sustainability

MDPI

Article

Significance of Agriculture for Bioeconomy in the Member States of the European Union

Anna Nowak, Anna Kobiałka and Artur Krukowski *

Department of Economics and Agribusiness, University of Life Sciences in Lublin, Akademicka 13, 20-950 Lublin, Poland; anna.nowak@up.lublin.pl (A.N.); anna.kobialka@up.lublin.pl (A.K.)
* Correspondence: artur.krukowski@up.lublin.pl; Tel.: +48-(81)4610061

Abstract: Bioeconomy is a response of the European Union and its member states to global challenges such as ensuring food security, mandatory sustainable management of natural resources, mitigating climate change and reducing dependency on non-renewable resources. One of the sectors playing an important role in the development of bioeconomy is agriculture, which accounts for the largest part of biomass used as a raw material for producing bioproducts. This paper is an attempt to answer the following questions: What is the essence and significance of the bioeconomy sector in the EU? How significant is agriculture to the bioeconomy sector? What is the potential and competitiveness of agriculture in EU countries? Data used in surveys is sourced from the Data-Modelling platform of agro-economics research and covers the years 2008–2017. The position of agriculture in the bioeconomy was determined based on measures such as level of employment and gross value added (GVA), turnover, while its competitiveness was assessed based on labour productivity. The results of surveys showed that more than 50% of all bioeconomy workers were employed in agriculture. The sector produced nearly 30% GVA and had a more than 18% share in bioeconomy turnover. Member states of the European Union featured diverse agricultural potential. At the same time, the productivity of agriculture was one of the lowest in the bioeconomy sector. The importance of agriculture stems not only from its food function, but also from the production of biomass. However, its social function is equally important, and in the face of escalating environmental problems the function connected with reducing external costs and producing environmental public goods has become complementary.

Keywords: agriculture; bioeconomy; EU countries; employment; gross value added; turnover

Citation: Nowak, A.; Kobiałka, A.; Krukowski, A. Significance of Agriculture for Bioeconomy in the Member States of the European Union. *Sustainability* **2021**, *13*, 8709. https://doi.org/10.3390/su13168709

Academic Editor: Luis Jesús Belmonte-Ureña

Received: 20 June 2021
Accepted: 28 July 2021
Published: 4 August 2021

1. Introduction

The term 'bioeconomy' has recently become increasingly popular. It has been a part of various reports and a subject of strategies in many countries [1]. Interest in the concept of bioeconomy results from numerous challenges faced by the global economy. These challenges include sustainable management of natural resources, sustainable production, public health improvement, mitigation of adverse effects of climate change, integrated social and economic development and sustainable global development [2]. Many countries associate the development of a bioeconomy with prospects of innovation development, economic growth and creating new jobs. Considering the population growth forecast for 2050 to about 9 billion, it is quite clear that the pressure on natural resources will continue to increase in the absence of an adequate development strategy. Therefore, in light of the present-day challenges, including bioeconomy in the development strategies of EU member states seems a reasonable choice [3].

Beluhova-Uzunova et al. [1] emphasize that the view of bioeconomy changes along with prospects, global objectives and challenges. It should be noted that definitions differ not only at an international but also at a national and regional level. This development concept was also criticised in terms of the negative effects of its implementation [4,5],

including primarily increased competition for land and intensification of agriculture. As a response to these critical discussions, the updated bioeconomy strategy of the European Commission announces that the "European Bioeconomy needs to have sustainability and circularity at its heart" [6]. Jonsson et al. [7] underline that this is based on five main goals: to ensure food and nutrition security; sustainably manage natural resources; reduce dependence on non-renewable, unsustainable resources; limit and adapt to climate change; strengthen European competitiveness and create jobs.

The bioeconomy sector covers all activities associated with innovative production and the use and conversion of biological resources [7–9]. Thus, it consists of sub-sectors such as agriculture, forestry, fishery, food and cellulose and paper production, as well as parts of the chemical, biotechnology and energy industries [10]. Bioeconomy can be perceived differently from country to country and with reference to various sectors of the economy. However, it is supra-sectoral. A shared characteristic independent of the sector is that the concept is considered from the point of view of innovativeness and the economic benefits that may arise from its development [11]. Bioeconomy covers a peculiar processing and value-creating chain in which products from the sectors of original biomass production move across the processing sectors and exchange and distribution chains and reach end users as food and biomaterials for further processing and as industrial products and products for consumption creating an entire closed-circuit economic system. These three elements, i.e., biomass production, processing and production, and distribution and consumption, are integrated through the system of creating and using knowledge and innovation [11].

One of the sectors of bioeconomy is agriculture, which is the largest principal production sector [2,12]. Agriculture shapes cultural landscapes while at the same time being associated with the degradation of soils and water resources and the degradation of related goods and ecosystem services. It is responsible for the loss of biological diversity and for 13.5% of global greenhouse gas emissions [13]. Therefore, in the future.#, bioeconomy agriculture must be sustainable. This means that agricultural production should be managed so that a sufficient amount of food and biomass is supplied to a growing population, at the same time maintaining the functions of the ecosystem and biological diversity [2,14]. This sector, producing food and goods other than food, requires a balance between an adequate level of food supply to humans and environmental sustainability. Here, agro-biotechnology (agricultural biotechnology) aiming to meet the challenges of the contemporary world related to agricultural production becomes extremely important.

Agriculture and forestry play an important role in bioeconomy in the context of the ambitious objectives of the EU regarding climate and energy until 2030. They also help other sectors in decarbonisation (for instance, by decarbonising transport through shifting to advanced biofuels and removing coal from the atmosphere). Agriculture produces the largest share of the biomass raw material for the bioeconomy. Therefore, not only does bioeconomy contribute to sustainable agriculture but it can be an important source of varied income for farmers and a factor in creating employment opportunities, competitiveness and growth in rural areas [15]. The European Union's bioeconomy strategy states with regard to agriculture that its aim is to provide knowledge and tools for productive, resource-efficient and resilient systems for food, feed and biobased raw materials, in conjunction with policies that support rural livelihoods without comprising ecosystem services [14]. In addition, the proposed CAP reform in the years 2021–2027 imposes an obligation on member states to explain how their national strategic plans can lead to more sustainable agriculture, ensure environmental protection and combat climate change [16].

Although measuring bioeconomy is a difficult task, various efforts have been made to assess the significance of this sector at a national level [17–19] and at a European level [20].

Bioeconomy has been a subject of numerous scientific studies. However, most of them refer only to the idea of bioeconomy and the political framework of this concept [4,10,21,22]. On the other hand, the significance of respective sectors for the development of bioeconomy is mentioned more rarely. Such an analysis was carried out for the year 2010, among others,

by Fuentes-Saguar et al. [23]. These authors identified the following sectors: primary agriculture, food processing, biomass supply, bioenergy, bio-industry, and non-bio-based activity. In turn, Loizou et. al [24] examined the role of all bio-based sectors in terms of employment and production based on the Input–Output model. However, they focused on the bioeconomy of Poland only. No studies, however, have been carried out regarding the position of agriculture in the bioeconomy sector. Research concerning agriculture more frequently focuses on its diversity in the European Union [25,26], productivity [27,28], sustainability level [29,30] and competitiveness [31,32]. In contrast, few works refer to its potential [33–35] and role in implementing the concept of bioeconomy [11,36,37]. This paper attempts to fill this gap.

Thus, the need for a wide use of agriculture is not due to the necessity to produce food and ensure food security only but also the need to produce biomass that is a primary source of renewable energy and biomaterials [38]. It is expected that the developing bioeconomy will require an increase in the supply of biomass. However, not all the produced biomass can be made available for use [2]. In Europe the bioeconomy is to a considerable degree linked to the Common Agricultural Policy (CAP) as this refers to common goals related to food security and development of rural areas. Production of non-food-biomass from agriculture was considerably supported by the CAP, in particular since the Agenda 2000 reform introducing the rural areas development policy as a second pillar [39]. Simultaneously, the Revision of the EU Bioeconomy Strategy and the role of the agricultural sector [15] notes that the most important actors in the agricultural primary production (farmers) are not well integrated into the bioeconomy value chain, playing more the role of biomass suppliers than of producers of bioproducts. A revised bioeconomy strategy should therefore consider the needs of farmers more and include actions to strengthen the role of primary producers in new bioeconomy value chains. It also underlined that the sustainable development of the bioeconomy in rural areas will undoubtedly be a major positive factor for tackling depopulation by creating jobs and business opportunities based on modern digital technologies and innovative business practices.

This paper is an attempt to answer the following questions: What is the essence and significance of the bioeconomy sector in the EU? How significant is agriculture to the bioeconomy sector? What is the potential and competitiveness of agriculture in EU countries?

