Spatial Concentration of Biomass Production Sector in the European Union

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Abstract:

Since the beginning of this decade, the European bioeconomy has gained political momentum and strategic importance. Long-term strategic target of the European Union for creating a competitive, resource-efficient and low-carbon economy by 2050 lays high expectations upon bioeconomy development. The transition from fossil-based economy to bioeconomy fosters increasing demand for biomass both within domestic markets and global market. The demand for biomass is further enhanced by the increasing need for food and feed, bioenergy and other bio-based products. Production of the main share of biomass will first of all rely on the primary biomass production activities. The aim of this paper is to assess the spatial concentration of biomass production sector in the European Union through applying a location quotient technique in order to quantify relative importance of biomass production (as well as its separate activities – agriculture, forestry, fishing and aquaculture) in each member state economy compared to the whole European Union economy. The gross value added and biomass export were used for location quotient analysis. To identify medium-term shifts in relative concentration of biomass production changes in the location quotients were analysed. The findings indicate that the differences in relative concentration of forestry as well as fishing and aquaculture are quite high among the European Union member states – strong spatial concentrations exist in one or another state, whilst differences in relative concentration of agriculture are noticeably lower. Positive and moderately strong correlation between relative concentration of biomass production and relative specialisation in biomass export was established.

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1. INTRODUCTION

Long-term projections by OECD (2015) and European Commission (2015) suggest that the current trends of increasing global population as well as economic growth and development will have serious impacts on natural resources and the ecosystem, unless policy changes deviate the current path of development. As McCormick and Kautto (2013) state, current societal and environmental changes should be responded inter alia by redirecting the economy from the use of fossil fuels to biomass first of all. The transition from fossil-based economy to bioeconomy fosters increasing demand for biomass both within domestic markets and the global market. Thus, the rapidly growing demand for biomass is enhanced by the increasing need for food and feed, bioenergy and other bio-based products.

As indicated in the new United Nations (2017) report, the current world population of 7.6 billion is expected to reach 9.8 billion by 2050 and 11.2 billion by 2100. This growth, along with rising incomes in developing countries, and subsequently changing diets (i.e. eating more protein and meat) are driving up a global demand for food. The projections (Valin et al., 2014) show that the demand for food is expected to increase by 59-98 percent by 2050 if compared to 2005. According to Ray et al. (2013), several studies have shown that in order to meet the projected demands from rising population, diet shifts, and increasing biofuels consumption, the global crop production alone needs to double by 2050. However, current yield trends are insufficient to meet this goal. Foley et al. (2011) observe, that in order to meet the world's future food security and sustainability needs, food production must increase

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significantly, while the environmental footprint of agriculture must shrink dramatically, i.e. the growing demand for food, feed and energy requires to meet two contradicting goals: to expand and intensify biomass production, and, on the other hand, to comply with sustainability requirements due to stricter environmental standards, rising from the increasing environmental pressures.

Expanding energy needs foster total primary energy supply (equal to consumption), which is likely to increase globally (IEA, 2017). The primary energy demand growth is anticipated to decrease in the coming years up to 2060, while per capita energy demand is expected to peak before 2030 as a result of new technologies and energy policies (WEC, 2016). The growing energy needs encourage the search for new energy sources, while the demand for biomass, as one of the sources, is increasing. Energy scenarios show increasing use of energy, combined with increasing bioenergy shares (Gerbens-Leenes, 2017). Unlike in the past, the emerging rise in consumption will essentially be covered by renewable energy sources (Schiffer et al., 2018). According to International Renewable Energy Agency (IRENA, 2018), renewables can make up to 60% or more of many countries' total final energy consumption, and the use of biomass could provide a little under two-thirds of renewable energy used for heating and fuel used in industry, transport and the building sectors by 2050. The steep increase in bioenergy production will require careful planning, considering sustainability of biomass supply.

Other uses of biomass are also becoming increasingly popular, though in many cases the growth of output is rather slow due to complex inefficient and costly manufacturing processes and decreasing economic viability of the products (Ramos et al., 2017; Budzianowski, 2017; Schoenung and Efroymson, 2018). Ramos et al. (2017) claim that there is a slight bias towards the development of bioproducts, such as bioplastics, a range of acids, surfactant resins and biochemicals in Europe, whilst in North America there is a clear tendency to produce biofuels. Moorkens et al. (2017) observe that biopharmaceutical medicines represent a growing share of the global pharmaceutical market. Dos Santos et al. (2018) find that biopharmaceuticals represent one‐ quarter of all pharmaceutical sales and provide suitable and efficient medical care for many previously untreatable diseases.

The increasing demand for the different uses of biomass, according to Gerbens-Leenes (2017) and Birner (2018), has two important implications for the bioeconomy. First, the potential tension between ensuring food availability and use of biomass, which has recently became an important topic in the public policy debate surrounding the bioeconomy. Second, increasing attention is being paid to the need to improve the productivity of biomass production and to develop options for producing and using biomass that are not in conflict with food availability.

Since the beginning of this decade, the European bioeconomy has gained political momentum and strategic importance (Cristóbal et al., 2016). In 2012, the European Commission published the first EU Bioeconomy Strategy "Innovating for Sustainable Growth: a Bioeconomy for Europe" and in 2018, published an updated EU Bioeconomy Strategy "A sustainable bioeconomy for Europe: strengthening the connection between economy, society and the environment". The European Commission has set a long-term target for creating a competitive, resource-efficient and low-carbon economy by 2050. It is expected that bioeconomy will be an important element of the low-carbon economy (Scarlat et al., 2015). The bioeconomy covers the "production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy" (European Commission, 2012, p. 3). The EU bioeconomy constitutes an important part of the whole European Union economy. According to European Commission's Joint Research Centre (JRC) data, in 2015 with a turnover value of almost EUR 2.3 trillion it created around 18.1 million full-time jobs and generated approximately EUR 621 billion value added at factor costs. This means that the bioeconomy represents around 8% of the whole economy in terms of employment and turnover as well (Ronzon et al., 2017).

The aim of this paper is to assess the spatial concentration of biomass production sector in the European Union through applying a location quotient technique in order to quantify relative importance of biomass production (as well as its separate activities – agriculture, forestry, fishing and aquaculture) in each member state economy if compared to the whole European Union economy. In this paper the term biomass is used in the bioeconomy context and its definition according to the European Commission Mandate addresses standardised deliverables of bio-based products. According to this Mandate, biomass is a material of biological origin excluding material embedded in geological formations and/or fossilised. This biomass definition refers to the well-known short-cycle of carbon, i.e. the life cycle of biological materials such as plants, animals, algae, marine organisms, forestry, micro-organisms, and biological waste from households, agriculture, animals and food/feed production (European Commission, 2011). This paper focuses only on primary production sector that produces biomass and generates biowaste (i.e. agriculture, forestry, fisheries and aquaculture). The other biowaste generating sectors (such as manufacture of food/feed, leather, wood and related products, food service, municipal and households, etc.) are not included in this study.

