

## EMPLOYMENT AND LABOUR PRODUCTIVITY IN THE BIOECONOMY – AN OVERVIEW OF THE MEMBER STATES OF THE EUROPEAN UNION

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**Purpose:** This study aimed to assess labour productivity in the bioeconomy and the significance of this sector to the labour market in the member states of the European Union.

**Design/methodology/approach:** The surveys were based on data retrieved from the EU Bioeconomy Monitoring System developed by the European Commission's Joint Research Center for the years 2010-2020. The official classification of economic activity in Europe (NACE) was used. The analysis took into account the size and structure of employment, the percentage share of bioeconomy workers in the total workforce, and labour productivity.

**Findings:** The study showed that in 2020 bioeconomy employed 16.5 million people in 27 EU member states, but in comparison to the year 2010, the rate of employment decreased by almost 14%. The agricultural and food sector, which from 2010 to 2020 employed 78.5% of bioeconomy workers, plays a predominant role in the market. Member states differ in the number and structure of bioeconomy workers, but also in labour productivity. Labour productivity leaders in the bioeconomy were Ireland, Belgium and Sweden, while the bio-based electricity sector was the most productive one. Agriculture achieved the lowest efficiency in utilising the labour factor, so countries with a high level of employment in agriculture also featured relatively low labour productivity in the bioeconomy.

**Practical and social implications:** New conditions to which the European economy needs to adapt imply a need for the development and social acceptance of the bioeconomy. This also provides a rationale for further research taking into account new socio-economic conditions, including labour market conditions.

**Originality/value:** The study fills the research gap in the assessment of the bioeconomy from the perspective of the labour market.

**Keywords:** bioeconomy, European Union, labour market, labour productivity.

**Category of the paper:** Research paper.

## 1. Introduction

Bioeconomy is a concept proposed in response to the multiple challenges of the 21st century, in particular climate change, food and water security, energy security, and global pollution (Barañano et al., 2021). The idea of bioeconomy involves a strategic concept of sustainable development, that is, a way of accomplishing the existing economic goals while minimising the consumption of natural resources and negative environmental impact thanks to new engineering solutions (Faber, Jarosz, 2023, p. 6). Currently, the bioeconomy is a well-founded concept. Over the past decade more than sixty countries on all continents, both developed and developing, including clusters of countries such as the European Union (EU), developed their bioeconomy strategies (Aguilar, Twardowski, 2022). The strategy was put into operation in the European Union in 2012 (European Commission, 2012), and was updated in 2018 (European Commission, 2018). These events are regarded as important factors in accomplishing the goal of the European Green Deal, that is, achieving climate neutrality by 2050 (European Commission, 2018; European Commission, 2022). This strategy is also linked to achieving territorial integration and accomplishing the objective associated with reinforcing the competitiveness of Europe and creating job opportunities (Lasarte-López et al., 2022, p. 3).

Over the years the idea of bioeconomy had different definitions. The OECD (2009, p. 22) defines bioeconomy as making use of biotechnology, bioprocesses and bio-based products to produce new, sustainable, eco-efficient and competitive products and services. The sector of bioeconomy covers all activities associated with innovative production and the use and conversion of biological resources (Jonsson et al., 2021). Thus, it consists of sectors such as agriculture, forestry, fishery, food and cellulose and paper production, as well as partly the chemical, biotechnology and energy industries (European Commission, 2012). The bioeconomy is an instrument for implementing sustainable development, and thus an essential part of the European Union's economy. It features a significant social potential – it is expected to provide one million new jobs by 2030, in particular in rural and coastal areas (Nowak et al., 2022, p. 99). Therefore, it is worth viewing bio-economy from a slightly different perspective than only as an idea and from the point of view of the political framework of this concept. The study aimed to evaluate labour productivity in the bioeconomy and the significance of this sector to the labour market in the member states of the European Union.

## 2. Literature review

Interest in the concept of bioeconomy results from numerous challenges faced by the global economy (Mougenot, Doussoulin, 2022, pp. 1031-1032). Policies regarding bioeconomy authorise green and socially just transition. This is supposed to reduce disparities and create new, so-called green jobs in the emerging sectors of industry and services based on the circular economy and biotechnology, including in the food industry, which will increase the value of regional economies (European Commission, 2022). Bioeconomy has been the subject of numerous scientific studies. Table 1 shows scientific studies devoted to bioeconomy in the European Union.