The paper is organized as follows. The following chapter presents an overview of methods and sources of data used in the study. In part three the authors discuss selected indicators illustrating how significant agriculture is to the bioeconomy sector. An important element of the analysis is the assessment of agricultural competitiveness of 28 EU member states. The last part contains conclusions from the analyses.

2. Materials and Methods

This paper aimed to assess the significance of agriculture to the bioeconomy sector and its competitiveness in 28 member states of the European Union. The countries often attempt to assess the contribution of the bioeconomy to their economy as a whole, considering different variables that usually reflect their priorities. National goals and bioeconomy priorities include economic growth, employment and energy security. Given differences between countries, no uniform method for assessing the contribution of bioeconomy and its sectors to the national economy has been worked out so far [40]. No studies have been carried out regarding the significance of respective sectors for the development of bioeconomy.

The methodology used in this paper is based on the following three steps:

1. Identification of variables characterizing the position of agriculture in the European Union.
2. Comparison of 28 European Union member states in terms of how significant their agriculture is to the bioeconomy sector.

3. Assessment of agricultural competitiveness in EU countries from the perspective of labour productivity in this sector.

In order to determine the position of agriculture in bioeconomy, this paper makes use of the following measures:

- Share of agricultural workers in the total number of bioeconomy workers (%).
- Share of agriculture in gross value added (GVA) of the bioeconomy (%). GVA is the gross income from operating activities after adjusting for operating subsidies and indirect taxes [41].
- Turnover of agriculture in the turnover of the bioeconomy (%). Turnover is defined, in the context of structural business statistics, as the totals invoiced by the observation unit during the reference period, which corresponds to the total value of market sales of goods and services to third parties, including production costs.

The competitiveness of agriculture was assessed based on the labour productivity ratio calculated as this sector's gross value added to the number of people it employs. This measure is adopted because the labour productivity level is commonly considered one of the key development parameters of economies, as it leads to reduced costs, increased supply of less expensive goods and services, increased market dynamics, increased purchasing power of societies, their affluence and competitive potential [42].

The variables were used according to the EU classification of economic activities (NACE). In this classification, agriculture (NACE code A01) is a sector co-creating bioeconomy. Other sectors include Forestry, Fishing and Aquaculture, Food, beverage and tobacco, Bio-based textiles, Wood products and furniture, Paper, Bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels), Liquid biofuels, and Bio-based electricity.

Data used in the study is sourced from the Data-Modelling platform of agro-economics research [43] The timeline of the study is 2008–2017, and most indices are presented for the extreme years of the study period. This allowed observation of how the position of the agricultural sector in the bioeconomy changed over 10 years. The subjects of the study were 28 member states of the European Union. The United Kingdom was also included in the study as in the years covered by the study it was a member of the EU.

3. Results

The sector of the economy playing a significant role in creating the EU's GDP is agriculture. This is a key sector and its significance as a producer of food and non-food goods leads to seeking a compromise between ensuring adequate food supplies to society and sustainability of the natural environment. Bioeconomy, relying largely on renewable resources from agricultural and forestry production, opens up new possibilities and creates new chances for these sectors, but simultaneously entails environmental risks that should be taken into account in eliminating the negative environmental impact of production [44].

An important element co-describing the production potential of bioeconomy, including the agricultural sector, is the number of workers [35]. The level of employment and the land-labour ratio directly determine labour productivity in agriculture and thereby the competitiveness of this sector both on the domestic and international market [45].

Bioeconomy is an essential sector for the labour market. In 2017, it employed 186,366,000 people in 28 countries of the European Union. Although this figure was 12.1% lower than in 2008, employment in this sector still accounted for 8.4% of all workers in the economy (9.7% in 2008). Figure 1 presents changes in the number of workers in bioeconomy and in agriculture, including the trend line and linear trend model. This model is a special case of linear regression where the only explanatory (independent) variable is time. The presented equations imply that the mean annual employment decrease figure in the bioeconomy in the years 2008–2017 was close to 276,000 people (Figure 1). This downward trend in the level of employment in the study period was also observed for agriculture. On average, year on year it decreased by 234,9000 people in the EU, and the total decrease throughout the study period was 17.6%. Kołodziejczak [12] explains that releasing labour resources from the agriculture of EU member states, and in particular new

ones, was a result of modernisation in agriculture and transformations in the categories of farms due to utilising funds under CAP and EU structural programmes. The pending CAP reform provides an option for renewing the objectives that inspired the programming of instruments for the previous timeframes. These were used to determine objectives reflecting the economic, social and environmental significance of the new CAP. Among them, next to issues related to income, sustainable development and climate, there were also objectives concerning generational renewal, value chains, eco-system services, as well employment and bioeconomy [16].

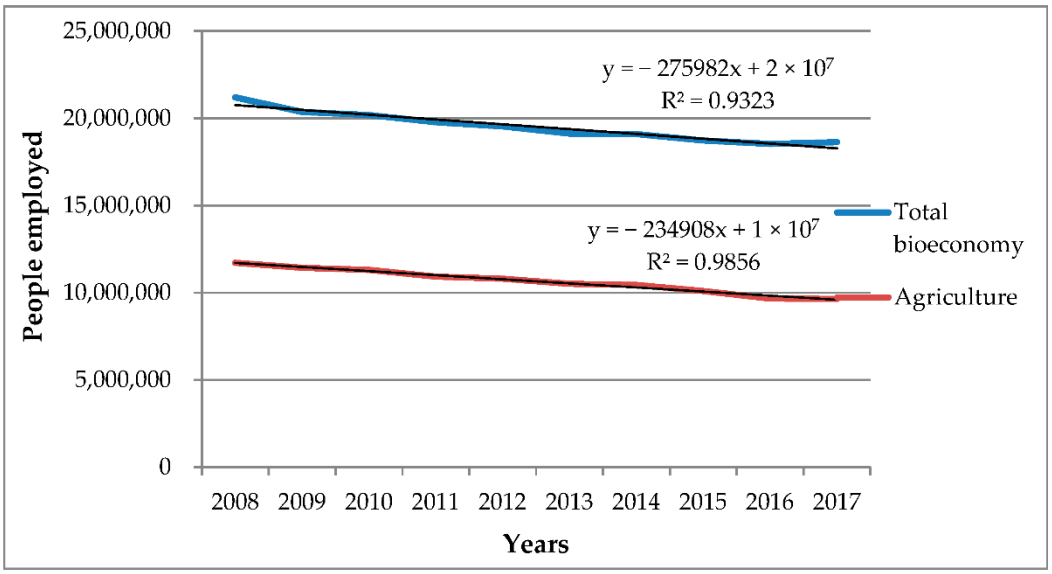

Figure 1. Bioeconomy sector and agricultural workers in EU-28 in 2008–2017. Source: Own elaboration based on Data-Modelling platform of agro-economics research.

A revised Bioeconomy Strategy of the European Union (EU) aims at more natural environment-friendly and sustainable economic growth. It is expected that its implementation will increase the level of employment [6]. To anticipate related needs, it is important to have a clear picture of the present structure of employment in all sectors co-creating the bioeconomy and of how it has changed recently [46]. Table 1 presents the structure of employment in the bioeconomy sector in 2008 and 2017. It implies that the sector most significant to the market is agriculture. Its share in total employment in the bioeconomy exceeded 50%. At the same time, in the analysed years this share decreased by 3.5 percentage points from 55.3% in 2008 to 51.8% in 2017. This is a result of a decrease in the number of agricultural workers, as shown in Figure 1. The sector ranked second in terms of employment in the bioeconomy is Food, beverage and tobacco. Here, the percentage of employees was observed to have increased from 22.3% in 2008 to 26.1% in 2017. In 2017, the Wood products and furniture sector employed 8.2% of all bioeconomy workers, noting a slight decrease in comparison to the year 2008. However, despite this decrease, the number of workers in this sector in the analysed years increased by 25%. In the analysed years the share of workers also increased in most of the remaining sectors. The share of the Liquid biofuels sector in total employment in the bioeconomy remained unchanged but internal changes in the structure of employment occurred inside this sector. The number of workers in the Biodiesel area decreased (12%), while the number of people employed in the Bioethanol area increased nearly twofold. On the other hand, Bio-based textiles became less significant when the number of workers in 2008–2017 decreased by 32%, that is, by 336 6000 persons. Further changes in the structure of employment in the sector will probably be determined by the growth rate of demand for services, structural alignment through matching the characteristics of the rural population with the requirement for

a labour force in the services sector and the rate of structural transformations in rural areas [12].

Table 1. Share of respective sectors in the total level of employment in the bioeconomy in EU-28 in the years 2008 and 2017 (%).