2. METHODOLOGY

2.1. Methodology Rationale

Location quotient has widely been used in economic geography and regional economics since the 1940s (Miller et al., 1991) for comparing a certain area characteristics relative to a reference larger geographic area. In most cases, location quotient technique allows for the comparison of local area characteristics to the national characteristics (Moineddin, 2003). Location quotient is also applied in regional impact assessment (Isserman, 1977). The location quotient technique has remained popular up till now in a large part due to its computational simplicity and low data requirements (Tian, 2013)

For many years, Location Quotients index (LQ) has been used to assess a region's specialisation in a given industry (Carroll et al. 2008; Morrissey, 2014; Yan et al., 2017; Brache and Felzensztein, 2017). According to Miller, Botham, Martin and Moore (2001, cited in Carroll et al., 2008, p. 452), areas with LQ indexes of an industry greater than one are considered to be specialised in that industry. Similarly, as Mayer and Pleeter (1975) state, location quotient is one of the most widely used tool of export specialisation. LQ helps to identify exporting industries. Also, LQ is one of the most common indexes employed to measure spatial concentration of an industry (Miller and Blair, 2009; Rivera el al. 2014; Weterings and Marsili, 2015; Joint Research Centre, 2017), for demonstrating the importance of a particular sector in the local economy relative to a reference area economy (Yu et al., 2010), most often to the national economy.

As stated by Miller and Blair (2009), when the LQ is greater than one, this implies that a sector of interest is concentrated in reported region relative to the nation as a whole; and vice versa, if the LQ is less than one, it is assumed that the reported region is being less able to satisfy regional demand for its output. As stated by Morrissey (2014), if the LQ is less than one, this indicates that sector of interest is underrepresented in the regional economy and unable to meet all of the needs of regional purchasing sectors for that input. Thus, as argued by Moineddin et al. (2003), location quotient is a way to measure relative contribution of one specific area to the whole for a given outcome.

There is an argument that location quotient analysis is one of the three principal methods for measuring and evaluating regional clusters. The other two clustering methods are shift-share analysis and input-output (I-O) analysis (Purdue University Center for Regional Development, et al., 2007). The interest in spatial concentration or clusters has increased over the last two decades for the reasons of a regional development perspective (Erkus-Ozturk, 2009; Spencer, et al, 2010; Stejskal and Hajek, 2012; Morrissey, 2014; Kowalski, 2016). In this respect, location quotient technique is used for regional impact assessment.

In addition, the location quotient technique is being increasingly used by researchers in several disciplines for various purposes and in different contexts. Different coefficient modifications have been created. For instance, Carleton et al. (2014) used the location quotient for supplementing traditional crime rates for purposes of explaining crime patterns within rural environments. While, Ha and Andresen (2017) used location quotient technique for investigating the criminal activity specialisation. Meanwhile, Yu et al. (2010) suggested ways to use this technique to assess regional and global water footprints. They assess and compare domestic and total water footprints of the South-East and North-East of England and the UK. Suchecki (2014) has analysed spatial diversification of the regional expenses on culture. The author applied the Location Quotient, which reflects a spatial distribution of expenditure on culture in relation to reference expenses incurred by the cultural institutions in Poland. Weterings and Marsili (2015) used LQ to define spatial concentration of industries in order to identify regions with a higher relative concentration of firms in the same industry, using NUTS-3 level micro regional data of firms registered in the Netherlands, i.e. LQ was used for firm-level data analysis.

2.2. Methodology Specification and Data

2.2.1. The Measure of Spatial Concentration

As stated by Thulin (2015), both the originally developed LQ concept and its later applications were mostly based on employment data while the author argues that other measures of economic activities can also be used. A similar view is held by Miller and Blair (2009) and Stimson et al. (2006), whose location quotient technique is built on the gross product of a sector. The authors conclude that other measures of regional and national economic activities (such as employment, value added, earned income, etc.) are often used in cases where regional output data are not consistently available by sector, or where analysts feel it is appropriate. In this paper, two measures (in other words variables V) are used – Gross Value Added (GVA) and export. The simple location quotient (LQ) for sector (or activity) i in a given region r is computed as:

$$LQ_i^r = \frac{V_i^r / V^r}{V_i^n / V^n} \qquad (1)$$

where V_i^r and V^r denote GVA (or export) of sector i and total GVA (or total export) respectively, in region r. Similarly, V_i^n and V^n denote these totals at the national level. As Miller and Blair (2009) state, the interpretation of this measure is straightforward. In expression (1), the numerator (V_i^r / V^r) indicates the share of a given region r's GVA (or export) that is contributed by sector i. The denominator (V_i^n / V^n) represents the share of total national GVA (or export) that is contributed by sector i, nationally. In case, whenever LQ>1 – sector i is more localised, or concentrated in a given region r if compared with the nation as a whole. Vice versa, an LQ>1 indicates that sector i is less localised, or less concentrated, in a given region r as a whole.

Miller and Blair (2009) note that the simple algebra generates an alternative expression of LQ, namely in our case:

$$LQ_i^r = \frac{V_i^r / V_i^n}{V^r / V^n} \qquad (2)$$

where the numerator (V_i^r / V_i^n) indicates a given region r's share in the national GVA (or export) that is generated in sector i. The denominator (V_i^r / V^r) represents region r's share in the total national GVA (or total export)) generated from all economic activities. LQ values calculated according to both expressions (1) and (2) are identical. While, LQ calculated using the equation (2) tells a somewhat different "story", the interpretation is much the same (Miller and Blair (2009). LQ>1 indicates a sector i which is relatively concentred (or localised) in a given region r.

Location quotient analysis can also be extended to consider dynamics by comparing changes in the location quotient over

Average annual percent change in the location quotient ΔLQ	LQ<1	LQ>1
ΔLQ>0	Sector/ economic activity location category 3: [LQ<1; ΔLQ>0] Relatively deconcentrated but is shifting towards concentration over time	Sector/ economic activity location category 1: [LQ>1; ΔLQ >0] Relatively concentrated and is becoming more concentred over time
ΔLQ <0	Sector/ economic activity location category 4: [LQ<1; ΔLQ<0] Relatively deconcentrated and is becoming more deconcentrated over time	Sector/ economic activity location category 2: [LQ>1; ΔLQ <0] Relatively concentrated but is becoming less concentrated over time

Size of location quotient (LQ)

Fig. (1). Location mapping matrix: four categories of sectors (or activities) that can be identified based on their LQ–ΔLQ composition.

time. (Purdue University Center for Regional Development, et al., 2007; Chen and Jackson 2018). Assessing both the size and change in LQ adds a dynamic element to the analysis, enabling evaluation of the direction of change in spatial concentration over time. Thus, the average annual percentage change of LQ index (ΔLQ) is calculated and applied in this study. The sectors (or economic activity) are further classified into four categories based on their LQ size and dynamics (ΔLQ) as depicted in four LQ-ΔLQ composition matrix quadrants in Fig. (**1**). The matrix shows which sectors (or economic activities) are more or less concentrated/ deconcentrated in a given region relative to the national economy (or the whole economy of other larger geographic area, i.e. EU), and whether their degree of concentration/ deconcentration is rising or decreasing.

