Rivista di Economia Agraria, Anno LXXII, n. 3, 2017: 311-326

Nina Drejerska,
Jarosław Gołębiewski

Warsaw University of Life Sciences

Key words: bioeconomy, primary sector, region, spatial analysis, Poland

JEL code: C21, R12, Q57

The role of Poland's primary sector in the development of the country's bioeconomy

The main objective is to assess the role of the primary sector in the Polish economy as a prerequisite for development of the bioeconomy. Based on the data on the main suppliers of biomass, it can be clearly noticed that agriculture with its share of 76% plays an important role in biomass supply of the entire country. The share of the primary sector in GVA was used for spatial analyses for the period 2004-2012. Analyses conducted with the use of the global Moran *I* and local Moran statistics show that biomass production in Poland differs considerably by subregion – there are clusters of subregions where the primary sector plays an important role, and others where it has only a marginal character. These clusters cross regional administrative boundaries, justifying an interregional approach in strategic and policy planning, facilitating development of the bioeconomy in Poland.

1. Introduction

The bioeconomy has been defined and discussed by various authors. For example Staffas, Gustavsson and McCormick in 2013 distinguished the terms bioeconomy (BE) and bio-based economy (BBE). According to their comparative analysis of selected national strategies and policies in these fields, BE refers to the biotechnological and life science part of an existing economy, whereas BBE is applied for describing an economy which is predominantly based on biomass for food, feed, energy and other purposes, rather than fossil-based resources. They concluded that these two terms can also be used interchangeably. Maciejczak and Hofreiter (2013) reviewed a number of definitions of the bioeconomy and found that the core of this concept lies in the sustainable transformation of renewable biological resources based on innovation in the life sciences and turned into products and processes that aim at meeting both private and public expectations. Generally, the production of biomass — that is, all raw materials and products of biological origin, which are renewable and produced in agriculture, forestry, fishing and waste management — is the base of the value chain in the bioeconomy (Gołębiewski 2013). Lewandowski (2015) uses a general defi-

DOI: 10.13128/REA-22806
ISSN (print): 0035-6190
ISSN (online): 2281-1559

nition of biomass referring to all organic material originating from plants, animals or microorganisms.

The concept of the bioeconomy was introduced and approved at the level of the European Union as for example within the European Strategy for building a sustainable bioeconomy, which is supposed to support a solution to many social challenges (European Commission, 2012). Furthermore, some EU Member States have developed their own national bioeconomy strategies. Germany, can be an example of advanced programming (National Research Strategy BioEconomy 2030) and implementation of different initiatives in this field, some of which come from Bioökonomierat - the Bioeconomy Council an independant advisory body to the German Federal Government.

In Poland, no special strategy or other document has addressed the issues attending the bioeconomy. Some aspects can be found in three integrated strategies, which are included in the implementation of the Medium-Term Strategy for the Development of the Country defining development goals for Poland until 2020 (Strategia Rozwoju Kraju 2020). In spite of a lack of a comprehensive strategy, the bioeconomy and organic food are both important parts of Poland's national smart specialisations (Gołębiewski, 2014). For their part, regional authorities also see the bioeconomy playing a role in the development of their territories. Research shows that the majority of Polish regions base their future development on natural resources. Poland's regional self-authorities have introduced topics related to the bioeconomy in their smart specialisations. However, regions traditionally associated with primary production frequently lack innovation, so support in building competitive advantage is important for them (Drejerska, 2013b).