Sector	Share of Sectors in Employment in the Bioeconomy (%)		Change in 2008–2017 (in p.p.)
	2008	2017	
Agriculture	55.3	51.8	−3.5
Forestry	2.4	3.0	+0.6
Fishing and aquaculture	0.9	1.0	+0.1
Food, beverage and tobacco	22.3	26.1	+3.8
Bio-based textiles	5.0	3.9	−1.1
Wood products and furniture	8.7	8.2	−0.5
Paper	3.2	3.5	+0.3
Bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels)	2.0	2.4	+0.4
Liquid biofuels	0.1	0.1	0
Bio-based electricity	0.03	0.1	+0.07

Note: p.p.—percentage points. Source: Own elaboration based on Data-Modelling platform of agro-economics research.

Respective member states of the European Union have a different potential labour force at their disposal in the bioeconomy. Countries whose share of the EU's total employment in the bioeconomy in 2017 exceeded 10% include Poland, Romania, Germany and Italy. In France this percentage was also high and amounted to 9.2%. It was also one of four countries where the number of workers in the bioeconomy sector did not decrease in the analysed period. It should be highlighted that in Germany, similar to other highly developed countries of Western Europe, agriculture is a so-called primary sector of the economy and accounts for a small share of employees, whereas industrial sectors of the bioeconomy at further levels of the value chain are more important [17].

It can also be noted that in most countries that joined the EU in or after 2004, the decrease in the level of employment in bioeconomy was bigger than in the so-called old EU countries. For instance, in Croatia it decreased by 37.8%, in Romania by 29.5%, and in Poland by 18.5%.

Evaluating the significance of the given sector for the development of the bioeconomy, including to the extent of labour resources, is also essential [47]. This paper analyses agriculture which at the EU level employs more than half of all workers in the bioeconomy. On the scale of respective countries, the significance and potential of agriculture differ. This diversity is reflected by the share of agricultural workers in the total number of workers in the bioeconomy of the given country. In the analysed years this share was the highest in Romania, Bulgaria, Greece, Poland, Portugal and Ireland. Agriculture in each of these countries accounted for more than 60% of all workers in the bioeconomy. In turn, a share of less than 30% was noted in Belgium, Estonia, Sweden, Malta, and in 2017 also in Germany and Slovakia. In 15 member states of the EU a decrease in this share can be observed (Table 2). The largest drop of employment in agriculture in 2008–2017 took place in Romania (by 29.5%), Croatia (by 37.2%), Portugal (by 20.8%), Finland (by 19%), Poland (by 18.5%), Slovenia (by 17.3%), Latvia (by 16.8%), and Bulgaria (by 12.3%). Thus, this mostly refers to new member states entering the development path that more developed countries have already completed. Kołodziejczak [12] also mentions that employment in agriculture decreases as the level of socio-economic development increases. He points out that economic development in the first place leads to a decrease in the role of agriculture (as

a primary sector), which is replaced by the growing role of industry (secondary sector), and then to a decrease in the role of agriculture and industry due to the increasing significance of the services sector. Godlewska-Dzioboń [48] shares these observations claiming that agriculture remains an important sector of the economy. Yet structural changes feature, in particular, high dynamics of employment, production and productivity in sectors making use of high technologies, participating in the innovation network and investing in intangible assets.

Table 2. Number of workers in the bioeconomy sector in EU countries in 2008 and 2017.

Country	Bioeconomy Sector Workers		Share in the Total Number of Bioeconomy Workers in the EU (EU-28 = 100)	Share of Agricultural Workers in the Total Number of Bioeconomy Workers in Respective Countries	
	2008	2017	2017	2008	2017
Austria	368,647.2	334,095.2	1.79	48.43	43.52
Belgium	226,861.1	209,643.7	1.13	29.27	26.72
Bulgaria	966,586.1	847,766.5	4.55	74.18	75.73
Croatia	348,809.8	216,809.8	1.16	52.99	42.62
Cyprus	36,399.1	32,250.37	0.17	44.23	44.31
Czech Republic	401,444.8	386,167.3	2.07	34.50	36.03
Denmark	184,988.4	165,093.2	0.89	35.68	37.74
Estonia	71,429.1	65,509.48	0.35	25.03	25.22
Finland	228,828.8	185,307.2	1.00	40.12	37.38
France	1,709,445.0	1,719,248	9.23	43.76	40.95
Germany	2,021,026.3	1,999,215	10.74	30.38	28.51
Greece	696,466.6	619,632.5	3.33	71.98	70.67
Hungary	372,631.4	374,514.7	2.01	44.07	46.03
Ireland	180,963.0	178,981.2	0.96	61.68	58.4
Italy	2,068,338.5	1,880,207	10.10	43.75	45.49
Latvia	151,840.4	126,300.6	0.68	42.46	36.85
Lithuania	228,911.8	206,565.3	1.11	42.49	44.03
Luxembourg	9,261.9	9610.858	0.05	40.06	34.82
Malta	8873.0	8840.772	0.05	28.18	29.07
Netherlands	408,785.0	387,275	2.08	49.90	49.86
Poland	3,058,344.2	2,492,153	13.38	69.58	62.73
Portugal	864,968.2	684,659.4	3.68	63.86	58.71
Romania	3,416,075.4	2,409,839	12.94	83.27	81.58
Slovakia	169,224.2	167,825.9	0.90	32.84	27.8
Slovenia	137,573.3	113,719.2	0.61	55.85	58.13
Spain	1,531,824.2	1,416,358	7.61	48.58	52.46
Sweden	273,101.5	261,106.5	1.40	20.87	23.83
United Kingdom	1,065,766.3	1,120,609	6.02	32.21	34.72

Source: Own elaboration based on Data-Modelling platform of agro-economics research

This effect on structural transformations in agriculture, in particular in the so-called EU-13 countries, emerges from the CAP. Improvement in the categories of farms in most of the new member states is usually accompanied by decreasing employment in agriculture.

In turn, Helming and Tabeau [49] emphasize that the CAP does not contain instruments oriented directly at maintaining employment in agriculture. Garrone et al. [50] argue that Tier 1 payments have no impact on reducing the outflow of workforce from agriculture. They estimate that increasing the CAP budget by 10% could prevent 16 people from leaving the agricultural sector every year. The European Commission [51] estimated that a decrease in the workforce in agriculture due to structural changes at EU level will slow down to 1% per annum in the following years and should be primarily due to technological progress in machinery and equipment. It will certainly be higher for the majority of new member states.

Gross value added (GVA) reflects the production capacity of the accumulated and used production factors. Knowledge within the sectoral structure of creating gross value added and its change dynamics in respective sectors makes it possible to separate the sources of economic growth according to sectors [34]. Only in four EU member states (Croatia, Cyprus, Greece, and Romania) did gross value added of the bioeconomy decrease in 2008–2017. In other countries, positive growth dynamics were noted, the highest in Lithuania, Ireland, Latvia, Slovakia, Denmark, Estonia and Belgium. Analysing the share of respective countries in the EU's GVA of the bioeconomy, the leading position of Germany, France, Italy, Spain and the United Kingdom is noticeable. The first three countries in 2017 generated, respectively, 16%, 15.3% and 13.2% GVA of the bioeconomy in the EU, and the next two—9.7% each. This means that their total contribution to the EU's GVA for this sector was 64%. The Netherlands and Poland with their respective shares of 4.3% and 5% are also worth noting. In most countries agriculture had a big influence on generating GVA of the bioeconomy, but in some countries its share in this sector's GVA was lower than 20% (Finland, Belgium, Ireland, and Estonia). Countries featuring the biggest share of agriculture in the added value of the bioeconomy sector are usually at a lower level of socio-economic development, i.e., these are mostly new member states, Romania, Bulgaria, Malta and Hungary, where in 2017 agriculture produced from 47.5% to 56.7% GVA of the bioeconomy. Among old member states, agriculture plays a significant role in the Netherlands, Spain, Italy, Greece and France. At the same time, in 15 EU member states the share of agriculture in the GVA of the bioeconomy decreased. The largest decrease took place in new member states including Bulgaria, Romania, Croatia and Lithuania (Table 3). Kołodziejczak [52] underlines that the decreasing share of agriculture in the structure of gross value added in less developed countries was not so much due to a reduction in the level of employment in this sector as to an increase in the GVA in industry and services, so its foundation was identical to that previously observed in countries featuring a higher level of economic development.