In this study, the average annual percentage change of location quotient ΔLQ of reporting sector (or activity) i in a given region r between time t0 and time t is mathematically expressed as follows:

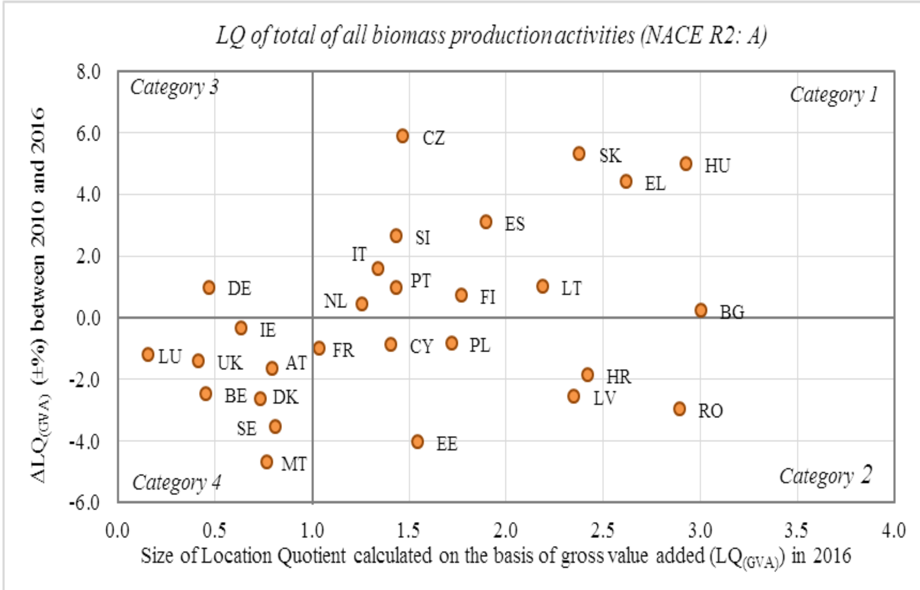
$$\Delta LQ_{i;r}^{t} = 100 \times \left[\left(\frac{LQ_{i;r}^{t}}{LQ_{i;r}^{t_0}} \right)^{1/(t-t_0)} - 1 \right] \quad (3)$$

ΔLQ includes values between $-\infty$ and $\pm\infty$ (in percent). Positive values indicate that concentrated sector (or economic activity)) i in a given region r is becoming more concentred over time or deconcentrated sector (or economic activity) i is shifting towards concentration over time relative to the national economy (see location categories 1 and 3, respectively, in Fig. **1**). Vice versa, ΔLQ negative values reflect that concentrated sector (or economic activity) i in a region r is becoming less concentrated over time (see location category 2); while, deconcentrated sector (or economic activity) i is becoming even more deconcentrated over time relative to the national economy (see location category 4).

In this study, the location quotient is used as a measure of spatial concentration (or localisation) of biomass production in the European Union in order to quantify how "concentrated" biomass production sector (and its separate activities – agriculture, forestry, fishing and aquaculture) is in a separate EU member state compared to EU as whole. The spatial concentration/ deconcentration of the biomass production is analysed by each individual member state of the EU relative to the EU as whole. Additionally, the LQ is used as a measure of capability of biomass production sector (and its separate activities – agriculture, forestry, fishing and aquaculture) to satisfy the demands placed upon it by other industries and by the final demand in each separate EU member state, in the following way – an LQ less than one (LQ<1) indicates that the biomass production sector is not concentrated (not localised) in a given state relative to the EU as whole. This implies that a given state produces less than demand for biomass quantity in a domestic market is, and there is a demand for biomass imports to satisfy domestic needs. If the LQ is equal to one (LQ=1), it can be assumed that the biomass production sector in a given EU member state produces just enough to self-satisfy domestic demand for biomass. If the LQ is greater than one (LQ>1), the biomass production sector is more concentrated in a given member state than in the EU as whole. This implies that the sector is capable to meet all the domestic demand for biomass and its "output surplus" may be exported to the rest of the world. On the other hand, the consideration that anything with an LQ higher than 1.0 is concentrated or specialised is essentially a conceptual interpretation. Indeed, it is doubtful if any significant differences in spatial concentration when the LQ of 0.99 and 1.01 are found. There is an argument that in practice, LQ that exceeds 1.2 is the standard (Purdue University Center for Regional Development, et al., 2007) or critical cut-off value. Some researchers (e.g. Tian, 2013 and Morrissey, 2016) use other cut-off values, such as LQ>1.25 or 2. In our empirical study, the cut-off value 1.25 LQ is used for the analysis of biomass sector concentration in the EU member states.

2.2.2. Research Scope and Data Sources

The study sample includes 28 member states of the EU (by its composition in 2013-2016). The location quotient analysis is targeted at two levels of aggregation, i.e. the whole biomass production sector that covers primary economic activities, such as agriculture, forestry and fishing, and each of the economic activities separately. The period of the empirical study covers the years 2010-2016. The empirical analysis is based on the Eurostat and the International Trade Centre (ITC) data. To measure the LQ, the gross value added (GVA) and biomass export data is used. GVA data by the EU member states was



AT Austria	CZ Czechia	DE Germany	LV Latvia	PL Poland	ES Spain
BE Belgium	DK Denmark	EL Greece	LT Lithuania	PT Portugal	SE Sweden
BG Bulgaria	EE Estonia	HU Hungary	LU Luxembourg	RO Romania	UK United
CY Cyprus	FI Finland	IE Ireland	MT Malta	SK Slovakia	King-dom
HR Croatia	FR France	IT Italy	NL Netherlands	SI Slovenia	

Source: own calculations based on the EUROSTAT National accounts aggregates by industry data (see Appendix)

Fig. (2). Location mapping of biomass production sector across the EU member states: based on the gross value added LQ.

obtained from the Eurostat database of the National accounts aggregates by industry (up to NACE A, A01, A02 and A03 activities). Biomass export data by the EU member states was obtained from the ITC Tarde Map data of yearly exports series, based on the Harmonized Commodity Description and Coding System (HS).

To aggregate the biomass exports series data from the ITC Tarde Map, HS codes 6-digit (or in some isolated cases 8-digit) were used. To identify the biomass codes the Correspondence Table of the Statistical Classification of Products by Activity (CPA version 2.1) and the Combined Nomenclature (CN version 2017), developed by the Eurostat's metadata server RAMON were used, based on the fact, that CN is fully harmonised with the HS at the six-digit level. All products coded in CN (respectively HS) at 4 and 6-digit or 8-digit correspond the codes in CPA section A (Products of Agriculture, Forestry and Fishing) were included into biomass exports collected data for each kind of biomass production activity separately and for the biomass production sector as a whole.