2. Measuring the importance of the primary sector and the bioeconomy

It is not easy to transform the state of affairs or the policy approach into measurable indicators in order to gain scientific insight into development of the bioeconomy. One reason is that there are many traditional industries which not only produce biomass, but also process raw materials of biological origin. Efken and co-authors assume that the primary sector belongs entirely to the bioeconomy, as it produces biological resources, which are the bioeconomic inputs for downstream industries. However, it is difficult to valuate and separate the non-biobased and bio-based activities in this sector (Efken *et al.* 2016). Efken and co-authors did not limit their measuring of the importance of the bioeconomy to the primary sector only, but also included, to take one example, the monetary weight of power generation from biological resources based on different sources of information. However, they admit-

ted that because bioenergy is a relatively new area of economic activity, there is no well-established foundation in the official statistics. Poland faces similar problems in measuring its bioeconomy – the lack of reliable data make it difficult to measure it. Another barrier is the territorial unit analysed in this paper – the subregion (NUTS 3). There are results of bioeconomy measuring, which include other sectors that use inputs from the primary sectors, but they are provided for a single country (a national level), as for example the Netherlands (Heijman, 2016). Characterizing and measuring bioeconomy for NUTS 3 regions is a complex issue, as we can observe it for example in collaboration of research and private partners in the BERST project (BioEconomy Regional Strategy Toolkit for benchmarking and developing strategies, 2016).

At fora and consortia of organisations working for the European Union, basic indicators concerning Gross Domestic Product (GDP) or employment in activities included in the bioeconomy are used (The European Bioeconomy in 2030). Distinguishing the bioeconomy into four types of sectoral bio-based activities according to their nomenclature in the Statistical Classification of Economic Activities in the European Community (NACE) is also applied, which leads to the use of comparable statistical data on economic activities in both EU and world regions on: primary sector activities (natural resource-based activities that directly exploit the bio-resources to be used as input for the bioeconomy), secondary sector activities (conventional/direct users of raw agricultural products), tertiary sector activities (new users of renewable raw materials) and ecosystem or non-market services (conventional users of green resources, such as sea, parks and forest) (Van Leeuwen, *et al.* 2013). Recently, a systematic approach to understanding and quantifying the EU's bioeconomy was provided for example by Ronzon and others (Ronzon, *et al.* 2017). They used some Eurostat databases and designed a methodology to provide bioeconomy monitoring indicators. Furthermore, they also identified three main types of bioeconomy across the EU Member States. It resulted in qualification of Poland in a group with labour productivity in the bioeconomy below EU average and average employment share in biomass-producing sectors above EU.

3. Material and methods

The main objective of the study is to assess the role of the primary sector in the Polish economy as a prerequisite for development of the bioeconomy. Specific objectives include an attempt to verify if Polish subregions (66 territories according to the NUTS 3 level) can be grouped into clusters by similarity of primary sector development and determine if these clusters fit into administrative regional boundaries. If such clusters extend beyond the borders, it

is reasonable to undertake a specific interregional policy to support activities which can contribute to developing the bioeconomy.

As biomass is central to the bioeconomy, and the primary sector is the basic one supplying it, data on agriculture, forestry and fisheries (the primary sector) were used. General data about biomass supply in Poland come from data portal of agro-economics modelling – DataM of the Joint Research Centre of the European Commission. Its use illustrates biomass supply from the quantity perspective. However, this kind of data are not available for a more detailed (e.g. subregional) level of territorial division. Then, the structure of the Gross Value Added (GVA) by sector was taken into account and the share of the primary sector in GVA was the basic indicator used for the spatial analyses. The data used were from the Central Statistical Office of Poland (CSOP). The study covers the average values for the periods 2004-2006 and 2010-2012, so from Poland's accession to the European Union to the most recent data available on this level of the territorial division. Principles of spatial autocorrelation (the Moran's statistics) were used to facilitate the investigation of these interactions.

Analysis of the spatial autocorrelation is based on the values attributed to spatial objects. Spatial autocorrelation means that objects that are geographically close are more similar to each other than those far away from each other. This phenomenon usually causes the formation of spatial clusters of similar values. W.R. Tobler, a precursor of spatial econometricians, invoked the first law of geography with the simple statement: "everything is related to everything else, but near things are more related than distant things" (Tobler, 1970). Following these words with suitable mathematic equations, he justified why spatial relations should be taken into account in any means all. Some examples of this measures' use referring to the primary sector can be found in the work of Bartova and Konyova (2015) and Motamed, Florax and Masters (2014). Methodological aspects of its use are discussed by Schabenberger and Gotway (2005), among others. Generally, an issue of clustering of agricultural activities including a spatial dimension was investigated for example by Davidova and others (2009), D'Amico and others (2013) as well as Toma and Dobre (2016).

