TRADE DEPENDENCE AND FOOD SECURITY: A COMPARATIVE ANALYSIS OF THE WHEAT SECTOR IN EUROPE

Biljana Grujić Vučkovski[1]*, Aleksandar Grubor*[2]*, Nikola Ćurčić* [3]
**Corresponding author E-mail: grujic@institut-tamis.rs*

A R T I C L E I N F O

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A B S T R A C T

This study explores regional disparities in three key indicators of agri-food security related to wheat across Europe: the Import Dependency Ratio (IDR), the Self-Sufficiency Ratio (SSR), and wheat consumption per capita (Cpc). The analysis was conducted at two levels: (1) Europe as a whole, based on a sample of 10 annual observations, and (2) 35 individual European countries, comprising a panel of 350 observations for the period 2014–2023. To compute the aforementioned indicators, the study draws on four primary variables related to wheat: production (tonnes), import volume (tonnes), export volume (tonnes), and population size (in thousands). Descriptive statistical methods were first applied, including the coefficient of variation (Cv) following logarithmic transformation, Pearson correlation coefficients, scatter plots and heatmap. The main objective of this research is to examine the interrelationships between wheat security indicators and key demographic and economic factors across Europe.

Introduction

Agricultural production plays a vital role in ensuring global food security, making it a strategic priority for all nations (Grujić Vučkovski et al., 2022). In addition, agriculture provides essential raw materials to the food processing sector, enabling timely delivery of products to consumers (Ugrinov et al., 2024). Wheat (*Triticum aestivum*), as one of the three most important cereal crops worldwide, is widely cultivated due to its adaptability to various terrains and altitudes (Gutierrez-Moya et al., 2021; Tadesse et

1 Biljana Grujić Vučkovski, Senior Research Associate, „Tamiš“ Research and Development Institute, 26000 Pančevo, Serbia, E-mail: grujic@institut-tamis.rs, ORCID ID (https://orcid.org/0000-0003-2588-4888)

2 Aleksandar Grubor, Full professor, Faculty of Economics in Subotica, University of Novi Sad, 21000 Novi Sad, Serbia, E-mail: aleksandar.grubor@ef.uns.ac.rs, ORCID (https://orcid.org/0000-0001-9798-0401)

3 Nikola V. Ćurčić, Senior Research Associate, Institute for Multidisciplinary Research, University of Belgrade, 11000 Belgrade, Serbia, E-mail: curcic@imsi.bg.ac.rs, ORCID (https://orcid.org/0000-0003-3375-2690)

al., 2019). From a production standpoint, wheat is also favorable because it can be easily stored and processed into grain (Teodor et al., 2018).

Wheat production is a demanding process requiring comprehensive knowledge of agronomic practices. Yield, quality, and profitability largely depend on the extent to which optimal production conditions are met (Grujić, Kljajić, 2012). As the global population continues to grow, there is a rising need to expand both the cultivated area and overall production of wheat (Ziegler et al., 2023; Silveira et al., 2017). In the European Union (EU), wheat production is supported through funding mechanisms provided by the Common Agricultural Policy (CAP). Additionally, countries that have obtained EU candidate status may access financial assistance via IPARD programs, while simultaneously strengthening their legislative frameworks to align with EU agricultural policy (Grujić, Vuković, 2018; Grujić, Joksimović, 2019; Popović, Grujić, 2015).

Global wheat trade operates within a complex network of interdependent trade flows, where disruptions in one country can significantly impact others. For example, export bans in major exporting countries such as Russia have ripple effects on wheat-importing nations, particularly those in Africa, where approximately 72% of wheat is imported—primarily from Russia (Popescu & Andrei, 2011; Popescu et al., 2017; Burkholz, Schweitzer, 2019; Alborghetti, 2023; Pantović et al., 2024). Zhang et al. (2023) emphasize that countries with weak agricultural policies are more vulnerable to import shocks, whereas the EU, with its internal market structure, is better equipped to absorb such risks.

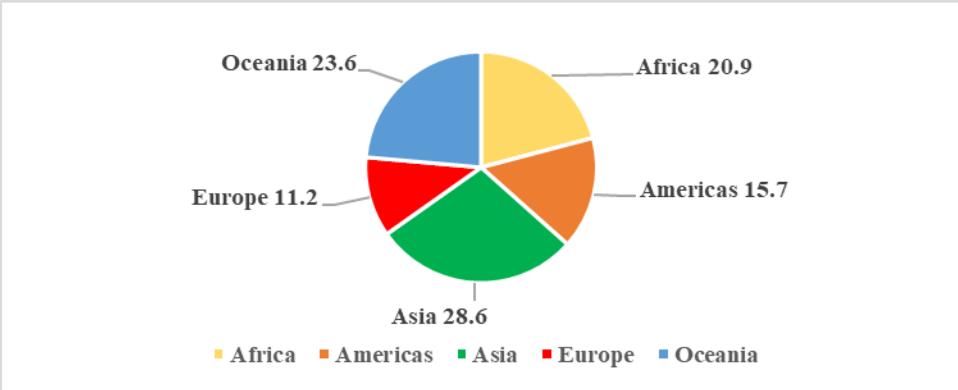
Wheat prices play a critical role in the global economy and trade. External shocks such as extreme weather events, geopolitical conflicts, and pandemics directly influence key wheat market indicators (Schmidhuber et al., 2022). Moreover, political decisions significantly affect supply and demand dynamics, and therefore price formation. The ongoing war in Ukraine (since 2022) has led to substantial wheat yield losses and a decline in the country's export potential (Zhang et al., 2024). The producer price of wheat has a direct effect on the final cost of consumer goods in which wheat serves as a primary raw material (Esmaeili, Shokoohi, 2011, Šobić et al., 2023).