Bioeconomy consists of sectors mainly covering the producers of biomass, constituting a raw material to be processed into food, animal feed, energy, biomaterials and bioproducts. These are diverse sections and divisions of the national economy linked with the value chain, starting from the sector of producers of agricultural biomass supplied to industrial processors of food, animal feed, textiles and other materials, bioenergy and biomaterial. Next, agricultural raw materials and those deriving from forestry and fisheries are used and processed, mainly in the food industry, including the production of beverages and tobacco and in the animal feed industry. Textile, wood, paper making and the chemical, cosmetic and pharmaceutical industry play an equally significant role in processing biomass into bioproducts. In addition, a high share of biomass produced in the EU is allocated to energy purposes, which contributes to the practical implementation of sustainable development of industrial and agricultural production. This refers in particular to the production of liquid biofuels based on rapeseed esters such as biodiesel and bioethanol, the latter being added to fuels combusted in diesel engines [10].

Table 3. Gross value added generated by the bioeconomy sector in the EU member states in 2008 and 2017.

Member State	Gross Value Added (GVA) of the Bioeconomy		Agriculture's Share in the GVA of the Bioeconomy	
	MEUR		%	
	2008	2017	2008	2017
Austria	14,008.7	17,159.9	20.59	19.08
Belgium	14,038.9	18,670.0	16.86	14.50
Bulgaria	3587.0	3990.1	56.30	47.51
Croatia	3953.2	3465.4	40.42	31.80
Cyprus	963.1	905.9	38.24	39.23
Czech Republic	8089.2	9307.7	28.32	31.64
Denmark	10,443.4	13,848.2	15.64	25.25
Estonia	1263.7	1671.7	17.69	16.86
Finland	11,736.0	14,099.7	10.97	9.41
France	79,644.6	102,526.6	33.91	30.95
Germany	87,414.7	106,893.5	21.38	21.63
Greece	12,618.7	11,363.7	47.76	52.03
Hungary	7273.8	9069.4	48.55	49.69
Ireland	11,902.1	16,556.1	12.28	19.81
Italy	77,615.7	88,745.2	36.09	33.58
Latvia	1558.6	2083.7	23.74	24.14
Lithuania	2178.0	3439.2	41.69	36.01
Luxembourg	363.6	446.4	29.70	28.27
Malta	138.6	155.6	47.76	50.46
Netherlands	24,229.0	29,036.1	41.85	45.45
Poland	26,449.8	33,403.3	31.06	33.92
Portugal	9790.1	11,660.3	25.96	24.67
Romania	13,919.5	12,482.0	63.01	56.75
Slovakia	2897.9	3844.8	42.00	36.50
Slovenia	2241.8	2333.4	19.39	20.19
Spain	61,058.5	65,132.1	39.02	45.95
Sweden	18,125.8	21,681.5	15.09	15.04
United Kingdom	62,063.3	65,107.9	18.67	20.58
EU-28			29.75	29.57

Source: Own elaboration based on Data-Modelling platform of agro-economics research.

The largest sector of bioeconomy in the European Union in terms of turnover and employment is the food industry, including the production of food, beverages and tobacco. In 2017 its share in the turnover of the bioeconomy sector was 50.5%, which was close to the 49.2% recorded in 2008 (Figure 2).

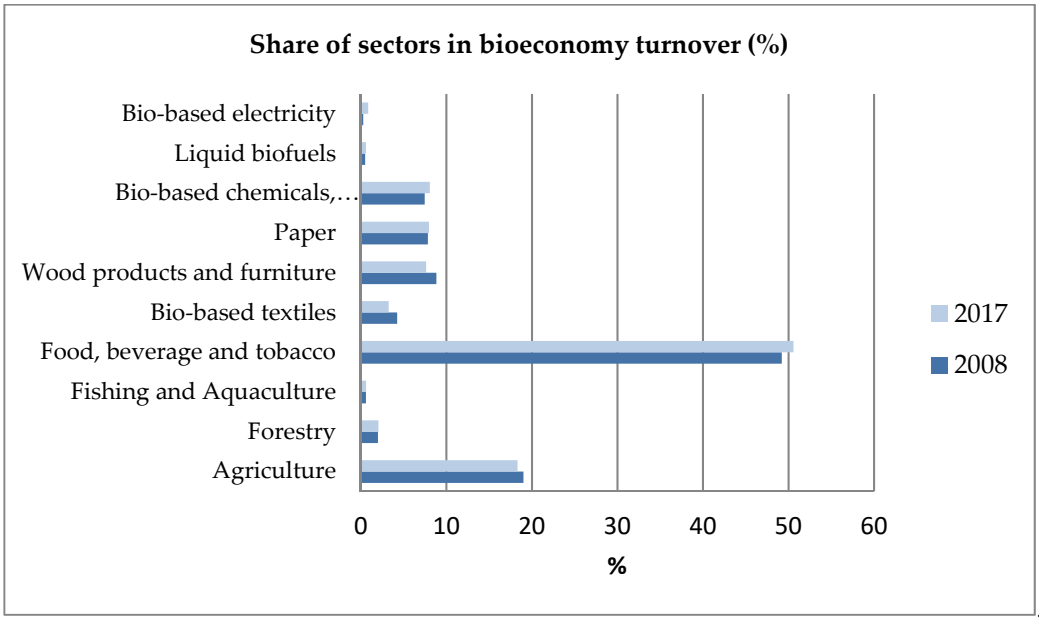

Figure 2. Share of sectors in the bioeconomy turnover of the European Union in 2008 and 2017 (%).

The second largest sector of the bioeconomy is agriculture, being a primary source of biomass, thanks to plant and animal production comprising cultivation of crops and animal breeding and rearing. Biomass deriving from natural resources, including resources of plant and animal origin and microorganisms, can be used for satisfying diverse human needs and producing food and animal feed, materials such as cellulose and paper pulp, wood, chemicals and other products based on natural resources, as well as producing various renewable energy carriers. In 2017 the share of agriculture in the bioeconomy sector was 18.3%, which denoted a small decrease in comparison to the year 2008 when it amounted to 19.0%.

In turn, the forest sector, constituting a significant source of raw materials for other sectors of the bioeconomy, in many EU countries, is a material branch of their national economy responsible for the use of forests and the production of wood and for maintaining longevity of wood stands. Forest biomass includes both wood from forests, orchards, clearances and special arboriculture such as polars and energy willows, as well as special species of energy crops, and dry biomass waste from timber and related industries used to produce heat and electricity. In the analysed years, forestry accounted for more than 2% of the EU bioeconomy sector.

Significant industrial sectors using biomass produced by primary sectors of the bioeconomy such as agriculture, forestry, fisheries and aquaculture, include sectors producing paper, wood products and furniture and products such as biochemicals and biopharmaceuticals. Their share in the EU's bioeconomy turnover in 2017 was 7%–8%. The figure for the producers of paper was 7.9%, for furniture and wood products producers 7.64%, and for producers of biochemicals, biopharmaceuticals and bioplastics 8.06%. The figures were not very different from the levels recorded in 2008. Apart from the three above-mentioned sectors, the bio-based textiles sector also makes use of plant and animal raw materials. In 2017 its share amounted to 3.2%, which denoted a decrease by 1 percentage point in comparison with the year 2008 (Figure 2).

Agriculture, apart from its direct function, which is food production, is also an important supplier of raw materials used for producing electricity, heat and fuels. Such raw materials can be both food products and by-products or waste products of agriculture and other sectors. Their utilisation in the production of energy and fuels allows the mitigation of the problem of by-products and waste products management and reduces the load on the environment caused by storage processes. In terms of the links between agriculture and renewable energy, the processing of agricultural raw materials and production waste

and by-products from biogas plants and biofuel production is particularly worth noting. Forestry, fisheries and aquaculture sectors responsible for supplying raw biomass play a similar role to agriculture in bioenergy and biofuel production [53].

Biomass of agricultural origin can be used effectively through the process of methane fermentation in agricultural biogas plants. The biogas produced can be used to generate electricity, heat or, following treatment, directly for household needs. Agricultural biogas plants can use substrates such as agricultural raw materials, agricultural by-products, liquid or solid animal faeces, waste or residues from the processing of products of agricultural origin or forest biomass, and agricultural biomass obtained from land other than that recorded as agricultural land or forest land. In addition to bioenergy production, an important economic sector using biomass and contributing to the development of bioeconomy is the production and use of biofuels for industry and transport. Using sustainably produced biomass to produce biofuels allows a transition towards using renewable energy to replace fossil fuels and reduce greenhouse gas emissions into the atmosphere. In the European Union, the liquid biofuels sector accounted for 0.61% of the turnover of the EU bioeconomy as a whole in 2017, which denoted an increase in comparison with 2008 (0.5%). An even higher share and growth rate was recorded in the bioenergy sector, where the share in the total turnover of the bioeconomy increased from 0.28% in 2008 to 0.86% in 2017, which corroborates the growing importance of these products for the proper functioning of the EU economy, while implementing the principles of sustainable development [54].