The value of Moran's statistic generally falls into the interval [-1, 1] and three different situations may occur:

- $I = 0$ - no autocorrelation
- $I < 0$ - negative autocorrelation (objects that are located next to each other at a specified distance have different values)
- $I > 0$ - positive autocorrelation (objects located next to each other, at a specified distance, have similar values).

The Global Moran's statistic is described by the formula (1):

$$I_i = \frac{n}{W} \frac{^2\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \tag{1}$$

w_{ij} – weight of the connections between units i and j (1st order matrix standardised according to rows),
x_i x_j – value of the variables in spatial units i and j (1st order matrix standardised according to rows),
$\bar{x}$ – arithmetic mean value of the analysed variable for all spatial units.

The local Moran's statistic is also widely used to examine how the value of one region is formed in comparison with neighbouring regions, as compared to a random distribution of values in the tested area. The local Moran's statistic is expressed by the formula (2):

$$I_i = \frac{(x_i - \bar{x})^2 \sum_{i=1}^{n} w_{ij}(x_j - \bar{x})}{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n}} \tag{2}$$

Description as previously.

The results of the global Moran I and local Moran statistics for the share of the primary sector in GVA are presented in the maps and graphs. Then results are interpreted.

4. Results

This significant role of agriculture in the Polish economy allows to consider it also as a substantial prerequisite for the bioeconomy's sector. According to the classification used by the European Commission[1], bioeconomy can be divided into sectors producing biomass (agriculture, forestry, fishing and fisheries), sectors wholly based on raw materials of biological origin (food industry, production of beverage and tobacco, wood industry, paper industry, pro-

[1] https://biobs.jrc.ec.europa.eu/research/private-investment (Accessed 20.09.2015).

duction of leather goods) and sectors partially using raw materials of biological origin (the chemical, pharmaceutical, furniture, production of rubber and plastics, and construction industries). Important branches of the bioeconomy are also sectors of the production of bioenergy and biofuels as parts of the fuel and energy sectors. As the agriculture, forestry, fisheries, aquaculture and algae sectors are the main suppliers of biomass (Ronzon *et al.,* 2017), a structure of their contribution to biomass production in Poland is presented in the Table 1. It can be clearly noticed that agriculture with its share of 76% plays an important role in biomass supply of the entire country.

Table 2 presents the basic characteristics of Poland's biomass production sector. Despite a decreasing tendency in agricultural employment it is still one of the highest indicator in Europe. Although, a phenomenon referred to desagrarisation of rural areas occurs (Wilkin, 2016) this sector still plays and important role in providing workplaces.

Given the above, it can be stated that the share of the primary sector (agriculture, forestry and fisheries) in Gross Value Added (GVA) is one of the basic values characterising the scale of biomass production. In Poland, this indicator had values ranging from 2.77% to 3.62% (Fig. 1) in the 2004-2012 period. It should also be stressed here that despite the fact that sectors of material pro-

Tab. 1. Biomass supply in Poland (last data available)

Sector	Commodity	1000 T of dry matter	%	%
Agriculture	Crop harvested residues	11188	*14.38*	*75.90*
	Crops	42091	*54.10*	
	Grazed biomass	5771	*7.42*	
Fishery	Capture Fisheries	50	*0.06*	*0.21*
	Aquaculture	7	*0.01*	
	Fish and seafood	66	*0.09*	
	Fishmeal and oil	39	*0.05*	
Forestry	Wood pulp	1376	*1.77*	*23.89*
	Post-consumer wood	452	*0.58*	
	By- & co- products (incl. wood pellets)	3919	*5.04*	
	Primary woody biomass	12843	*16.51*	
Total		77802	*100.00*	*100.00*

