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SEASONALITY ELEMENTS IN THE PRODUCTION AND USE OF LIQUID BIOFUELS IN POLAND AND GERMANY

Key words: liquid biofuels, Poland, Germany, seasonality

ABSTRACT. The aim of the paper is to identify elements of seasonality in supply and demand in the liquid biofuels sector in Poland and Germany. An additional purpose is to present forecasts for selected aggregates until 2020. Two research questions have been formulated for their implementation: (1) is biofuel production in Poland higher in spring or summer (due to the seasonality of agricultural raw material production) than e.g. in winter?; (2) Is the consumption of biofuels seasonal in both countries? The research applies quarterly data for the following aggregates from the biofuels sector: for Poland – production and sale of biofuels in the quarters of 2006-2018, for Germany – biofuel consumption in the quarters of 2007-2017, import and export of bioethanol in the quarters of 2007-2015, import and export of esters in the quarters of 2007-2017. The work focuses on identifying seasonal fluctuations in order to identify purified seasonality indicators, so that it is possible to present forecasts for the biofuels sector. The research conducted in the article leads to the conclusions that, in the liquid biofuels sector, in Poland and Germany, there are elements of seasonality, especially in the field of sales / consumption of biofuels, which in turn is the effect of the changing demand for traditional fuels in which liquid biocomponents are admixed or (less often) used separately as fuel. Differences in the values of variables in Poland and Germany in quarters, in the analysed periods, can be significant – they usually reach several dozen (up to even over 100%), although in nominal terms these differences are usually several or several percentage points. The consumption of biofuels in both countries was higher in the second and third quarters, i.e. in the spring-summer period than others.

INTRODUCTION

The liquid biofuels sector in the European Union, including Poland and Germany, taking into account the industrial scale of production and consumption, has been developing for about 15 years. There are several important factors behind this process, mainly of an economic as well as environmental nature. The first group includes the following aspects [Directive 2009/28/EC, ACEA 2017, Borychowski, Czyżewski 2017]:

1) significant fluctuations in oil prices, supply and demand shocks on its market, as well as concerns about extraction and availability for countries without deposits of this resource;
2) a growing number of vehicles fueled by liquid fuels and therefore growing demand for energy in transport;

3) surpluses of agricultural raw materials and the possibilities and willingness to use them, as well as avoiding the necessity of their utilisation in the event that they lose their usefulness for food production;
4) willingness to stimulate the development of agriculture and rural areas by creating an additional source of demand for agricultural raw materials, which contributes to an increase in agricultural income, and indirectly also to the development of the entire economy (jobs, turnover generated in the sector – see Table 1).

Among environmental factors, the most important are [Biokraftstoffe 2014, Directive 2009/28/EC, Rosiak et al. 2011]: lower emissions of harmful substances into the atmosphere compared to fossil fuels, in particular carbon dioxide; the natural origin of biofuels and their renewable nature; safety in transport and storage as well as biodegradability of liquid biofuels. Legal regulations were a separate factor for the development of the biofuels sector – 3 x 20% package (climate and energy package), including the regulation that by 2020, in the European Union, the share of biofuels in total fuel consumption in transport is to be 10% [Directive 2009/28/EC].

Basic data on the liquid biofuels sector in Poland and Germany are presented in Table 1. They are average values for 2016-2017. During this period around 200 thous. tonnes were produced in Poland and nearly 900 thous. tonnes of esters per year, while production in Germany reached the size of over 700 thous. tonnes of ethanol and over 3.1 million tonnes of esters. The consumption of biofuels in Poland was close to the production

Table 1. Basic data on the liquid biofuels sector in Poland and Germany in 2016-2017 (average values for 2016-2017)

