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BIOECONOMY LABOUR MARKET AND ITS DRIVERS IN THE CZECH REPUBLIC

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Abstract:

During the last decade, we can observe the increasing importance of a new phenomenon – the bioeconomy. The bioeconomy or biobased economy encompasses the biobased resources production and its conversion into food, feed, bioenergy, and biobased materials. It can contribute to building a more competitive, innovative, and prosperous society. The development of the bioeconomy is closely connected with particular sectors. The main aim of this paper is to focus on and evaluate the changes in the bioeconomy labour market in the Czech Republic. For this, the sectoral approach is used, and a set of statistical data is collected. As a methodology, the literature review, desk research, correlation, and regression analysis were used. Based on the results, the share of people employed in bioeconomy sectors declined in 2000 – 2020 in the Czech Republic. Regarding the structure of employment in the bioeconomy sectors, the highest number of employees is in the traditional sectors of the national economy, such as agriculture, forestry and fishing, food products, beverages and tobacco, and wood products and furniture. The main drivers of employment in the bioeconomy sectors are GDP, wages/salaries, and subsidies. Due to current public support, we expect an increasing number of new green jobs connected with the bioeconomy and upgrading the original ones in all bioeconomy devoted sectors.

Key words:

bioeconomy; labour market; sectoral approach; employment; regression analysis; Czech Republic.

JEL: J21, O13, Q57

1 Introduction

1.1 Bioeconomy

The need for clean and environmentally friendly production is increasing, especially in industrialized societies. We can observe a new economic phenomenon – the bioeconomy. The bioeconomy or biobased economy encompasses the production of biobased resources and their conversion into food, feed, bioenergy, and biobased materials (Ronzon et al., 2017).

Based on scientific literature (Ronzon et al., 2015), the national bioeconomies of the EU states can be divided into four groups of countries, such as agricultural bioeconomies (Slovenia, Greece, Romania), agro-food industry and bio-based chemical industries (Italy, France, Germany), forestry bioeconomies (Finland, Sweden, Estonia), and non-specialised bioeconomies (the Czech Republic, Slovakia, Hungary).

Based on the labour market data, we can evaluate how the bioeconomy sector is divided between more or less traditional sectors. The development of the bioeconomy as a whole is closely connected with the particular sectors. Regarding the sectoral approach, the key methodology was performed by the

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Data-Modelling platform of agroeconomic research (European Union, 2021). This approach is described in Table 1.

Table 1: Overview of bioeconomy sectors – pure and hybrid

Bioeconomy sector	NACE Code
Agriculture	A01
Forestry	A02
Fishing	A03
Food, beverages and tobacco industry	C10; C11; C12
Bio-based textiles*	C13*; C14*; C15*
Wood products and furniture*	C16*; C31*
Paper and paper products	C17
Bio-based chemicals, pharmaceuticals and plastics (excl. biofuels)*	C20*; C21*; C22*
Liquid biofuels (bioethanol and biodiesel)*	C2014*; C2059*
Bio-based* electricity	D3511*

*Hybrid sectors: bio-based shares are applied to estimate the activity generated by the manufacture of biomass feedstock only

Source: own processing, based on methodology European Commission (2021)

Some sectors are pure bioeconomy sectors, some are so-called hybrid sectors – only bio-based shares are applied to the calculations. It is not easy to set a bio-based share of some sectors. Therefore, in our analysis presented in this paper, we will work with pure bioeconomy sectors.

The main aim of this paper is to focus on and evaluate the changes in the bioeconomy labour market in the Czech Republic. For this, the sectoral approach will be used. The methodological approach and particular methods are described in a separate chapter below. The results will show us the changes in the labour market both in the whole bioeconomy group and in its various sectors. The main findings will help us to formulate the key policy recommendations.

The paper is divided as follows: key scientific studies are described in chapter 1.2. “Literature overview”, chapter 2 will focus on the “Methodological approach”, then the key findings will be presented in the “Results” chapter, and then “Discussion” of results within the broader context and answering research questions will follow. Finally, “Conclusions” will underline the key findings and formulate policy recommendations.

1.2 Literature overview

Regarding scientific studies focusing on bioeconomy issues, there is still a lack in this field. The most of available scientific studies are national case studies. The socio-economic effects of the bioeconomy, such as employment, turnover, and GDP, are not very well known as a whole. Concerning these issues, we focused our literature review on scientific studies relevant to the employment effects of the bioeconomy. Such studies will be presented in the following paragraphs.

