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Comparative analysis of European Union countries based on selected aspects of food security

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Abstract: This study assesses 24 European Union countries in terms of food security in 2021. In this paper, we develop a composite food security index considering various weights of indicators. The data were obtained from the FAOSTAT and Eurostat databases. The weights of 10 input indicators were estimated using a principal component analysis-based factor analysis model. The results showed that the harmonised index of consumer prices – food had the greatest impact on the food security index, while the impact of median equivalised net income and moderate or severe food insecurity had the lowest impact. Ireland achieved the highest ranking according to the Food Security Index. Bulgaria experienced the most unfavourable situation among EU countries. Slovakia ranked 22nd out of 24 countries due to its lowest protein supply, including animal-derived proteins. As part of the analysis, our research compared the food security index with the official Global Food Security Index. The Spearman's rank correlation coefficient of 0.84 indicated a robust correlation between the two indexes. Consequently, this newly developed Food Security Index is appropriate for assessing the food security status of European Union countries. Furthermore, it broadens the assessment of food security by including countries that are not in the commonly used Global Food Security Index (GFSI).

Keywords: composite index; Europe; factor analysis; food security pillars; sustainability

Food insecurity, traditionally a major concern for developing countries, now elicits increased attention in developed countries. While numerous European nations rank highly in terms of food security, the continent encounters emergent challenges. The economic repercussions of the COVID-19 pandemic, combined with geopolitical instability stemming from the Russia-Ukraine conflict, pose substantive threats to ensuring consistent food security across European states. Food supply and demand in Europe have been significantly influenced by the Common Agricultural Policy (CAP), which is driven by the EU's commitment to support long-term food supply and meet the growing demand for food in Europe and the world (European Commission 2010). As a result of CAP and rising incomes, the share of European household expenditure on food has been steadily declining over the years. However, international food prices have recently risen and are likely to remain high, primarily because of the escalating cost of inputs and surging world demand. Rising food

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prices create serious difficulties, especially for vulnerable, low-income households that spend a substantial proportion of their income on food. According to the FAO (2021), the entire world was not on track to fulfil its commitment to eradicate hunger and malnutrition by 2030, even before the pandemic outbreak. Moreover, agri-food production and supply networks were also subject to shocks produced by natural catastrophes, war conflicts, and fluctuations in food prices in the past. At the same time, they have been exposed to long-term challenges caused by climate change and environmental degradation. However, the pandemic has proven that shocks can be abrupt and have a long-term worldwide impact on food security, nutrition and living standards (d'Errico et al. 2023). Recent data shows that in 2022, 2.4 billion people did not have year-round access to sufficient, safe, and nourishing food. This group included a disproportionately high number of women and individuals living in rural areas. Billions of people still lack access to an affordable, healthful diet because of the pandemic's ongoing effects on people's disposable income, the rising cost of health care, and general inflation increases (FAO et al. 2023). The current state of food security in Europe, particularly within the European Union (EU), reflects a complex landscape influenced by geopolitical tensions, agricultural policies, and the overarching goal of ensuring a resilient food supply chain. The European Commission has launched a dashboard on food security in the EU to provide timely and transparent monitoring essential for deciding the measures to mitigate impacts on food supply and security. This tool also focuses on food affordability, highlighting food inflation rates and detailing EU households' food spending by country and income level. Additionally, the EU has formulated several emergency plans within its Farm to Fork Strategy to safeguard food supplies and maintain food security during crises (Directorate-General for Agriculture and Rural Development 2022).

Literature review. Food and nutrition insecurity is a global issue since it causes both physical and psychological problems, such as a lack of micronutrients and reduction of dietary diversity throughout the lifespan (Hanson and Connor 2014, Pereira et al. 2022). Food security is defined as a person's ability to always have access to enough food, their ability to make informed food decisions and their financial capacity to acquire and buy nutrient-dense foods (Savoie-Roskos et al. 2016). A frequently used definition from the FAO declares that 'food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life' (FAO 2001). Based on the FAO definition, food security is monitored through four pillars: food availability, economic and physical access, utilisation, and stability (FAO 2001). One of the measures of food insecurity is the Food Insecurity Experience Scale (FIES). Cafiero (2016) outlined that FIES is designated to assess food insecurity by capturing an individual's direct experiences related to accessing food. The FIES has been globally standardised to enable comparison between countries, positioning it as a primary measure of food insecurity (Saint Ville et al. 2019). With the official framework for tracking progress on the sustainable development goals (SDGs), the prevalence of moderate or severe food insecurity in a country, as determined by FIES, is defined as SDG Indicator 2.1.2 (UN General Assembly 2017). Another widely used metric monitoring national-level food security across 113 countries through food affordability, availability, quality and safety, sustainability, and adaptation is the Global Food Security Index or GFSI (EIU 2022). FIES and GFSI serve as complementary indicators, optimally utilised together for a comprehensive understanding and tracking of a national level of food security (Allee et al. 2021). Thomas et al. (2017) suggest in their review using the GFSI in conjunction with indicators of food insecurity that concentrate on the population's nutritional status and food consumption as outcomes of food security. Research on food and nutrition insecurity has an established history in high-income nations like the USA, Canada, Australia, and the United Kingdom, where prevalence rates range from 4% to 12% (Borch and Kajernes 2016; Gundersen 2016; Carrillo-Álvarez 2023). Even though nearly 8% of the population, or the equivalent of the Italian population, is experiencing moderate or severe food insecurity, research is still in its early stages in Europe (FAO et al. 2022). Food demand responses in the middle-income former socialist countries, now member states of the European Union (EU), were studied with microdata using the Quadratic Almost Ideal Demand System (QUAIDS) model by Cupák et al. (2015). The authors shed light on the food security situation of households in Slovakia, a middle-income East European new member state (NMS) with a well-performing economy and the lowest income inequality in the EU (Eurostat 2024). As undernutrition and malnutrition exist to a considerable degree in both developed countries and developing and transition countries, Cupák et al. (2015) study of the food security situation in the EU new member states

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(NMS) was particularly useful. Palkovič and Fusková (2016) used multivariate analysis to cluster EU member countries based on Global Food Security Indicators from 2015. The findings found an enhancement in economic well-being and accessibility of food across European countries but highlighted the escalating obesity rate as a factor adversely affecting the quality of life. Grimaccia and Naccarato (2020) analysed food insecurity in Europe from a gender perspective based on micro-level data. The findings highlighted the significance of gender differences, the powerful effect of education in combating hunger, and the influence of income as key determinants of food security for both males and females. Another study by Matkowski et al. (2020) compared the state of food security in crisis conditions in Western Balkan and EU's countries based on FAO indicators using the Promethee method. A higher level of food security was observed in Scandinavian and Western European countries, as well as in Italy and Malta. The rest of the EU countries, except Croatia, Bulgaria and Romania, formed the second group with a medium level of food security. Western Balkan countries and the members that joined the EU after 2008 experienced lower levels of food security. Dudek et al. (2021) explored food insecurity in selected Central and Eastern European countries using multinomial logistic regressions on Gallup World Pool data for 2017–2019. The analysis revealed distinct differences in food insecurity (FI) profiles within the Central and Eastern European (CEE) countries studied, with Lithuania showing the lowest food security and Slovakia the highest. Abdullaieva (2022) assessed the effects of the Russian-Ukrainian war on food security in the European Union, highlighting the significant decline in the Global Food Security Index and the disparities in food security levels between more and less economically developed EU countries. Mostova and Hutorov (2023) compared Central and Eastern European countries based on the selected macroeconomic indicators. The authors highlighted the economic availability of food as a problem due to low income levels and the growing share of food expenses in households' budgets. According to the literature review of Carrilo-Álvarez (2023), nutrition security assessments in Europe lag behind those of food security and are rarely merged with evaluations of food insecurity. It is essential to track food and nutrition insecurity at both national and regional scales to identify its occurrence, root causes, and related factors.