Specification	Poland	Germany
Bioethanol production [thous. t]	198.5	705.6
Bioethanol consumption [thous. t]	196.5	1,108.9
Bioethanol import [thous. t]	69.6	269.6 [a]
Bioethanol export [thous. t]	6.6	44.1 [a]
Consumption of raw materials for bioethanol production [thous. t]	704.8	1,141.0 [b]
Ester production [thous. t]	882.2	3,150.0
Ester consumption in thous. tonnes	886.7	2,177.6
Ester import [thous. t]	263.4	774.1
Ester export [thous. t]	775.3	1,570.7
Consumption of raw materials for the production of esters [thous. t]	886.1	1,994.0 [b]
Employment (direct and indirect jobs)	33,100	18,650
Turnover [mln EUR]	1,210	1,970

[a] – data on import and export of bioethanol for Germany: from 2015, [b] – data on the use of agricultural raw materials for biofuel production in Germany: for 2016

Source: own calculation and elaboration based on [KOWR 2019, Burghardt et al. 2016, EUROBSERV'ER 2018, BDBe 2018, GUS 2018, UFOP 2018]

volume, while in Germany the consumption of bioethanol exceeded its production (by approx. 400 thous. tonnes) and shortages were solved by imports and stocks, while in the ester industry there was significant surplus production over consumption (nearly 1 million tonnes), which, to some extent, was sold abroad. For the production of bioethanol in Poland, mainly maize and wheat are used, and for the production of esters – rapeseed oil [KOWR 2019]. In Germany, corn, wheat and sugar beet are used to produce ethanol, while esters are produced mainly from rapeseed and palm oil [UFOP 2018].

Among economic reasons, the role of energy security and access to liquid fuels in transport was indicated, hence the occurrence of the phenomenon of seasonality in the liquid biofuels sector seems worth examining. In these considerations, what should be taken into account in the perspective of several years (after 2000 until now) is the fact that the demand for liquid petroleum fuels (mainly diesel oil and gasoline), in which biofuels are usually an admixture, has been growing both in Poland and Germany. The only exception being noted after 2007 when there was a short slowdown in fuel demand due to the global economic crisis [EC 2018]. This means that the economy needs permanent access to energy for development, hence determining seasonality together with forecasts may allow for the better organisation and coordination of economic processes (also at a macroeconomic level).

RESEARCH MATERIAL AND METHODS

The aim of the work is to identify elements of seasonality in supply and demand in the liquid biofuels sector in Poland and Germany. In addition, forecasts for selected aggregates up to 2020 were presented. To implement the plans, two auxiliary research questions were formulated:

1) is biofuel production in Poland higher in spring or summer (due to the seasonality of agricultural raw material production) than e.g. in winter; is it the highest in the third quarter?
2) is the consumption of biofuels seasonal in both countries?

Quarterly data in thous. tonnes for the following aggregates from the biofuels sector:

– for Poland: the production and sale of biofuels (bioethanol and esters separately) in the quarters of 2006-2018;
– for Germany: consumption of biofuels (bioethanol and esters separately) in 2007-2017 quarters, import and export of bioethanol in 2007-2015 quarters, import and export of esters in 2007-2017 quarters.

A certain limitation for the conducted research was the availability of data – easier and more data can be found aggregated on an annual basis than on a quarterly basis, hence the number of variables is somewhat limited. The sources of data were industry institutions and organisations in Poland: Krajowy Ośrodek Wsparcia Rolnictwa (National Support Centre for Agriculture), Urząd Regulacji Energetyki (Energy Regulatory Office**)** and in Germany: Agrarmarkt Informations-Gesellschaft (The Agricultural Market Information Society) and Union zur Förderung von Öl- und Proteinpflanzen (Union for the Promotion of Oil and Protein Plants – UFOP). In time series, fluctuations result from several reasons:

– root causes (developmental trends or tendencies);
– seasonal causes (periodic, related to the specifics of the phenomenon studied and lead to seasonal fluctuations);
– accidental causes (occurring irregularly and unpredictably).