**Table 1.**

*A review of scientific studies on bioeconomy in the EU*

Author and year	Time range	Purpose of the study
D'Adamo et al. (2020)	2017	This paper proposes a 'socio-economic indicator for the bioeconomy' (SEIB) to measure the socio-economic performance of bioeconomy sectors.
Czyżewski et al. (2021)	2001-2018	The prerequisites for the bioeconomy development in selected EU member states depending on their overall economic development level were specified. Surveys involved four highly developed and four medium-developed member states.
Nowak et al. (2021)	2008-2017	The paper explores the significance of agriculture to the bioeconomy sector. We evaluated the bioeconomy potential and competitiveness of the EU member states.
Jurga et al. (2021)	2018	The authors attempted to answer the question if the national strategy of bioeconomy development should correspond with the regional strategy.
Lakner et al. (2021)	2005-2015	The place and role of the bioeconomy in the structural transition of the economy were investigated using detailed intersectoral input-output matrices. The analysis covered the Visegrád Group countries (V4), and in particular Poland, followed by Czechia, Slovakia, and Hungary.
Ronzon et al. (2022)	2008-2017	Adopting the output-based approach, the authors analysed efficiency indicators and characterised the sources of bioeconomy growth. The analysis covered all member states of the EU.
Dolge et al. (2023)	2012-2018	The paper presents the results of a comparison of 22 EU member states in terms of the bioeconomy development level. We applied TOPSIS (the Technique for Order of Preference by Similarity to Ideal Solution) to design a synthetic index (Bioeconomy Sustainability Index).
Firoiu et al. (2023)	2015 and 2020	The study aimed to assess the progress of EU member states to the extent of the bioeconomy, including sectors dealing with biomass production and conversion. The analysis makes use of the hierarchical clustering method.

Source: Authors' elaboration based on a review of literature.

However, most of the available studies refer only to the idea of bioeconomy and the political framework of this concept (McCormick, Kautto, 2013). Others investigate the role of agriculture in the development of bioeconomy (Nowak et al., 2021) or progress in the development of bioeconomy in individual member states of the EU (Lakner et al., 2021; Firoiu et al., 2023; Dolge et al., 2023). In contrast, the significance of particular sectors in the context of the labour market is mentioned more rarely. Meanwhile, Afrouzi et al. (2021) point out the essential role of evaluating the significance of the given sector for the bioeconomy development, including the extent of labour resources. Using data from the labour market,

we can assess how the bioeconomy sector is divided into more or less conventional sectors (Zimmermannová, Perunová, 2022, pp. 33-46). Czyżewski et al. (2021) argue that the development of the bioeconomy holds promise for growth in employment, especially in rural, coastal or industrial areas, and that the higher the degree of innovation implemented in agriculture, energy, biofuel production and biotechnology sectors, the more effective the development of the bioeconomy can be. This justifies the need to undertake research into the level and structure of employment in the bioeconomy and the labour productivity level changes taking place.