Source: the authors' calculations based on https://datam.jrc.ec.europa.eu/datam/mashup/BIOMASS_FLOWS/index.html (Accessed 25.10.2017)

Tab. 2. Basic characteristics of the biomass' production sector in Poland

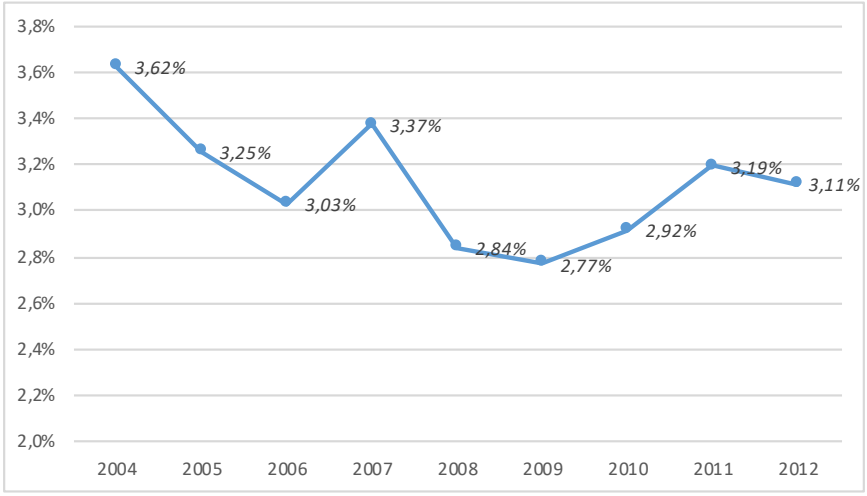
Specification	Average for 2010-2013
Employed in agriculture, forestry, fishing and fisheries (thousands of persons)	2382.3
Proportion employed in agriculture, forestry, fishing and fisheries in the total number employed in the Polish economy (%)	17
Gross Value Added of agriculture, forestry, fishing and fisheries (million zł)	42077
Proportion of Gross Value Added of agriculture, forestry, fishing and fisheries in total GVA (%)	3
Gross Value Added per one employee (thousand zł)	19.5
Ratio of Gross Value Added in agriculture, forestry, fishing and fisheries to GVA per employee in the national economy	0.21
Average farm area (ha)	9
Total number of farms (thousand)	1518.2
Agricultural land area (thousand ha)	14541.8
Total cereal crops (thousand tonnes)	27748.6
Oilseed rape and turnip rape crops (thousand tonnes)	2158.4
Milk production (thousand tonnes)	12519.75
Production of animals for slaughter (thousand tonnes)	5243.6
Total forest area (thousand ha)	9151.6
Timber harvesting (thousand m3)	36909.1

Source: the authors' calculations based on CSOP data.

duction (industry, construction and agriculture) contribute only to one third of the value added of the entire Polish economy, they are its pillars determining real driving forces and considerably influence on the GDP growth rate (Matkowski *et al.,* 2016).

As Poland is a relatively large country (the 6th largest in the EU by surface area), the role of the primary sector differs across the country. There are some territories, particularly urban ones, where the share of the primary sector in GVA is close to zero, but there are also subregions (NUTS 3 level) where it reaches nearly 14%. Analysing the spatial patterns of the primary sector's development in Poland is no simple task. The global Moran's *I* statistic was calculated as the first step to verifying if neighbouring subregions affected the share of the primary sector in the GVA in the period investigated. Figure 2 presents the Moran scatter plots, which make it possible to divide objects according to specific spatial regimes: High-High (upper right part), Low-Low