In the paper, the author focuses on isolating seasonal fluctuations (thanks to which seasonality indices) are obtained, which is one of the elements of the time series decomposition procedure. The research procedure was as follows [Jóźwiak, Podgórski 2012, StatSoft 2019, Węziak-Białowolska 2019]:

– trend functions were adjusted for selected time series, guided by goodness of fit (in this case, they were a linear or polynomial (square) trend);
– individual seasonality indicators (*isi*) were determined: $isi = \frac{y_t}{\bar{y}_t}$, where y_t is the empirical value of the variable *y* in period *t* and $\bar{y}_t$ the value of the variable resulting from the trend;
– raw seasonality indicators (*rsi*) were determined: $rsi = \frac{1}{n_i - 1} \sum_{t \in N_i} \frac{y_t}{\bar{y}_t}$ for i = 1, ... 4, where *d* is the number of subperiods in the cycle (here: 4 for quarters in a year), and *n* is the number of cycles;
– the correction factor / correction factor (*cf*) has been calculated: $cf = \frac{\sum_{i=1}^{d} rsi}{d}$;
– purified seasonality indices (*psi*) were calculated: $psi = \frac{rsi}{cf}$.

RESEARCH RESULTS

In 2006-2018, nearly 2 million tonnes of bioethanol were produced in Poland, and sales almost reached 1.4 million tonnes. In quarterly terms, production was distributed fairly evenly, i.e. around 25% of the value for a given year for each quarter. In turn, sales were the highest in the second quarters of the analysed period and amounted to 26.3%, and the lowest in the fourth quarter (22.7%). As for the ester sector, production exceeded 7.25 million tonnes in the analysed thirteen years and 7.6 million tonnes in sales. The highest volumes of ester production and sales were noticed in the third quarters, i.e. 27.6% and 28.1%, respectively. It is worth emphasising that they were higher than the value in the first quarter by nearly 25% (5.5 p.p. – percentage points) and 33% (6.9 p.p.). The higher consumption of liquid biofuels in the second and third quarters may be due to the fact that biofuels are hygroscopic and it is not recommended to use them at very low temperatures, therefore in winter periods (first and fourth quarters) [Borychowski, Czyżewski 2017]. A higher consumption of biofuels in the months March-August is therefore a common phenomenon. Detailed data on the production and sale of biofuels in Poland, detailing the quarters are presented in Table 2.

In turn, Table 3 presents detailed data on the liquid biofuels sector in Germany, highlighting quarters in 2007-2017 (or until 2015). The use of biofuels in this country is much higher than in Poland. The consumption of bioethanol in the analysed eleven years

Table 2. Production and sale of liquid biofuels (bioethanol and esters separately) in Poland in the period 2006-2018 – summed values for quarters and shares of quarters in years

Specification	Bioethanol sector		Esters sector	
	production	sale	production	sale
thous. t				
I quarter	491.7	342.2	1,604.7	1,610.0
II quarter	494.6	351.5	1,835.7	2,084.5
III quarter	492.2	340.3	2,002.9	2,136.6
IV quarter	511.6	304.0	1,815.4	1,775.2
Total	1,990.1	1,338.1	7,258.6	7,606.4
%				
I quarter	24.7	25.6	22.1	21.2
II quarter	24.9	26.3	25.3	27.4
III quarter	24.7	25.4	27.6	28.1
IV quarter	25.7	22.7	25.0	23.3

Source: own calculation and elaboration based on [KOWR 2019, URE 2019]

Table 3. Use, export and import of liquid biofuels (bioethanol and esters separately) in Germany in the period 2007-2017* – summed values for quarters and shares of quarters in years