The agricultural sector contributes significantly to the development of the bioeconomy through its economic, social and environmental functions. Countries of the European Union show significant differences in the intensity of farming, use of yield-creating resources and the involvement of capital in agricultural production, and the production performance is influenced by the diverse agricultural and climatic conditions, quality of agricultural production space, terrain relief and water regimes in respective countries.

This diversity can be seen in the impact of the agricultural sector on the development of the bioeconomy in respective countries, measured in terms of its share in the total turnover of all the ten sectors creating the bioeconomy in respective countries.

The analysis shows that the highest contribution of agriculture to the turnover generated by the bioeconomy occurs in countries that joined the European Union in 2004 and 2007, i.e., Hungary, Romania and Bulgaria. The contribution of Romanian agriculture to the development of national bioeconomy in 2008–2017 averaged 41.4%, while Bulgarian agriculture contributed 34.7% and Hungarian 33.3%. In contrast, a specific situation exists in Greece where agriculture does not stand out significantly in terms of production performance compared to other EU countries, but due to the worse performance of other sections of the bioeconomy, the contribution of Greek agriculture in the analysed years averaged 36.1% (Figure 3).

In some countries of the European Union the agricultural sector does not contribute significantly to the development of the bioeconomy due to specific natural and climatic conditions and historical traditions that do not foster large-scale agricultural production. These countries support non-agricultural activities to a greater extent and rely on highly developed industrial sectors that make use of agricultural raw materials to manufacture bio-products. This is the case in: Finland (9.8%), Sweden (12.0%), Belgium (12.0%) and Austria (13.7%), Germany (13.0%) and Ireland (14.4%), where the share of agriculture in generating revenues of the bioeconomy sector is relatively small (Figure 3).

At the next stage of research respective sectors of the bioeconomy were compared in terms of their gross value added, number of employees and share of the total bioeconomy turnover (Figure 4). This analysis shows that two sectors, i.e., Food, beverage and tobacco and Agriculture, play a leading role. Although agriculture generated 20% less gross value added and its share of bioeconomy turnover was lower by 36%, it employed almost twice as many workers. Thus, apart from its production and income function, it also plays a social function. The significance of this function is emphasized by Boháčková et al. [55] and Loizou et al. [24], but it is also mentioned in the concept of sustainable development,

according to which social and economic goals are fully integrated with environmental goals [56,57]. In addition, De Castro et al. [16] underline that the Green Deal communication points to the need for considering the assumption of the Green Deal, From Farm to Fork strategy and biodiversity strategy in national strategic plans. New assumptions of CAP point to, for instance, reinforcing the contribution of agriculture in mitigating and adapting to climate change, improving the management of natural resources used by agriculture, promoting sustainable food production systems and decreasing the imbalance of bargaining power in supply chains.

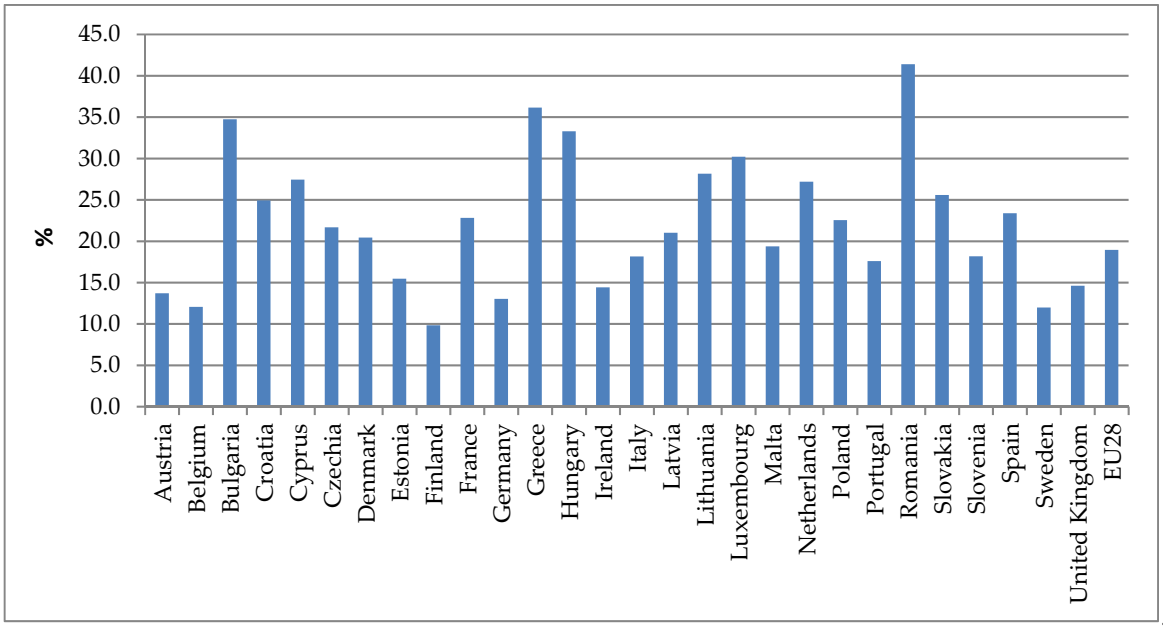

Figure 3. Share of agriculture in the bioeconomy turnover in EU countries in 2008–2017 (%).

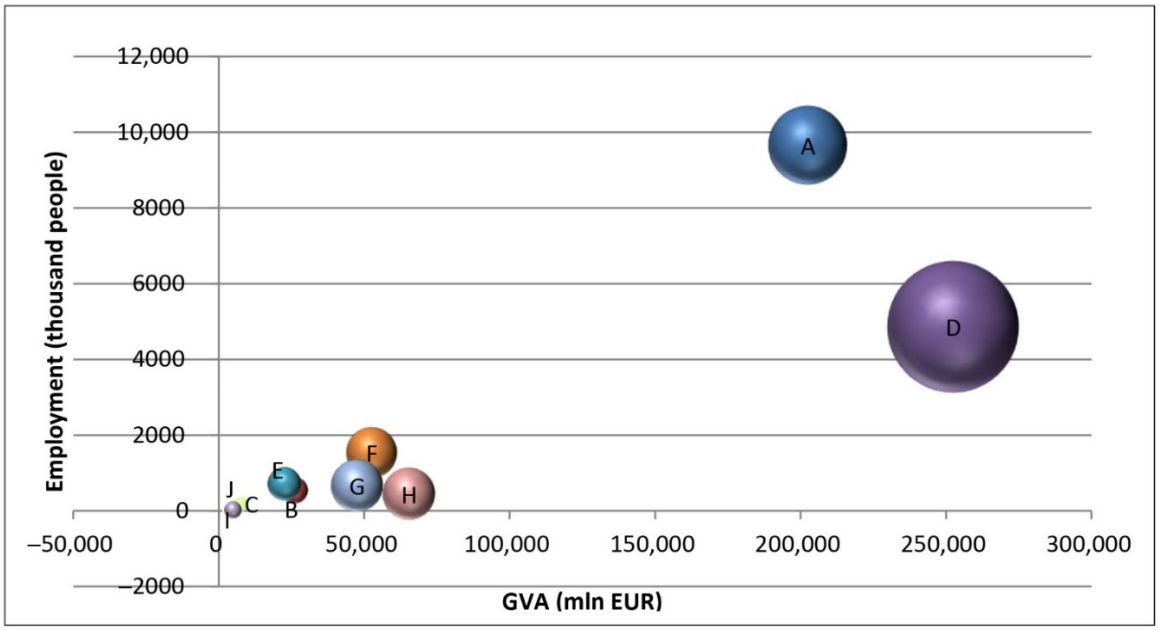

Figure 4. Share of sectors in bioeconomy turnover compared to the number of employees and gross value added (GVA) in 2017. **Note:** A—Agriculture, B—Forestry, C—Fishing and Aquaculture, D—Food, beverage and tobacco, E—Bio-based textiles, F—Wood products and furniture, G—Paper, H—Bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels), I—Liquid biofuels, J—Bio-based electricity. The size of balls corresponds to the share of respective sectors in the bioeconomy turnover.