Fig. 1. Share of the biomass production in the GVA in Poland



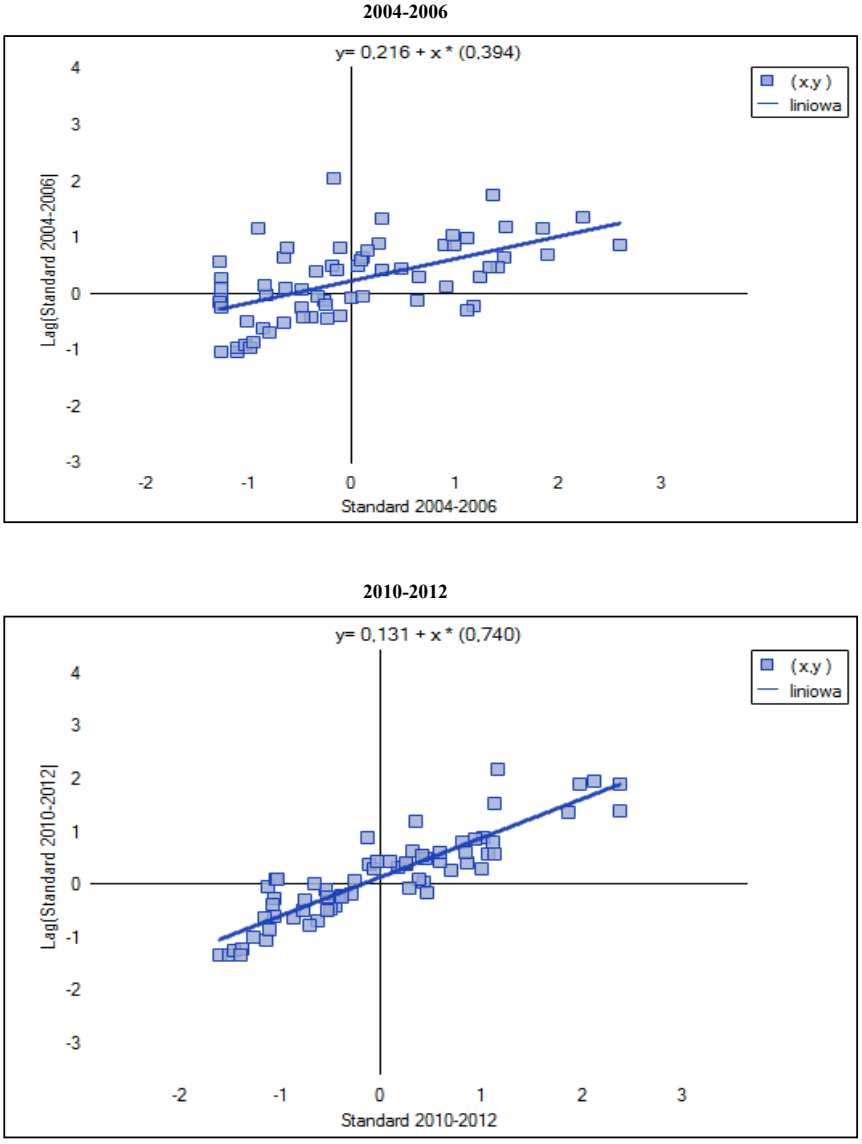
Source: the authors' calculations based on CSOP data.

(bottom left part), Low-High (bottom right part), High-Low (upper left part). Positions of points in the lower left and upper right quadrants indicate spatial clustering of similar values: low values (that is, less than the mean) in the lower left and high values in the upper right (Anselin, 1995). The slope of the regression line represents the Moran's *I* statistic (Pietrzykowski, 2011) and proves the autocorrelation for the analysed data is positive. For 2004-2006 it was 0.39 while for 2010-2012 it was 0.74.

Values of the local Moran's statistic are presented in Figure 3. The following clusters of regions can be found: regions characterised by the low (statistically significant) local Moran's statistic value and surrounded by regions with the low value of the local Moran's statistic (Low-Low; areas marked in blue); as well as regions characterised by the high (statistically significant) local Moran's statistic value and surrounded by regions with the high value of the local Moran's statistic (High-High; areas in red). A similar way of interpreting the local Moran's statistic can be found in Chrzanowska (2016) and her analyses of agricultural land prices by region in Poland.