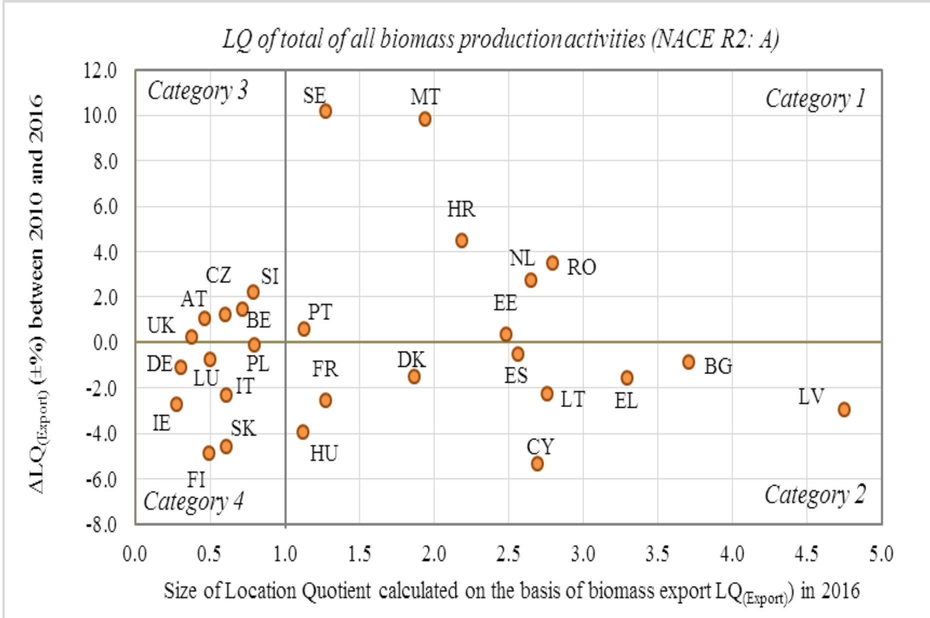
3. EMPIRICAL RESULTS

The spatial concentration of biomass production sector in the European Union across 28 member states were analysed in the following manner:

- Location Quotients were calculated based on gross value added LQ and biomass export LQ in 2016;
- Correlation between gross value added LQ and export LQ was analysed;
- Average annual percentage change in gross value added LQ and export LQ was analysed for the 2010-2016 period;
- Two levels of aggregation were used for the analysis – the biomass production sector as a whole (NACE R2: A), and primary economic activities, i.e. Agriculture, Forestry, Fishing and Aquaculture (NACE R2: A01, A02 and A03, respectively) separately.

Fig. (**2**) describes the biomass production sector location across the EU member states based on two LQ dimensions, i.e. size and direction of the change. The LQ value in 2016 is shown along the horizontal axis of the matrix, representing the degree of spatial concentration/ deconcentration. It indicates in which EU member states biomass production sector is more strongly represented than they are in the EU as whole. The direction of the LQ change is shown on the vertical axis of the matrix, representing the positive or negative change in LQ for each individual state over the 2010-2016 period. It indicates in which states the concentration (or deconcentration) in biomass production sector is rising and in which states it is decreasing.

As expected, different EU member states have different degree of relative concentration in the biomass production sector. In fact, biomass production is unevenly distributed among the EU member states, and the specialisation of each state is changing over the 2010-2016 period. Based on LQ-ΔLQ composition matrix, four categories of relative spatial concentration (or localisation) of biomass production are distinguished, as indicated in the Fig. (**1**). Twelve states, i.e. almost 43 percent of the EU member states fell within biomass production Location Category 1, eight states (i.e. nearly 29 percent) fell within Location Category 4, seven states (i.e. 25 percent) fell within



AT Austria	CZ Czechia	DE Germany	LV Latvia	PL Poland
BE Belgium	DK Denmark	EL Greece	LT Lithuania	PT Portugal
BG Bulgaria	EE Estonia	HU Hungary	LU Luxembourg	RO Romania
CY Cyprus	FI Finland	IE Ireland	MT Malta	SK Slovakia
HR Croatia	FR France	IT Italy	NL Netherlands	SI Slovenia

Source: own calculations based on the ITC Trade Map time series trade data (see Appendix)

Fig. (3). Biomass export location mapping across the EU member states: based on the export LQ.

Location Category 2 and only Germany alone fell within Location Category 3. Note that France has the gross value added LQ almost equal to one (1.04 in 2016) and it has been decreasing over the past seven years.

As Fig. (**2**) shows, nearly two thirds (or eighteen) of the EU member states have relative concentration of biomass production with the gross value added LQ that exceeds 1.25 (see on the right-hand side of the Matrix the quadrants 1 and 2). Consistently, the biomass sector's share in the total GVA at national level is at least by 25 percent higher than the EU average. It is assumed that the biomass production is relatively more concentrated in the particular states relative to the EU as whole. This implies that all the eighteen countries are capable of meeting all domestic requirements for biomass and have potential to export biomass in order to satisfy the growing demand for it not only on the EU internal market, but also on global markets. The highest concentration of biomass production was found in Bulgaria (LQ=3.01), Hungary (LQ=2.93), Romania (LQ=2.90) and Greece (LQ=2.62). Note that all these countries, except Hungary, also have high relative specialisation in biomass export with the export LQ that exceeds 2.8 (all results of biomass export analysis are compiled in Fig. **3**). A high LQ in biomass production sector shows a competitive advantage in that sector for national economy.

Positive change of the gross value added LQ indicates that the biomass production sector became more concentred from 2010 through 2016 in twelve of nineteen states which have LQ that exceeds 1.2 (see quadrant 1 in location mapping matrix in Fig. **2**). The increase in LQ higher than 5 percent per year on average was found in Czechia, Slovakia and Hungary, slightly lower – in Greece, Spain and Slovenia. The changes indicate significantly increased biomass production concentration in all these states relative to the EU as whole. The positive LQ changes were found also in Finland, Netherlands and Bulgaria (less than 0.7 percent a year on average) and in Italy, Lithuania and Portugal (about 1 percent on average per year). However, low average annual percentage change indicates that relative concentration of biomass production in these six states remained virtually unchanged or changed very slightly during 2010-2016 period. Moreover, it was determined that only four of twelve states which fell within biomass production Location Category 1 have positive trend of biomass export LQ change, i.e. Netherlands, Slovenia, Czechia and Portugal (where export LQ increased by 2.7, 2.2, 1.2, and 0.6 percent per year on average, respectively). This may indicate that the relative specialisation in biomass export is rising only in these four states and decreasing in the rest of states, especially Hungary, Slovakia and Finland (see in Fig. **3**).

By contrast, nearly one third of the EU member states (i.e. Luxembourg, United Kingdom, and Belgium, Ireland, Denmark, Malta, Austria, Sweden and Germany) have low representation of biomass production sector (LQ <0.8), see on the left-hand side of the Matrix (quadrants 3 and 4 in Fig. **2**). Moreover, almost all these states have declined in degree of relative concentration of biomass production over the past seven years, except for Germany, where the average annual percentage change of LQ was nearly 1 percent during the same time period. This implies that biomass production is insufficient to meet domestic demand and there is a need for biomass imports. On the other hand, it should be noted that in Sweden strong relative concentration of forest biomass production (a 5.1 LQ in 2016) exists, while in Malta and Denmark strong concentration was found in fishing and aquaculture (a 5.2 and 2.9 LQ, respectively). All the latter three countries have an above average biomass export specialisation with the LQ greater than the cut-off value of 1.25.

As mentioned above, the gross value added LQ analysis reveals the degree of biomass production sector's capability to satisfy demands of the states' domestic market and to export its output surplus to the other EU states or the rest of the world. On the other hand, both theoretically and practically, biomass exports and imports are possible irrespective of the degree of relative concentration/ deconcentration of biomass production and the degree of states' self-sufficiency in biomass. Therefore, the following step in our analysis is estimation of the states' relative specialisation in biomass export using the measures of export LQ and their change (ΔLQ). Correlation analysis based on the EU 28 states' sample shows that both the LQ calculated according to the gross value added and the LQ calculated according to the biomass export are positive and moderately strongly correlated (Spearman's correlation coefficient $r = 0.60$ at the level 0.01 of significance) in biomass production sector.