The purpose of this study is to assess the current state of food security in 24 selected European Union countries using a new composite index – FSI, that incorporates both determinants and outcomes of food security. The aim is to compare the food security status among the EU countries using the FSI, dividing the countries based on their achieved scores into four groups and identifying areas requiring priority attention and interventions to enhance food security.

MATERIAL AND METHODS

The study analysed 24 member states of the EU. The analysis excluded countries such as Cyprus and Croatia due to the lack of data on several investigated indicators. Additionally, Luxembourg was not included as it was considered an outlier, particularly in terms of gross domestic product. Development was assessed by monitoring specific indicators within the timeframe of 2015–2022. The composite food security index was formulated using data from the year 2021, because the data for 2022 was limited to only five indicators. The data in the analyses were normalised to ensure consistent developmental direction using the min–max method. The maximising indicators were adjusted through the subsequent equation:

$$z_i = \frac{x_i - x_i(\min)}{x_i(\max) - x_i(\min)} \quad (1)$$

The minimising indicators were adjusted through the subsequent equation:

$$z_i = \frac{x_i(\max) - x_i}{x_i(\max) - x_i(\min)} \quad (2)$$

where: z_i – normalised value of i^{th} indicator; x_i – actual value of i^{th} indicator; x_i(min) – the lowest value of i^{th} indicator; x_i(max) – the highest value of i^{th} indicator.

The normalised values of the indicators fell within the range [0; 1], where 0 represents the country with the lowest value of the given indicator, and conversely, 1 represents the country with the highest rating. During the construction of the Food Security Index, the varying weights of individual indicators were considered. The methodology of factor analysis in SAS Enterprise Guide software was used to determine the share of influence of the indicators on the summary index. The principal component analysis (PCA) was employed to estimate the factor analysis model. The factor analysis model reduces the dimension and multicollinearity in the original dataset by using a linear combination of indicators based on the following equation:

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$$X_1 = a_{11}F_1 + a_{12}F_2 + \ldots a_{1m}F_m + U_1 + \mu_1$$

$$X_2 = a_{21}F_1 + a_{22}F_2 + \ldots a_{2m}F_m + U_2 + \mu_2 \quad (3)$$

$$X_p = a_{p1}F_1 + a_{p2}F_2 + \ldots a_{pm}F_m + U_p + \mu_p$$

where: $X_1, \ldots, X_p$ – original indicators; $F_1, \ldots, F_m$ – common factors; $a_{11}, \ldots, a_{pm}$ – loadings; $U_1, \ldots, U_p$ – specific factors representing random deviations; $\mu_1, \ldots, \mu_p$ – constants.

The suitability of applying factor analysis (FA) was evaluated by utilising Kaiser-Meyer-Olkin (*KMO*) measure of sampling adequacy based on the comparison of correlation coefficients with partial correlation coefficients:

$$KMO = \frac{\sum_{i \neq j}^{p} \sum_{j \neq j}^{p} r_{ij}^2}{\sum_{i \neq j}^{p} \sum_{j \neq j}^{p} r_{ij}^2 + \sum_{i \neq j}^{p} \sum_{j \neq j}^{p} r_{ij_{parc.}}^2} \quad (4)$$

where: *KMO* – Kaiser-Meyer-Olkin measure, r_{ij} – pairwise correlation coefficient between X_i and X_j indicators, $r_{ij\ parc}$ – partial correlation coefficient between X_i and X_j indicators, while *KMO* measure above 0.6 level is acceptable (Stankovičová and Vojtková 2007).

Weights for each individual indicator were calculated using the factor loadings obtained from varimax rotation. The methodology of constructing scales was employed by Nicoletti et al. (2000). The process involves aggregating individual indicators with the highest factor loadings into an intermediate composite indicator. Each individual temporary composite is combined by assigning a weight to each of them, which is equal to the proportion of explained variance in the data set. Afterwards, the acquired values are multiplied by the weight of the corresponding factor. The resulting weights are adjusted to ensure that their total is equivalent to 1. The composite Food Security Index was computed based on the following equation:

$$FSI = \sum_{k=1}^{n} w_j \times i_{j,k} \quad (5)$$

where: *FSI* – Food Security Index; w_j – the weight of i-indicator for j = 1, 2,...,10; $i_{j,k}$ – the normalised value of j^{th} indicator of k^{th} country.

One significant drawback and point of criticism for composite indices is the subjectivity of the decisions made at each stage. Accordingly, it is imperative to investigate how the output changes when different approaches are used (i.e. uncertainty analysis) and to comprehend which kind of uncertainty is more important in deciding how different countries score from one another (i.e. sensitivity analysis) (Saltelli et al., 2008). Because of this, Santeramo (2015) advised researchers to consider the implications that each method conveys and to emphasise the algorithm used to transform raw data into a single index when proposing new compos-

Table 1. List of selected indicators

Indicator	Unit	+/–	Source
Average protein supply; 3-year average	g/cap/day	+	FAOSTAT (2023)
Average protein supply of animal origin; 3-year average	g/cap/day	+	FAOSTAT (2023)
Gross domestic product *per capita*	purchasing power standard; constant 2017 international dollar	+	FAOSTAT (2023)
Prevalence of moderate or severe food insecurity in the total population	%	–	FAOSTAT (2023)
Political stability and absence of violence/terrorism	index	+	FAOSTAT (2023)
Share of population using sagely managed sanitation services	%	+	FAOSTAT (2023)
At risk of poverty or social exclusion rate	%	–	Eurostat (2023d)
Share of food and non-alcoholic beverages expenditures	% of total households' expenditures	–	Eurostat (2023a)
Harmonised index of consumer prices – food	index; 2015 = 100	–	Eurostat (2023b)
Median equivalised net income	(purchasing power standard/capita)	+	Eurostat (2023c)

+ maximising indicators; – minimising indicators
Source: Authors' own elaboration

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ite indexes. Therefore, according to Izraelov and Silber (2019) the similarity and stability of countries' rankings based on GFSI and our FSI were examined by Spearman's rank correlation coefficient based on the following equation:

$$r_s = 1 - \frac{6\sum d_i^2}{n\left(n^2 - 1\right)} \quad (6)$$

where: r_s - Spearman's rank correlation coefficient; d_i – difference between the two ranks of each observation; n – number of observations.

Table 1 presents the selected indicators utilised in the development of Food Security Index for 24 European Union countries. These indicators were chosen based on a comprehensive literature review (Caccavale and Giuffrida 2020) and the examination of official food security metrics documented in the FAO database. The selection encompasses various dimensions of food security, including availability, access, stability, and utility, as outlined by FAOSTAT (2023). Additionally, the Global Food Security Index provides indicators from the affordability dimension. These include the harmonised index of consumer prices for food, which evaluates changes in average food costs; at risk of poverty or social exclusion rate as multidimensional poverty index; and the median equivalised net income, which reflects household-adjusted income (EIU 2021). Furthermore, the share of food and non-alcoholic beverages expenditures offers insights into the economic aspects of food access within households.