Annual global wheat production typically ranges between 750 and 800 million tonnes. The largest producers include China, India, Russia, the United States, and France, while Egypt, Indonesia, and Turkey are among the top wheat-importing countries (Erenstein et al., 2022).

Over the past decade (2014–2023), the average global harvested area under wheat was approximately 218,138,655 hectares, of which Europe accounted for 61,629,556 hectares, representing a 28.3% share (FAOSTAT, 2025). In 2023 alone, Europe contributed 27.9% of the global wheat-harvested area and 33.7% of total wheat production, confirming that nearly one-third of global wheat output originates from Europe (FAOSTAT, 2025).

From 2014 to 2022, the average global share of agricultural land in total land area was 36.7%. When disaggregated by continent, Asia accounted for the largest proportion (28.6%), followed by Africa and Oceania, while Europe recorded the lowest share, with only 11.2% (FAOSTAT, 2025) *(Figure 1.)*.

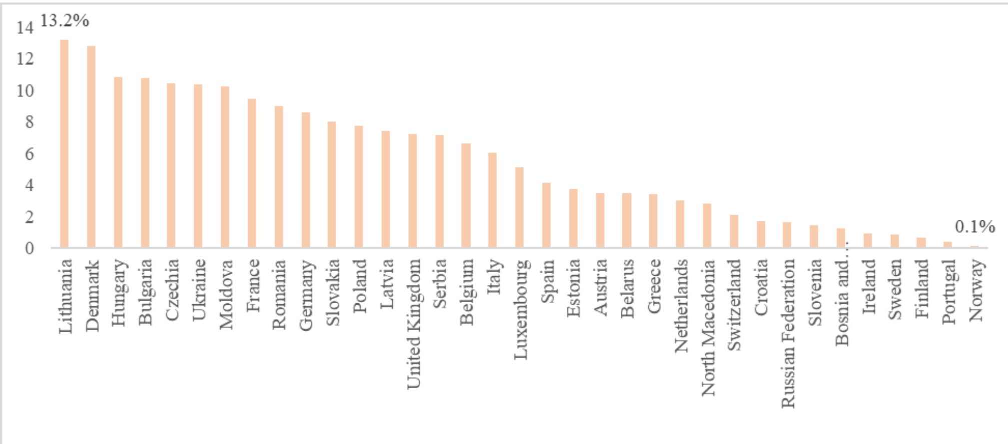
Figure. 1. Average share of agricultural land in land area by continent, 2014-2022 (in %)



Source: Author's elaboration based on FAOSTAT data (2025).

Figure 2. presents the average share of wheat-harvested area relative to the total land area of European countries over the period 2014–2023. The largest wheat-growing area was recorded in the Russian Federation, with an average of 27,360,632.2 hectares per year. However, this accounted for only 1.6% of the country's total land area. Ukraine ranked second, with an average annual wheat area of 6,248,200 hectares, representing 10.4% of its total land area. In terms of land use intensity for wheat cultivation, France ranked third, with an average of 5,187,471.9 hectares per year, corresponding to 9.4% of the country's total land area.

Figure. 2. Average annual share of wheat-harvested area relative to national land area, 2014-2023 (in %)



Source: Author's elaboration based on FAOSTAT data (2025).

The analysis of Average Annual Rates of Change (AARC) over the observation period reveals substantial differences among countries in terms of trends in wheat production, exports, and imports, as well as demographic dynamics (*Table 1.*).