Productivity is often used as a measure of competitiveness [58], and the European Commission regards it as the most reliable indicator of long-term competitiveness [59]. This study uses labour productivity expressing gross value added per individual worker. The highest productivity among bioeconomy sectors in the years 2008–2017 was achieved for Bio-based electricity (Figure 5). Added value exceeding EUR 100,000/person was achieved for Bio-based chemicals, pharmaceuticals, plastics and rubber (excl. biofuels) at EUR 128,7000/person and for Liquid biofuels at EUR 112,000/person. With value added in Bio-based electricity decreasing by 30% over the analysed period, in Liquid biofuels it increased by 61% and for Bio-based chemicals, pharmaceuticals, plastics and rubber it was 23% higher. Productivity in other bioeconomy sectors did not exceed the average value set for the whole sector at EUR 72000/person. Among these sectors, the highest gross value added expressed in EUR 1000 per worker was achieved in the Paper (65) and Food, beverage and tobacco (48) branches, as well as for Forestry (43.3). The productivity of agriculture was below its average level for the bioeconomy, although its value added increased during the analysed period from EUR 14.54 thousand /person to EUR 20.99 thousand/person, which corresponded to an increase of nearly 45%. This was the lowest productivity level of all branches of the bioeconomy. This is due to the commodity nature of the agricultural sector. The impact of Tier 2 payments on productivity is disputed also in the scientific literature. A study by the JRC (Joint Research Centre) suggests that regions receiving higher Tier 2 payments for investment in tangible assets, development of human capital or agri-environmental resources increase productivity [60]. It is also emphasized that various CAP instruments help farmers create added value and integrate with organisations of manufacturers, but their impact was smaller than expected [61]. Considering the present-day challenges to agriculture, it seems that new directions for the development of this sector outlined in the CAP still focus, to a greater extent, on environmental rather than economic aspects. De Castro et al. [16] underline that, out of nine detailed objectives of the reformed CAP, only a few relate directly to agricultural productivity and the rest focus on environmental, social, territorial and health aspects connected with a broader concept of agriculture and its sustainability.

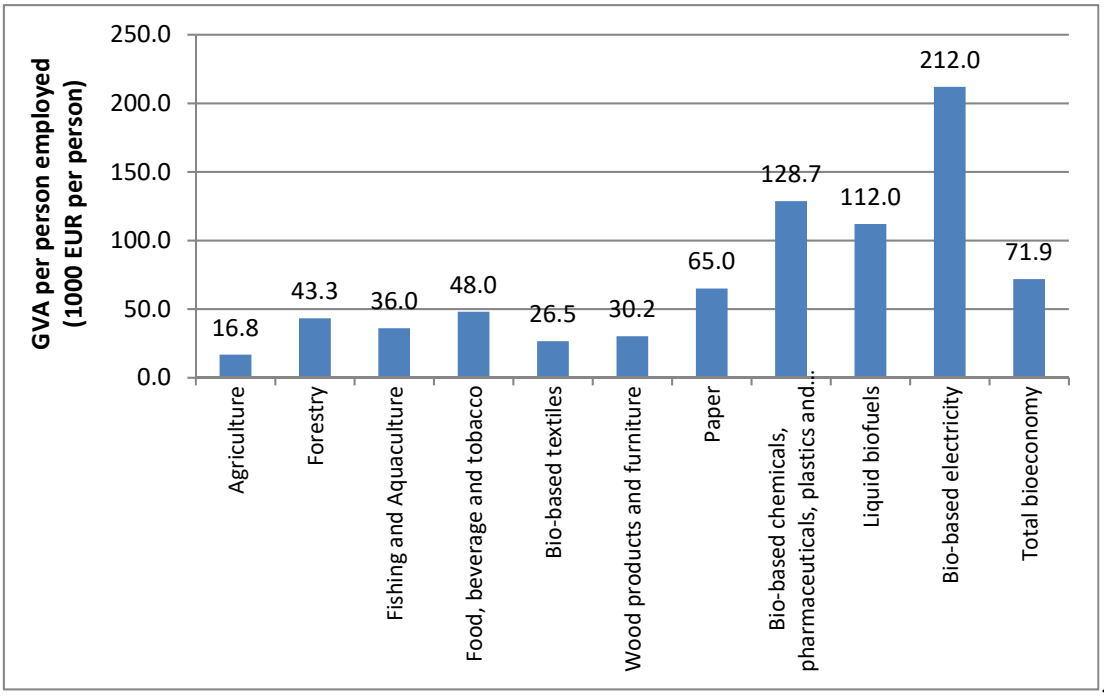

Figure 5. Value added per person employed in bioeconomy in EU-28 in 2008–2017 (1000 €/person).

Gołaś [42] emphasizes that the level of labour productivity of the agricultural sector in EU countries is strongly differentiated and significantly lower than in other sectors of the economy. This was corroborated by our studies. In the analysed period the highest average labour productivity in agriculture was achieved in the Netherlands at close to EUR 57,000 per agricultural worker (Figure 6). This was nearly 3.5 times more than on average in EU-28. This value resulted from an increase in the country's gross value added in 2008–2017 by 38%. No other country exceeded the value of the analysed indicator, i.e., EUR 50,000/person. Sweden recorded less than EUR 48,000 gross value added per worker. Three countries achieved GVA of more than EUR 40,000 per person—Belgium 428,000, Denmark 41,100, and France 406000. Gross value-added exceeding EUR 30,000 per person was generated in Germany, Italy, Luxembourg and the United Kingdom. Malta and Slovakia were close to this level, and Hungary generated less than EUR 24,000 per person. The lowest values—EUR 5000 or less—were recorded in Bulgaria, Poland, Portugal and Romania. Despite the differences in the level and average values of productivity across countries, there has been an increase in productivity in each country. Studies by Kijek et al. [28] show, in addition, that in the case of labour productivity in the agriculture of EU countries, convergence processes of significantly different intensity are observed. Labour productivity convergence does not apply to all economies, but only to those with similar economic and structural conditions.

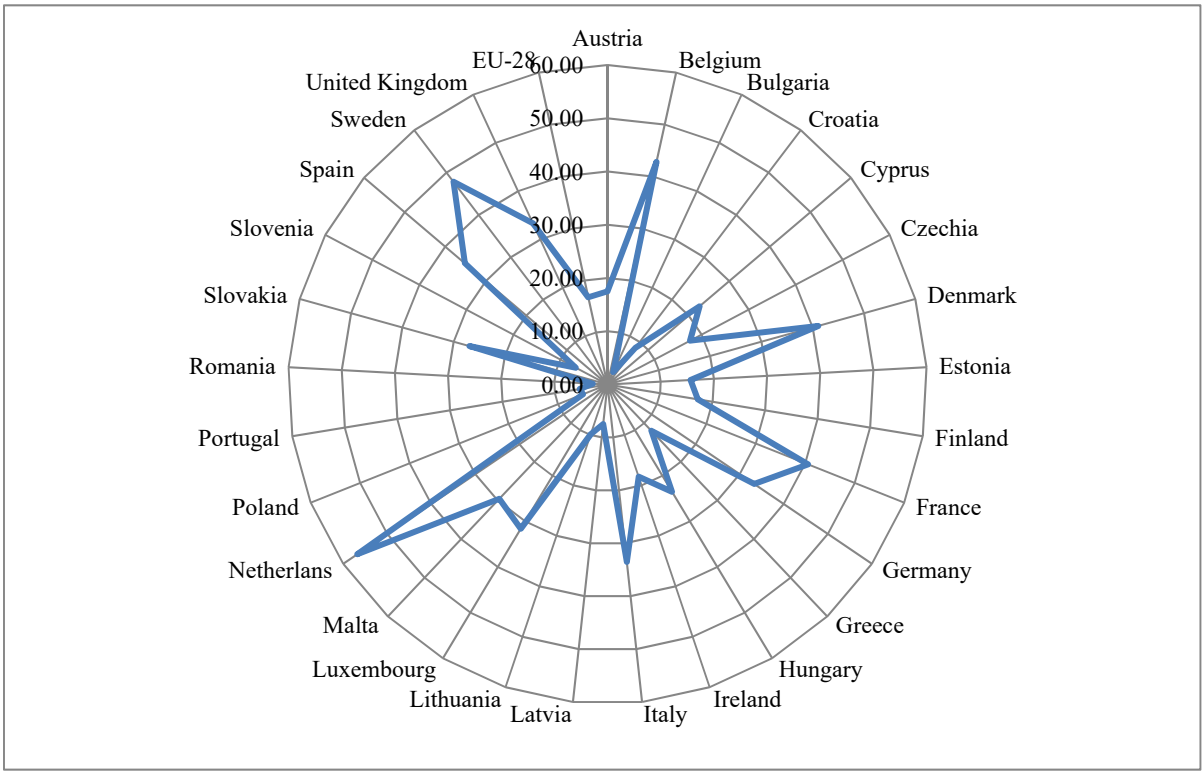

Figure 6. Value added per person employed in agriculture in EU countries in 2008–2017 (1000 €/person) (mean).

