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IMPORTANCE OF LABOUR FACTOR IN BIOECONOMY SECTORS – POLAND VS. EUROPEAN UNION COUNTRIES

Renata KUBIK[1], Aneta ZAKRZEWSKA[2*]

[1] University of Life Sciences in Lublin; renata.kubik@up.lublin.pl, ORCID: 0000-0002-8227-945X
[2] University of Life Sciences in Lublin; aneta.zakrzewska@up.lublin.pl, ORCID: 0000-0001-8972-220X
* Correspondence author

Purpose: Bioeconomy is one of the largest and most important sectors of the European Union economy. It employed over 17 million people in 2021 and generated an added value of approximately EUR 728 billion. This study assessed the utilisation of the labour factor in bioeconomy sectors in Poland compared with other European Union countries.
Design/methodology/approach: An analysis was conducted on employment levels and labour productivity from 2010 to 2021. The study also attempted to classify EU countries based on relative measures of average labour productivity in the bioeconomy and the dynamics of changes observed.
Findings: In Poland, the bioeconomy recorded a labour productivity of EUR 12,552 per employee, which represented only 38% of the EU average. Poland ranked 25th in the bioeconomy labour productivity. Throughout the analysed period, labour productivity in Poland rose by 78%. Changes in the sectoral employment structure were noted, with a shift of employees from low-productivity sectors to those with higher productivity. Like most countries that joined the EU after 2004, Poland is one of the countries that are "catching up" due to low labour productivity, which is growing at an above-average rate. Investing in technology and innovations that enhance labour efficiency is essential for competing with countries that have high labour productivity.
Research limitations/implications: The key methodological limitations identified in the analysis concern data availability, both temporal and cross-sectional.
Originality/value: In this article, the authors attempt to classify EU Member States according to relative measures of average labour productivity in the bioeconomy and the dynamics of its changes in the years 2010-2021 in order to indicate the existence of beta convergence.
Keywords: bioeconomy, labour, productivity.
Category of the paper: Research paper.

1. Introduction

Many authors have noted the lack of consensus concerning a uniform, universally accepted definition of bioeconomy (NASEM, 2020; Maciejczak, Hofreiter, 2013; Kozyra et al., 2023). Since the first presentation of the bioeconomy concept by Enriquez and Martinez in 1997 (Enriquez, 1998), its definition has been evolving – it has been expanded and narrowed down, and the emphasis on its various aspects has shifted. Nevertheless, many authors have stressed the common elements, such as, for example, the importance of the concept of sustainable development, the application of knowledge, research and innovation in biotechnology, and replacing fossil fuels with biological resources (Maciejczak, Hofreiter, 2013). Individual definitions emphasise various aspects and priorities: technological, economic and social, and address various conditions and concepts of development, such as sustainable or innovative development (Adamowicz, 2017). According to the definition of bioeconomy formulated by the European Commission, it "includes production of renewable biological resources and transformation of such resources and streams of waste into added-value products, such as food, fodder, bioproducts and bioenergy" (European Commission, 2012a, p. 3). This gives bioeconomic sectors considerable potential for innovation because they make use of multiple fields of science and various technologies.

The bioeconomy concept was introduced in the European Union as a strategy under the title "Innovations for sustainable growth: bioeconomy for Europe" in 2012 (European Commission, 2012). This is the European Union's answer to the most topical challenges, such as ensuring food security, sustainable management of natural resources, mitigating climate change and limiting dependence on non-renewable resources (Nowak, Kobiałka, Krukowski, 2021). The aim of this strategy was to present a comprehensive approach to current issues, including ecological and environmental issues, energy generation, supply chains and challenges concerning the protection of natural resources in Europe. This served as a foundation for domestic strategies aimed at bioeconomy development in individual member states, implemented in countries such as Finland, Austria, France, Germany, Ireland, Italy, Latvia, the Netherlands, Spain, and Portugal (The bioeconomy…, 2025). Poland still does not have a separate strategy for the bioeconomy. There is no single ministry in Poland which is responsible for developing its framework centrally or for defining its development directions due to the cross-sectional and intersectoral nature of the bioeconomy (Mapa drogowa…, 2021). However, Poland participates in the macroregional bioeconomy initiative, BIOEAST, developed by countries of Central and Eastern Europe, which was joined by the Visegrád Group countries as well as Bulgaria, Romania and Slovenia (Kozyra et al., 2023). The domestic bioeconomy strategy is being developed within the BIOEAST platform (Knowledge Centre…, 2025). The main documents concerning bioeconomy in Poland include:

- Roadmap for transformation towards circular economy (2019).
- National Smart Specialisation (MR, 2020).
- State Scientific Policy (MEiN, 2022).