### **3. Research methods**

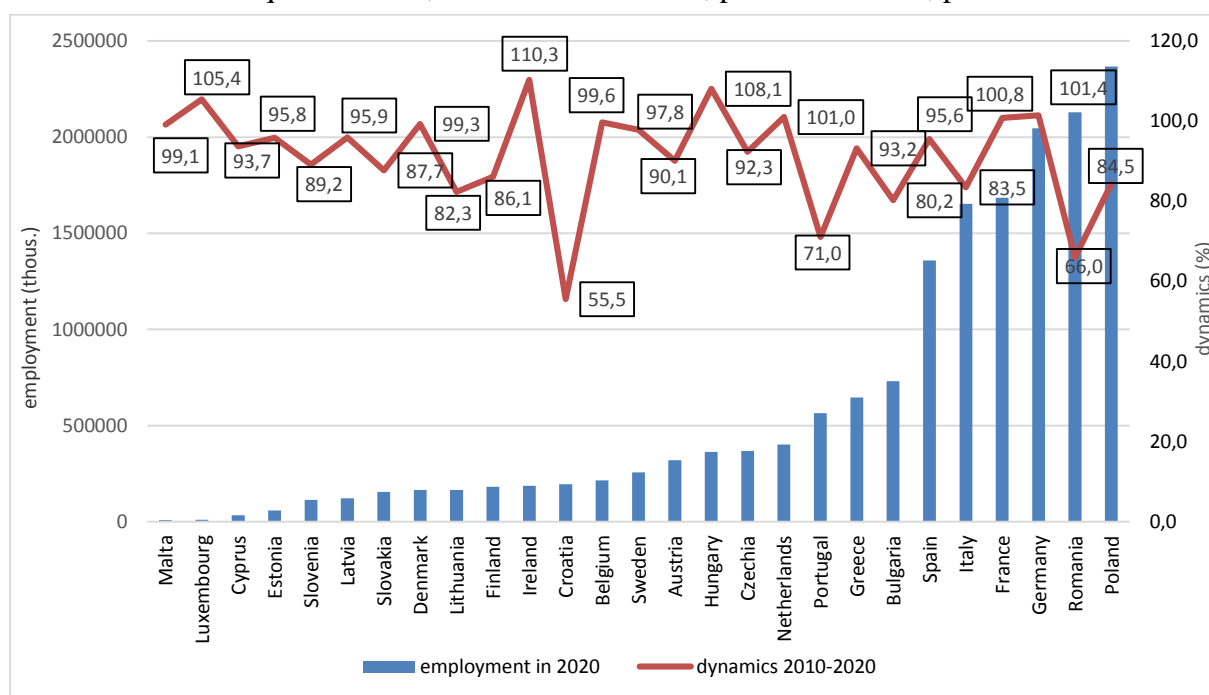
This paper uses data from the EU Bioeconomy Monitoring System developed by the European Commission's Joint Research Center (European Commission, 2022). The monitoring system aims to provide a coherent approach to tracking progress in the bioeconomy across the EU, reflecting the five objectives of the EU Bioeconomy Strategy and covering all three dimensions of sustainability (economic, environmental, and social) (Robert et al., 2020). The official classification of economic activity in Europe (NACE) was used. Bioeconomy components were adopted after the Report of the EU Joint Research Centre (M'barek, Parisi, Ronzon, 2018, p. 6). These include: A) Agriculture, B) Forestry, C) Fishing and aquaculture, D) Food, beverage and tobacco, E) Bio-based textiles, F) Wood products and furniture, G) Paper, H) Bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels), I) Liquid biofuels, and J) Bio-based electricity. The analysis covered the period from 2010 to 2020, the temporal scope of the analysis was due to the availability of statistical data, the most up-to-date data was included in the study. Most of the figures were presented as an average for 2010-2020 or the marginal years of the study period.

The subjects were 27 member states of the EU without the UK, which formally left the EU under the Withdrawal Agreement on 31 January 2020. The analysis took into account the size and structure of employment, the percentage share of bioeconomy workers in the total workforce, and labour productivity.

### **4. Results and discussion**

Labour resources are a fundamental source of competitiveness for the sector. Analysing the significance of the bioeconomy to the labour market, the change in the number of workers between 2010 and 2020 was assessed (Fig. 1). In 2020, it amounted to 16.5 million people in

27 countries of the EU. Countries with the highest rate of workers employed in the bioeconomy are Poland, Romania, Germany, France, Italy, and Spain, but their employment structure varies (Tab. 2). On average from 2010 to 2020, they employed more than 12.2 million workers, which accounted for 68.3% of the total number of bioeconomy workers in the EU. The highest growth dynamics were recorded in Ireland, where it amounted to 110.3%. In contrast, 21 member states noted a reduction in the number of bioeconomy workers, which was the highest in Croatia (by 41.1%). It was mainly a result of the outflow of workers from the agricultural sector, forestry, wood products and furniture, as well as liquid biofuels while increasing employment in sectors such as liquid biofuels, bio-based chemicals, pharmaceuticals, plastics and rubber.



**Figure 1.** Employment in the bioeconomy in the EU member states from 2010 to 2020.

Source: Authors' elaboration based on the Data-Modelling Platform of Agricultural Economics Research.