Specification	Bioethanol sector			Esters sector		
	use	export	import	use	export	import
thous. t						
I quarter	2,554.8	76.2	434.5	5,991.2	2,982.1	1,359.2
II quarter	2,961.9	70.0	427.9	6,979.1	3,355.1	2,452.8
III quarter	2,996.5	82.4	470.9	7,267.4	3,973.7	2,769.0
IV quarter	2,893.4	92.5	469.4	6,707.8	4,021.9	1,849.3
Total	11,406.6	321.1	1,802.7	26,945.5	14,332.9	8,430.2
%						
I quarter	22.4	23.7	24.1	22.6	20.8	16.1
II quarter	26.0	21.8	23.7	25.7	23.4	29.1
III quarter	26.3	25.6	26.1	26.7	27.7	32.8
IV quarter	25.4	28.8	26.0	25.0	28.1	21.9

* data on export and import of bioethanol are from 2007-2015

Source: own calculation and elaboration based on [Burghardt et al. 2016, UFOP 2006, 2011, 2012, 2015, 2017, 2018]

exceeded 11.4 million tonnes and esters was close to 27 million tonnes. This proves that the biofuels sector is much more developed in Germany than Poland, which, in turn, is a consequence of higher overall fuel and energy consumption in the economy, as well as the strength and size of the economy itself. In foreign trade, the export and import of esters, with a volume exceeding 14.3 million tonnes and 8.4 million tonnes, in 2007-2017, are particularly important. Bioethanol use was higher in the two middle quarters of the year, i.e. 26% in the second quarter and 26.4% in the third and the lowest in the first quarter. Ester use was similar – it was the highest in the third quarter (26.7%), and then in the second quarter (25.7%), while the lowest in the first three months of the year (22.6%), i.e. lower than in the third quarter by more than 15% (approx. 4 p.p.). In this context, it is worth underlining the quarterly distribution of ester imports to Germany – by far the most esters were purchased abroad in the middle months of the year, i.e. in the third quarter: 32.8% and 29.1% in the second quarter, thus for the remaining two quarters only 38% of import volume was noticed (16% in the first quarter and 22% in the fourth quarter). This proves that in the second and third quarters domestic demand (higher than in winter) is supported by esters from abroad, among others, from Argentina, Austria, France, Cyprus and Sweden [UFOP, Biodiesel 2017/2018]. The above presented data on the Polish and German liquid biofuels sector and the conducted research allow to indicate the elements of seasonality, especially in the sale / use of biofuels (higher use in the second and third quarters), which, in turn, is the effect of the changing demand for traditional fuels in which biocomponents are an admixture or are used as independent fuels, especially B100 (i.e. esters being an independent fuel used only in periods with positive air temperatures). Differences in the values of variables in Poland and Germany, in particular quarters in the analysed periods, are sometimes significant – they even reach several dozen (to over 100%), although in nominal terms these differences usually amount to several or several percentage points.

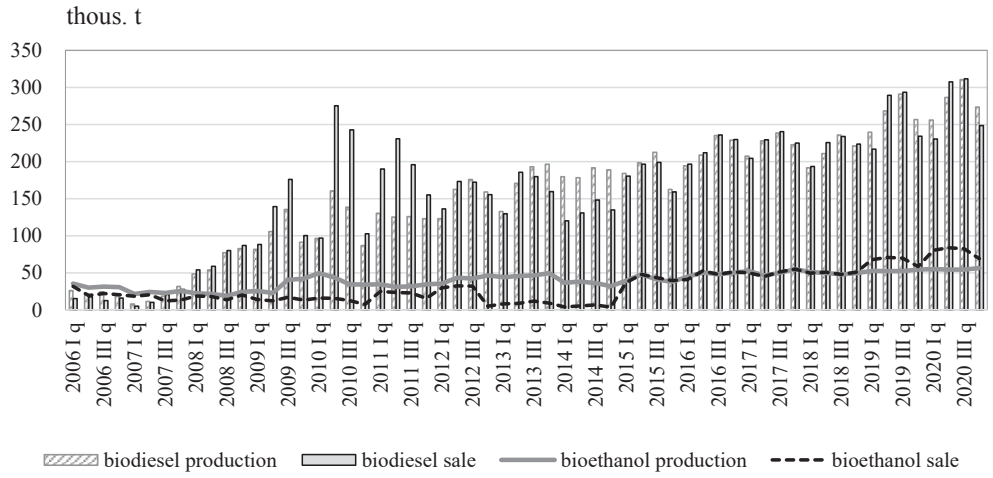
Based on the research procedure described in the section "Research material and methodology", seasonality indicators were calculated, which in the purified version are presented in Table 4. These indicators were extracted on the basis of the abovementioned quarterly data for the production and sale of biofuels (bioethanol and esters) in Poland and for Germany: the bioethanol use and the use and export of esters. On their basis, it can be