Fig. (**3**) pictures the EU state's relative specialisation in biomass export based on two biomass export LQ dimensions, i.e. size and direction of the change. As shown in Fig. (**3**), a half (or fourteen) of the EU member states are relatively specialised in biomass export with LQ that exceeds 1.25 (see on the right-hand side of the Matrix the quadrants 1 and 2). That is, the biomass export share in the total commodities export at national level is at least by 25 percent higher than the EU average. The highest degree of biomass export specialisation in 2016 was found in Latvia (4.75), Bulgaria (3.71), and Greece (3.30), but all these states became less specialised during the 2010-2016 period. On the contrary, only five of fourteen states that maintain export LQ greater than the cut-off value of 1.25 became more specialised in biomass export at the same time, i.e. Sweden, Malta, Croatia, Romania and the Netherlands. In addition, some of the EU member states (Slovenia, Belgium, Czechia and Austria) that maintain a low exports' LQ below 0.8 and their positive change in 2010-2016, shifts towards specialisation in biomass export.

In the EU as a whole, about 85 percent of the total biomass production sector GVA was generated in the agriculture (max 96 percent in the Netherlands and min 25 percent in Sweden), 12 percent in the forestry (max 73 percent in Sweden and min 1 percent in Greece), and 3 percent in the fishing and aquaculture (max 24 percent in Malta and min 0.4 percent in Hungary) in 2016. These results reveal extreme structural differences of biomass sector according to primary production activities among the EU states. Measurement of both LQ and ΔLQ of separate primary biomass production activities (i.e. agriculture, forestry, fishing and aquaculture) in each EU member state, is the first step towards determining where a given state's capability to self-satisfy biomass domestic needs lies and where its export potential is. Also, LQ-ΔLQ analysis by kind of biomass production activities may be one of the first steps towards determining where a given state's comparative advantage lies and what is the dynamics of comparative advantage in terms of its progress or reversion. The results of spatial concentration analysis focused on three separate primary biomass production activities are shown in the Tables 1, 2 and 3. There, the EU member states are classified into four categories (as shown in Location mapping matrix in Fig. **1**) according to the gross value added LQ size in 2016 and the direction of its change (ΔLQ) during the years 2010-2016.

The results of spatial concentration analysis based on the gross value added and agro-biomass export LQ in agriculture across EU member states are presented in Table **1**. Correlation analysis shows that agro-biomass production concentration and agro-biomass export specialisation are positively and moderately strongly correlated ($r2 = 0.67$, $p<0.01$).

Agro-biomass production is relatively concentrated in fifteen, i.e. nearly 54 percent of all the EU member states with the gross value added LQ that exceeds 1.25 (see the right-hand side in Table **1**). It can be concluded that all these states are capable to meet all domestic needs for biomass and have the potential to export biomass. Most of them had positive LQ changes indicating that agro-biomass production became more concentrated, while some of them experienced a decrease in concentration during the med-term period (2010-2016). Although Portugal has an LQ somewhat lower than the cut-off value, positive LQ change indicated increased concentration in agro-biomass production during the considered period. An LQ less than 0.75 was found in eleven EU member states (see the left-hand side of Table **1**) this indicates that relative concentration of agriculture is low or underrepresented. This was well expressed in Sweden, United Kingdom, Luxembourg and Germany where gross value added LQ did not reach 0.5.

Most of the sates, where relative concentration of agriculture is present, are also relatively specialised in agro-biomass export with the exports LQ exceeding 1.25, except for Portugal, Hungary and Slovakia. Estonia and Denmark were also relatively specialised in agro-biomass export despite the fact that agriculture is underrepresented (the gross value added LQ was less than 0.75). On the contrary, six other states (Portugal, Poland, Italy, Slovakia, Czechia and Slovenia) were not specialised in agro-biomass export (export LQ < 0.75) although their higher relative concentration in ago-biomass production (gross value added LQ > 1.25).

Table **2** presents the results of location quotient analysis based on GVA and forest biomass export in the forestry across EU member states except Malta. Positive and moderately strong correlation ($r2 = 0.63$, $p<0.01$) is observed between both LQ measures. Fifteen states have the gross value added LQ that exceeds 1.2 as it can be seen on the right-hand side in the table. This implies that forest biomass (most of which consists of wood biomass) production is relatively concentrated in nearly 54 percent of all the EU member states. A strong relative concentration of forest biomass production was found in six states, including Finland (LQ=10.7), Estonia (LQ=7.8) and Slovakia (LQ=5.6) with positive changes of gross value added LQ indicating increasing concentration from 2010 through

Table 1. Agricultural location mapping across the EU member states: based on the gross value added LQ.

Location Quotient / Average annual rate of change	LQ(GVA) < 1 (in 2016)					LQ(GVA) ≥ 1 (in 2016)				
	Countries	LQ(GVA) value	ΔLQ(GVA) (±%)	LQ(Export) value	ΔLQ(Export) (±%)	Countries	LQ(GVA) value	ΔLQ(GVA) (±%)	LQ(Export) value	ΔLQ(Export) (±%)
Positive ΔLQ(GVA) from 2010 to 2016	Luxembourg	0,18	0,4	0,39	-0,3	Portugal	1,22	1,2	0,99	3,6
	Germany	0,48	0,7	0,31	-0,6	Slovenia	1,29	3,7	0,38	-5,4
	Ireland	0,74	2,4	0,22	-5,7	Czechia	1,35	9,6	0,47	0,8
						Latvia	1,51	0,9	3,26	1,3
						Netherlands	1,51	1,6	2,91	2,8
						Italy	1,55	3,1	0,65	-2,3
						Spain	2,14	4,1	2,78	-0,2
						Slovakia	2,15	6,2	0,57	-2,7
						Lithuania	2,27	2,6	2,78	-1,9
						Greece	2,89	5,9	2,70	-1,0
						Bulgaria	3,36	1,9	4,12	-0,5
						Hungary	3,45	6,5	1,25	-3,6
Negative ΔLQ(GVA) from 2010 to 2016	Sweden	0,26	-3,8	0,19	4,8	France	1,14	-0,5	1,36	-2,3
	United Kingdom	0,46	-0,7	0,31	-0,4	Cyprus	1,54	-0,6	2,25	-7,6
	Belgium	0,53	-1,5	0,77	1,6	Poland	1,58	-3,2	0,84	0,5
	Finland	0,62	-2,1	0,45	-5,6	Croatia	2,32	-1,5	1,52	6,6
	Estonia	0,66	-11,0	1,67	0,5	Romania	3,15	-3,0	3,15	4,2
	Austria	0,70	-0,6	0,45	2,5					
	Denmark	0,70	-3,0	1,59	-3,5					
	Malta	0,73	-4,0	0,53	-2,1					

Notes: in the whole sample of the EU countries, positive moderately strong correlation was found between values of LQ(GVA) and LQ(Export) – Spearman's Correlation Coefficient r = 0.673; correlation is significant at the 0.01 level (2-tailed).

Source: own calculations based on the EUROSTAT National accounts aggregates by industry data and the ITC Trade Map time series trade data.

Table 2. Forestry location mapping across the EU states: based on the gross value added LQ.