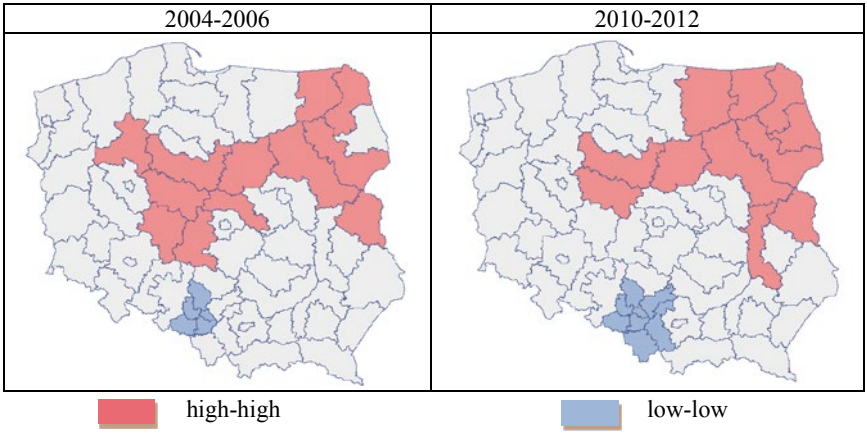
As it can be seen on the maps and in the Table 3, the primary sector does not play a significant role in the group of subregions in the southwest part of Poland. This is a traditional industrial area, where subregions whose primary sectors contribute little to GVA (Low-Low, marked blue) are surrounded by

Fig. 2. Moran scatter plots for share of the primary sector in GVA in Polish subregions



Source: the authors' calculations.

Fig. 3. Location of statistically significant local Moran values for the share of the primary sector accounts for in GVA by Polish subregions



Source: the authors' calculations.

Tab. 3. Types of statistically significant spatial relationships for determining the share of the primary sector in GVA by Polish subregions

Spatial relationship	Subregions
	2004-2006
High-High	ostrołęcko-siedlecki, ciechanowsko-płocki, bialski, skierniewicki, sieradzki, pilski, kaliski, suwalski, łomżyński, koniński, ełcki, włocławski
Low-low	katowicki, tyski, gliwicki, rybnicki, bytomski
	2010-2012
High-High	ostrołęcko-siedlecki, ciechanowsko-płocki, bialski, puławski, suwalski, łomżyński, koniński, białostocki, ełcki, olsztyński, włocławski
Low-low	oświęcimski, katowicki, tyski, gliwicki, rybnicki, bielski, sosnowiecki, bytomski

Source: the authors' calculation.

similar ones. On the other hand, there is a quite stable cluster of subregions in the country's northeast and centre where biomass production figures prominently in GVA (High-High, marked with red colour). They are surrounded by similar subregions that play a similar role in the bioeconomy.

5. Discussion

About 60% of the Polish territory is used by the agricultural sector and further 30% by the forestry. The agri-food (agribusiness) is the largest subsystem of the Polish economy (Baer-Nawrocka, Poczta, 2014). Polish rural areas significantly depend on agriculture and are still in need of restructuring and modernisation. Despite the decreasing share of farmers living in rural areas, they highly depend on agriculture-oriented policies (Kozak, 2014). During the last decade more dynamic structural changes were observable in the Polish agriculture, food and rural areas. The following are indicated as ones of the most important (Wigier, 2014):

1. reduction in the number of farms, while increasing the share of the largest holdings, which has a direct impact on the increase in the average farm area;
2. decline in employment in agriculture;
3. progressive concentration and specialisation of production.

From the international perspective, it can be stated that Polish agriculture is a significant component of the agricultural production sector in the European Union (EU). The basic effects of integration with the EU in this regard include changes in legislation of safety and quality of food, the changing environmental standards, legislation concerning foreign investments and international trade. Accession to the EU resulted in a possibility to take advantage of the phenomenon of globalization, allowing the Polish entrepreneurs to enter the internal market of the Community (Gołębiewski 2013). Since 2004, export growth rate in Polish agri-food products has been faster than the import one and Poland turned from an agricultural net importer to a net exporter (Grzelak, Roszko-Wójtowicz 2015). These processes are visible and reported even in the headlines of the international press, as for example the Economist referring to a golden age for Polish farming and Poland as a country surpassing China as the world's biggest exporter of apples in 2013 (The Economist, 2014).