RESULTS AND DISCUSSION

Prior to constructing the composite index, the development of input indicators was evaluated (Figure 1). The results from Figure 1 show that the indicators of average protein supply (Figure 1A), average supply of animal protein (Figure 1B), index of political stability, absence of violence or terrorism (Figure 1E) and share of safely managed sanitation services (Figure 1F) remained consistent over time.

In terms of development and variability, economic and social indicators reacted more sensitively to shocks in the monitored period. In 2020, the pandemic caused a decrease in the gross domestic product (Figure 1C), along with a rise in the rate of moderate or severe food insecurity (Figure 1D) and a notable increase in the share of expenditure on food and non-alcoholic beverages (Figure 1H). In 2022, the European Union implemented a range of economic and financial sanctions in response to the armed conflict between Russia and Ukraine. Russia intentionally decreased gas supplies, leading to a subsequent rise in gas and electricity costs. This increase was reflected in higher prices for other products and services, including food prices, as measured by the HICP (Figure 1J). Figure (1J) illustrates a notable growth in the disparities among European countries in 2022. The at risk of poverty or social exclusion (AROPE; Figure 1G) indicator exhibited a declining trend, however, with a deceleration in the rate of decline in recent years. The economic indicator under examination was the median equivalent disposable income (Figure 1I), which exhibits a gradual upward trend over time.

Exploratory factor analysis was employed to determine the weights assigned to each indicator. The suitability of applying the FA was evaluated by utilising Kaiser's measure of sampling adequacy. The overall metric achieved a value of 0.70, which suggests that FA was appropriate for research purposes. Table 2 displays the outcomes of the factor analysis. We decided to consider three factors that cumulatively accounted for 78.4% of the variability in the original data. The first factor accounted for 50.2% of variability, the second for 16.5%, and the third for 11.7%.

The weights of indicators were derived from the factor loadings after varimax rotation, estimated using PCA (Table 3). The results of Table 3 indicate that three indicators had the most significant positive impact on the formation of the first factor: the harmonised index of consumer prices – food, the share of spending on food and non-alcoholic beverages, and the GDP. The indicators median equivalised net income and prevalence of moderate or severe food insecurity could also be regarded as significantly influential. The first factor could be considered as an indicator of economic well-being, which focuses on the prosperity and financial health of society. The second factor was significantly correlated with three indicators: average protein supply, average protein supply of animal origin and population using safely managed sanitation services. We labelled it a health factor, referring to the nutritional and hygienic aspects of food safety that are critical to maintaining overall health and well-being. The third factor was significantly correlated with two indicators: at risk of poverty or social exclusion, the index measuring political stability and the absence of violence or terrorism. We labelled it as a factor of inclusive stability, capturing the stability, inclusion, and well-being of all members of society.

Table 3 displays the values of the explained variability for each factor, used to recalculate the proportion of in-

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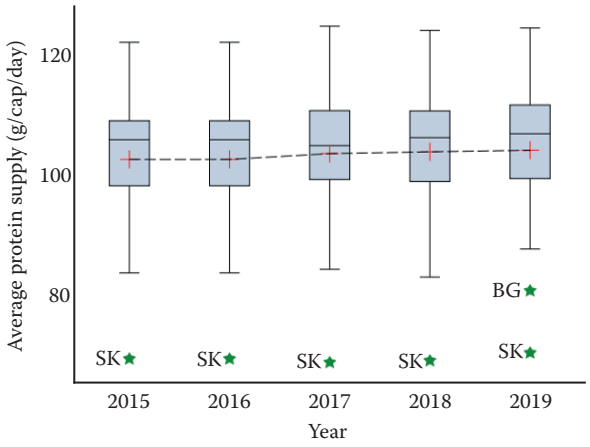
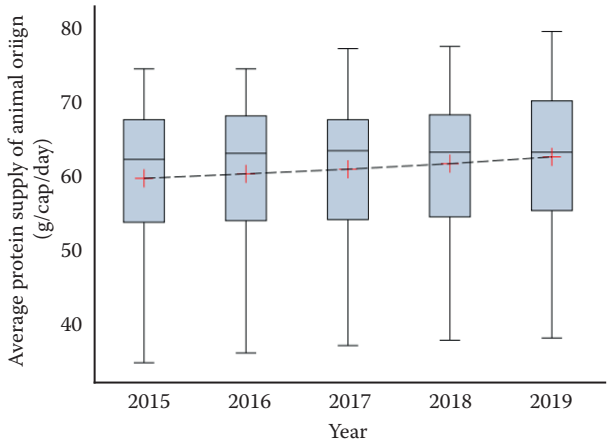
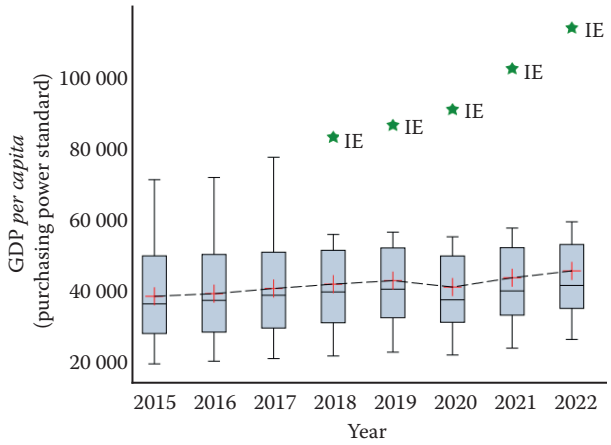
(A) Average protein supply



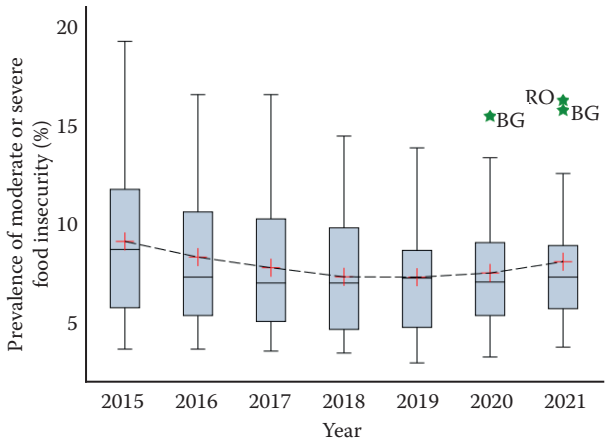
(B) Average protein supply of animal origin