Table 4. Purified seasonality indices for the production and use of biofuels in Poland and Germany

Specification	I quarter	II quarter	III quarter	IV quarter
Bioethanol production in Poland	1.0127	0.9952	0.9822	1.0099
Bioethanol sale in Poland	1.0818	1.0793	1.0187	0.8202
Ester production in Poland	0.9312	1.0256	1.0939	0.9493
Ester sale in Poland	0.8580	1.1290	1.1270	0.8859
Bioethanol use in Germany	0.9406	1.0442	1.0308	0.9845
Ester use in Germany	0.8827	1.0320	1.0813	1.0039
Ester export in Germany	0.8571	0.9341	1.1178	1.0909

Source: own calculation and elaboration based on data mentioned in the section "Research material…"

stated by what percentage the value of the variable (e.g. ester sales) in a given phase (here: quarter) is higher or lower than the level that the variable would have achieved if there were no fluctuations, and the variable would have values resulting from the estimated trend function. Therefore, the values of the indicators prove that there are seasonality elements in the biofuels sector in both countries. Knowing the development trends (thanks to the estimation of the trend function) and seasonality indicators gives the opportunity to build forecasts for particular aggregates in the liquid biofuels sector in Poland and Germany. This may be particularly important in the context of the European Union's energy policy, which assumes that the share of biofuels in fuel consumption in transport in 2020 will reach 10%, which, in turn, requires the production and use of an appropriate amount of biocomponents. Based on observations from previous years, it is possible to estimate the production or use of these biofuels and assess the chance of implementing this postulate. It is worth mentioning that the estimation of production volume, e.g. in 2020 based on data on production capacities, may lead to erroneous conclusions, as some production capacities (several to several dozen percent) in both Poland and Germany remain unused [UFOP, Biodiesel 2017/2018], i.e. actual production is not closely related to the installed production potential.



From the first quarter of 2019, forecast values after taking into account purified seasonality indices from Table 4:

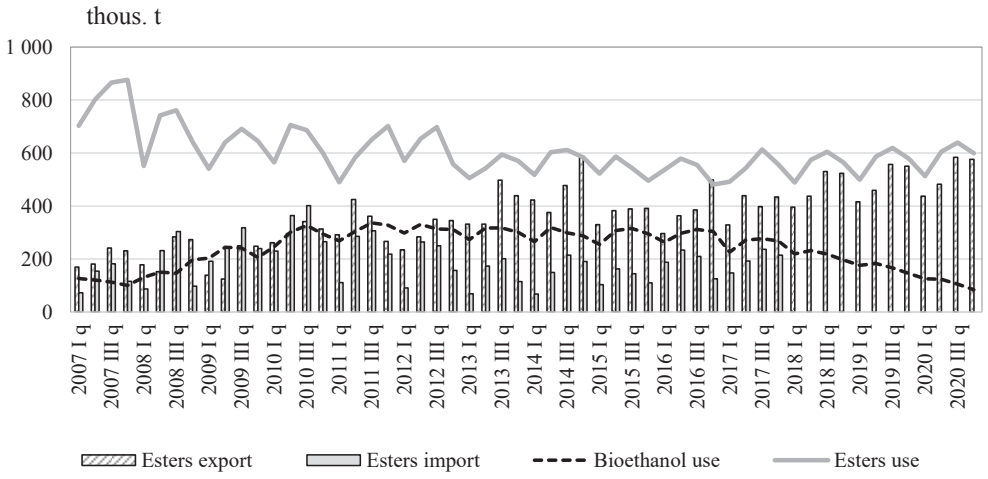
– for bioethanol production: according to linear trend ($y = 0.5200 \times t + 24.4897$; $R^2 = 0.6268$);
– for the bioethanol sale: according to polynomial trend ($y = 0.0394 \times t^2 - 1.4022 \times t + 26.338$; $R^2 = 0.6511$);
– for ester production: according to linear trend ($y = 4.4388 \times t + 21.962$; $R^2 = 0.8978$);
– for ester sale: according to linear trend ($y = 4.0041 \times t + 40.167$; $R^2 = 0.6453$).