According to Adamowicz (2017), the bioeconomy concept can play an important role in the integration of various economic sectors. The intensification of bioeconomy research and its support for the practical development of bioeconomy can be important factors in boosting Poland's international competitiveness.

Issues related to the bioeconomy have been dealt with in many scientific papers. For example, a search for the word "bioeconomy" in the Mendeley database yielded 12,261 records with scientific papers and 1648 books (Mendeley). Many of these studies have dealt with the theoretical problems of a bioeconomy (Maciejczak, Hofreiter, 2013; Adamowicz, 2020; Heiden, Lucas, 2022), while others have focused on the dominant role of agriculture in the bioeconomy (Nowak, Kobiałka, Krukowski, 2021). There are also papers presenting analyses of individual sectors of the bioeconomy (Ronzon et al., 2017; Ronzon et al., 2020) and analyses of the bioeconomy in European Union countries (Bălan, Cismas, 2022; Morone, D'Adamo, Cianfroni, 2022; Ronzon, Iost, Philippidis, 2022).

Research on bioeconomy as a crucial economic strategy within the European Union supports the objective of this study, which aims to evaluate the labour factor's application in the bioeconomy sectors across the EU, with a specific focus on Poland.

2. Methods

The study used data on the bioeconomy and its individual sectors during the period between 2010 and 2021. The data were obtained from the EU Bioeconomy Monitoring System, which is the source of the most important information on the bioeconomy in the EU (Data-Modelling platform…). The geographical range covers EU member states (27 states without the UK). Bioeconomy by sectors in the Statistical Classification of Economic Activities in the European Community (NACE) (Giuntoli et al., 2020) includes the following sectors:

I. Agriculture (A01).
II. Forestry (A02).
III. Fishing and aquaculture (A03).
IV. Food, beverage and tobacco (C10, C11, C12).
V. Bio-based textiles (C13, C14, C15).
VI. Wood products and furniture (C16, C31).
VII. Paper (C17).

VIII. Bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels) (C20, C21, C22).
IX. Liquid biofuels (C2014, C2059).
X. Bio-based electricity (D3511).

The assessment of the labour factor in the bioeconomy involved a comprehensive analysis of employment and labour productivity. This analysis aimed to classify EU member states based on relative measures of average labour productivity in the bioeconomy and the dynamics of its changes. Specifically, the employment analysis utilised structure and dynamics indices, while labour productivity was calculated using data on added value and employment within each bioeconomy sector. This productivity index demonstrates how effectively the labour factor is utilised to generate added value. Additionally, changes in productivity encapsulate the cumulative effects of capital modifications, as well as advancements in technology, organisation, and efficiency. These changes also reflect the influence of economies of scale and varying degrees of production capacity utilisation (OECD, 2001). The data analysed were primarily presented as averages over the study period.

3. Results

Average annual employment in the EU bioeconomy during the period of 2010-2021 was nearly 18 million people (Data-Modelling platform…, 2024), with the largest portion (nearly 10 million) working in agriculture (Fig. 1). This was followed by the food, beverage, and tobacco production sectors, as well as the wood products and furniture manufacturing sectors. Poland was the country with the highest employment in the bioeconomy sector of all the EU countries in 2021 (2.4 million). Agriculture alone employed 1.6 million people, which accounts for 65% of all those employed in the bioeconomy in Poland. As in the whole EU, the sector of food, beverage and tobacco production was the second largest bioeconomy in terms of employment.