Table 1. Comparative Overview of AARC Values for Key Indicators in Wheat Trade Across European Countries, 2014–2023 (in %)

Country	AARC of production	AARC of export quantity	AARC of import quantity	AARC of population
Austria	-0.4	-2.9	4.4	0.7
Belarus	-2.2	16.8	18.5	-0.4
Belgium	-1.2	-9.7	-1.5	0.5
Bosnia and Herzegovina	3.3	-1.9	-5.8	-1.2
Bulgaria	2.8	9.4	12.3	-0.7
Croatia	2.8	15.5	6.1	-0.9
Czechia	-0.4	1.3	12.8	0.3
Denmark	-4.0	-6.2	-2.5	0.6
Estonia	1.3	8.9	1.7	0.4
Finland	-4.1	-11.8	6.9	0.3
France	-0.9	-4.5	-11.4	0.3
Germany	-2.8	-5.2	2.1	0.4
Greece	-2.0	2.4	3.3	-0.7
Hungary	1.4	2.6	5.6	-0.2
Ireland	-4.3	7.5	6.2	1.2
Italy	-0.4	-7.0	1.6	-0.2
Latvia	4.3	6.2	13.0	-0.6
Lithuania	3.6	4.4	8.8	-0.3
Luxembourg	-0.8	-0.1	2.4	2.0
Netherlands	-1.9	-12.2	-0.9	0.7
North Macedonia	-3.2	20.8	-1.5	-1.0
Norway	-8.7	-35.3	-5.9	0.8
Poland	1.2	9.0	4.9	0.1
Portugal	-11.0	15.2	2.2	0.0
Moldova	3.9	10.8	18.4	-1.0
Romania	2.7	5.7	2.3	-0.5
Russian Federation	4.9	4.0	-22.0	0.0
Serbia	4.2	6.2	-5.2	-0.7
Slovakia	2.1	10.5	4.1	0.2
Slovenia	-1.9	17.8	16.0	0.3
Spain	-5.1	-14.6	7.9	0.3
Sweden	-1.2	-10.1	-6.8	0.9
Switzerland	-2.3	-5.8	-0.1	0.9
Ukraine	-1.2	4.9	39.0	-2.2
United Kingdom	-1.9	0.1	-0.7	0.6

Source: Author's calculation based on FAOSTAT data (2025).

At the level of wheat production, positive growth rates have been recorded in countries such as Russia, Latvia, Serbia, Moldova, and Lithuania, indicating a sustained expansion of the domestic agricultural sector. Conversely, Norway, Portugal, Finland, and Ireland have experienced a decline in production capacity, which may result from unfavorable agro-climatic conditions, demographic trends, or structural changes in the sector.

Regarding exports, exceptionally high AARC have been observed in North Macedonia, Belarus, Croatia, Slovenia, and Portugal, indicating increased competitiveness and breakthroughs into foreign markets. On the other hand, significant export declines have been noted in Norway, Spain, and the Netherlands, which may suggest changes in trade policies or decreases in domestic production.

In terms of wheat imports, high growth rates are particularly pronounced in Ukraine, Belarus, Moldova, Slovenia, and Latvia, which may reflect increased consumption, weaknesses in domestic production, or a shift toward a more liberal market model. The most pronounced decline in wheat imports was observed in Russia, further confirming its position as a dominant net exporter.

Demographic trends show a slight population growth in most European countries, while Ukraine, Bosnia and Herzegovina, Moldova, and North Macedonia experience population decline. These demographic changes may have long-term implications for domestic consumption, available labor force, and agricultural productivity.

Overall, some economies increasingly rely on trade and export growth, while others depend more on imports or exhibit stagnation in production. These differences are crucial for understanding the supply and demand structure in the European grain market, especially in the context of increasing uncertainty caused by climate change, geopolitical instability, and global price fluctuations.

Analyzing the share of European countries in the import and export of wheat within the total European wheat trade is an important step toward understanding regional disparities and potential supply chain risks.

When examining the average share of individual European countries in total European wheat imports, the largest shares are observed in Italy (20%) and Spain (15.2%). These countries import wheat mainly for the food industry, specifically milling and pasta production (EUROSTAT, 2025; World Grain, 2025). The Netherlands also imports significant quantities (12.7%), with these three countries together accounting for nearly 50% of total European wheat imports. This indicates a high concentration of import demand in a limited number of countries. Conversely, many countries have negligible average shares in total imports — below 1% (Estonia, Ukraine, Moldova, Serbia). Such distribution highlights significant differences in import dependency among European countries, which may stem from varying levels of domestic production, consumption, and agricultural policy (FAOSTAT, 2025).

The largest exporters are the Russian Federation (28.3%), France (17.4%), and Ukraine (15.3%), which together account for over 60% of total European wheat exports. This concentration indicates an exceptionally dominant position of a few countries in export flows, with these states representing key players in the international grain market (FAOSTAT, 2025).

These findings point to pronounced heterogeneity in the role of wheat imports and exports in the food systems of European countries and emphasize the need for a more targeted approach in planning strategies for self-sufficiency and trade resilience.

In the context of contemporary challenges related to food security and shifts in global trade flows, the analysis of basic indicators of self-sufficiency, import dependency, and food consumption becomes critically important for formulating sustainable agricultural policies. Wheat, as one of the strategic cereals and staple foods in most European countries, represents a key resource whose availability directly impacts domestic market stability and population supply security.