For example, in the study performed by Ronzon et al. (2018), authors completed the picture of the bioeconomy in the European Union and identified four broad bioeconomy patterns within the EU that differ according to the specialization of Member States’ labour markets in the bioeconomy (location quotient) and according to the apparent labour productivity of their bioeconomies. Third, they examined temporal dynamics over the period 2008–2015, and finally, they take a closer look at the East–West bioeconomy disparities within Europe and suggest measures to promote EU bioeconomies. According to their estimations, the EU-28 bioeconomy employed 18 million people and generated EUR 2.3 trillion of turnover or EUR 620 million of value added in 2015. Based on the results, the bioeconomy sector employed 8.2 % of the EU-28 labour force and generated 4.2 % of the EU-28 GDP. Over time,

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bioeconomy employment tends to reduce while value added increases. The number of people working in the bioeconomy was 2.5 million fewer in 2015 than in 2008, mainly because of the ongoing restructuring of the agricultural sector, and the apparent labour productivity has also improved from EUR 28 000 value added per person employed in 2008 to EUR 34 400 in 2015.

Another scientific study, prepared by Ronzon's team, too (Ronzon et al., 2020), presents a methodology to monitor the contribution of the bioeconomy to jobs and growth within the European Union and its Member States. Sectoral shares are applied to indicators of employment, and value added is reported in Eurostat–Structural business statistics. The results of this scientific paper show that the bioeconomy of the EU employed around 17.5 million people and generated EUR 614 billion of value added in 2017. The study describes cases of transition over the 2008–2017 period. The number of persons employed in the EU bioeconomy did not decrease in 2017, which was the first time that this number did not decrease over the 10 years monitored. The strong decline in agricultural employment observed in previous years drastically reduced by −38 600 workers in 2016–2017 while the food and beverage industry was a strong employer for the second consecutive year (+127 000 workers in 2016–2017).

The results of the article focused on a systematic approach to understanding and quantifying the EU's bioeconomy (Ronzon, et. al., 2017) show that in 2014, approximately 18.6 million people in the EU were employed in the bioeconomy, generating an annual turnover of around EUR 2.2 trillion. And over the period 2008-2014, almost all sectors of the bioeconomy in the EU experienced labour productivity gains (in terms of turnover per person employed). Between 2008 and 2014, employment in the European bioeconomy contracted, with the loss of nearly 2 million people employed.

On the contrary, the new estimation of employment and turnover figures, carried out by the nova-Institute (Dammer, 2017) concludes that the bio-based economy accounted for EUR 674 billion in turnover and 3.3 million persons employed in 2014.

Publication by European Commission's Knowledge Centre for Bioeconomy concludes that in 2017, the bioeconomy generated 4.7 % of the gross domestic product of the EU-27 and employed 8.9 % of the labour force. The employment in the primary production sectors decreased by around 4.2 % in the second quarter of 2020, in comparison to the second quarter of 2019, while the total hours worked decreased by 5.6 %. In 2017, the bioeconomy employed 17.5 million people in the EU-27, which represents 8.9 % of the total labour force. More than half worked in agriculture (53 %) and a quarter in the food, beverages, and tobacco industry (25 %).

The purpose of another study in the field (CEPI, 2011) was to analyse direct and indirect value added and employment in the European pulp, paper, and paperboard industry for the year 2008. The study concludes that in 2008, the value added in the pulp, paper and paperboard industry was around EUR 97.1 billion. Also, the number of employees was estimated at 208 200 in the pulp, paper and paperboard industry, at 337 300 in upstream and 1 051 700 in downstream activities, coming to a total of 1 597 200 employees, directly and indirectly, working for this industry. Moreover, an alternative use of wood and recovered paper was studied and the comparison to a theoretical energetic usage of the same amount of biomass concludes that the use in material industries creates much more value added and employment than the energy use could.

Paper by Carus (2012) presents the first ever collection and analysis of data on the bioeconomy at an EU-27 level. It gives an overview of the quantitative dimensions of Europe's bio-based economy with a focus on the industrial material use of biomass. To calculate the volume of industrial biomass flows, and for different macroeconomic effects generated by several bio-based industries, Eurostat data was used. The calculation of macroeconomic effects includes indicators such as the number of enterprises, employed persons and value added. This study has found that the industrial material use of biomass generates employment and added value that is higher than the effects generated by energy use by a factor of 5-10 (per t of biomass or hectare), mainly due to longer and more complex value chains.

Another study (Efken et al., 2012) focuses on national aspects of Germany and assesses the macroeconomic impact of the bio-based economy in Germany for the year 2007. The study is based on

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the four following indicators: the number of companies, employment, turnover, and gross value added. Altogether, five million employees (12.5 % of all employees) and EUR 165 billion (7.6 % of German gross national product) have been calculated as the share of the biobased economy in Germany.