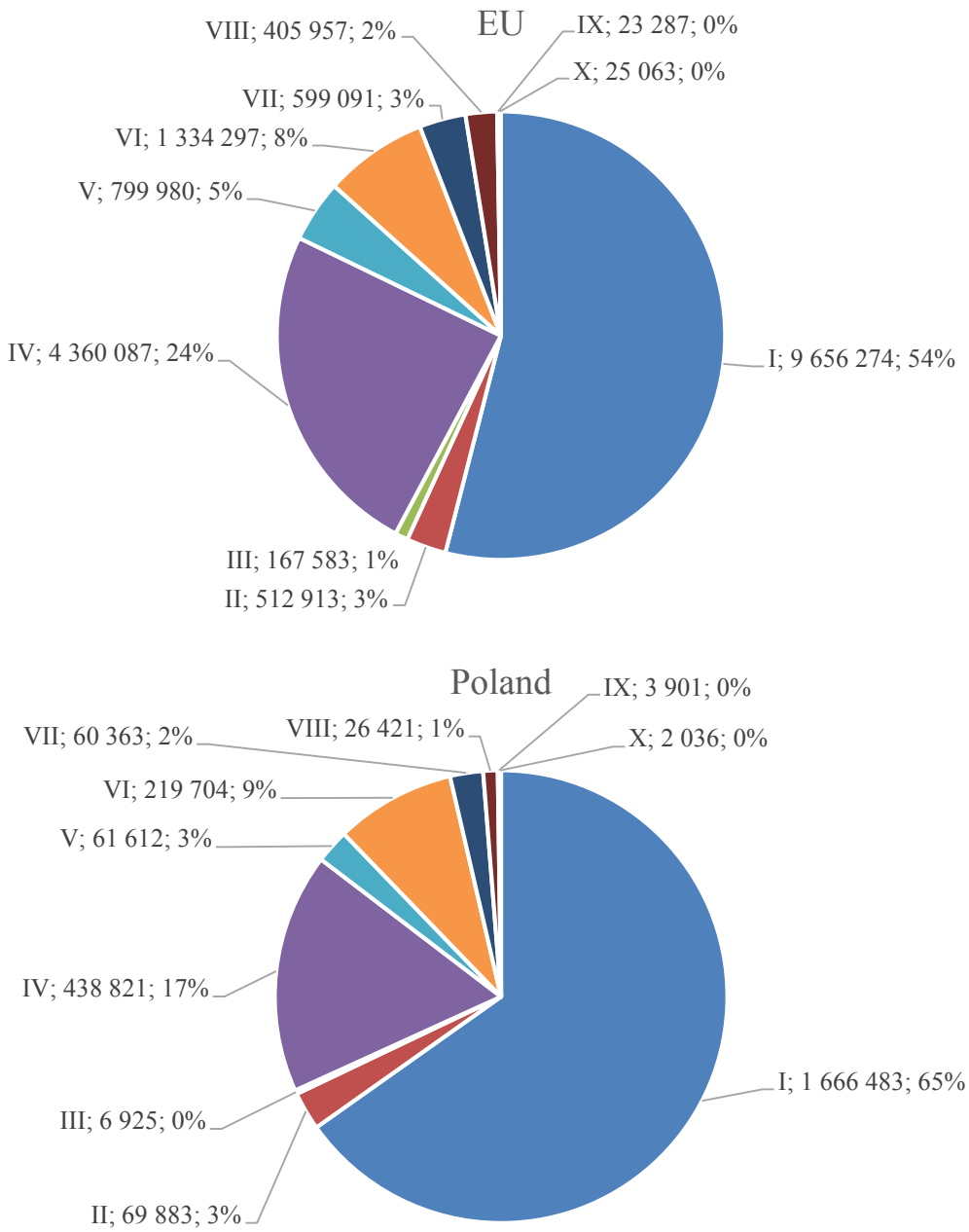

Figure 1. Size and structure of employment in bioeconomy sectors in the European Union and in Poland in 2010-2021.

Source: Authors' elaboration based on the Data-Modelling platform of resource economics.

Labour productivity is one of the major measures of labour factor utilisation efficiency. Figure 2 shows the average labour productivity in individual bioeconomy sectors in Poland and the average level in the EU during the 2010-2021 period. The average labour productivity in the EU, measured by the added value generated in the whole bioeconomy per one employee in all sectors of biomass production and processing, was EUR 33,219. The labour factor utilisation was less efficient in Poland. The overall average labour productivity in the bioeconomy in Poland was 2.5 times lower than the EU average (EUR 12,552 per employee).