General processes in the agricultural sector indicated above as well as 76% of contribution of this sector to biomass supply in Poland allow to state that it plays a significant role as a prerequisite for development of the bioeconomy. Results characterizing its spatial patterns are not surprising as a significant regional differentiation of the Polish agriculture is traditionally noted by researchers (Poczta, Bartkowiak, 2012) as well as the central authorities (Ministry of Agriculture and Rural Development, 2015) or international organizations (OECD, 2008). However, all mentioned studies and a lot of others investigate the differences determined by a number of factors, both agri-climatic and socio-economic, at the regional level (NUTS 2) whereas this study, realized for NUTS3 (subregions), proved that there is a necessity of interregional

approach to bioeconomy – clusters of subregions exceed borders of administrative regions (NUTS2) were identified. It is important because as it was mentioned before, some regional authorities included the bioeconomy or some of its aspects into their development strategies. They can also use some parts of Rural Development Programme 2014-2020 (as the second pillar of the Common Agricultural Policy), so they have instruments to support this part of the economy. Finally, regional authorities can also apply some funds of regional policy, which programmed at the European level is conducted as cohesion policy (Drejerska, 2013a), to support for example entrepreneurship or technological progress of companies in the field of bioeconomy. All these activities programmed and implemented from an interregional perspective are reasonable as biomasses, due to their extreme diversification (by sector of origin of the raw material) and their strong link with the territory may generate positive impacts at the local level, in terms of employment, land care and maintenance and optimal use of agro-forestry resources (Romano, *et al.* 2013).

Identification of a necessity to interregional approach to bioeconomy is a strength of this study. It can lead to more efficient addressing of this sector by agricultural policy, including the regional government selection criteria to distribute European funds referred for example by Di Vita and others (2014) from a perspective of wine sector. Although it should be noticed that the applied methodology concerns only the primary sector. Such an approach can be perceived as a limitation of this study from the perspective of the entire bioeconomy sector. Other scientists indicate for example localization of bio-clusters and bio-parks as well as companies of pharmaceutical biotechnology in the largest Polish cities (Wozniak, Twardowski, 2017b). These localizations are not covered by the clusters identified within this study. However, the refereed researchers in their other work claim that the structure of the Polish bioeconomy is dominated by traditional sectors, such as agriculture and agro-food industries (Wozniak, Twardowski, 2017a). This statement together with clear objectives of the study referring to the primary sector and bioeconomy provide background for the research performed. Similar research can also be provided as example for subregions of other EU countries in order to facilitate understanding of functional regions with considerable biomass production, which create clusters crossing administrational regional or even national borders.

6. Conclusions

The spatial differentiation of the bioeconomy undoubtedly requires further research. A particular challenge remains quantifying the bioeconomy on a lower level of territorial analysis as the majority of data has been compiled

for the national level. However, studies on the role of the primary sector in subregional economies can illustrate where the biomass production sector (agriculture, forestry and fisheries) is important; and, as a consequence of its significant role for the bioeconomy, where the bioeconomy can be supported as an important part of the overall economy.

The analyses conducted for the purpose of this study with the use of Moran's statistics proved that the role the primary sector plays in Poland varies considerably across regions. There exist clusters of similar subregions (NUTS 3) that play a significant role in the economy's biomass production sector. These results not only have cognitive value, but can also provide some background for regional and local policy-making as they confirm that the bioeconomy is worth our concern, as is a system policy approach in the Polish subregions indicated. Moreover, the subregional clusters that play a relatively significant role in biomass production exceed administrative regional borders, so it is reasonable to undertake a specific interregional policy to support activities which can further the development of the bioeconomy.

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