Location Quotient / Average annual rate of change	LQ(GVA) < 1 (in 2016)					LQ(GVA) ≥ 1 (in 2016)				
	Countries	LQ(GVA) value	ΔLQ(GVA) (±%)	LQ(Export) value	ΔLQ(Export) (±%)	Countries	LQ(GVA) value	ΔLQ(GVA) (±%)	LQ(Export) value	ΔLQ(Export) (±%)
Positive ΔLQ(GVA) from 2010 to 2016	Netherlands	0,12	0,1	0,98	26,9	Hungary	1,32	0,3	0,61	-7,7
	United Kingdom	0,20	3,7	0,17	-4,5	Romania	2,59	4,5	0,86	-9,9
	Greece	0,24	8,3	0,40	-1,6	Portugal	2,96	2,3	2,21	-10,3
	Italy	0,48	0,5	0,27	26,5	Slovenia	3,45	1,3	8,94	11,3

	Spain	0,62	1,0	0,72	2,9	Slovakia	5,56	3,9	2,09	-11,0
	Denmark	0,62	0,2	2,11	17,6	Estonia	7,80	1,7	19,40	0,0
	Germany	0,70	9,1	0,44	-3,3	Finland	10,67	1,0	1,47	-3,4
	France	0,91	3,9	0,91	-4,2					
Negative $\Delta LQ_{(GVA)}$ from 2010 to 2016	Ireland	0,07	-26,1	0,31	-5,1	Poland	1,81	-1,6	1,18	-3,7
	Luxembourg	0,14	-6,2	2,86	-2,8	Austria	2,01	-3,2	1,43	-4,5
	Belgium	0,14	-2,2	0,68	6,1	Bulgaria	2,50	-5,4	1,93	-2,9
	Cyprus	0,58	-0,2	0,01	42,7	Lithuania	2,75	-3,1	6,13	-3,4
						Croatia	2,99	-1,2	10,10	1,4
						Czechia	3,31	-1,0	3,05	1,0
						Sweden	5,13	-4,7	0,81	-5,2
						Latvia	9,07	-6,5	34,59	-8,1

Notes: 1) Malta is not included because its forestry data is not available; 2) in the whole sample of the EU countries, positive moderately strong correlation was found between values of $LQ_{(GVA)}$ and $LQ_{(Export)}$ – Spearman's Correlation Coefficient r = 0.633; correlation is significant at the 0.01 level (2-tailed).
Source: own calculations based on the EUROSTAT National accounts aggregates by industry data and the ITC Trade Map time series trade data.

Table 3. Location mapping of fishing and aquaculture across the EU states: based on the gross value added LQ.

Location Quotient / Average annual rate of change	$LQ_{(GVA)} < 1$ (in 2016)					$LQ_{(GVA)} \geq 1$ (in 2016)				
	Countries	**$LQ_{(GVA)}$ value**	**$\Delta LQ_{(GVA)}$ (±%)**	**$LQ_{(Export)}$ value**	**$\Delta LQ_{(Export)}$ (±%)**	**Countries**	**$LQ_{(GVA)}$ value**	**$\Delta LQ_{(GVA)}$ (±%)**	**$LQ_{(Export)}$ value**	**$\Delta LQ_{(Export)}$ (±%)**
Positive $\Delta LQ_{(GVA)}$ from 2010 to 2016	Austria	0,15	9,0	0,04	14,0	Netherlands	1,00	1,8	0,85	1,2
	Germany	0,16	0,0	0,12	-6,7	Lithuania	1,46	5,3	0,28	-4,1
	Czechia	0,27	2,4	0,39	7,0	Romania	2,22	25,5	0,03	8,2
	Belgium	0,32	5,8	0,15	-2,2	Cyprus	3,09	12,2	9,46	1,3
	Poland	0,40	5,5	0,08	-0,4	Spain	3,17	6,7	1,31	-5,7
	Slovakia	0,56	59,2	0,02	-6,8	Portugal	3,38	1,2	2,05	-6,0
	France	0,70	0,3	0,61	-3,4	Estonia	3,45	0,6	0,30	-12,0
	United Kingdom	0,74	0,7	1,30	-0,5	Croatia	6,25	1,9	4,41	-2,6
	Bulgaria	0,88	10,5	0,30	0,4	Greece	7,97	2,4	11,96	-6,2
Negative $\Delta LQ_{(GVA)}$ from 2010 to 2016	Slovenia	0,23	-0,5	0,05	12,5	Finland	1,14	-1,3	0,35	6,5
	Hungary	0,29	-1,6	0,08	9,2	Italy	1,20	-5,5	0,34	-5,1
	Sweden	0,37	-0,7	13,88	7,64	Latvia	2,81	-2,1	1,49	-11,1
	Ireland	0,97	-7,7	0,97	8,9	Malta	5,21	-3,3	19,26	12,2

Notes: 1) Luxembourg is not included because its fishery and aquaculture data is not available; 2) in the whole sample of the EU countries, positive moderately strong correlation was found between values of $LQ_{(GVA)}$ and $LQ_{(Export)}$ – Spearman's Correlation Coefficient r = 0.621; correlation is significant at the 0.01 level (2-tailed).
Source: own calculations based on the EUROSTAT National accounts aggregates by industry data and the ITC Trade Map time series trade data

2016; while although Latvia and Sweden have relatively high LQ (of 9.1 and 5.1, respectively) but decreasing concentration over the same period (-6.5 and -4.7 percent a year on average, respectively). In addition, in Latvia and Estonia forest biomass export specialisation is strongly expressed with export LQ reaching 34.6 and 19.4 percent respectively. High export specialisation with LQ of 6.1 and higher was found in Lithuania, Slovenia and Croatia. Seven states have a low representation of forest biomass production (LQ < 0.5). Most of them were not specialised in forest biomass export, except for Luxembourg with high export LQ of 2.9 (see on the left-hand side in Table).

The results for spatial concentration analysis based on the gross value added LQ and aquatic biomass export LQ in fishing and aquaculture across EU member states except for Luxembourg are presented in Table **3**. Positive and moderately strong correlation ($r2 = 0.62$, $p<0.01$) was observed between both LQ measures. Relative concentration of fishing and aquaculture was found in the eleven EU member states (LQ>1.25), and nine of these states had also positive location quotient changes indicating concentration increase from 2010 through 2016. Fishing and aquaculture are very well represented in Greece, Croatia and Malta where gross value added LQ exceed 5.2. In addition, Cyprus, Greece, Malta and Sweden have strong aquatic biomass export specialisation LQ that exceeds 9.5, despite the fact that relative concentration of fishing and aquaculture is nearly absent (gross value added LQ bellow 0.5) in Sweden. Concentration of fishing and aquaculture is also nearly absent (or at least underrepresented) in twelve EU member states (see on the left-hand side in the table) and many of these states have very low aquatic biomass export LQ of 0.61 and less, excluding Ireland and the United Kingdom.

4. CONCLUSION

Location Quotient is widely used in economic analysis for different purposes using different measures of economic activities, such as employment, gross output, value added, earned income, etc., depending on analysts' intentions and data availability. In this paper, LQ serves (i) to determine the location of biomass production sector in European Union in order to quantify how "concentrated" biomass production is in separate EU member states relative to the EU as a whole; and (ii) to identify the dynamics of the sector – whether it is becoming more concentrated or deconcentrated in a particular country over time. For these purposes location quotients are calculated on the basis of gross value added and biomass export using medium-term data of twenty-eight member states of the EU. The analysis addresses total biomass production sector and its three activities (agriculture, forestry, fishing and aquaculture) in each separate state. According to the LQ size and the direction of change (LQ-ΔLQ) the biomass production sector and biomass primary production activities are classified into four categories shaping the sector location matrix. Measurement of both the LQ and ΔLQ of biomass sector as a whole of separate primary biomass production activities in each EU member state allows revealing where a given state's capability to self-satisfy biomass domestic needs lies and where its export potential is expressed.