A comparative analysis between Poland and the EU revealed significant differences in labour productivity within the bioeconomy overall and across its individual sectors. Notably, the electric bioenergy sector proved to be the most productive when measured against labour input. While labour productivity in Poland reached a high of EUR 107 thousand per employee, it is important to note that this figure was nearly half that of the EU average in the sector. Furthermore, high labour productivity was also evident in the EU's chemicals of biological origin sector (EUR 140,026) and the liquid biofuels sector (EUR 133,869). In Poland, the chemical sector occupied second place, with a productivity value of EUR 42,635 per employee, which represented just one-third of the EU average for this sector. Additionally, the paper production sector showed a productivity level of EUR 38,397, equating to 55% of the EU average, while the liquid biofuels sector recorded EUR 35,136, which is merely 26% of the EU average. These discrepancies, particularly in the biofuel and chemical sectors, indicate that their potential is not being fully utilised in Poland. In contrast, agriculture emerged as the least productive sector during the analysed period, with the average employee in Poland generating added value of only EUR 6268, which is one-third of the EU average.

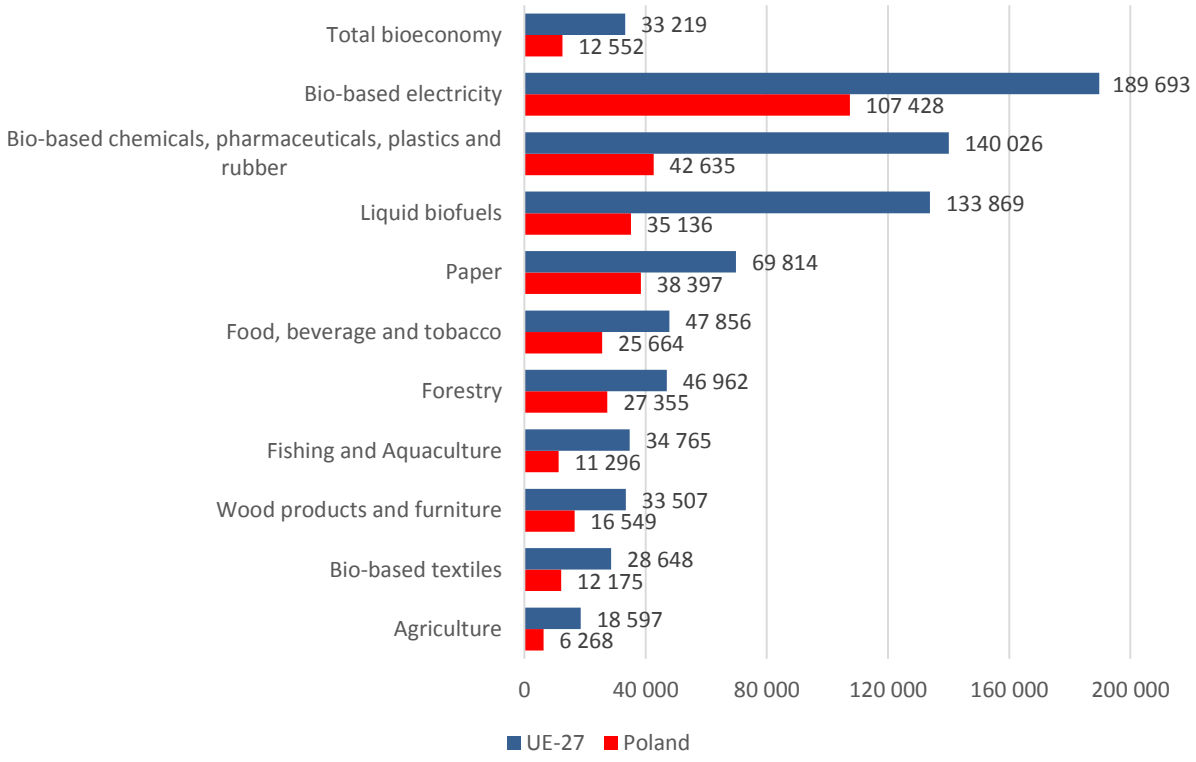

Figure 2. Productivity of labour in bioeconomy sectors in the European Union and in Poland in 2010-2021, average in EUR/employee.

Source: Authors' elaboration based on the Data-Modelling platform of resource economics.