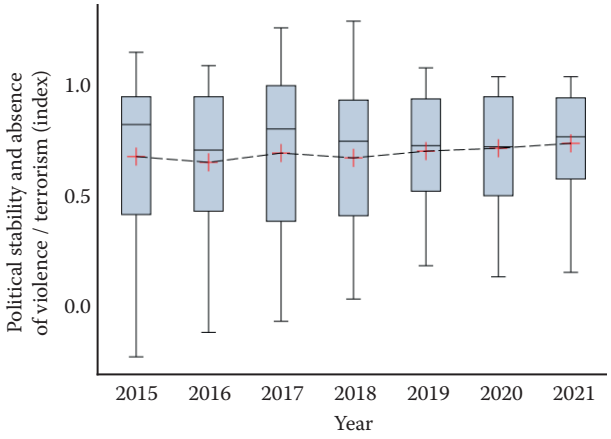
(C) Gross domestic product *per capita*



(D) Prevalence of moderate or sever food insecurity in the total population



(E) Political stability and absence of violence / terrorism



(F) Population using safely managed sanitation services

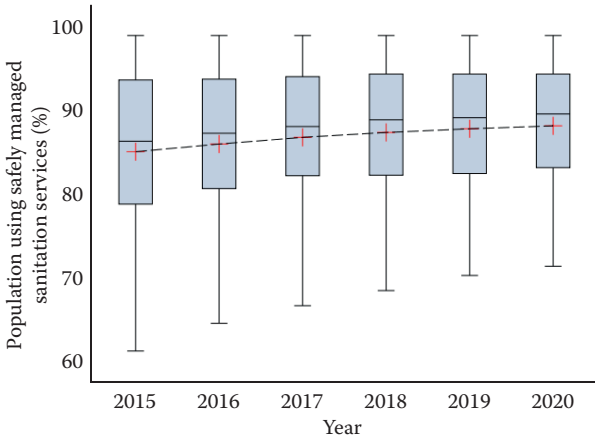


Figure 1. Development of indicators

SK – Slovakia; BG – Bulgaria; RO – Romania; IE – Ireland; FI – Finland;

Source: Authors' calculations in SAS Enterprise Guide software based on data from FAOSTAT and Eurostat Database (Eurostat 2023a,b,c,d; FAOSTAT 2023)

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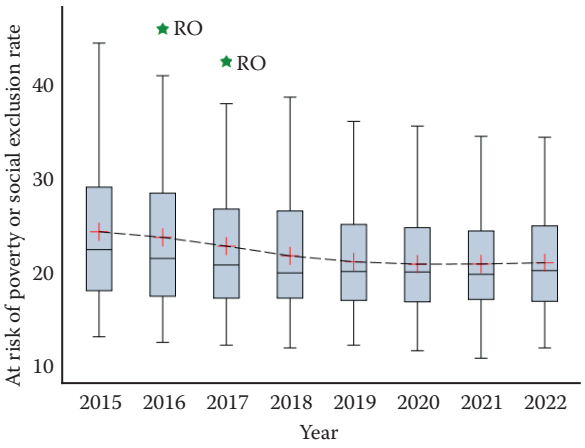
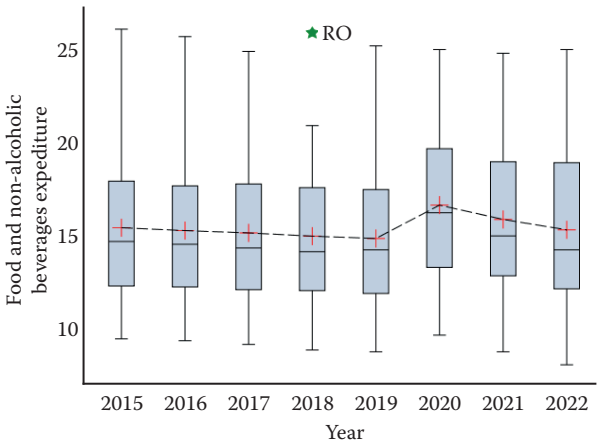
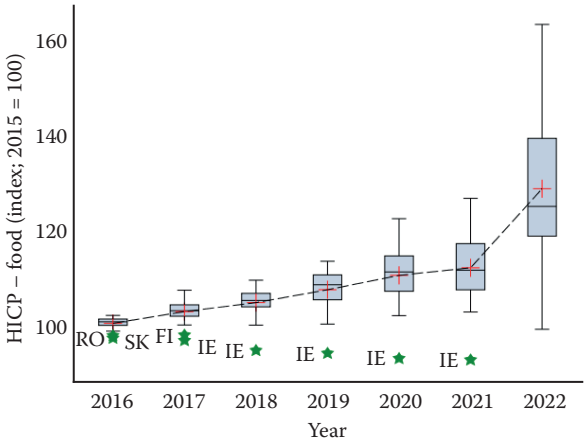
(G) At risk of poverty or social exclusion rate



(H) Food and non-alcoholic beverages expeditures



(I) Harmonised index of prices – food



(J) Median equalised net income

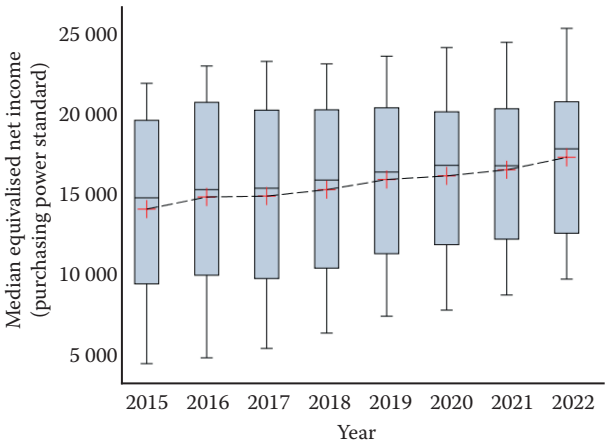


Figure 1 to be continued

Table 2. Factor analysis: factors in the context of food security

Factor	Total variance	Proportion of the variance	Cumulative proportion of the variance
1	5.018	0.502	0.502
2	1.651	0.165	0.667
3	**1.168**	0.117	**0.784**
4	0.986	0.099	0.882
5	0.475	0.048	0.930
6	0.300	0.030	0.960
7	0.205	0.021	0.980
8	0.080	0.008	0.988
9	0.070	0.007	0.995
10	0.048	0.005	1.000

Bold numbers highlight that the first three factors, significant according to the Total variance > 1, cumulatively, they explain 78.4% of total variance.

Source: Authors' calculation in SAS Enterprise Guide software

dividual factors. The construction of the weights was derived from the squared values of the eigenvectors representing the proportion of the total unit variance of the indicator explained by each factor. We adopted the methodology employed by Nicoletti et al. (2000). The calculated weights are shown in Table 4. Indicators are arranged in descending order according to the highest weight. The last column shows the designation of the factors in which the relevant indicator was significantly manifested. Based on the obtained weights harmonised index of consumer prices (HICP) – food (0.131), average protein supply (0.125), average protein supply of animal origin (0.123) and share of food and non-alcoholic beverages expenditures (0.111) appeared to be most influential. On the contrary, two indicators had the lowest weight at 0.067, namely the median equivalised net income and the prevalence of moderate or severe food insecurity.

Based on the scales constructed in this way, a summary Food security index (FSI) was subsequently calculated for each country, which is presented in Figure 2.

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Table 3. Rotated factor pattern after varimax rotation

Indicator	Factor 1	Factor 2	Factor 3
Average protein supply	0.346	**0.872**	–0.113
Average protein supply of animal origin	0.350	**0.867**	0.074
Gross domestic product *per capita*	**0.806**	0.195	0.292
Prevalence of moderate or severe food insecurity	**0.588**	0.221	0.483
Political stability/absence of violence or terrorism index	0.058	0.257	**0.743**
Population using safely managed sanitation services	–0.043	**0.706**	0.400
At risk of poverty or social exclusion rate	0.293	–0.185	**0.807**
Share of food and non-alcoholic beverages expenditures	**0.821**	0.122	0.481
Harmonised index of consumer prices – food	**0.894**	0.208	–0.148
Median equivalised net income	**0.636**	0.352	0.546
Variance explained by each factor	3.207	2.378	2.252
Factor variance / Total variance (%)	40.92	30.35	28.73

Bold values highlight the indicators, that had the greatest impact on forming each factor.