Therefore, the aim of this research is to provide insight into the degree of Europe's and individual European countries' dependence on external sources and their capacities to meet domestic demand through their own production, based on statistical analysis of these wheat-related indicators.

Numerous scientific publications analyze various indicators in different parts of the world and for specific products. Thus, the presented literature review includes results from peer-reviewed scientific papers available in reputable databases, enhancing the reliability of the analysis and supporting sound conclusions.

Based on the literature review and observed average values of harvested area, production, exports, and imports of wheat in Europe, three research questions are posed:

- Is Europe and its countries dependent on wheat imports?
- Do Europe and its countries produce sufficient wheat quantities for domestic consumption?
- What are the trends in per capita wheat consumption in Europe and the observed countries?

Statistical analysis of empirical data using appropriate descriptive methods, equations, and graphical presentations will provide answers to these questions, which are thoroughly analyzed and discussed in the *"Results and Discussion"* chapter.

Materials and methods

The statistical analysis of the study consists of two parts. In the first part, descriptive statistical methods were applied, while the second part of the research utilized three statistical indicators. For the purposes of these analyses, two samples were formed. A sample of 10 observations (10 years, 2014–2023) is present in the results when considering Europe as a whole. A sample of 350 observations, encompassing 35 countries over a 10-year period, is used when analyzing individual European countries. The countries included in the analysis are: Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, North Macedonia, Norway, Poland, Portugal, Moldova, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, and the United Kingdom.

The first part of the statistical analysis examined the following descriptive statistics parameters: minimum (Min), maximum (Max), mean, coefficient of variation (Cv), Pearson correlation coefficient, p-values of variables, and coefficient of determination (R^2). These descriptive statistics indicators are presented according to the formed sample groups and observed variables.

Table 2. presents the observed variables along with their abbreviations, units of measurement, and data sources.

Table 2. Variables included in the statistical analysis

Variable	Abbreviation	Unit of measure	Source
Production	Pr	t	FAOSTAT Database
Export	E	t	FAOSTAT Database
Import	I	t	FAOSTAT Database
Population	Po	Thousand habitants	FAOSTAT Database

Source: author's view.

Since the data do not follow a normal distribution due to varying values of the variables across years and European countries, it was necessary to perform a log-transformation of the variables prior to calculating the coefficient of variation (Cv). Accordingly, the equation for calculating Cv after log-transformation (Equation 1) is expressed as follows (Canchola, 2017):

$$Cv_{log} Pr, E, I, Po = \frac{std\,(log\ Pr, E, I, Po)}{mean\ (log\ Pr, E, I, Po)}\ x\ 100 \quad (1)$$

The aim of this descriptive analysis was to determine the basic characteristics of the analyzed variables and to identify possible correlation relationships among them. These variables were selected in order to calculate the statistical indicators that are the focus of the analysis in the second part of the study.

Following the tabular presentations, the descriptive statistics also included scatter plots with accompanying linear regression lines as a graphical representation of the obtained results. These charts display the strongest correlation relationships and the highest recorded values of the coefficient of determination observed at different levels of the data.

In the second part of the statistical analysis of empirical data, three statistical indicators were analyzed: Import Dependency Ratio (IDR), Self-Sufficiency Ratio (SSR), and Consumption per Capita (Cpc). These indicators provide answers to the research questions posed in the introductory section of the study.

The Import Dependency Ratio (IDR) indicator is expressed as a percentage and is calculated according to the following formula (Equation 2) (FAO, 2025; Somaweera et al., 2024):

$$IDR = \frac{I}{Pr + I - E} * 100 \quad (2)$$

This indicator shows whether a country/region can rely on its own production or is to some extent dependent on imports (expressed as a percentage). A negative value indicates that the country is a net exporter (Abdelmajid et al., 2021; FAO, 2025). A high value of this indicator may signal that the country lacks a tradition in producing a particular product and is therefore forced to import it (Kopp and Wallace, 1990).

The Self-Sufficiency Ratio (SSR) indicates whether domestic production can meet domestic consumption needs, expressed as a percentage, and is calculated according to the following formula (Equation 3) (FAO, 2025; Kim et al., 2025):

$$SSR=\frac{Pr}{Pr+I-E}*100 \qquad (3)$$

According to Brankov and Matkovski (2022), if countries have an SSR < 100, it means that their domestic production cannot satisfy domestic consumption needs. If SSR = 100, it means that the domestic food supply can fully meet domestic consumption. Countries with SSR > 100 produce more food than they consume.

The Consumption per Capita (Cpc) indicator shows the trend in wheat consumption per capita (Equation 4). It is expressed in tons per capita (*t/per capita*) and is calculated according to the following equation (Grujić Vučkovski, Nedeljković, 2023):

$$Cpc=\frac{Total\ Quantity\ Consumed}{Estimated\ population}=\frac{Pr+I+E}{Estimated\ population} \qquad (4)$$

This indicator is also important to us due to the fact that the inclusion of social influences, not just economic ones, is becoming increasingly important in every society (Milenković et al., 2025).