Not only do the individual economies feature a different dynamic but also a different direction of changes in the workforce flow (Tab. 2). The agri-food sector plays a significant role in the bioeconomy, employing 78.5% of the bioeconomy workforce at the EU level from 2010 to 2020 (54.66% in agriculture and 23.86% in food, beverage and tobacco production). According to Ronzon et al. (2020), from 2010 to 2017 this percentage was also 78%. In the period under review, the share of agricultural workers in the number of bioeconomy workers exceeded 70% in Bulgaria and Greece, and in Romania, it was higher than 80%. Poland, Portugal, Slovenia and Ireland also showed a higher share of this sector in the employment structure than the EU average. However, with the economic growth, the importance of agriculture in the labour market, as well as in generating gross value added relative to the food industry, marketing and services, is declining. From 2010 to 2020, employment in agriculture on the EU level dropped by 10%. This trend is confirmed by

Godlewska-Dzioboń (2020) who points to an increase in employment in services, mainly in knowledge-intensive services.

Luxembourg, Belgium, Germany and Malta were countries with the highest share of the food, beverage and tobacco-related sector in the employment structure. Furthermore, in these countries, unlike the others (except Sweden), the percentage of workers employed in this sector was higher than in agriculture. Bio-based textiles engaged 4.54% of the workforce, with Italy and Portugal standing out, with 12.3% and 10% of the workforce respectively. The wood and furniture products sector accounted for an average of 7.4% and paper for 3.3% of the employment structure. The bio-based chemicals, pharmaceuticals, plastics and rubber sectors (excluding biofuels) employed 2.2%, liquid biofuels and bioelectricity 0.12% of bioeconomy workers.

**Table 2.**

*Structure of employment in the bioeconomy in the EU member states from 2010 to 2020 (%)*

Member state	Bioeconomy sectors									
	A	B	C	D	E	F	G	H	I	J
Austria	44.82	6.77	0.10	24.40	2.62	12.54	4.96	3.31	0.29	0.20
Belgium	27.31	1.12	0.21	47.02	3.40	8.07	5.47	6.71	0.43	0.26
Bulgaria	75.22	2.44	0.16	11.80	5.33	3.06	1.15	0.75	0.09	0.02
Croatia	48.49	8.24	2.80	25.04	4.15	8.14	1.83	1.22	0.05	0.03
Cyprus	44.72	1.24	1.67	38.63	1.22	8.17	1.81	2.46	0.01	0.07
Czech Republic	35.18	5.86	0.38	29.32	5.26	15.68	5.03	3.30	0.00	0.00
Denmark	35.69	3.45	1.32	34.75	1.22	7.64	3.16	12.28	0.12	0.37
Estonia	26.24	9.46	1.42	23.00	5.40	31.63	2.12	0.46	0.00	0.27
Finland	39.08	10.94	0.88	20.33	1.51	12.38	11.75	2.10	0.46	0.59
France	42.88	1.73	1.10	38.38	2.84	5.22	3.96	3.72	0.16	0.00
Germany	28.64	1.96	0.24	44.49	2.38	9.40	7.16	4.85	0.18	0.71
Greece	73.41	1.04	3.14	16.48	1.94	1.96	1.15	0.77	0.09	0.01
Hungary	44.88	5.42	0.39	29.88	4.40	7.42	3.71	3.67	0.09	0.14
Ireland	58.95	1.77	1.86	27.66	0.76	3.73	1.75	3.52	0.00	0.00
Italy	45.14	1.98	1.46	23.17	12.27	9.50	3.79	2.52	0.07	0.09
Latvia	38.10	13.32	1.13	19.43	3.85	21.40	1.13	1.45	0.00	0.19
Lithuania	46.38	5.81	0.69	20.70	5.26	18.40	2.07	0.41	0.16	0.13
Luxembourg	34.09	3.42	0.00	53.99	0.20	7.09	0.00	1.07	0.00	0.13
Malta	22.39	0.00	7.94	46.56	2.08	10.34	3.05	7.64	0.00	0.00
Netherlands	49.73	0.51	0.77	34.00	1.89	6.04	4.55	2.44	0.07	0.00
Poland	65.84	2.83	0.27	16.84	2.43	8.31	2.27	0.99	0.15	0.07
Portugal	61.59	1.85	2.13	15.40	10.05	6.34	1.55	0.93	0.10	0.05
Romania	83.22	1.87	0.09	6.88	3.28	3.62	0.50	0.51	0.04	0.01
Slovakia	29.06	15.29	0.12	25.24	6.64	17.95	4.35	1.17	0.04	0.15
Slovenia	58.37	5.59	0.20	14.43	4.05	10.50	3.76	3.05	0.00	0.04
Spain	51.87	1.29	3.08	28.25	3.78	5.86	3.25	2.45	0.13	0.03
Sweden	23.72	15.60	0.42	25.08	0.87	15.72	12.80	4.80	0.62	0.37
EU-27	54.66	2.88	0.94	23.86	4.54	7.37	3.32	2.19	0.12	0.12