The study by Dammer (2014) does not contain data on socio-economic benefits itself but provides a comprehensive overview and analysis of the current statistical framework in Europe. The study was carried out by the nova-Institute for the JRC. Existing databases and data gaps were identified. It then proceeds to suggest different methodologies of how these data gaps could be filled.

The Bioeconomy in the European Union in numbers (Joint Research Centre IPTS, 2015) is a short briefing paper on biomass extraction and use as well as on turnover and employment generated by the bioeconomy in the EU. Data are based on cooperation between Joint Research Centre IPTS and nova-Institute for ecology and innovation. Based on this publication, the European bioeconomy generates a turnover estimated at around EUR 2 trillion and employs more than 17 million persons.

Concerning subsectors of bioeconomy, Piotrowski et al. (2016) analyses turnover and employment generated by the bioeconomy and different sub-sectors for the EU-28 and its Member States for the year 2013. The results show EUR 2.1 billion turnover and 18.3 people employed by the EU bioeconomy.

A report by Parisi and Ronzon (2016) presents the conclusions of a workshop between bioeconomy stakeholders from the EU, Canada, the US, and Brazil and provides a clear common interest between these countries/regions in measuring and monitoring the bioeconomy sector. A common issue is the lack of data. The report gives a good overview of the different activities going on to collect data: nova-Institute, Joint Research Centre, Renewable Raw Materials (RRM) group, CEFIC, specific FP7 projects (e.g., BIO-TIC), Member State level - the Netherlands. Joint Research Centre and Wageningen UR are modelling the socio-economic impacts of the EU bioeconomy in a general equilibrium model (MAGNET) in the project SAT-BBE.

Another national case study is focused on the Dutch economy. Report Macroeconomic outlook of sustainable energy and biorenewables innovations (Van Meijl et al., 2016) is a macroeconomic assessment of large-scale deployment of biomass to 2030 and shows that a bioeconomy can positively contribute to the Dutch economy. High technological change and global markets with low biomass prices are important to achieve these impacts. The economic impact is very much related to volatile fossil energy prices. Low fossil energy prices reduce the macroeconomic benefits but the contributions of the bioeconomy to emission reduction remain. To achieve the positive macroeconomic impacts and emission reduction a stimulus by policies (e.g., CO2 taxes, R&D policies) is necessary.

Report Analysis of the European Crude Tall Oil Industry – Environmental Impact, Socioeconomic Value & Downstream Potential by Rajendran, et al. (2016) undertook a scientific, quantified, and comprehensive analysis to estimate and compare the environmental impact, the economic added value, and the social impact (direct, indirect, and induced jobs). The total employment generated by the pine chemicals industry and its downstream value chain is at least 20 times more than that generated from the production of renewable diesel.

The study by Debergh et al. (2016) quantifies the different economic effects associated with the activities of the industrial biotechnology sector in Europe. The results show that total employment in the industrial biotechnology value chain amounts to about 486 000 full-time equivalents. About 94 000 full-time equivalents are generated themselves, while some 269 000 are created in the upstream part of the value chain. In addition, some 98 000 full-time equivalents are generated downstream of the industrial biotechnology sector, whereas the employment of about 25 000 people is induced by the spending of employees in the earlier categories.

Regarding studies focusing on the Czech Republic, besides the above mentioned study performed by Ronzon et al. (2017), there are studies presented by Purwestri et al., (2020) or Hajek et al. (2020). However, such studies are not focused directly on the bioeconomy labour market. For example, Purwestri et al. (2020) deal with the current forest policy in the Czech Republic in meeting the purposes of the European forest-based bioeconomy and compare the Czech Republic and Germany in their forest strategies and the implementation of a forest-based bioeconomy in the country. Secondly, Hajek et al.

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(2020) observe the current status of the development of the bioeconomy in the Czech Republic, underlining connected research and development activities. Based on this study, the Czech Republic has a strong research performance in chemistry and biology, which together with developed agriculture, forestry and food industries, provides a good foundation for the development of locally based circular systems. On the other hand, this study contains no data or overview of the bioeconomy labour market and its development in the Czech Republic.

Based on the above literature, it is clear, that there is still a gap in the field of labour market structure and development of the bioeconomy sector in the Czech Republic. Therefore, this study will try to fill this gap.

2 Methodological approach

2.1 Data

For the purposes of our research, various data sources were used, both from scientific databases and official institutional online sources. Generally, all materials and data focus mainly on the bioeconomy, labour market, and employment in bioeconomy sectors.