The average values of the mentioned indicators are presented in tabular form for Europe as a whole. A graphical data visualization using colors to represent different values, known as a heat map (Gu, 2022), was employed to compare these indicators at the national level of European countries. The colors in the heat map facilitated easier identification of relationships and variations among the observed indicators. The results of these indicators are discussed in detail in the Results and Discussion chapter.

According to the defined methodology and observed variables, the following general hypothesis (H_0) was formulated: *there is a significant difference in the average values of the IDR, SSR, and Cpc indicators among European countries, indicating pronounced heterogeneity in the degree of import dependency, self-sufficiency, and per capita wheat consumption.*

Statistical data processing was performed using the Microsoft Excel add-in (XLSTAT, version 2019.2.2).

Results and Discussion

At the beginning, the results of the descriptive statistics for the observed variables are presented based on two formed samples, the European region and individual European countries (*Table 3.*).

Table 3. Descriptive statistics of the observed variables for the period 2014–2023 in Europe and individual European countries

Variables	Europe				European countries			
	Min	Max	Mean	Cv, %	Min	Max	Mean	Cv, %
Pr (t)	242,187,345.9	283,253,013.9	261,622,493.0	4.8	34670.000	104233944.0	7467583.9	11.6
E (t)	91,221,762.9	117,433,778.3	104,636,255.0	8.5	1.000	43965626.3	2989500.1	23.4
I (t)	34,776,926.1	42,356,629.9	37,699,085.1	7.6	281.040	9636177.5	1069415.4	18.4
Po (000 habitants)	742,640.0	749,523.5	746,907.8	0.3	206241.0	146533067.0	21215.2	8.1

Source: Author's calculation based on FAOSTAT data (2025).

Regarding the results presented in *Table 3.* for the European region, the following conclusions can be drawn:

- Cv_Pr = 4.8% indicates relatively stable wheat production during the observed period;
- Cv_E = 8.5% shows moderate variability in wheat exports over the observed period;
- Cv_I = 7.6% points to a moderate level of variability in imports;
- Cv_Po = 0.3% suggests that the population size was stable during the given period.

The descriptive statistics indicators, primarily Cv, analyzed by variables and individual European countries lead to the following conclusions:

- Cv_Pr = 11.6% indicates moderate variability and relatively stable differences among countries, considering the presence of large producers;
- Cv_E = 23.4% points to more pronounced differences among countries regarding export activity, which is expected due to variations in agricultural production, wheat output, and export capacities;
- Cv_I = 18.4% indicates somewhat lower, yet still notable variability in import dynamics among countries compared to export changes;
- Cv_Po = 8.1% suggests relatively low variability, although significant differences exist in population size between the smallest and largest countries in the sample.

The analysis of descriptive statistics at the European level and for individual countries highlights significant differences in absolute values as well as in the degree of variability of the observed economic and demographic indicators. Data variability is greater when examining European countries individually, as this reflects the insurmountable differences in agricultural production, export and import capacities, which may result from economic, geographic, and political factors.

The next table (*Table 4.*) presents the results of the correlation analysis (Pearson coefficient). This analysis indicates significant differences in the interrelationships between the observed variables when comparing aggregated data for Europe as a whole with data for individual European countries.

Table 4. Pearson correlation matrix for key wheat sector and demographic variables at aggregate (European) and national levels in Europe, 2014–2023

Variables	Europe				European countries			
	Pr (t)	E (t)	I (t)	Po (000 habitants)	Pr (t)	E (t)	I (t)	Po (000 habitants)
Pr (t)	**1**	-0.305	-0.085	0.171	**1**	0.929*	0.009	0.893*
E (t)	-0.305	**1**	0.471	0.644*	0.929*	**1**	-0.095	0.770*
I (t)	-0.085	0.471	**1**	-0.083	0.009	-0.095	**1**	0.351*
Po (000 habitants)	0.171	0.644*	-0.083	**1**	0.893*	0.770*	0.351*	**1**

Note: Values with * are different from 0 with a significance level α =0.05

Source: Author's calculation based on FAOSTAT data (2025).

At the aggregate level, the correlation between exports and population (r = 0.644) shows the strongest positive association among the variables. The correlation between exports and imports (r = 0.471) is also positive, indicating moderate intensity relationships at this level. However, a negative correlation was observed between wheat production and exports (r = –0.305), as well as between production and imports (r = –0.085), which may point to certain structural mismatches between production and foreign trade.

On the other hand, at the national level, significantly stronger and positive correlations emerge between production and exports (r = 0.929), as well as between production and population (r = 0.893), confirming the expected conclusion that countries with larger populations also have higher production and, consequently, greater export potential. Additionally, the strong correlation between exports and population (r = 0.770) further emphasizes the role of demographic factors in shaping trade flows. The observed correlation between population and imports (r = 0.351) indicates that larger countries also rely on import channels to meet domestic population needs due to insufficient production capacities.