Source: Authors' calculations in SAS Enterprise Guide software

Table 4. Relevance of food security indicators based on their weights constructed using principal component analysis

Indicator	Weight of i^{th} indicator	Factor
Harmonised index of consumer prices – food	0.131	F1
Average protein supply	0.125	F2
Average protein supply of animal origin	0.123	F2
Share of food and non-alcoholic beverages expenditures	0.111	F1
At risk of poverty or social exclusion rate	0.107	F3
Gross domestic product *per capita*	0.107	F1
Political stability/absence of violence or terrorism index	0.091	F3
Population using safely managed sanitation services	0.082	F2
Median equivalised net income	0.067	F1
Prevalence of moderate or severe food insecurity	0.067	F1

F1 – Factor 1; F2 – Factor 2; F3 – Factor 3

Source: Author's own elaboration based on factor patterns after rotation (Table 1)

The analysis, which considered the composite FSI for 2021, revealed a mean score of 0.54 with a standard deviation of 0.17, indicating a moderate level of food security across the selected countries yet underscores the significant variability among them. The upper quartile consisted of Western and Northern European countries – specifically Ireland, Denmark, Austria, Finland, Netherlands, and Sweden. This group exemplifies higher food security standards attributable to robust economic conditions, effective agricultural policies, and well-established food distribution systems. Overall, Western and Northern European countries, together with Lithuania and Southern European countries except Greece, have achieved FSI scores above the average. The position of Lithuania was quite surprising and could be related to the highest levels of protein supply derived from animal-based proteins (De Boer and Aiking 2018) compared to other post-socialistic countries. Conversely, Central and Eastern European countries showed FSI scores below the average, delineating a regionally segmented pattern of food security. The analysis further identified the 25% of countries with the most unfavourable food security scores – Greece, Latvia, Hungary, Slovakia, Bulgaria, and Romania – as areas necessitating urgent policy attention and support.

Figure 3 visualises four groups of countries, as sorted in Figure 2, utilising the individual indicators from the composite index. Additionally, an independent examination of Slovakia was included to uncover the underlying reasons for its lower standing. The comparison focused on determining the similarities and differences between groups that were not apparent through scoring by the composite index. As seen in Figure 3, the 25% of the most food-secure countries were leading in indicators of economic well-being with the lowest prevalence of moderate or severe food insecurity (Factor 1) and good overall geopolitical stability. Together with other Western and Southern European countries with FSI scores above average, they were best perform-

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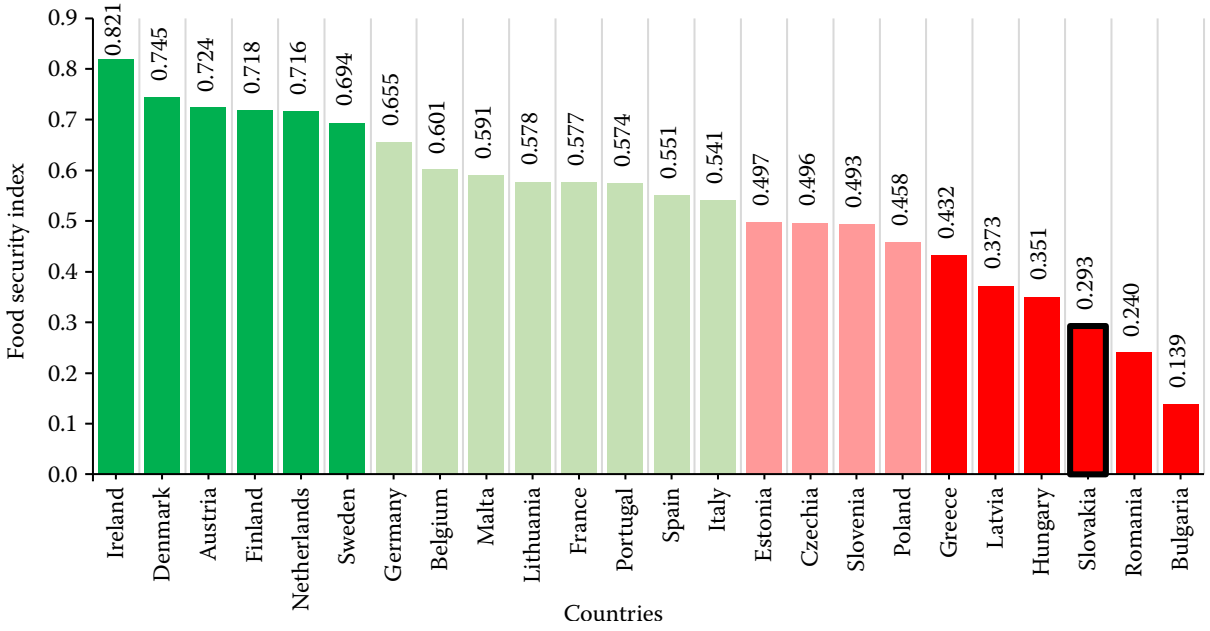

Figure 2. Ranking of European Union countries based on the Food Security Index in 2021

Source: Authors' own elaboration

ers from the point of nutritional and hygienic aspects of food safety (Factor 2). In the third group of countries, below the EU's average, multidimensional poverty did not seem to be the reason for the relatively low scores. These countries were also similar to Western and Southern European countries from the second group in purchasing parity adjusted GDP *per capita*, prevalence of moderate or severe food insecurity and political stability. This means that the lower scoring stemmed from indicators of economic well-being together with nutritional and hygienic aspects of food security. The last group of countries, mostly affected by the risk of food insecurity, were lacking in all individual indicators. Slovakia, presented in Figure 3 individually, was also one of the most vulnerable countries, but we can see some similarities with the group of countries scoring below EU's average. The disparities stemmed from the average total protein supply but also from the average protein supply of animal origin and lower median equivalised net income of households.

To evaluate the informational value of the proposed composite Food Security Index, the Spearman's coefficient was used to compare it with the Global Food Security Index (EIU 2021). The given relationship is presented in Figure 4 through a scatter plot. Since in GFSI, 19 countries are evaluated within the EU, i.e. for the comparability, the countries Estonia, Latvia, Lithuania, Malta, and Slovenia are not presented in the picture. In Figure 3, the investigated countries are marked in green or red. The green colour means that the composite Food Security Index overestimated the country's rank compared to the GFSI, and the red colour indicates the opposite situation. The closer the country is located to the auxiliary diagonal, the more similar was the ranking of the country in both indices. The significance level of the Spearman rank coefficient (r_s = 0.844, P < 0.001) confirmed the validity of the composite FSI by demonstrating its comparability with the widely recognised GFSI ranking.