4. Conclusions

Interest in the bioeconomy results from numerous challenges faced by the global economy. These challenges include sustainable management of natural resources, sustainable production, public health improvement, mitigation of adverse effects of climate change, and integrated social and economic development. One of the sectors playing a significant role in the development of the bioeconomy is agriculture. This paper contains an assessment of the position of agriculture in the bioeconomy in terms of labour resources, gross value added generated by the sector and its share in the total turnover of the bioeconomy. In addition, the competitiveness of agriculture in respective member states of the European

Union was analysed by assessing the labour productivity achieved in this sector. Although the role of agriculture as one of the sectors of the economy decreases with the increasing level of socio-economic development, it remains significant for the bioeconomy sector. The importance of agriculture stems not only from its food function, but also from the production of biomass, which is a primary source of renewable energy, bio-based raw materials and bio-based materials. This sector is also essential from the point of view of macroeconomic indicators such as the level of employment and the created gross value added. Thus, it can be stated that the food-providing function of agriculture since its origins has given it a strategic position among other sectors of the economy. However, its social function is equally important, and in the face of escalating environmental problems the function connected with reducing external costs and producing environmental public goods has become complementary.

At the heart of the bioeconomy is the biologization of economic processes in which non-renewable resources are replaced by renewable biological resources produced in a sustainable manner. Therefore, the development of a bioeconomy requires collaboration between many sectors of the economy, including agriculture. The rising global attention focusing on natural environment protection and conservation for future generations has made the concept of bioeconomy a subject of multiple scientific studies. However, there is a deficiency of studies concerning the significance of the respective sectors co-creating the bioeconomy, especially those considering all EU member states. This justifies analyses carried out on the indicated subject, and this paper is an attempt at filling this gap. The studies should be treated as preliminary surveys that need to be continued using a wider selection of variables and other methods allowing a comprehensive assessment of the significance of agriculture and other sectors for the development of the bioeconomy. Research consisting in the development of a synthetic measure assessing the importance of individual sectors and their competitive position internationally would be particularly valuable.

Author Contributions: Conceptualization, A.N., A.K. (Anna Kobiałka) and A.K. (Artur Krukowski); methodology, A.N., A.K. (Anna Kobiałka) and A.K. (Artur Krukowski); formal analysis, A.N., A.K. (Anna Kobiałka) and A.K. (Artur Krukowski); resources, A.N., A.K. (Anna Kobiałka) and A.K. (Artur Krukowski); data curation, A.N., A.K. (Anna Kobiałka) and A.K. (Artur Krukowski); writing—original draft preparation, A.N., A.K. (Anna Kobiałka) and A.K. (Artur Krukowski); writing—review and editing, A.N., A.K. (Anna Kobiałka) and A.K. (Artur Krukowski); visualization, A.N., A.K. (Anna Kobiałka) and A.K. (Artur Krukowski); funding acquisition, A.N., A.K. (Anna Kobiałka) and A.K. (Artur Krukowski). All authors have read and agreed to the published version of the manuscript.

Funding: The APC was funded by the University of Life Sciences, Faculty of Agrobioengineering, grant number RUA/S/8/2021 (EFI) and the vouchers.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data used in surveys is sourced from the Data-Modelling platform of agro-economics research. Raw data were converted in accordance with the adopted methodology given in the publication. Data from databases are widely available for use. (https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html, accessed on 21 January 2021).

Conflicts of Interest: The author declares no conflict of interest.

References

1. Beluhova-Uzunova, R.; Shishkova, M.; Ivanova, B. Concepts and key sectors of the bioeconomy. *Trakia J. Sci.* **2019**, *17*, 227–233. [CrossRef]
2. Lewandowski, I.; Lippe, M.; Castro Montoya, J.; Dickhöfer, U. Agricultural Production. In *Bioeconomy: Shaping the Transition to a Sustainable, Biobased Economy*; Lewandowski, I., Ed.; Springer: Cham, Switzerland, 2018; pp. 99–175. [CrossRef]
3. Rodino, S. Bioeconomy concept: Challenges and perspectives for agriculture. In *Agrarian Economy and Rural Development—Realities and Perspectives for Romania, Proceedings of the 9th Edition of the International Symposium, Bucharest, Romania, 15 November 2018*; The Research Institute for Agricultural Economy and Rural Development (ICEADR): Bucharest, Romania, 2018; pp. 77–81.
4. McCormick, K.; Kautto, N. The Bioeconomy in Europe: An Overview. *Sustainability* **2013**, *5*, 2589–2608. [CrossRef]

5. Pfau, S.F.; Hagens, J.E.; Dankbaar, B.; Smits, A.J.M. Visions of sustainability in bioeconomy research. *Sustainability* **2014**, *6*, 1222–1249. [CrossRef]
6. European Commission. *A Sustainable Bioeconomy for Europe: Strengthening the Connection between Economy, Society and the Environment*; Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Brussels, Belgium, 2018.
7. Jonsson, R.; Rinaldi, F.; Pilli, R.; Fiorese, G.; Hurmekoski, E.; Cazzaniga, N.; Robert, N.; Camia, A. Boosting the EU forest-based bioeconomy: Market, climate, and employment impacts. *Technol. Forecast. Soc. Chang.* **2021**, *163*, 120478. [CrossRef]
8. European Commission. *Review of the 2012 European Bioeconomy Strategy*; European Commission (EC): Brussels, Belgium, 2017.
9. Patermann, C.; Aguilar, A. The origins of the bioeconomy in the European Union. *New Biotechnol.* **2018**, *40*, 20–24. [CrossRef]
10. European Commission. Innovating for Sustainable Growth. In *A Bioeconomy for Europe*; Publications Office of the European Union: Luxembourg, 2012.
11. Adamowicz, M. Bioeconomy as a concept for the development of agriculture and agribusiness. *Probl. Agric. Econ.* **2020**, *365*, 135–155. [CrossRef]
12. Kołodziejczak, W. Employment and Gross Value Added in Agriculture Versus Other Sectors of the European Union Economy. *Sustainability* **2020**, *12*, 5518. [CrossRef]
13. IPCC. Guidelines for national greenhouse gas inventories. In *Eggleston HS*; Buendia, L., Miwa, K., Ngara, T., Tanabe, K., Eds.; IGES: Hayama, Japan, 2006.
14. Diakosavvas, D.; Frezal, C. Bio-Economy and the Sustainability of the Agriculture and Food System: Opportunities and Policy Challenges. Available online: https://www.oecd-ilibrary.org/docserver/d0ad045d-en.pdf?expires=1627635134&id=id&accname=guest&checksum=74C1D56C302D5E723C06CFAEBDC40828 (accessed on 15 April 2021).
15. Council of the European Union. *Revision of the EU Bioeconomy Strategy and the Role of the Agricultural Sector*; 5757/18, AGRI 52; Council of the European Union: Brussels, Belgium, 30 January 2018.
16. De Castro, P.; Miglietta, P.P.; Vecchio, Y. The Common Agricultural Policy 2021–2027: A new history for European agriculture. *Ital. Rev. Agric. Econ.* **2020**, *75*, 5–12. [CrossRef]
17. Efken, J.; Dirksmeyer, W.; Kreins, P.; Knecht, M. Measuring the importance of the bioeconomy in Germany: Concept and illustration. *NJAS Wagenin. J. Life Sci.* **2016**, *77*, 9–17. [CrossRef]
18. Heijman, W. How big is the bio-business? Notes on measuring the size of the Dutch bio-economy. *NJAS Wagenin. J. Life Sci.* **2016**, *77*, 5–8. [CrossRef]
19. Woźniak, E.; Twardowski, T. The bioeconomy in Poland within the context of the European Union. *New Biotechnol.* **2018**, *40*, 96–102. [CrossRef] [PubMed]
20. Ronzon, T.; Piotrowski, S.; M'Barek, R.; Carus, M. A systematic approach to understanding and quantifying the EU's bioeconomy. *Bio-Based Appl. Econ.* **2017**, *6*, 1–17. [CrossRef]
21. Motola, V.; De Bari, I.; Pierro, N.; Giocoli, A. *Bioeconomy and Biorefining Strategies in the EU Member States and Beyond*; IEA Bioenergy Task 42: Wageningen, The Netherlands, 2018.
22. Stegmann, P.; Londo, M.; Junginger, M. The circular bioeconomy: Its elements and role in European bioeconomy clusters. *Resour. Conserv. Recycl.* **2020**, *10*, 100029. [CrossRef]
23. Fuentes-Saguar, P.D.; Mainar-Causapé, A.J.; Emanuele Ferrari, E. The Role of Bioeconomy Sectors and Natural Resources in EU Economies: A Social Accounting Matrix-Based Analysis Approach. *Sustainability* **2017**, *9*, 2383. [CrossRef]
24. Loizou, E.; Karelakis, C.; Galanopoulos, K.; Mattas, K. The role of agriculture as a development tool for a regional economy. *Agric. Syst. Elsevier* **2019**, *173*, 482–490. [CrossRef]
25. Csaki, C.; Jambor, A. The diversity of effects of EU membership on agriculture in new Member States. In *Policy Studies on Rural Transition, No. 2009-4*; FAO Regional Office for Europe and Central Asia: Budapest, Hungary, 2009.
26. Ciutacu, C.; Luminita, C.; Jean, A. Similarities and dissimilarities between the EU agricultural and rural development model and Romanian agriculture. Challenges and perspectives. *Land Use Policy* **2015**, *44*, 169–176. [CrossRef]
27. Cuerva, M.C. Dynamics of European agricultural productivity: An analysis of regional convergence. *Rev. Agric. Environ. Stud.* **2011**, *92*, 237–258.
28. Kijek, A.; Kijek, T.; Nowak, A.; Skrzypek, A. Productivity and its convergence in agriculture in new and old European Union member states. *Agric. Econ.* **2019**, *65*, 1–9. [CrossRef]
29. Czyżewski, B.; Matuszczak, A.; Grzelak, A.; Guth, M.; Majchrzak, A. Environmental sustainable value in agriculture revisited: How does Common Agricultural Policy contribute to eco-efficiency? *Sustain. Sci.* **2021**, *16*, 137–152. [CrossRef]
30. Dos Santos, M.J.P.L.; Ahmad, N. Sustainability of European agricultural holdings. *J. Saudi Soc. Agric. Sci.* **2020**, *19*, 358–364. [CrossRef]
31. Carraresi, L.; Banterle, A. Agri-food Competitive Performance in EU Countries: A Fifteen-Year Retrospective. *Int. Food Agribus. Manag. Rev.* **2015**, *18*, 37–62.
32. Nowak, A.; Różańska-Boczula, M.; Krukowski, A. Competitiveness of Agriculture in New Member States of the European Union. *Eur. Res. Stud. J.* **2020**, *23*, 160–175. [CrossRef]
33. Pawlewicz, A.; Pawlewicz, K. Regional differences in agricultural production potential in the European union member states. In *Economic Science for Rural Development, Proceedings of the 19th International Scientific Conference, Jelgava, Latvia, 9–11 May 2018*; Latvia University of Life Sciences and Technologies: Jelgava, Latvia, 2018; pp. 483–489. [CrossRef]