By comparing data at the European and individual country levels, we noticed that aggregated data can mask the true relationships between variables, whereas analysis at the level of individual countries presents a different and more relevant picture.

The following table shows the statistical significance of the relationships between the analyzed variables (*Table 5.*).

Table 5. p-values for Pearson correlation coefficients of key variables at aggregate and national levels in Europe, 2014–2023

Variables	Europe				European countries			
	Pr (t)	E (t)	I (t)	Po (000 habitants)	Pr (t)	E (t)	I (t)	Po (000 habitants)
Pr (t)	**0**	0.392	0.815	0.637	**0**	< 0.0001	0.866	< 0.0001
E (t)	0.392	**0**	0.169	0.045	< 0.0001	**0**	0.075	< 0.0001
I (t)	0.815	0.169	**0**	0.819	0.866	0.075	**0**	< 0.0001

Variables	Europe				European countries			
	Pr (t)	E (t)	I (t)	Po (000 habitants)	Pr (t)	E (t)	I (t)	Po (000 habitants)
Po (000 habitants)	0.637	0.045	0.819	**0**	< 0.0001	< 0.0001	< 0.0001	**0**

Source: Author's calculation based on FAOSTAT data (2025).

The results in Table 5 indicate whether the observed correlation relationships, derived from the Pearson Correlation Matrix, are statistically significant. Conclusions are based on the p-value criterion ($p < 0.05$). At the aggregate level for Europe as a whole, a statistically significant association exists only between exports and population ($p = 0.045$), while correlations between other variables in the matrix are not statistically significant.

At the national level of European countries, there is a high statistical significance of correlations, namely: production and export ($p < 0.0001$), production and population ($p < 0.0001$), export and population ($p < 0.0001$), and import and population ($p = 0.0001$).

This analysis shows that the relationships between agricultural production, trade flows, as well as economic and demographic characteristics, are considerably more pronounced at the level of individual countries than at the aggregate European level.

The following table presents the variance relationships between variables that can explain the changes among variables (*Table 6.*).

Table 6. Coefficients of determination for interdependencies among observed variables in Europe and European countries, 2014–2023

Variables	Europe				European countries			
	Pr (t)	E (t)	I (t)	Po (000 habitants)	Pr (t)	E (t)	I (t)	Po (000 habitants)
Pr (t)	**1**	0.093	0.007	0.029	**1**	**0.863**	0.000	**0.797**
E (t)	0.093	**1**	0.222	**0.414**	**0.863**	**1**	0.009	**0.592**
I (t)	0.007	0.222	**1**	0.007	0.000	0.009	**1**	0.123
Po (000 habitants)	0.029	**0.414**	0.007	**1**	**0.797**	**0.592**	0.123	**1**

Source: Author's calculation based on FAOSTAT data (2025).

When observing Europe as a whole, we notice that the R^2 values are generally low, with the strongest association found between exports and population ($R^2 = 0.414$). This means that about 41% of the variance in exports can be explained by variations in population size. This can also be interpreted as larger countries generally having higher export volumes, while other relationships are weaker.

At the level of individual European countries, the interpretation of the tabular results is quite different. Specifically, production and export have a very high R^2 ($R^2 = 0.863$), meaning that as much as 86.3% of the variance in exports can be explained by production. A very high R^2 is also observed between production and population ($R^2 =$

0.797), as well as exports and population ($R^2 = 0.592$), confirming that demographic changes and characteristics can significantly influence the production, economic, and trade aspects of society. There is also a case where $R^2 = 0.000$ occurs in the relation between production and import of wheat, indicating that some European countries produce a lot and do not need to import wheat, and vice versa.

After this analysis, we conclude that data at the aggregate European level do not indicate significant relationships between variables, whereas these relationships are more pronounced at the level of individual European countries.

For additional insight into the relationship between demographic characteristics and trade activity in wheat during the period 2014–2023, scatter plots with accompanying linear regression lines are presented in *Graphs 3a.* and *3b.* Considering the strongest correlations and highest coefficients of determination, the Figure for Europe as a whole shows the relationship between population size and wheat export volume, while at the level of individual European countries, it illustrates the relationship between population size and wheat production.