Regarding bioeconomy, bioeconomy sectors, and features of such sectors, the key data sources are represented by the data published in scientific studies (scientific databases Web of Science, Scopus, Research Gate, etc.), official websites of the European Union, Eurostat, the Bio-based Industries Consortium and nova-Institute for ecology and innovation. To find the necessary data on employment in the bioeconomy in the EU-27 and the Czech Republic, two sources of data were used – the Eurostat database (Eurostat, 2021) and the Data-Modelling platform of agro-economics research (European Union, 2021). Regarding employment in the bioeconomy sectors, we work with the same sectors as Ronzon et al. (2020), namely agriculture, forestry, fishing, the manufacture of food products, beverages and tobacco, the manufacture of bio-based textile, the manufacture of wood and wood products, the manufacture of paper, the manufacture of bio-based chemicals, the manufacture of bio-based pharmaceuticals, the manufacture of bioplastics, the manufacture of liquid biofuels and the production of bioelectricity.

For the period 2000 – 2020, detailed data connected with pure bioeconomy sectors, namely agriculture, forestry, fishing, and the manufacture of food products, beverages and tobacco, were used from Eurostat (2022) and the Czech Statistical Office (CZSO, 2022). Table 2 shows the overview of all data/variables used for research presented in this paper, including abbreviations and units of the variables.

Table 2. List of variables

Variable	Abbreviation	Unit
Employment	EM	Thousand persons
Employment in agriculture, forestry and fishing	EMAFF	Thousand persons
Employment in manufacture in food products, beverages and tobacco	EMMFBT	Thousand persons
Gross domestic product at market prices	GDP	Current prices, million euro
Exports of goods and services	X	Current prices, million euro
Imports of goods and services	M	Current prices, million euro
Wages and salaries	WG	Current prices, million euro
Subsidies	SUB	Current prices, million euro
Subsidies on products	SUBPR	Current prices, million euro
Time	TM	Year

Source: own processing

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The following table 3 summarizes the parameters of each of the variables. For each of the variables the minimum and maximum values, the mean, and the median are indicated. For the analyses, we used 21 observations (21 years) for each variable.

Table 3. Overview of the data statistics

Variable	Minimum	Maximum	Standard deviation	Median
EM	4 828.89	5430.34	151.39	5090.63
EMAFF	155.68	226.85	14.17	175.71
EMMFBT	126.08	156.22	10.03	130.98
GDP	67032.5	225568.7	46186.96	157920.8
X	32236.6	166682.7	43765.01	103506.1
M	33486.3	153171.8	38411.28	98678.3
WG	19989.3	77380.2	16662.86	50328.5
SUB	1470.7	7975.8	1833.28	3857.5
SUBPR	552.5	4028.5	1224.96	1919.3
TM	2000	2020	6.21	2010

Source: own processing

2.2 Methodology

The main aim of this paper is to focus on and evaluate the changes in the bioeconomy labour market in the Czech Republic. For this, the sectoral approach will be used, and the statistical data collected. Besides the literature review, desk research, and time series analysis, the sectoral comparative analysis will be presented.

Linking up with the paper objective, various data will be observed focusing on the bioeconomy labour market in the Czech Republic. At first, the share of bioeconomy sectors on the labour market in the Czech Republic will be evaluated.

Besides the general category “bioeconomy sector” and its time series analysis, the key approach is the sectoral one, focusing on the sectoral distribution of the labour force. According to the study performed by Porc and his team (2020), the bioeconomy includes the following sectors: pharmaceuticals, chemicals and plastics, bioenergy, biofuels, paper, and paper products, forest-based industry, textile and textile products, tobacco products, beverages, food products, forestry sector, and agriculture. Taking these sectors into account, firstly, a detailed time series analysis will be performed for particular sectors. As a second step, data sets from such sectors will be compared. The comparison will focus on selected labour market indicators, such as employment.

Regarding the structure of the bioeconomy labour market, the changes during the time are also important. Therefore, the analysis will be performed for the period 2000 - 2020, to observe possible changes and transformation processes of the labour market. The observed period can give us an overview of the bioeconomy sector’s development concerning the labour market.

Focusing on the main goal of the paper, the following three research questions should be answered:

Q1: What is the structure of the bioeconomy labour market in the Czech Republic?
Q2: What are the main drivers of the bioeconomy labour market in the Czech Republic?

For our research, we used the following methods: literature review, data analysis, correlation analysis, and regression analysis.

Correlation analysis (Pearson’s correlation coefficient) and regression analysis were carried out based on the above described data (Table 2 and Table 3). The possible links and connections between

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the variables were evaluated. The potential impact of the selected indicators in the Czech Republic was examined. The authors use the linear regression models. The key one is the regression model MOD1 which counts the relation between employment in agriculture, forestry, and fishing or employment in manufacture in food products, beverages and tobacco and all other variables.