The findings based on the detailed analysis of primary biomass production activities indicated extreme structural differences in biomass production sector according to primary production activities among the EU member states. According to the share in total GVA of biomass production sector, the proportion of agriculture ranges from 25 to 96 percent, the proportion of forestry deviates from 1 to 73 percent, and the proportion of fishing and aquaculture – from less than 1 to 24 percent in 2016. The findings indicate that the differences in relative concentration of forestry as well as of fishing and aquaculture are quite high among EU member states – strong spatial concentrations exist in one or the other states, whilst differences in relative concentrations of agriculture are substantially lower.

Relative concentration of biomass production was found in nearly two thirds of the EU member states. Biomass production sector is the most represented in Bulgaria, Hungary, Romania and Greece Slovakia Lithuania Latvia and Croatia. Latvia, Bulgaria and Greece have high biomass export specialisation. The highest relative concentration of agriculture with an increasing trend in 2010-2016 was found in Hungary and Bulgaria. Romania also has high relative concentration in agriculture, however with the decreasing trend. Agriculture is very well represented in Greece, Lithuania, Slovakia, Spain and Croatia. Generally, higher than average and increasing relative concentration of agro-biomass production was found in eleven states of the EU. A strong relative concentration with an increasing trend in forestry in 2010-2016 period was found in Finland, Estonia and Slovakia, while Latvia and Sweden fell into the other group of countries, having strong relative concentration with a decreasing trend. Forest biomass export specialisation is strongly expressed in Latvia and Estonia, while Lithuania, Slovenia and Croatia also have high relative export specialisation, though more moderately expressed. Fishing and aquaculture are very well represented in Greece, Croatia and Malta, while Cyprus, Greece, Malta and Sweden also have strong aquatic biomass export specialisation, though more modestly expressed.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

Appendix. Location quotient calculated based on GVA and biomass export in biomass production sector.

	$LQ_{(GVA)}$		Average annual change (±%) $\Delta LQ_{(GVA)}$ 2001-2016	$LQ_{(export)}$		Average annual change (±%) $\Delta LQ_{(export)}$, 2001-2016
	2010	2016	2010-2016	2010	2016	2010-2016
Austria	0,88	0,80	-1,65	0,44	0,47	1,05
Belgium	0,53	0,45	-2,48	0,66	0,72	1,43

Bulgaria	2,97	3,01	0,22	3,92	3,71	-0,90
Cyprus	1,48	1,41	-0,87	3,75	2,69	-5,36
Croatia	2,71	2,42	-1,86	1,68	2,19	4,46
Czechia	1,04	1,47	5,89	0,56	0,60	1,23
Denmark	0,86	0,73	-2,66	2,05	1,87	-1,53
Estonia	1,98	1,55	-4,03	2,43	2,49	0,36
Finland	1,69	1,77	0,72	0,67	0,50	-4,89
France	1,10	1,04	-1,02	1,49	1,28	-2,57
Germany	0,45	0,47	0,97	0,33	0,31	-1,14
Greece	2,03	2,62	4,39	3,62	3,30	-1,55
Hungary	2,19	2,93	4,98	1,44	1,13	-3,98
Ireland	0,65	0,64	-0,36	0,33	0,28	-2,72
Italy	1,22	1,34	1,56	0,70	0,61	-2,34
Latvia	2,75	2,35	-2,57	5,69	4,75	-2,96
Lithuania	2,06	2,19	0,99	3,17	2,76	-2,27
Luxembourg	0,17	0,16	-1,24	0,53	0,51	-0,74
Malta	1,03	0,77	-4,71	1,11	1,94	9,82
Netherlands	1,23	1,26	0,44	2,25	2,65	2,74
Poland	1,81	1,72	-0,84	0,81	0,80	-0,13
Portugal	1,36	1,44	0,95	1,10	1,13	0,56
Romania	3,47	2,90	-2,98	2,27	2,79	3,49
Slovakia	1,75	2,38	5,30	0,81	0,61	-4,61
Slovenia	1,23	1,44	2,63	0,70	0,79	2,18
Spain	1,58	1,90	3,07	2,65	2,56	-0,54
Sweden	1,01	0,81	-3,54	0,71	1,28	10,17
United Kingdom	0,45	0,42	-1,41	0,38	0,38	0,22

Note: positive moderately strong correlation was found between values of LQ(GVA) and LQ(Export) – Spearman's Correlation Coefficients r2 = 0.727 in 2010 and r2 = 0.600 in 2016, correlation is significant at the 0.01 level (2-tailed).

Source: own calculations based on the EUROSTAT National accounts aggregates by industry data and the ITC Trade Map time series trade data

ENDNOTES

[1]Jobs and Wealth in the European Union Bioeconomy
https://datam.jrc.ec.europa.eu/datam/mashup/BIOECONOMICS/index.html

[2]The Location Quotient, built upon by Florence (1929), cited in Thulin 2015, p. 220, is "a measure of the concentration of any particular industry in any given area by comparing the proportion of all occupied persons that were occupied in that industry in the given area with the corresponding proportion for the country as a whole".

REFERENCES

[1]. Birner, R.: Bioeconomy Concepts. In Bioeconomy Springer, Cham (pp. 17-38) (2018).

[2]. Brache, J.; Felzensztein, C.: Geographical co-location on Chilean SME's export performance. J Bus Res Article in press (2017).

[3]. Budzianowski, W.M.: High-value low-volume bioproducts coupled to bioenergies with potential to enhance business development of sustainable biorefineries. Renew Sust Energ Rev 70: 793-804 (2017).

[4]. Carleton, R.; Brantingham, P.L.; Brantingham, P.J.: Crime specialization in rural British Columbia, Canada. Can J Criminol Crim Justice 56: 595-622 (2014).

[5]. Carroll, M.C.; Reid, N.; Smith, B.W.: Location quotients versus spatial autocorrelation in identifying potential cluster regions. Ann Regional Sci 42: 449-63 (2008).

[6]. Chen, J.; Jackson, R. Regional Industry Cluster Analysis for the Potomac Highlands in West Virginia. Regional Research Institute of West Virginia University. Resource Document, 2018-03 (2018).