Figure 1. Production and sale of liquid biofuels (bioethanol and esters) in Poland in 2006-2018 and forecasts for 2019-2020

Source: own calculation and elaboration based on data mentioned in the section "Research material…"

The actual sale of bioethanol in Poland is much higher in the first (by over 8%) and second (by almost 8%) quarter and slightly higher in the third quarter (by 2%) than would result from the trend function estimated for this series. In this situation, in order to obtain a reliable forecast of bioethanol sales in Poland in the last quarter, the values resulting from the trend should be clearly adjusted down (by 18%), which is indicated by the value of the purified seasonality index. Partially, the quarterly sales of esters in Poland should be treated in a similar way, i.e. the projected values resulting from the trend for the second and third quarters should be increased by less than 13%, as shown in Table 4, and the values for the first and last quarters – reduced by – respectively – 14% and 11.4%. Quarterly (actual) volumes of production and sales of liquid biofuels in Poland, in the years 2006-2018, along with forecasts for the next two years are shown in Figure 1. According to forecasts in 2020, in Poland, bioethanol production is to amount to 220 thous. tonnes and sales of 315 thous. tonnes, while ester production should exceed 1,125 thous. tonnes, and sales fluctuate around 1.1 million tonnes.

A similar situation occurs for the use of bioethanol and esters in Germany, i.e. forecast values resulting from the estimated trend function for middle quarters should be



From the first quarter of 2018, forecast values after taking into account purified seasonality indices from Table 4:

- for bioethanol use: according to the polynomial trend ($y = -0.2995 \times t^2 + 16.894 \times t + 79.054$; $R^2 = 0.8365$);
- for ester use: according to the polynomial trend ($y = 0.1576 \times t^2 - 12.097 \times t + 779.4$; $R^2 = 0.5074$);
- for ester exports: according to the linear trend ($y = 6.0374 \times t + 189.9$; $R^2 = 0.5653$).
- for ester import: no forecast values due to a lack of a well-fitted trend function.

Figure 2. Use of bioethanol and use, export and import of esters in Germany in 2007-2017 and forecasts for 2018-2020

Source: own calculation and elaboration based on data mentioned in the section "Research material…"

increased by a few percent (see Table 4), and a downward adjustment is needed for the first quarter. Also, for ester exports from Germany, estimated values for the third and fourth quarters need to be adjusted upwards. Figure 2 presents bioethanol use as well as ester use, export and import in Germany in the quarters of 2007-2017 and forecasts for the next three years. Based on estimated trend functions and seasonality indicators, it is forecasted for 2020 in Germany that bioethanol consumption will be close to 440 thous. tonnes, ester consumption will exceed 2.35 million tonnes, and ester exports will exceed 2 million tonnes. Although, in recent years, the use of liquid biofuels in Germany on an annual basis is relatively stable (esters) or even decreasing (bioethanol), this should not be treated as a symptom of sector stagnation or sector shrinking. It is because, since 2015, the use of biofuels has no longer been measured according to calorific value (i.e. the share of the amount of biofuels used in relation to total fuels used in transport), but based on the objectives of reducing greenhouse gas emissions (in comparison to fossil fuels). Therefore, to achieve the goals of biofuel policy it is possible to use fewer biocomponents, but of higher quality [FNR 2019].