Apart from examining labour productivity in individual bioeconomy sectors, an analysis of the importance of the labour factor in the Polish bioeconomy should also determine the position of Poland compared with the other EU countries. Figure 3 shows a list of EU countries ranked

by the average labour productivity in the bioeconomy during the 2010-2021 period. The average labour productivity in the EU bioeconomy amounted to EUR 33,219 per employee. This index varies from one EU country to another. The top ranking is held by the Irish economy, which boasts an average labour productivity of EUR 90,976, nearly three times higher than the EU average. Labour productivity in the Polish bioeconomy was EUR 12,552, accounting for a mere 38% of the EU average and placing Poland in the 25th position among 27 member states. A lower index level was found only in Romania and Bulgaria, with the added value of EUR 5025 and EUR 4823, respectively, i.e. approximately 1/7 of the EU average. It is noteworthy that 13 out of the 27 member states achieved labour productivity above the EU average, 12 of which were "old" EU member states. On the other hand, the lower half of the ranking (with labour productivity levels below the EU average) mainly included countries that joined the EU in 2004 or later, i.e. "new" EU countries.

A horizontal analysis shows that labour productivity increased in all EU member states in 2021 compared to the analysis baseline, i.e. the year 2010 (cf. Fig. 3). The average added value per employee in the EU bioeconomy increased from EUR 26,775 in 2010 to EUR 42,371 in 2021, i.e. by 58%. The highest change dynamics were found in countries in the lower half of the ranking, i.e. those with labour productivity below the EU average. This group also included the Polish bioeconomy, where labour productivity increased from EUR 9,261 in 2010 to EUR 16,480 in 2021, which is a growth of 78%. In contrast, the growth rate of the index in countries with above-average labour productivity was lower than the EU average.

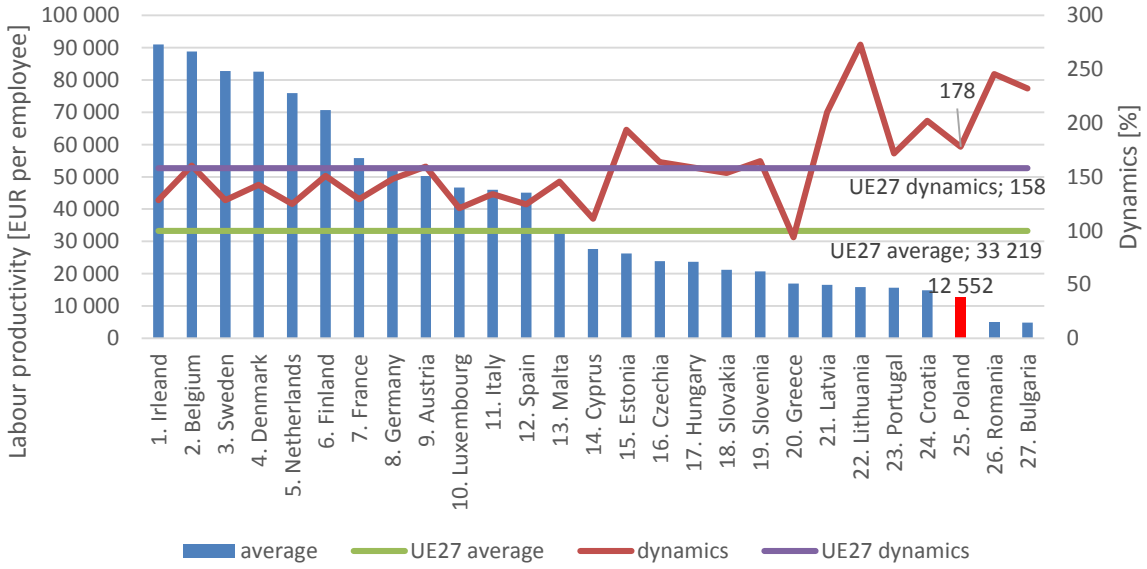

Figure 3. Labour productivity in the bioeconomy in EU member states in 2010-2021, average (EUR/employee) and change dynamics (%).

Source: Authors' elaboration based on the Data-Modelling platform of resource economics.