In this research, we evaluated the current state of food security in 24 selected EU countries using a novel composite index – the Food Security Index (FSI), which integrates both determinants and outcomes of food security. Carrilo-Álvarez (2023) noted that assessments of nutritional security in Europe lag behind those of food security and are seldom linked with evaluations of food insecurity. For these reasons, the proposed new composite measure FSI, constructed from selected socioeconomic and nutritional indicators as suggested by Thomas et al. (2017), enriches the overview of the state of food security in the European Union. Additionally, the weights of the indicators were assigned endogenously through FA (Nicoletti et al. 2000). The Global Food Security Index (GFSI), which evaluates 113 countries and provides an overview of 19 countries within the EU, is one of the most frequently

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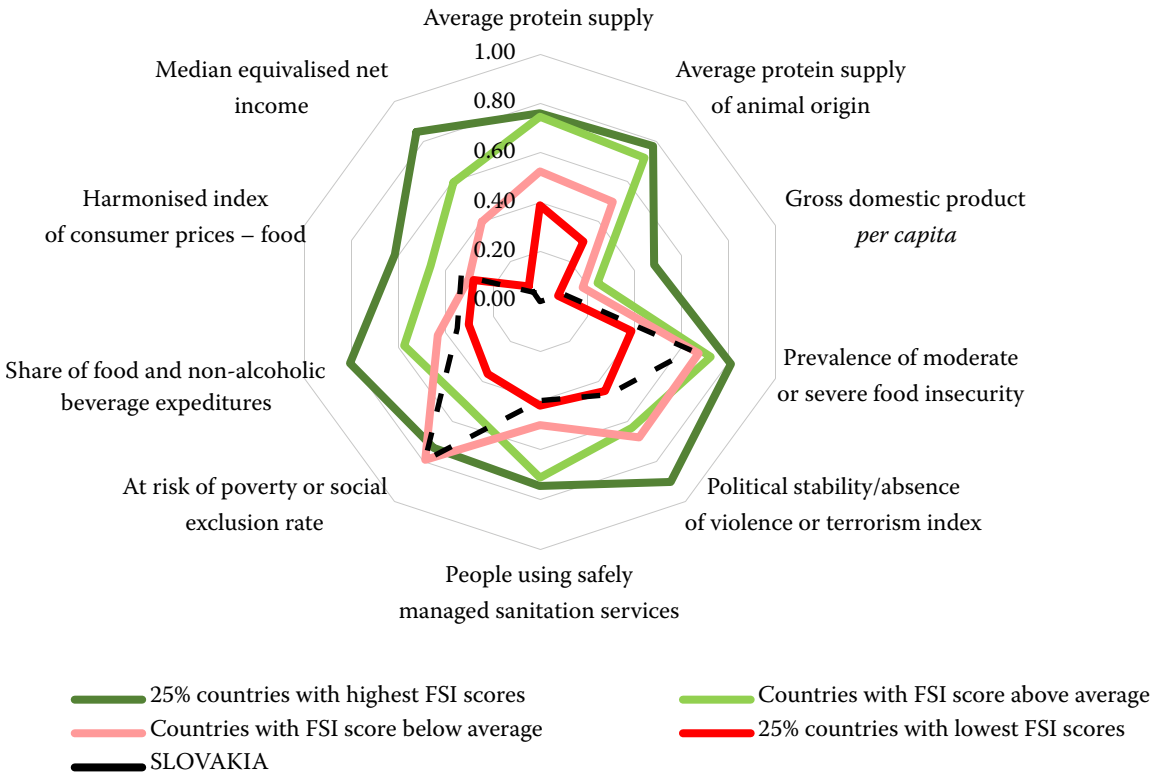

Figure 3. Comparison of selected European countries based on the individual indicators

FSI – Food Security Index
Source: Authors' own elaboration

used measures of food security at the national level. The authors identified the subjective determination of weights based on the averaging of weights proposed by a panel of experts as a primary issue with the GFSI index. The resulting weights of the input indicators for FSI and GFSI were not entirely comparable as they were constructed from a different number of variables. However, a comparative analysis of the rankings of the common countries based on both indexes showed that FSI and GFSI (EIU 2021) are comparable, particularly in assessing countries with higher risks of food insecurity, such as Greece, Hungary, Slovakia, Romania, and Bulgaria. The most significant discrepancies were observed in the resulting rankings of France, Portugal, and Czechia, where the composite FSI was underestimated in comparison with GFSI. Several studies focused on the issue of indicator selection (De Haen et al. 2011; Headey and Ecker 2013), comparisons of indicator weights in the GFSI index determined by a panel of experts with an index constructed based on an objective assignment of weights (Allee et al. 2021; Maricic et al. 2016; Smith et al. 2017), or the construction of their own index (Chen et al. 2019; Izraelov and Silber 2019; Caccavale and Giuffrida 2020), yet these studies evaluated countries on a global scale and none were directly focused on European countries. The gap in the existing literature was addressed by Palkovič (2023), who compiled a food security index for European countries based on indicators representing the various pillars of food security according to the FAO, with weights of the indicators determined objectively using the DEA model. Our results largely agree with the findings of Palkovič (2023), which stated that especially countries in Southern and Eastern Europe face problems with food security. However, the assessment of some countries was not unequivocal, particularly Hungary, which, according to our results, was ranked among the worst evaluated countries, while the findings of Palkovič (2023) suggested that it achieved a high level of food security, along with countries in Northern and Central Europe. Several reasons for this discrepancy may exist; firstly, the current state of food security in this research was assessed based on 2021 data, while Palkovič (2023) used 2020 data, even though both years were affected by the COVID-19 crisis. Secondly, we used different weighting schemes, which under-

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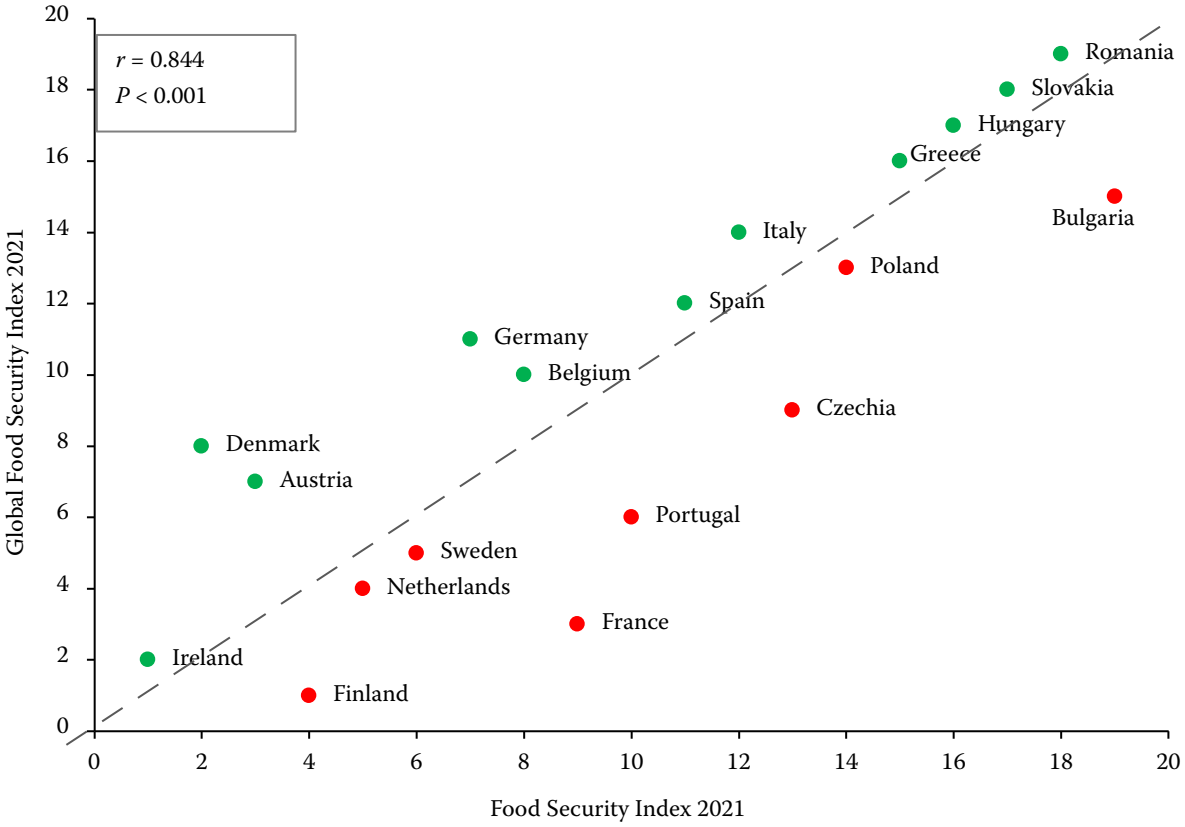