Note: for bioeconomy sector labels see the Methods section

Source: Authors' elaboration based on the Data-Modelling Platform of Agricultural Economics Research

The relevance of the bioeconomy to the labour market varies between EU member states. Across the EU, bioeconomy workers accounted for an average of 9.6% of total number of workers from 2010 to 2020. It can further be noted that, from 2010 to 2020, this percentage decreased from 10.5% to 8.7%. The analysed sectors play a special role in the labour markets of Romania, and Bulgaria, as well as Greece, Croatia, Poland, Portugal, and Lithuania (Tab. 3). However, these countries feature a relatively high percentage share of the agricultural sector in the employment structure, as well as a decreased percentage of bioeconomy workers, in particular in Romania, Croatia, and Bulgaria. In the majority of developed countries, the share of bioeconomy workers was lower than the EU average, with the lowest levels recorded in Luxembourg, Malta, the Netherlands, Belgium, Germany, and Sweden. Analysis of the impact the bioeconomy has on gross value added shows that the GVA is higher in member states admitted to the EU in 2004 and later (EU-13). This is largely a consequence of the significant role the agricultural sector plays in these countries. From 2010 to 2020, the average GVA share of the bioeconomy in the EU-13 was 6.4%, with the highest recorded in Latvia and Bulgaria. In the EU-15, the bioeconomy contributed to creating from 1% GVA in Luxembourg to 7.3% in Ireland, with an EU-15 average of 5.4%.

**Table 3.**

*Bioeconomy workers share of the total number of workers and share of the bioeconomy in total gross value added (GVA) in EU member states from 2010 to 2020*