The general regression equation of MOD1 is as follows:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + u \quad (1)$$

In this equation, parameters $\beta_0 - \beta_7$ represent regression coefficients that reflect the impact of the independent variable on the dependent variable. The dependent variable Y represents employment in selected bioeconomy sectors (employment in agriculture, forestry and fishing EMAFF and employment in manufacture in food products, beverages and tobacco EMMFBT). The parameter u represents a random element of the model. The independent variable X_1 in the regression equation is GDP, X_2 is an export (X), X_3 is an import (M), X_4 is a wage (WG), X_5 is subsidies (SUB), X_6 is subsidies to products (SUBPR), X_7 is a time (TM).

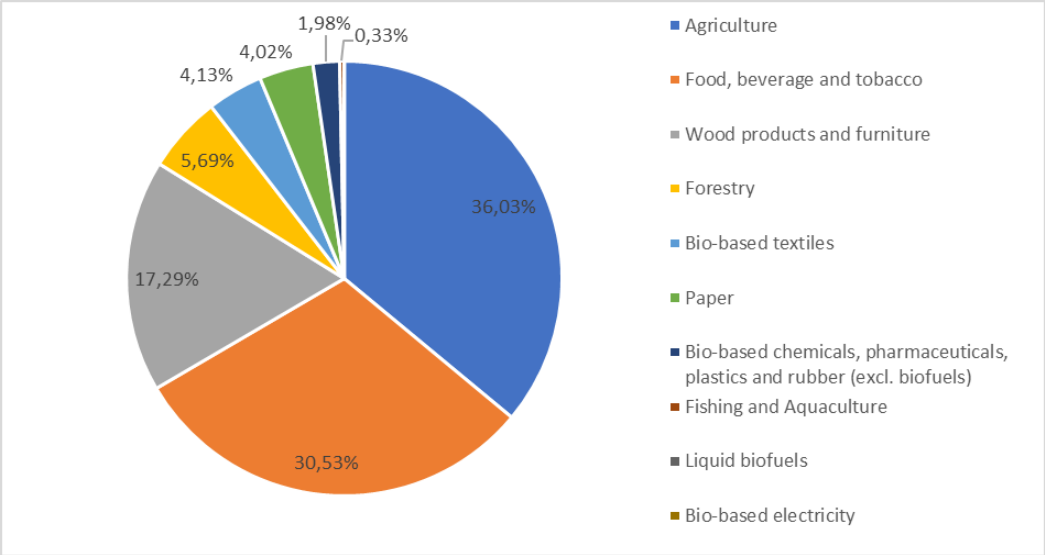
Regression models MOD2 and/or MOD3 represent more focused and statistically significant models. MOD 2 and MOD3 are described in the following chapter.

3 Results

3.1 Structure of the bioeconomy labour market in the Czech Republic

Figure 1 focuses on the bioeconomy structure in the Czech Republic in 2017 in more detail. Up-to-date data are not available, only for some sectors (see correlation and regression analysis below). The highest yield represents pure bioeconomy sectors: agriculture (36.03 %) and food, beverage, and tobacco (30.53%). The third sector is wood products and furniture (17.29 %). The next ones are forestry (5.69 %), bio-based textiles (4.13 %), paper (4.2 %), bio-based chemicals, pharmaceuticals, plastics, and rubber (excl. biofuels) (1.98 %), and fishing and aquaculture (0.33 %), liquid biofuels, and bio-based electricity with diminishing yield.

Figure 1: Structure of the bioeconomy in the Czech Republic in 2017



Source: European Commission (2021), own processing

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Table 4 shows data on employed persons in total, employed persons in the bioeconomy, and the share of the bioeconomy sectors on the whole labour market in the Czech Republic in the period 2008 - 2017.

Table 4: Share of the bioeconomy sectors on the labour market in the Czech Republic (%)

Year	Employed persons in total (in thousand persons)	Employed persons in the bioeconomy (in thousand persons)	Share of the bioeconomy sectors (%)
2008	5 002,500	401,445	8.03
2009	4 934,300	398,216	8.07
2010	4 885,200	385,535	7.89
2011	4 872,400	384,328	7.89
2012	4 890,100	388,348	7.94
2013	4 937,100	385,620	7.81
2014	4 974,300	384,186	7.72
2015	5 041,900	385,228	7.64
2016	5 138,600	383,281	7.46
2017	5 221,600	386,146	7.40

Source: Czech Statistical Office (2021), European Commission (2021), own processing

Table 4 shows that the share of the bioeconomy sectors in the labour market in the Czech Republic in the period 2008-2017 was around 7-8 %. The highest value of the share of the bioeconomy sectors on the labour market in the Czech Republic was in 2008 (8.025 %). In contrast, the lowest value of the share of the bioeconomy sectors on the labour market in the Czech Republic was in 2017 (7.395 %). The results show a declining trend in the share of the bioeconomy sectors on the labour market in the Czech Republic in the period 2008-2017.