34. Nowak, A.; Różańska-Boczula, M. Differentiation in the production potential and efficiency of farms in the member states of the European Union. *Agric. Econ.* **2019**, *65*, 395–403. [CrossRef]
35. Pawlak, K.; Smutka, L.; Kotyza, P. Agricultural Potential of the EU Countries: How Far Are They from the USA? *Agriculture* **2021**, *11*, 282. [CrossRef]
36. Jordan, N.; Boody, G.; Broussard, W.; Glover, J.D.; Keeney, D.; McCown, B.H.; McIsaac, G.; Muller, M.; Murray, H.; Neal, J.; et al. Sustainable Development of the Agricultural Bio-Economy. *Science* **2007**, *316*, 1570–1571. [CrossRef]
37. Vásáry, V. Knowledge-based agriculture in Central and Eastern European Countries' bioeconomy. *Econ. Environ. Stud.* **2019**, *19*, 137–154.
38. Twardowski, T.; Woźniak, E. Bioeconomics around us. *Nauka* **2016**, *3*, 147–160. (In Polish)
39. Fradj, N.B.; Jayet, P.A.; Rozakis, S.; Georganta, E.; Jędrejek, A. Contribution of agricultural systems to the bioeconomy in Poland: Integration of willow in the context of a stylised CAP diversification. *Land Use Policy* **2020**, *99*, 104797. [CrossRef]
40. FAO. Assessing the contribution of bioeconomy to countries' economy. In *A Brief Review of National Frameworks*; FAO: Rome, Italy, 2018.
41. European Commission. Commission Regulation (EC) No 250/2009 of 11 March 2009 Implementing Regulation (EC) No 295/2008 of the European Parliament and of the Council as Regards the Definitions of Characteristics, the Technical Format for the Transmission of Data, the Double Reporting Requirements for NACE Rev.1.1 and NACE Rev.2 and Derogations to Be Granted for Structural Business Statistics. Available online: https://eur-lex.europa.eu/legal-content/GA/TXT/?uri=CELEX:32009R0250 (accessed on 21 January 2021).
42. Gołaś, Z. Convergence of labour productivity in agriculture of the European Union. *Probl. Agric. Econ.* **2019**, *1*, 22–43. [CrossRef]
43. Data-Modelling Platform of Agro-Economics Research. Available online: https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html (accessed on 21 January 2021).
44. Pajewski, T. Bioeconomy as a strategic element of sustainable agriculture. *Rocz. Nauk. Ser.* **2014**, *16*, 179–184. (In Polish)
45. Martin-Retortillo, M.; Pinilla, V. Why did Agricultural Labour Productivity Not Converge in Europe from 1950 to 2005? October 2012. Available online: http://www.ehes.org/EHES_No25.pdf (accessed on 21 April 2021).
46. Robert, N.; Jonsson, R.; Chudy, R.; Camia, A. The EU Bioeconomy: Supporting an Employment Shift Downstream in theWood-Based Value Chains? *Sustainability* **2020**, *12*, 758. [CrossRef]
47. Jurga, P.; Loizou, E.; Rozakis, S. Comparing Bioeconomy Potential at National vs. Regional Level Employing Input-Output Modeling. *Energies* **2021**, *14*, 1714. [CrossRef]
48. Godlewska-Dzioboń, B. Sectoral employment structure in central and eastern European countries compared to highly developed countries in the European Union. In *New Challenges in Economic Policy, Business, and Management*; Ujwary-Gil, A., Gancarczyk, M., Eds.; Institute of Economics, Polish Academy of Sciences: Warsaw, Poland, 2020; pp. 85–105.
49. Helming, J.; Tabeau, A. The economic, environmental and agricultural land use effects in the European Union of agricultural labour subsidies under the Common Agricultural Policy. *Reg. Environ. Chang.* **2018**, *18*, 763–773. [CrossRef]
50. Garrone, M.; Emmers, D.; Olper, A.; Swinnen, J. Jobs and agricultural policy: Impact of the common agricultural policy on EU agricultural employment. *Food Policy* **2019**, *87*, 101744. [CrossRef]
51. European Commission. For markets, income and environment 2020–2030. In *EU Agricultural Outlook*; DG Agriculture and Rural Development: Brussels, Belgium, 2020.
52. Kołodziejczak, W. Employment and Gross Value Added in the Sectors of the European Union Economy in 2002 and 2016. *Probl. World Agric.* **2018**, *18*, 270–283. (In Polish) [CrossRef]
53. *Agriculture and Food Economy in Poland*; MRiRW: Warsaw, Poland, 2019. (In Polish)
54. Krukowski, A.; Kijek, T.; Nowak, A.; Kasztelan, A.; Kobiałka, A.; Matras-Bolibok, A. The potential of the European Union countries to produce biomass for biodiesel production and consumption purposes. In *Rural Development 2017: Bioeconomy Challenges, Proceedings of the 8th International Scientific Conference, Akademija, Kaunas, Lithuania, 23–24 November 2017*; Aleksandras Stulginskis University: Akademija, Lithuania, 2017; pp. 647–651.
55. Bohackova, I.; Hrabankova, M.; Svatosova, L. Role of agriculture in the development of rural regions. *Agric. Econ.* **2003**, *49*, 229–232.
56. Wiśniewska, J. Economic sustainability of agriculture conceptions and indicators. *Acta Sci. Pol. Oeconomia* **2011**, *10*, 119–137.
57. Janker, J.; Mann, S.; Rist, S. Social sustainability in agriculture—A system-based framework. *J. Rural. Stud.* **2019**, *65*, 32–42. [CrossRef]
58. Latruffe, L. Competitiveness, productivity and efficiency in the agricultural and agri-food sectors. *OECD Food Agric. Fish. Work. Pap.* **2010**, *30*, 1–63. [CrossRef]
59. European Commission. *European Competitiveness Report 2008*; European Commission: Brussels, Belgium, 2009.
60. Dudu, H.; Kristkova, S.Z. Impact of CAP Pillar II Payments on Agricultural Productivity. In *JRC Technical Report*; Publications Office of the European Union: Luxembourg, 2017. [CrossRef]
61. European Commission. Modernising and simplifying the CAP. In *Economic Challenges Facing EU Agriculture*; European Commission Directorate-General For Agriculture And Rural Development: Brussel, Belgium, 2017.