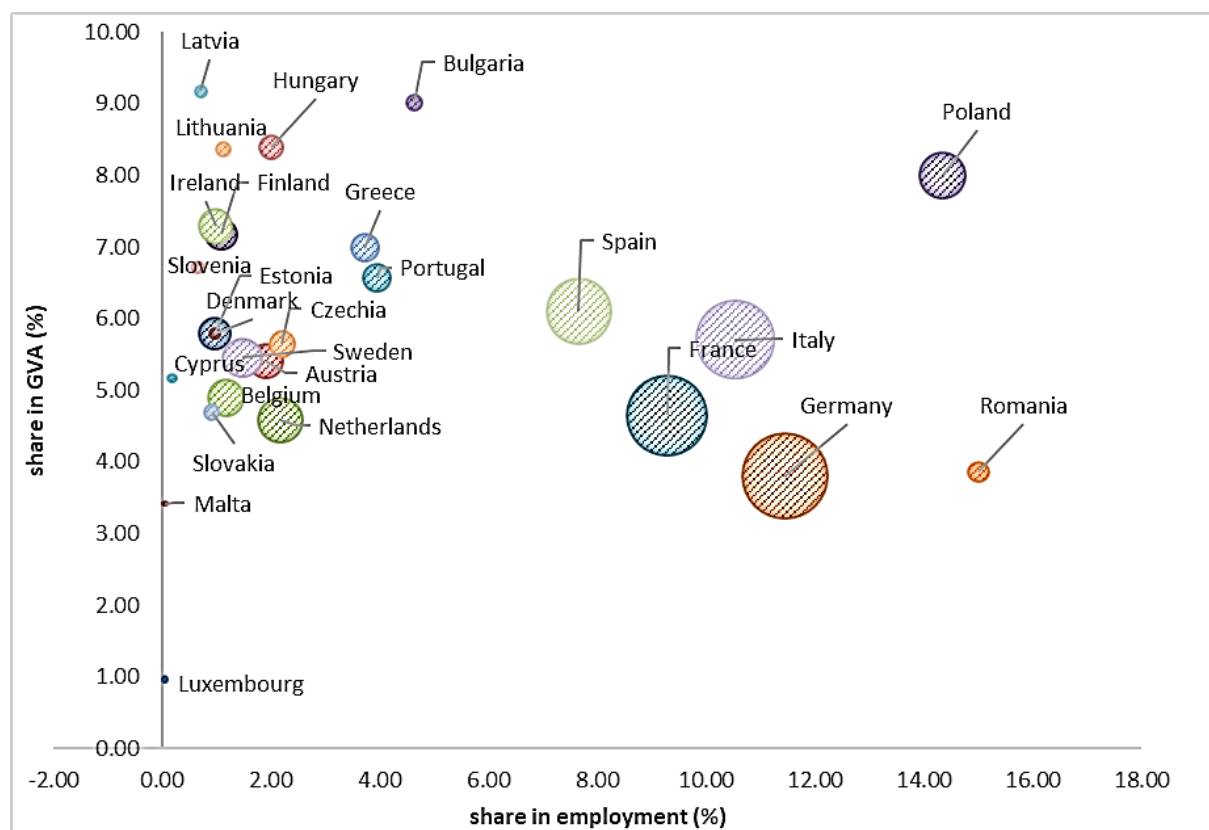
Member state	Share of employment				Share of GVA			
	2010	2020	2010-2020	Change from 2010 to 2020 (p.p.)	2010	2020	2010-2020	Change from 2010 to 2020 (p.p.)
Austria	9.0	7.7	8.3	-1.3	5.4	5.7	5.4	0.3
Belgium	4.8	4.5	4.6	-0.3	4.9	5.8	4.9	0.9
Bulgaria	30.5	24.5	28.1	-6.0	8.9	8.6	9.0	-0.3
Croatia	21.2	11.9	16.0	-9.3	9.1	8.8	8.7	-0.3
Cyprus	9.4	8.3	8.7	-1.1	5.7	5.2	5.2	-0.5
Czech Republic	8.3	7.2	7.9	-1.1	5.2	5.5	5.6	0.3
Denmark	6.4	6.0	6.5	-0.4	5.5	6.4	5.8	0.9
Estonia	10.8	9.3	10.4	-1.5	9.3	8.1	8.7	-1.2
Finland	8.8	7.5	8.1	-1.3	7.6	6.8	7.2	-0.8
France	6.3	6.3	6.3	0.0	4.6	4.9	4.6	0.3
Germany	5.5	5.2	5.3	-0.3	3.9	4.1	3.8	0.2
Greece	16.2	17.9	18.1	1.7	6.4	8.1	7.0	1.7
Hungary	8.7	8.0	8.4	-0.7	7.5	8.4	8.4	0.9
Ireland	9.0	8.6	8.7	-0.4	8.9	4.8	7.3	-4.1
Italy	9.0	7.6	8.6	-1.4	5.4	6.0	5.7	0.6
Latvia	15.2	14.2	14.8	-1.0	10.0	10.6	9.2	0.6
Lithuania	16.4	12.7	15.6	-3.7	7.6	9.3	8.4	1.7
Luxembourg	4.4	3.5	4.0	-0.9	1.1	0.9	1.0	-0.2
Malta	5.2	3.2	4.2	-2.0	4.7	2.6	3.4	-2.1
Netherlands	4.8	4.5	4.6	-0.3	4.7	4.6	4.6	-0.1
Poland	19.0	14.9	16.7	-4.1	8.2	8.3	8.0	0.1
Portugal	18.2	12.5	16.4	-5.7	6.2	6.8	6.6	0.6
Romania	44.9	28.0	36.5	-16.9	3.9	7.3	3.9	3.4
Slovakia	7.4	6.0	6.6	-1.4	4.7	4.3	4.7	-0.4
Slovenia	13.5	11.8	12.8	-1.7	6.7	7.3	6.7	0.6

Cont. table 3.