As is described in the Introduction, Table 1, some sectors are pure bioeconomy ones, some are hybrid sectors – only bio-based shares were applied to the calculations. It is not easy to set bio-based share of some sectors. Therefore, for the period 2000 – 2020, detailed data connected with pure bioeconomy sectors, namely agriculture, forestry, fishing (AFF), and the manufacture of food, beverage and tobacco (MFBT), were analysed (see Figure 2). AFF consists of 3 subsectors – agriculture (A01), forestry (A02) and fishing (A03).

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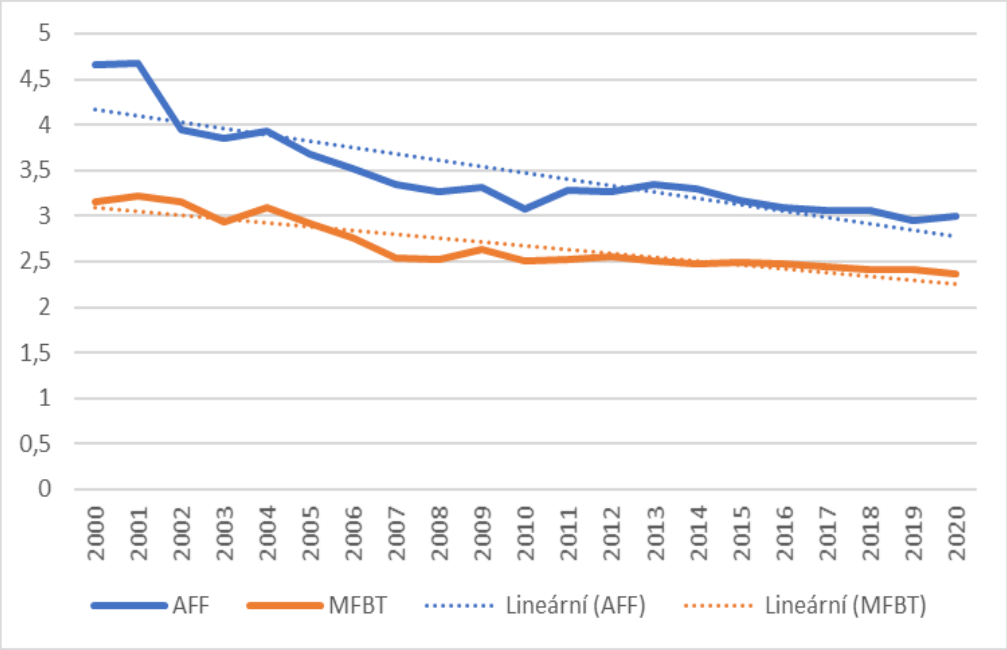
Figure 2 The share of selected bioeconomy sectors on the labour market in the Czech Republic



Source: own processing, based on Eurostat (2022)

In the period 2000 – 2020 as a whole, we can see the declining trend of the share of AFF and MFBT sectors on the labour market in the Czech Republic.

3.2 Drivers of the bioeconomy labour market in the Czech Republic

The following Table 5 shows the results of the correlation analysis. Regarding the variables, they are described in Table 2. List of variables and Table 3. Overview of the data statistics.

Table 5: Correlation analysis

	EM	EMAFF	EMMFBT	GDP	X	M	WG	SUB	SUBP	TM
EM	1									
EM AFF	-0.713	1								
EMMFBT	-0.723	0.906	1							
GDP	0.955	-0.841	-0.844	1						
X	0.934	-0.812	-0.848	0.978	1					
M	0.932	-0.819	-0.855	0.979	0.999	1				
WG	0.956	-0.809	-0.809	0.996	0.969	0.969	1			
SUB	0.871	-0.731	-0.791	0.939	0.944	0.938	0.949	1		
SUBP	0.852	-0.714	-0.766	0.916	0.954	0.949	0.923	0.974	1	
TM	0.922	-0.796	-0.816	0.968	0.985	0.979	0.969	0.973	0.973	1

Source: Own processing.

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Comparing results for EM, EMAFF, and EMMFBT, the bioeconomy labour market differs from the general one. We can observe negative correlations of employment with all selected variables (GDP, X, M, WG, SUB, SUBP, and TM) in both bioeconomy sectors AFF and MFBT. On the other hand, the general labour market is different- General employment is positively correlated with all selected variables.