Figure. 3a. Scatter plot with linear regression line at the European level, 2014-2023

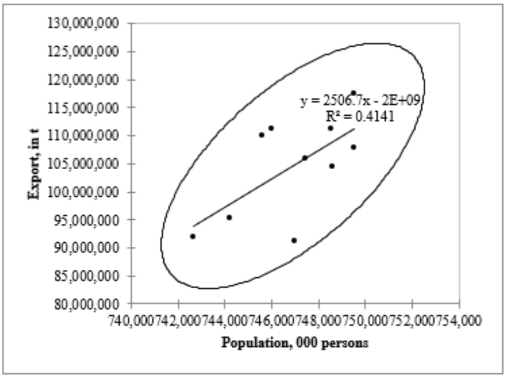
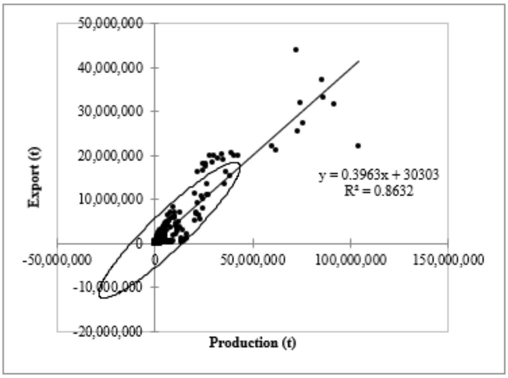


Figure. 3b. Scatter plot with linear regression line at the level of European countries, 2014-2023



Source: author’s calculation and view based on FAOSTAT data (2025)

The Figures above show a positive trend at the European level, where an increase in population is associated with rising exports. Similarly, in the analyzed European countries, increases in production correspond with growth in exports. These relationships are also confirmed by statistically significant correlations of $r = 0.644$ and $r = 0.929$, respectively ($p < 0.05$).

Since the analyzed variables demonstrated a satisfactory degree of variability, the second part of the statistical analysis of empirical data proceeds to the interpretation of three agroeconomic indicators obtained according to the previously described formulas: IDR, SSR, and Cpc. These indicators are analyzed on European and European countries level (*Table 7.* and *Figure. 4.*).

Table 7. Average values of the observed indicators (IDR, SSR, Cpc) at the European level, 2014-2023

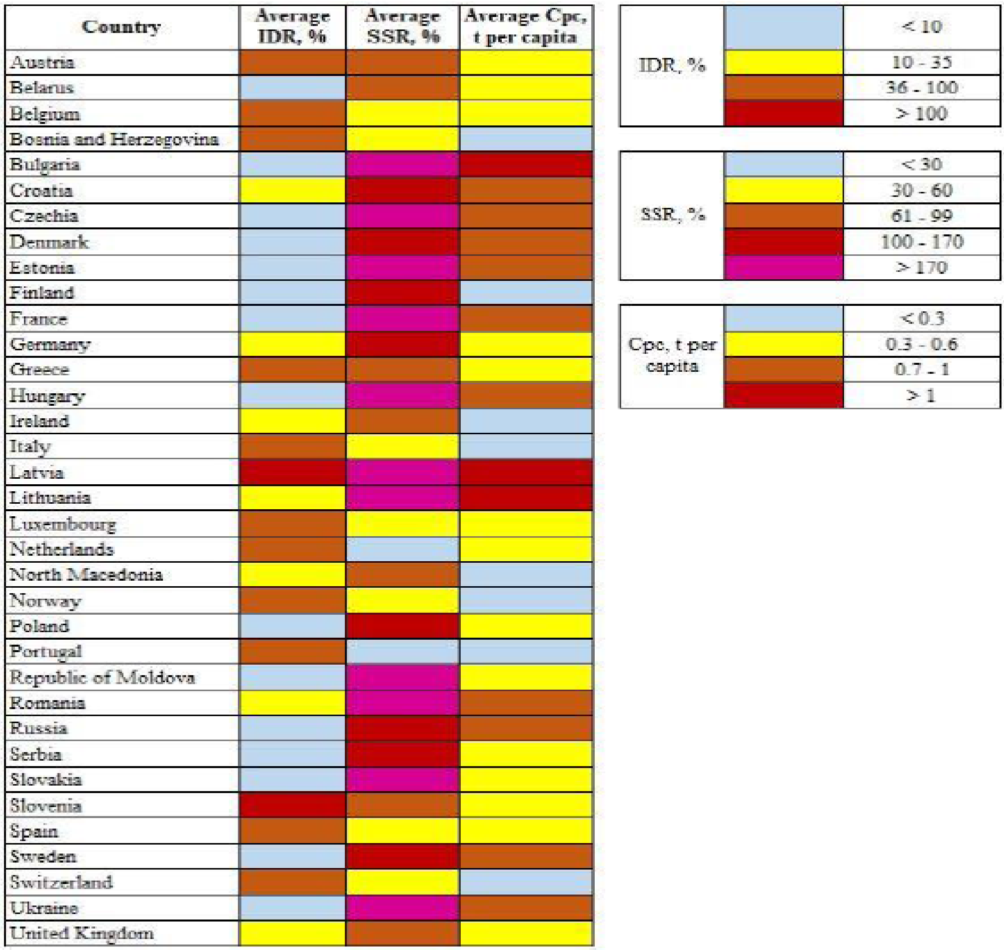
Europe	IDR, %	SSR, %	Cpc, t per capita
Average	19.5	134.8	0.5

Source: Author's calculation based on FAOSTAT data (2025).