Figure 4 illustrates an attempt to classify EU member states based on relative measures of average labour productivity in the bioeconomy and the dynamics of its changes from 2010 to 2021. Their values calculated for 27 EU countries were taken as the reference point

(the reference value for EU27 = 1.00). The analysis identified five groups of countries: "leaders", "saturated", "catching up" countries, "tail", and "average" countries. The first group includes "leaders" in terms of labour productivity in the bioeconomy, in which the index and the dynamics of change are above average. These criteria were met by two countries during the period under analysis: Belgium (BE) and Austria (AT). The group of countries "saturated" in terms of labour productivity includes countries with high levels of productivity but where the growth dynamics are below the EU average. Ten countries are included in this group: Ireland (IE), Denmark (DK), Sweden (SE), The Netherlands (NL), Finland (FI), France (FR), Germany (DE), Luxembourg (LU), Italy (IT) and Spain (ES). It is noteworthy that both of these groups are comprised of only old EU countries. The group of "catching-up" countries consists mainly of new EU states. It includes countries with low labour productivity in the bioeconomy but with an above-average growth rate. The group of "catching up" countries during the 2010-2021 period included Estonia (EE), Czechia (CZ), Hungary (HU), Slovenia (SI), Latvia (LV), Lithuania (LT), Portugal (PT), Croatia (HR), Poland (PL), Romania (RO) and Bulgaria (BG). The group referred to as the "tail" comprises countries with both low labour productivity and low growth rates. This group was comprised of three countries: Cyprus (CY), Slovakia (SK), and Greece (EL). The last group includes "average" countries, in which labour productivity and its change dynamics are close to the EU average. This group includes Malta (MT).

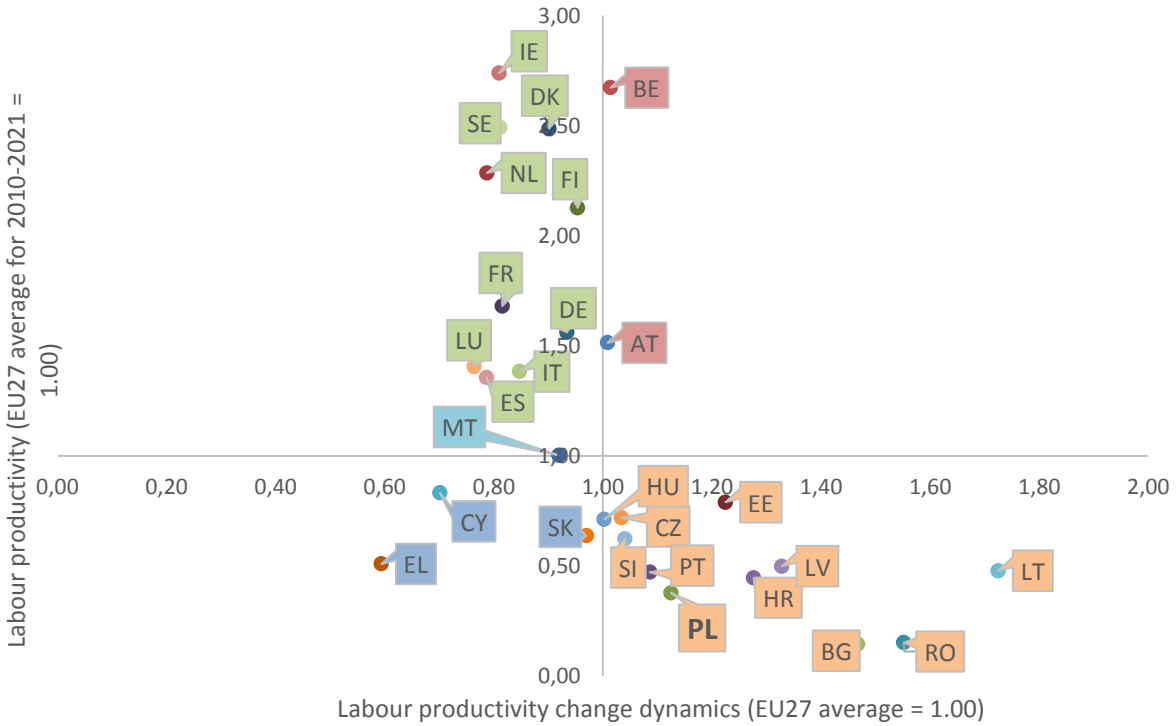

Figure 4. Classification of EU member states according to relative measures of average labour productivity in the bioeconomy and the dynamics of its change in 2010-2021.