SUMMARY AND CONCLUSIONS

The conducted research leads to the conclusions that in the liquid biofuels sector in Poland and Germany there are elements of seasonality, especially in the sale / use of biofuels, which, in turn, results from the changing demand for traditional fuels in which liquid biocomponents can be an admixture or an independent fuel (e.g. pure ester, i.e. B100 fuel used only during periods with positive air temperatures). The differences in sales or use, production or foreign trade of liquid biofuels between quarters are significant and even reach several dozen percent (up to over 100%), although, in nominal terms, these differences are usually a few or at most a dozen or so percentage points. In relation to the total use of liquid biofuels, higher seasonal fluctuations (on a quarterly basis, in percent) are noticed in Poland than in Germany, with a division by segment: ester sales in Poland are much more diverse, while bioethanol use in Germany is slightly more diverse than in Poland. Significant seasonal fluctuations between quarters took place in the case of German international trade in esters. Using the data described and based on the proposed research methodology, the author forecasts that in 2020 bioethanol production in Poland is to amount to 220 thous. tonnes and sales of 315 thous. tonnes, while ester production should exceed 1.1 million tonnes, and sales fluctuate around 1.1 million tonnes. In Germany, in turn, the estimated values are as follows: bioethanol use will be almost 440 thous. tonnes, ester use will exceed 2.35 million tonnes, and ester export will exceed 2 million tonnes.

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ELEMENTY SEZONOWOŚCI W PRODUKCJI I ZUŻYCIU BIOPALIW CIEKŁYCH W POLSCE I NIEMCZECH

Słowa kluczowe: biopaliwa ciekłe, Polska, Niemcy, sezonowość

ABSTRAKT

Celem pracy jest identyfikacja elementów sezonowości w podaży i popycie w sektorze biopaliw ciekłych w Polsce i Niemczech. Dodatkowym zamierzeniem jest przedstawienie prognoz dla wybranych agregatów do 2020 roku. Dla ich realizacji sformułowano dwa pytania badawcze: (1) czy produkcja biopaliw w Polsce jest wyższa w okresie wiosennym lub letnim (ze względu na sezonowość produkcji surowców rolnych) niż np. zimą? (2) czy zużycie biopaliw charakteryzuje się sezonowością w obu krajach? Do badań wykorzystano dane kwartalne dla następujących agregatów z sektora biopaliw: dla Polski: produkcja oraz sprzedaż biopaliw w kwartałach lat 2006-2018; dla Niemiec: zużycie biopaliw w kwartałach lat 2007-2017, import i eksport bioetanolu w kwartałach 2007-2015, import i eksport estrów w kwartałach 2007-2017. Skoncentrowano się na wyodrębnieniu wahań sezonowych w celu identyfikacji oczyszczonych wskaźników sezonowości, aby następnie możliwe było przedstawienie prognoz dla sektora biopaliw. Stwierdzono, że w sektorze biopaliw ciekłych w Polsce i Niemczech występują elementy sezonowości, szczególnie w zakresie sprzedaży/zużycia biopaliw, co z kolei jest efektem zmieniającego się popytu na tradycyjne paliwa, w których biokomponenty ciekłe stanowią domieszkę lub (rzadziej) są stosowane jako samodzielne paliwo. Różnice w wartościach zmiennych w Polsce i Niemczech w poszczególnych kwartałach w analizowanych okresach były znaczące – przeważnie sięgały kilkadziesiąt procent (do nawet ponad 100%), mimo że w ujęciu nominalnym te różnice wynoszą przeważnie kilka lub kilkanaście punktów procentowych. Zużycie biopaliw w obu krajach było wyższe w drugim i trzecim kwartale, czyli w okresie wiosenno-letnim, niż w pozostałych.

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