Regarding Europe, based on the indicators in Table 7, we can conclude the following: Europe imports 1/5 of its wheat needs because sufficient quantities are produced for domestic consumption; approximately 35% of total production can be realized through exports, and the average per capita consumption is around 0.5 tons.

Below is a visual comparison of the average values of the observed statistical indicators using a heat map *(Figure. 4.)* among European countries during the observed period.

Figure. 4. Heat Map of average indicator values (IDR, SSR, and Cpc) by European countries, 2014-2023



Source: author's calculation and view based on FAOSTAT data (2025)

The presented heat map clearly highlights pronounced differences among European countries in the values of the observed indicators. Regarding IDR, certain countries such as Slovenia and Latvia exhibit high values, indicating limited availability of domestic resources and potential vulnerability in the supply chain, thus relying on wheat imports. In contrast, countries like Bulgaria, Serbia, and Poland are characterized by low import dependency (IDR < 1%), which may suggest greater self-sufficiency in securing raw materials.

With respect to SSR, particularly high values are observed in countries with developed agro-industrial sectors (Latvia, Bulgaria, Lithuania), while lower values indicate reliance on imported sources.

Finally, regarding Cpc, significant variations are noticed, reflecting differences in the intensity of wheat usage among countries, which may also reflect specific production and consumption patterns.

To gain a broader understanding of the results obtained for Europe, it is useful to consider the situation in other world regions, where key indicators such as IDR, SSR, and per capita wheat consumption often show much more extreme values.

Globally, countries such as Armenia, Azerbaijan, and Georgia show high IDR rates. The average value of this index in the period 2017–2019 ranged from 38% in Azerbaijan, 63% in Armenia, to 82% in Georgia. These countries import 99% of their domestic wheat needs from Russia and Kazakhstan (Svanidze and Gotz, 2020). Somaweera et al. (2024) analyzed the wheat import dependency in Sri Lanka. Since wheat is the second most demanded crop, Sri Lanka is dependent on wheat imports. Until 2021, Russia had the dominant share among countries exporting wheat to Sri Lanka, but from 2021 Sri Lanka shifted to Australia and India (26.07% and 32.21% respectively), while imports from Russia dropped to only 4.7%. The wheat import dependency rate in Africa is about 72%, with the highest levels in North Africa (Silva et al., 2023).

SSR for wheat varies significantly among countries and regions. In Africa, for example, Ethiopia and Zambia show high self-sufficiency rates (80% and 73%, respectively), whereas Egypt, despite significant irrigation investments, has an SSR of only 45% (Silva et al., 2023). A special case is South Korea, where the wheat SSR dropped from 43% in the 1960s to 5% today due to complete reliance on imports to meet domestic consumption (Kim et al., 2025).

The largest absolute consumers of wheat per capita are China, India, and the United States. Seven out of the ten largest global wheat-consuming countries are in Asia, and five out of ten per capita consumers are (Azerbaijan, Uzbekistan, Turkey, Georgia, and Tajikistan) (World Population Review, 2025). In Africa, consumption ranges from about 50 kg in the sub-Saharan region to over 180 kg per capita in North Africa, where wheat represents a dietary staple (Silva et al., 2023).

The analysis of IDR, SSR, and Cpc for wheat enables a comprehensive understanding of food security at the national and regional levels. In the context of global challenges such as climate change, the war in Ukraine, and supply chain disruptions, these parameters become crucial for shaping sustainable and resilient wheat production and trade policies. Although Europe is currently largely self-sufficient, it must carefully monitor and balance these indicators to maintain the stability of its own food system.

Conclusions

The results of the descriptive statistics aggregated for Europe do not show statistically significant relationships among the main variables, whereas the analysis at the level of individual European countries reveals robust and significant interdependencies.

Particularly noteworthy is population as a stable and statistically significant predictor, confirming its role in shaping national production, consumption, and trade.

The analysis of key indicators (IDR, SSR, Cpc) points to pronounced heterogeneity among European countries regarding resource availability and utilization. The obtained results reveal that countries with a high import dependency rate often simultaneously exhibit high per capita consumption, which may indicate systemic issues in supplying wheat to the population. Conversely, countries with higher levels of self-sufficiency and lower per capita consumption demonstrate potential for more sustainable production and consumption models, as certain quantities of wheat can be allocated for export. Thus, we accept the general hypothesis (H_0).

These findings emphasize the need for creating differentiated, targeted policies at national and regional levels that would encourage wheat production and trade while reducing the rate of external dependency. Future research should encompass a deeper analysis of the interdependencies of these indicators in relation to economic growth, considering additional factors such as innovation, infrastructure investment, institutional capacities for resource management, and other socioeconomic factors.

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Conflict of interests

The authors declare no conflict of interest.

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