Spain	7.7	7.2	7.5	-0.5	5.9	6.7	6.1	0.8
Sweden	6.0	5.3	5.7	-0.7	6.2	5.2	5.5	-1.0
EU-27	10.5	8.7	9.6	-1.8	5.2	5.4	5.1	0.2

Source: Authors' elaboration based on the Data-Modelling Platform of Agricultural Economics Research

Figure 2 shows the position of EU Member States according to the share of bioeconomy in the country's GVA and the employment in the sector across the EU, while the size of the bubble corresponds to the country's share of the GVA generated by the EU bioeconomy. Noteworthy are Germany, France and Italy, which have the highest contribution to the GVA of the bioeconomy, together averaging 49.5% from 2010 to 2020. In contrast, the share of employment in the EU bioeconomy was much lower at 31.25%. Poland and Romania, on the other hand, represent a high percentage of EU employment, but their share of the GVA of the EU bioeconomy was 5.4% (5th place) and 1% (17th place) respectively.



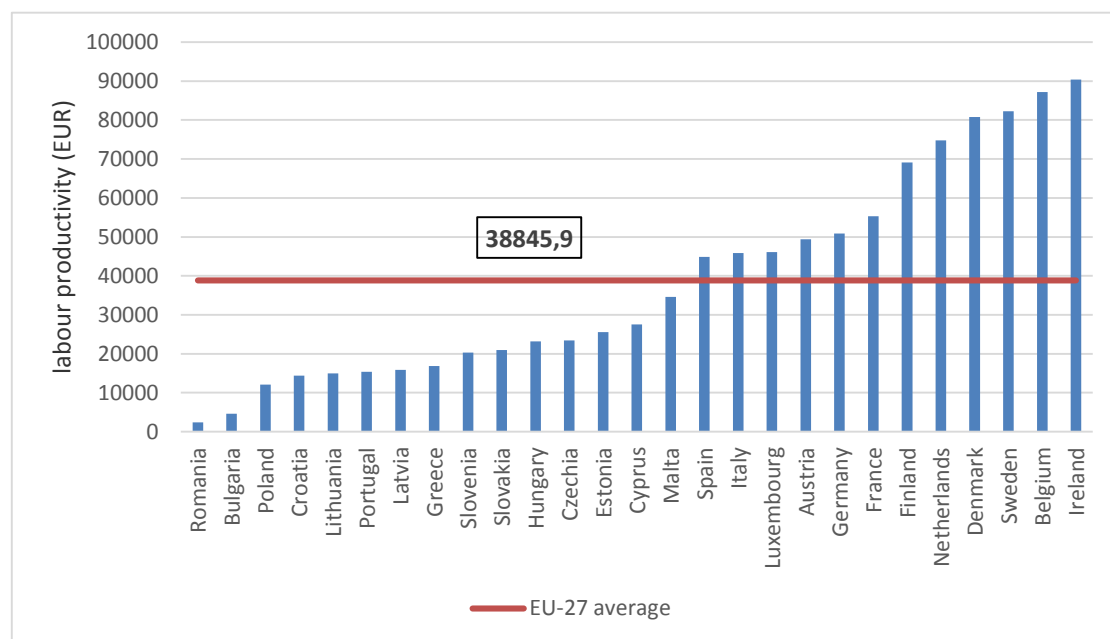
Note: Bubble size denotes the share of the specific member state in the GVA of the bioeconomy in the EU

**Figure 2.** Distribution of EU member states according to the bioeconomy share of employment and GVA from 2010 to 2020.

Source: Authors' elaboration based on the Data-Modelling Platform of Agricultural Economics Research.



