclusion, the author wants to emphasize that R&D expenses should be considered not only in the economic dimension but also in the environmental and social one. According to the author, the presented analyzes may be a starting point for further research on the sustainable growth factors. Such conclusions are taken from the assessment of funds assigned for innovativeness and with the assumption that new processes and commercial products will have a positive influence on the company management so also the whole economy.

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