For identifying the drivers of the bioeconomy labour market, we worked with a more sophisticated regression analysis. We created more regression models, with a focus on statistically significant solutions. The following Table 6 presents selected models MOD1, MOD2, and MOD3 for employment in agriculture, forestry, and fishing (EMAFF).

Table 6: Regression analysis - Employment in agriculture, forestry and fishing (EMAFF)

	MOD1		MOD2		MOD3	
	Sig.	Coef.	Sig.	Coef.	Sig.	Coef.
X1-GDP	0.007***	-0.002	0.191	-0.003	0.001***	-0.002
X2-X	0.049**	0.004	0.001***	0.001	X	X
X3-M	0.106	-0.003	x	x	X	X
X4-WG	0.006***	0.005	0.002***	0.006	0.006***	0.004
X5-SUB	0.503	0.004	x	X	X	X
X6-SUBP	0.998	-0.000	x	X	X	X
X7-TM	0.033**	-9.011	0.213	-2.475	X	X
Constant	0.031	18272.322	0.191	5206.977	0.000	252.278
Observ.	21		21		21	
R2	0.941		0.917		0.899	
Signif.	0.000***		0.000***		0.000***	
DW	x		x		1.14	

Statistical significance *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: Own processing.

MOD 1 consists of all independent variables (GDP, X, M, WG, SUB, SUBP, and TM). The whole model is statistically significant, on the other hand, not all selected variables are statistically significant. MOD2 represents variables with *** $p < 0.01$ and ** $p < 0.05$ statistical significance from MOD1 (GDP, X, WG and TM). The last model MOD3 is the statistically significant model – all variables are statistically significant and the whole model is also statistically significant. DW was calculated for this model and it is also acceptable (1.14). We can write the following regression equation:

$$Y = 282.278 - 0.002\ X1 + 0.004\ X4 \quad (2)$$

Employment in the AFF sector is positively dependent on wages/salaries and negatively dependent on GDP.

Table 7 shows results for models MOD1 and MOD2 for employment in the manufacture in food products, beverages, and tobacco (EMMFBT).

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Table 7: Regression analysis - Employment in manufacture in food products, beverages and tobacco (EMMFBT)

	Sig.	Coef.	Sig.	Coef.
X1-GDP	0,008***	-0.001	0.000***	-0.001
X2-X	0,062*	0.002	X	X
X3-M	0,057*	-0,002	X	X
X4-WG	0,001***	0.003	0.000***	0.003
X5-SUB	0,026**	-0.007	0.038**	-0.003
X6-SUBP	0,236	0.006	X	X
X7-TM	0,298	-1.756	X	x
Constant	0.275	3688.522	0.000	174.964
Observ.	21		21	
R2	0.959		0,937	
Signif.	0.000***		0.000***	
DW	x		1.75	

Statistical significance *** p < 0.01, ** p < 0.05, * p < 0.1. Source: Own processing.

Similarly like in regression analysis for the AFF sector, MOD 1 consists of all independent variables (GDP, X, M, WG, SUB, SUBP, and TM). The whole model is statistically significant; however, some variables are not statistically significant. MOD2 represents variables with *** p < 0.01 and ** p < 0.05 statistical significance from MOD1 (GDP, WG and SUB). MOD2 is statistically significant, including all variables. DW is 1.75. We can write the following regression equation:

$$Y = 174.964 – 0.001\ X1 + 0.003\ X4 - 0.003\ X5 \quad (3)$$

Employment in the MFBT sector is positively dependent on wages/salaries and negatively dependent on GDP and subsidies.

4 Discussion

The analysis presented in the “Results” chapter is performed for the period 2000 - 2020, to observe possible changes and transformation processes of the labour market in the Czech Republic. It is not easy to obtain up-to-date data in suitable structures connected with bioeconomy sectors, because some sectors are only partially covered. Previously, within the methodological part, we defined two research questions. Based on the obtained results, we can focus on such questions and discuss them in the following paragraphs.

Q1: What is the structure of the bioeconomy labour market in the Czech Republic? As was mentioned before, according to the methodology performed by Porc and his team (2020), the bioeconomy includes the following sectors: pharmaceuticals, chemicals and plastics, bioenergy, biofuels, paper, and paper products, forest-based industry, textile and textile products, tobacco products, beverages, food products, forestry sector, and agriculture. Focusing on the structure of employment in the bioeconomy sectors in the Czech Republic in the year 2017, the highest number of employees was employed in sectors of agriculture, food, beverage and tobacco, and wood products and furniture. Such sectors belong to traditional sectors of the national economy of the Czech Republic. Besides these sectors, there was significant employment also in the following sectors: forestry, bio-based textiles, paper, and bio-based chemicals, pharmaceuticals, plastics, and rubber (excl. biofuels). Latter ones represent industries with the potential for innovation and new, bio-based products.