[7]. Cristóbal, J.; Matos, C.T.; Aurambout, J.P.; Manfredi, S.; Kavalov, B.: Environmental sustainability assessment of bioeconomy value chains. Biomass Bioenergy 89: 159-71 (2016).
[8]. dos Santos, N.V.; de Carvalho Santos‐ Ebinuma, V.; Pessoa Junior, A.; Pereira, J.F.B.: Liquid–liquid extraction of biopharmaceuticals from fermented broth: trends and future prospects. J Chem Technol Biotechnol 93: 1845-63 (2018).
[9]. European Commission: Innovating for Sustainable Growth: A Bioeconomy for Europe. Communication from the Co-mmission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. COM(2012) 60 final. Brussels (2012).
[10]. European Commission: Mandate Addressed to Cen, Cenelec and Etsi for fhe Development of Horizontal European Standards and other Standardisation Deliverables For Bio-Based Products. Enterprise and Industry Directorate-General. Ref. Ares(2011)261856-09/03/2011. Brussels (2011).
[11]. European Commission: The mid-term review of the EU Biodiversity Strategy to 2020. Report from the Commission to the European Parliament and the Council, COM(2015) 478. Brussels (2015).
[12]. Erkuş-Öztürk, H.: The role of cluster types and firm size in designing the level of network relations: the experience of the Antalya tourism region. Tourism Management 30: 589-97 (2009).
[13]. Foley, J.A.; Ramankutty, N.; Brauman, K.A.; et al.: Solutions for a cultivated planet. Nature 478: 337 (2011).
[14]. Gerbens-Leenes, P.W.: Bioenergy water footprints, comparing first, second and third generation feedstocks for bioenergy supply in 2040. European Water 59: 373-80 (2017).
[15]. Ha, O.K.; Andresen, M.A.: Unemployment and the specialization of criminal activity: A neighbourhood analysis. J Crim Justice 48: 1-8 (2017).
[16]. IEA: World Energy Outlook 2017. International Energy Agency (IEA) Publications, London (2017).
[17]. IRENA: Global Energy Transformation: A roadmap to 2050, International Renewable Energy Agency, Abu Dhabi (2018).
[18]. Isserman, A.M.: The location quotient approach to estimating regional economic impacts. J Am Inst Planners 43: 33-41 (1977).
[19]. Joint Research Centre: Bioeconomy Report 2016. JRC Scientific and Policy Report. EUR 28468 (2017).
[20]. Kowalski, A.M.:Territorial location of ICT cluster initiatives and ICT-related sectors in Poland. In: Drewello, H, Helfer, M., Bouzar, M. (eds.) Clusters as a Driving Power of the European Economy, pp. 49-65. Nomos Verlagsgesellschaft / edition sigma, Baden-Baden, Germany (2016).
[21]. Mayer, W.; Pleeter, S.: A theoretical justification for the use of location quotients. Reg Sci Urban Econ 5: 343-55 (1975).
[22]. McCormick, K., Kautto, N.: The bioeconomy in Europe: an overview. Sustainability 5: 2589-608 (2013).
[23]. Miller, M.M.; Gibson, L.J.; Wright, N.G. Location quotient: A basic tool for economic development analysis. Econ Devel Rev 9: 65-8 (1991).
[24]. Miller, R.E.; Blair, P.D. Input–Output Analysis: Foundations and Extensions. Second Edition. Cambridge University Press, Cambridge, (2009).
[25]. Moineddin, R.; Beyene, J.; Boyle, E.: On the location quotient confidence interval. Geogr Anal 35: 249-56 (2003).
[26]. Moorkens, E.; Meuwissen, N.; Huys, I.; Declerck, P.; Vulto, A.G.; Simoens, S.: The market of biopharmaceutical medicines: A snapshot of a diverse industrial landscape. Front Pharmacol 8: 314 (2017).
[27]. Morrissey K.: Producing regional production multipliers for Irish marine sector policy: A location quotient approach. Ocean Coast Manage 91: 58-64 (2014).
[28]. Morrissey, K.: A location quotient approach to producing regional production multipliers for the Irish economy. Pap Reg Sci 95: 491-506 (2016).
[29]. OECD: Towards Green Growth? Tracking Progress, OECD Green Growth Studies, OECD Publishing, Paris (2015).
[30]. Purdue University Center for Regional Development, Indiana Business Research Center, and Strategic Development Group: Unlocking Rural Competitiveness: The Role of Regional Clusters. https://pcrd.purdue.edu/index.php. (2007). Retrieved October, 2018.
[31]. Ramos, J.L.; García‐ Lorente, F.; Valdivia, M.; Duque, E.: Green biofuels and bioproducts: bases for sustainability analysis. Microbial Biotechnol 10: 1111-3 (2017).
[32]. Ray, D.K.; Mueller, N.D.; West, P.C.; Foley, J.A.: Yield trends are insufficient to double global crop production by 2050. PLoS ONE 8: e66428 (2013).
[33]. Rivera, L.; Sheffi, Y.; Welsch, R.: Logistics agglomeration in the US. Transp Res Part A Policy Pract 59: 222-38 (2014).
[34]. Ronzon, T.; Lusser, M.; Klinkenberg, M.; et al. (Eds.): Bioeconomy Report 2016; JRC Science for Policy Report EUR-28468. Publications Office of the European Union. Brussels (2017).
[35]. Scarlat, N.; Dallemand, J.F.; Monforti-Ferrario, F.; Nita, V.: The role of biomass and bioenergy in a future bioeconomy: policies and facts. Environ Dev 15: 3-34 (2015).
[36]. Schiffer, H.W.; Kober, T.; Panos, E.: World energy council's global energy scenarios to 2060. Zeitschrift für Energiewirtschaft 42: 91-102 (2018).
[37]. Schoenung, S.; Efroymson, R.A.: Algae Production from Wastewater Resources: An Engineering and Cost Analysis (No. ORNL/TM-2017/720). Oak Ridge National Lab.(ORNL), Oak Ridge, TN (United States) (2018).
[38]. Spencer, G.M.; Vinodrai, T.; Gertler, M.S.; Wolfe, D.A.: Do clusters make a difference? Defining and assessing their economic performance. Reg Stud 44: 697-715 (2010).
[39]. Stejskal, J.; Hajek, P.: Competitive advantage analysis: a novel method for industrial clusters identification. J Bus Econ Manag 13: 344-65 (2012).
[40]. Stimson, R.J.; Stough, R.R.; Roberts, B.H.: Regional economic development: analysis and planning strategy. Springer Science & Business Media (2006).
[41]. Suchecki, A.M.: Spatial diversification of the regional expenses on culture in Poland 2003-2012. Comp Econ Res 17: 237-52 (2014).
[42]. Thulin, P.: 10 local multiplier and economic base analysis. In: Karlsson, C., Andersson, M. Norman T. (eds.) Handbook of Research Methods and Applications in Economic Geography, pp. 213-233. Edward Elgar Publishing, (2015).
[43]. Tian, Z.: Measuring agglomeration using the standardized location quotient with a bootstrap method. J Reg Anal Pol 43: 186-97 (2013).
[44]. United Nations: World Population Prospects: The 2017 Revision, Key Findings and Advance Tables. Department of Economic and Social Affairs, Population Division. Working Paper No. ESA/P/WP/248 (2017).
[45]. Valin, H.; Sands, R.D.; van der Mensbrugghe, D.; et al.: The future of food demand: understanding differences in global economic models. Agric Econ 45: 51-67 (2014).
[46]. WEC: World Energy Scenarios 2016 – The Grand Transition. World Energy Council, London (2016).
[47]. Weterings, A.; Marsili, O.: Spatial concentration of industries and new firm exits: Does this relationship differ between exits by closure and by M&A? Reg Stud 49: 44-58 (2015).
[48]. Yan, J.; Shen, Y.; Xia, F.: Differentiated optimization of sustainable land use in metropolitan areas: a demarcation of functional units for land consolidation. Sustainability 9: 2-19 (2017).
[49]. Yu, Y.; Hubacek, K.; Feng, K.; Guan, D.: Assessing regional and global water footprints for the UK. Ecol Econ 69: 1140-7 (2010).