Figure 4. Ranking of selected European countries based on FSI 2021 *vs.* GFSI 2021

FSI – Food Security Index; GFSI – Global Food Security Index
Source: Authors'own elaboration

scored the importance of selecting weights for input variables. Several studies supported the notion that while Western and Northern Europe exhibit higher levels of food security, Central and Eastern European countries face more significant challenges, necessitating targeted policy interventions (Abdullaieva et al. 2022; Mostova and Hutorov 2023). Our results showed that Lithuania was the most food-secure country among Central and Eastern European member countries. Lithuania had the highest levels of protein supply derived from animal-based proteins, especially from fish and seafood (De Boer and Aiking 2018). This finding was not in line with Dudek et al. (2021), who analysed food insecurity in selected Central and Eastern European countries based on Gallup World Pool data from 2017 to 2019 and identified Lithuania as the least food-secure country, while Slovakia was marked as the most food-secure country. The reason for this discrepancy may be a different approach to data selection, highlighting the need for further investigation of food security at both macro and micro levels. Another fuzzy approach-based study on food security in V4 countries confirmed our findings and revealed Czechia as the leading country, followed by Poland, with Hungary and Slovakia at higher risk of food insecurity (Dudek 2022).

Rising food prices, represented by HICP-food, together with a high share of food expenditures and low levels of disposable income, are significant factors of food insecurity. Our findings align with those of Reeves et al. (2017), who concluded that rising food prices combined with stagnant incomes were significant drivers of food insecurity. Bodnár and Schuler (2022) reported a substantial increase in prices in the Baltic States and Slovakia during the fourth quarter of 2022, with year-on-year changes exceeding 20%. This phenomenon could be linked to larger imports of fertilisers and food from Russia, Ukraine, and Belarus by these countries. In 2022, Hungary experienced the highest rise in food prices compared to other member countries of the European Union. The upward trend in inflation in Hungary could be ascribed to multiple factors, such as the constrained ag-

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ricultural output resulting from the drought in 2022, a significant shift from unprocessed to processed foods, and the inefficiencies caused by government-imposed price ceilings on specific food items (MNB 2022; Cohn-Bech et al. 2023).

CONCLUSION

The proposed Food Security Index (FSI) enhanced research on the state of food security in the EU by using multivariate methodologies for unbiased weighting of indicators and extending the scope of evaluated countries by Global Food Security Index (GFSI) by adding Malta, Slovenia, Latvia, Lithuania, and Estonia. This approach broadened the scope of assessment, offering valuable insights into previously overlooked countries. The results emphasised significant differences among member states. Western and Northern European countries, followed by Southern European countries, exhibited a higher level of food security compared to Central and Eastern European countries. Lithuania was the only post-socialistic country that achieved a better score of FSI than the average. This result was quite surprising, but it could be caused by a high supply of fish, seafood, and dairy, indicating the need for targeted policy interventions in these countries focused on addressing food insecurity. This policy may include financial aid, technology transfer, and capacity-building initiatives to improve agricultural productivity and food distribution systems. Indicators of economic well-being and nutrition are key determinants of food security, but political efforts should also focus on social inclusion and political stability. The FSI could be considered an additional useful tool for measuring food security, not only in EU countries. Its advantages over the previously used GFSI index are seen in the objective assignment of weights to input indicators and the comparability over time. Another advantage of the proposed index could be seen in combining determinants of food security together with the prevalence of moderate or severe food insecurity based on the FIES scale. Despite the contributions of current research, analyses were limited only to the national level of 24 EU countries. This underscores the necessity for a comprehensive approach to understanding the state of food security across the entire EU, ensuring no country is left behind. Future research should focus on identifying vulnerable socioeconomic groups and explore longitudinal trends in food security, examining the impact of political interventions over time. Additionally, expanding the range of indicators used in the FSI could provide a more detailed picture of food security, including aspects such as food waste, nutritional quality, and access to clean water.

REFERENCES

Abdullaieva A., Andrusenko N., Hromova O., Martynova L., Prutska O., Yurchyk I. (2022): The impact of the Russian-Ukrainian war on the EU Food Security. Economic Affairs, 67: 859–867.

Allee A., Lynd L.R., Vaze V. (2021): Cross-national analysis of food security drivers: Comparing results based on the Food Insecurity Experience Scale and Global Food Security Index. Food Security, 13: 1245–1261.

Bodnár K., Schuler T. (2022): The surge in euro area food inflation and the impact of the Russia-Ukraine war. Economic Bulletin Boxes, European Central bank, 4: 74–80. Available at https://www.ecb.europa.eu/pub/pdf/ecbu/eb202204.en.pdf (accessed Nov 30, 2023).

Borch A., Kjaernes U. (2016): Food security and food insecurity in Europe: An analysis of the academic discourse (1975–2013). Apetite, 103: 137–147.

Caccavale O.M., Giuffrida V. (2020): The Proteus composite index: Towards a better metric for global food security. World Development, 126: 104709.

Cafiero C. (2016): Methods for Estimating Comparable Prevalence Rates of Food Insecurity Experienced by Adults Throughout the World. Rome, FAO: 60.

Carrillo-Álvarez E. (2023): Perspective: Food and nutrition insecurity in Europe: Challenges and opportunities for dietitians. Advances in Nutrition, 14: 995–1004.

Chen P., Yu M., Shih J., Chang C., Hsu S. (2019): A reassessment of the Global Food Security Index by using a hierarchical data envelopment analysis approach. European Journal of Operational Research, 272: 687–698.

Cohn-Bech E., Foda K., Roitman A. (2023): Drivers of inflation: Hungary. Available at https://doi.org/10.5089/9798400234163.018 (accessed Nov 30, 2023).

Cupák A., Pokrivčák J., Rizov M. (2015): Food demand and consumption patterns in the new EU member states: The Case of Slovakia. Ekonomický časopis, 4: 339–358.

D'Errico M., Pinay J., Jumbe E., Luu A.H. (2023): Drivers and stressors of resilience to food insecurity: Evidence from 35 countries. Food Security, 15: 1161–1183.

Directorate-General for Agriculture and Rural Development (2022): The European Commission launches dashboard on food security in the EU. Available at https://agriculture.ec.europa.eu/news/european-commission-launches-dashboard-food-security-eu-2022-12-08_en (accessed Mar 12, 2024).

https://doi.org/10.17221/16/2024-AGRICECON

De Boer J., Aiking H. (2018): Prospects for pro-environmental protein consumption in Europe: Cultural, culinary, economic, and psychological factors. Appetite, 121: 29–40.

De Haen H., Klasen S., Qaim M. (2011): What do we really know? Metrics for food insecurity and undernutrition. Food Policy, 36: 760–769.