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Focusing on the period 2000 – 2020, the structure of the bioeconomy labour market in the Czech Republic remained almost the same, only with diminishing change. It supports the results of the study performed by Ronzon et al. (2015) concerning groups of national bioeconomies of the EU states. This study identified four key groups of countries, such as 1) agricultural bioeconomies, 2) agro-food industry and bio-based chemical industries, 3) forestry bioeconomies, and 4) non-specialised bioeconomies. The Czech Republic was identified as a non – specialised economy, together with other Visegrad countries, namely Slovakia and Hungary. Based on the bioeconomy labour market development in the Czech Republic in the period 2000 – 2020, we can agree that the Czech Republic belongs to the group of non – specialised economies.

Regarding the percentage expression, the share of the bioeconomy sectors on the whole labour market in the Czech Republic in the analysed period was around 7-8 %. The share of employed people in the bioeconomy within the whole economy shows a slightly declining trend. On the other hand, concerning the total number of employed people in the bioeconomy sectors in thousand persons, the declining trend is not so clear. Since 2010, some sectors are fluctuating or increasing, such as agriculture, and some are stable. In the year 2017, we can observe an increase in the total number of employed people in the bioeconomy sectors.

Q2: What are the main drivers of the bioeconomy labour market in the Czech Republic? Based on the results, we can say that employment in the AFF sector is positively dependent on wages/salaries and negatively dependent on GDP. Employment in the MFBT sector is positively dependent on wages/salaries and negatively dependent on GDP and subsidies. Therefore, the main drivers are the development of the economy expressed as GDP, development in the price of labour force (wages and salaries), and in the case of MFBT also development in public financial support, expressed as subsidies.

Similarly like in other post-communistic economies, the yield of agriculture, forestry, and fisheries sector in the Czech Republic is still decreasing. The wages in these sectors belong to the lower ones. It is also the case of employment in the manufacture of food products, beverages, and tobacco. Moreover, some processes were digitalized, and robots can substitute the work of people. Therefore, there is generally lower demand for employees in both the AFF and MFBR labour markets.

On the other hand, changes in the structure of bioeconomy sectors themselves can occur. For example, focusing on the forestry sector (Purwestri et al., 2020), the main challenge faced by the forest-based sector in the Czech Republic is to fulfill the demand for sustainable forest biomass and high-value-added products. We can expect an increase in the economic growth and job opportunities in the bioeconomy sector in rural areas (Purwestri et al., 2020). Moreover, as pointed out by Hajek et al. (2020), the Czech Republic has also a strong performance in chemistry and biology, which, together with developed agriculture, forestry, and food industries, provides a good foundation for the development of locally based circular systems. It can contribute to change in the labour market, create new jobs, and build a more competitive and innovative economy.

Regarding the structure of the labour market and various work positions, we can say that the market is also changing based on changes in environmental perception in society. Transforming current economic structures into a green economy is a complex process, determined by the type of jobs, including green jobs (Dordmond et al., 2021). For example, we can observe the greening of the agriculture sector. On the one hand, it contributes to creating new green jobs, on the other hand to upgrading the existing ones (Babugura, 2020). Significant employment increases are expected in resource renewal, earth repair, and to a lesser extent, environmental survey, and clean green agriculture.

Therefore, we can expect an increasing number of new green jobs connected with the bioeconomy and upgrading the original jobs, in all bioeconomy-devoted sectors.

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5 Conclusions

The main aim of this paper was to focus on and evaluate the changes in the bioeconomy labour market in the Czech Republic. For this, the sectoral approach was used, and a set of statistical data was collected. Besides the literature review and desk research, correlation and regression analysis were presented. Based on the results, we can say that the share of employed people in the selected bioeconomy sectors in the period 2000 – 2020 in the Czech Republic showed a declining trend. Regarding the structure of employment in the bioeconomy sectors in the Czech Republic, the highest number of employees is employed in the traditional sectors of the national economy, such as agriculture, forestry, fishing, food products, beverages, tobacco, and wood products and furniture. The main drivers of employment in the bioeconomy sectors are GDP, wages/salaries, and subsidies. However, we can expect an increase in employment in industries with the potential for innovation and new, bio-based products.

Since the concept of bioeconomy is connected both with socioeconomic and environmental aspects, it will be worth focusing the following research on a more complex analysis, possible contributions of bioeconomy sectors to national and/or regional GDP, and carbon emissions cuts, especially in forestry. Regarding possible recommendations connected with our research, we recommend to public authorities think about possible ways how to support innovation in bioeconomy sectors. It can be a challenge for both public and private institutions. As the result, such innovation can improve the competitiveness of the Czech Republic and its regions.

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