Source: Authors' elaboration based on the Data-Modelling platform of resource economics.

4. Discussion

The current study identified agriculture as the sector of the bioeconomy with the lowest labour productivity, both in Poland and in the EU. The low productivity of agriculture in Poland results largely from a high employment level (Zakrzewska, Nowak, 2024). Although this decreased by about 25% during the period under study, an increase in labour productivity in this sector was a consequence mainly of the growing amount of equipment owned by farmers (Kubik, Zakrzewska, 2024).

This analysis showed significant differences in labour productivity between individual sectors of the bioeconomy. Similar results were obtained by Ronzon et al. (2020), who analysed the 2015-2017 period. Differences in labour productivity between individual EU countries were noted by Nowak, Kobiałka and Krukowski (2021) and Ronzon, Iost and Philippidis (2022).

An attempt at classifying EU member states according to relative measures of average labour productivity in the bioeconomy and the dynamics of its change in 2010-2021 indicated the existence of beta convergence. In it, economies with a lower initial revenue are characterised by higher growth dynamics compared with better-developed economies of rich countries. In effect, it leads to gradual equalisation of the income per capita in the groups of economies under study (Baer-Nawrocka, Markiewicz, 2012).

5. Summary

The objective of this study was to assess the use of the labour factor in bioeconomy sectors in Poland compared with other European Union countries in 2010-2021.

Poland has the largest human labour resources among EU countries. Although this results in low labour productivity, it could also be viewed as a potential competitive advantage. Transformations in the sectoral employment structure, particularly "moving" employees from low-productivity sectors to high-productivity sectors, can bring benefits in a longer-term perspective or in cases of labour force shortage caused, for example, by a disadvantageous demographic structure. The period under study saw a gradual decrease in employment in agriculture, with an increase in other sectors, i.e. food processing and the manufacturing of products from wood and furniture.

The average labour productivity in the bioeconomy in Poland in 2010-2021 amounted to EUR 12,552 per employee, which was 2.5 times lower than the EU average and shows that labour factor utilisation in Poland is less effective.

The analysis also found considerable differences in the average productivity between individual bioeconomy sectors. In Poland, it was the highest in the electric bioenergy sector, and yet its level was about half of that achieved in the EU. Unused potential was also observed in the liquid biofuel sector and in the field of chemicals of biological origin. Agriculture proved to be the weakest link in terms of utilisation of the labour factor. Although it provides the largest number of jobs of all the bioeconomy sectors, its high employment level has an adverse impact on labour productivity. This amounted to a mere EUR 6268 per employee in agriculture in Poland, which was 1/3 of the EU average. The distance to the EU average can be reduced by increasing productivity in sectors with a high potential and by optimising the employment structure, particularly by an outflow of excessive employees from agriculture.

The current study also confirmed the diverse utilisation of labour in the bioeconomy of different EU countries. The highest productivity was achieved by Ireland (more than seven times higher than Poland), and most "old" EU countries exceeded the EU average (EUR 33,219). Poland was ranked 25th in terms of labour productivity in the bioeconomy, surpassing only Romania and Bulgaria. An increase in labour productivity in the period under analysis of 78% is a positive aspect. Like other "new" EU countries, Poland is growing faster than the richer economies, which suggests a gradual decrease in differences in productivity. However, investments in technologies and innovations to improve labour productivity in bioeconomy sectors are necessary to catch up with countries where it is higher.

This analysis revealed certain limitations, which can also offer a basis for future research. The key methodological limitations identified in the analysis concern data availability, both temporal and cross-sectional. The latest available data are from 2021, i.e. they do not fully reflect the consequences of the COVID-19 pandemic or the Russian invasion of Ukraine in the context of the efficiency of the labour factor utilisation in bioeconomy sectors in EU countries, including Poland. Another limitation is posed by the range of available data for the bioeconomy of individual countries, which covers only the number of employed, added value and the turnover generated by individual bioeconomy sectors. A broader range of data, such as revenue from sales or the value of fixed assets, would make it possible to conduct a causal analysis of labour factor utilisation and to develop a synthetic measure allowing for a comprehensive assessment of its importance. Therefore, this analysis should be regarded as a preliminary study which should be continued.

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