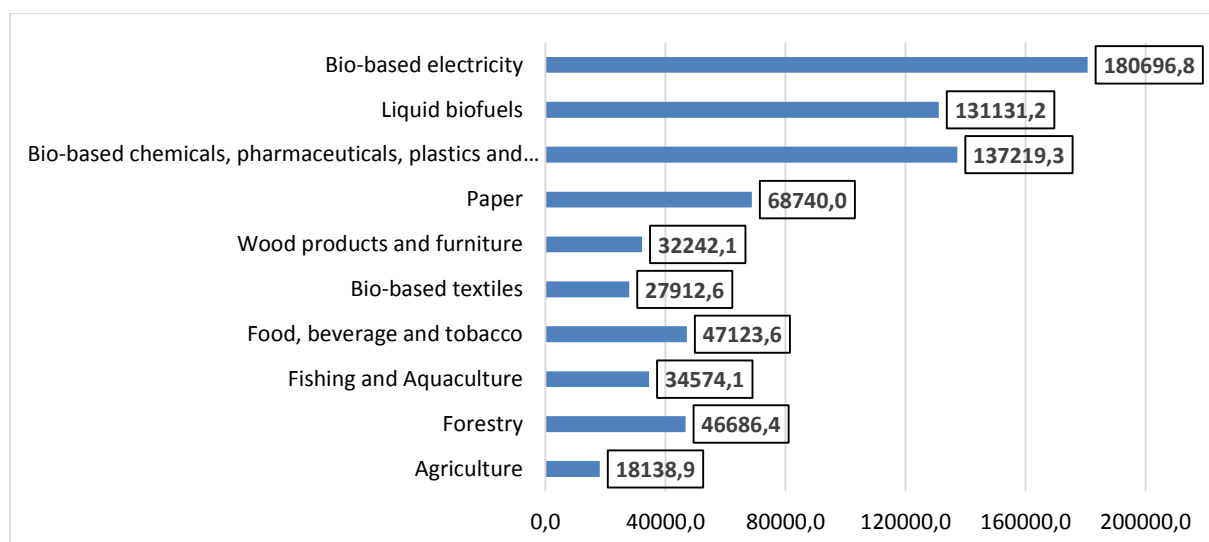
Another important aspect of assessing the performance of the bioeconomy as a group of sectors together forming the labour market is the measurement of labour productivity. It reflects the ratio of value added to employment in the corresponding sector. It is, therefore, an indicator that, in the most objective way possible, allows us to compare sectors in terms of their performance efficiency, and thus to compare their potential for development (Bas et al., 2019, p. 19). The average labour productivity in the bioeconomy from 2010 to 2020 was EUR 38,800 in the EU, ranging from EUR 2,400 in Romania to EUR 90,000 in Ireland (Fig. 3). Countries featuring labour productivity above the EU average include Spain, Italy, Luxembourg, Austria, Germany, France, Finland, the Netherlands, Denmark, Sweden, Belgium, and Ireland.



**Figure 3.** Labour productivity in the bioeconomy in the EU member states from 2010 to 2020.

Source: Authors' elaboration based on the Data-Modelling Platform of Agricultural Economics Research.

Surveys conducted by Muizniece et al. (2016, pp. 484-485) imply a large variation in labour productivity between the bioeconomy sectors. The results of studies presented herein also corroborate these observations (Fig. 4). The highest labour productivity is characteristic of the bio-based electricity sector (EUR 180,700 per capita), while the lowest labour factor efficiency is recorded in the agriculture sector (EUR 18,100 per capita).



**Figure 4.** Labour productivity in the bioeconomy sectors of the EU member states from 2010 to 2020 (EUR per capita).

Source: Authors' elaboration based on the Data-Modelling Platform of Agricultural Economics Research.

Pink and Wojnarowska (2020, pp. 87-101) underline that differences still exist between the member states of the European Union in terms of the development level and structure of the bioeconomy. This is because the premises for development differ and their rank depends on the specific features of the country and strategic priorities recognised in relevant documents. Also, studies by Nowak et al. (2022, p. 108) show differences between member states in terms of labour productivity in the bioeconomy. The authors explain that changes in labour productivity derive from both general and sector-specific economic processes.

## 5. Summary

Surveys showed that between 2010 and 2020 changes were taking place in the EU-27 not only in the number of workers and structure of employment in the bioeconomy but also in its share of the GVA. Furthermore, the member states of the EU and the bioeconomy sectors both differed in their labour factor efficiency. This was a result of, among other things, differences in the level of socio-economic development of individual countries. It is reasonable to believe that in countries admitted to the EU in 2004 and later, where structural transformation is still pending, the change dynamics will continue to increase. In addition, factors that influence and will certainly continue to influence the level and structure of employment in the bioeconomy are geopolitical (energy crisis) and related to progress in a broad sense. The EU development directions set by sectoral policies, and in particular those related to agriculture, fishing, forest management, environmental protection, energy but also science and innovation, also play an important role. New conditions to which the European economy needs to adapt imply a need

for the development and social acceptance of the bioeconomy. This also provides a rationale for further research taking into account new socio-economic conditions, including labour market conditions.

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