Dudek H., Myszkowska-Ryciak J., Wojewódzka-Wiewiórska A. (2021): Profiles of food insecurity: Similarities and differences across selected CEE countries. Energies, 14: 5070.

Dudek H. (2022): The risk and severity of food insecurity in V4 countries: Insight from the fuzzy approach. Engineering Economics, 33: 132–142.

EIU (2021): The global food security index 2021. The 10-year anniversary. Available at https://impact.economist.com/sustainability/project/food-security-index/resources/Economist_Impact_GFSI_2021_Global_Report_Oct_2021.pdf (accessed Oct 18, 2023).

EIU (2022): The global food security index 2022: Strenghtening food systems and the environment through innovation and investment. Available at https://impact.economist.com/sustainability/project/food-security-index/about (accessed Nov 27, 2023).

European Commission (2010): Communication from the Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of The Regions. The CAP towards 2020: Meeting the food, natural resources, and territioral challenges of the future. COM (672) 2010 final. Brussels, 18 November 2010, Brussels. European Commission: 1-16. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52010DC0672 (accessed Mar 19, 2024).

Eurostat (2023a): Final consumption expenditure of households by consumption purpose (COICOP 3 digit). Available at https://www.ec.europa.eu/eurostat/databrowser/view/NAMA_10_CO3_P3__custom_4560656/default/table?lang=en (accessed Oct 20, 2023).

Eurostat (2023b): HICP – annual data (average index and rate of change). Available at https://doi.org/10.2908/PRC_HICP_AIND (accessed Oct 20, 2023).

Eurostat (2023c): Mean and median income by age and sex – EU-SILC and ECHP surveys. Available at https://www.ec.europa.eu/eurostat/databrowser/view/ilc_di03/default/table?lang=en (accessed Oct 20, 2023).

Eurostat (2023d): People at risk of poverty or social exclusion. Available at https://ec.europa.eu/eurostat/databrowser/view/sdg_01_10/default/table?lang=en (accessed Oct 20, 2023).

Eurostat (2024): Gini coefficient of equivalised disposable income – EU-SILC survey. Available at https://doi.org/10.2908/ILC_DI12 (accessed Mar 12, 2024).

FAO (2001): The State of Food Insecurity in the World 2001. Rome, FAO: 65.

FAO (2021): The State of Food and Agriculture 2021. Making Agrifood Systems More Resilient to Shocks and Stresses. Rome, FAO: 182.

FAO, IFAD, UNICEF, WFP, WHO (2022): The State of Food Security and Nutrition in the World 2022. Repurposing Food and Agricultural Policies to Make Healthy Diets More Affordable. Rome, FAO: 206.

FAO, IFAD, UNICEF, WFP, WHO (2023): The State of Food Security and Nutrition in the World 2023. Urbanization, Agrifood Systems Transformation and Healthy Diets Across the Rural-Urban Continuum. Rome, FAO: 363.

FAOSTAT (2023): Suite of food security indicators. Available at https://www. https://www.fao.org/faostat/en/#data/FS (accessed Oct 21, 2023).

Grimaccia E., Naccarato A. (2020): Food insecurity in Europe: A gender perspective. Social Indicators Research, 161: 649–667.

Gundersen C. (2016): Understanding food insecurity in the USA and Canada: Potential insights for Europe. In: Biesalski H.K., Black R.E. (eds): Hidden Hunger: Malnutrition and the First 1,000 Days of Life: Causes, Consequences and Solutions. Basel, Karger: 54–60.

Hanson K.L., Connor L.M. (2014): Food insecurity and dietary quality in US adults and children: A systematic review. The American Journal of Clinical Nutrition, 100: 684–692.

Headey D., Ecker O. (2013): Rethinking the measurement of food security: From first principles to best practise. Food Security, 5: 327–343.

Izraelov M., Silber J. (2019): An assessment of the global food security index. Food Security, 11: 1135–1152.

MNB (2022): Inflation report (September 2022). Magyari Nemzeti Bank: 84. Available at https://www.mnb.hu/letoltes/eng-ir-digitalis-16.pdf (accessed Nov 29, 2023).

Maricic M., Bulajic M., Dobrota M., Jeremic V. (2016): Redesigning the global food security index: A multivariate composite I-distance indicator Approach. International Journal of Food and Agricultural Economics, 4: 69–86.

Matkowski B., Dokić D., Zekić S., Jurcević Ž. (2020): Determining food security in crisis conditions: A comparative analysis of the Western Balkans and the EU. Sustainability, 12: 9924.

Mostova A., Hutorov A. (2023): Food security in the countries of Central and Eastern Europe: State and strategic directions of provision. Ekonomika APK, 30: 20–29.

Nicoletti G., Scarpetta S., Boylaud O. (2000): Summary indicators of product market regulation with and extension to employment protection legislation, OECD, Economics department working papers No. 226. Available at https://

https://doi.org/10.17221/16/2024-AGRICECON

papers.ssrn.com/sol3/papers.cfm?abstract_id=201668 (accessed Oct 5, 2023).

Palkovič J., Fusková M. (2016): Food security: Overview of current situation in selected European countries. Journal of Central European Green Innovation, 4: 73–90.

Palkovič J. (2023): The Dynamics of European Food Security: Key Drivers and Measurement Framework. Nitra, Slovak University of Agriculture in Nitra: 82.

Pereira M.H.Q., Pereira M.L.A.S., Campos G.C., Molina M.C.B. (2022): Food insecurity and nutritional statis among older adults: A systematic review. Nutrition Reviews, 80: 631–644.

Reeves A., Loopstra R., Stuckler D. (2017): The growing disconnect between food prices and wages in Europe: Cross-national analysis of food deprivation and welfare regimes in twenty-one EU countries, 2004–2012. Public Health Nutrition, 20: 1414–1422.

Saint Ville A., Po J.Y.T., Sen A., Bui A., Melgar-Quiñonez H. (2019): Food security and the Food Insecurity Experience Scale (FIES): Ensuring progress by 2030. Food Security, 11: 483–491.

Saltelli A., Ratto M., Andres T., Campolongo F., Cariboni J., Debora G., Saisana M., Tarantola S. (2008): Global Sensitivity Analysis. The Primer. Chichester, John Wiley and Sons: 292.

Santeramo F.G. (2015): On the composite indicators for food security: Decisions matter! Food Reviews International, 31: 63–73.

Savoie-Roskos M., Durward C., Jeweks M., LeBlanc H. (2016): Reducing food insecurity and improving fruit and vegetable intake among farmers' market incentive program participants. Journal of Nutrition Education and Behavior, 48: 70–76.

Smith M.D., Rabbit M.P., Coleman-Jensen A. (2017): Who are the world's food insecure? New evidence from the Food and Agriculture Organization's food insecurity experience scale. World Development, 93: 402–412.

Stankovičová I., Vojtková M. (2007): Viacrozmerné štatistické metódy s aplikáciami. Bratislava, Iura Edition: 263. (in Slovak)

Thomas A.C., D'Hombres B., Casubolo C., Kayitakire F., Saisana M. (2017): The Use of the Global Food Security Index to Inform the Situation in Food Insecure Countries. Luxembourg, European Commission, Technical Report of the Joint Research Centre: 60.

UN General Assembly (2017): Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development. Pub. L. No. A/RES/71/313. Available at https://undocs.org/A/RES/71/313 (accessed Mar 11, 2024).

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