Doctoral School of Business and Management

THESIS SUMMARY

Boglárka Anna Éliás

Food Security and Crises
Analyses of Disruptions in Food Systems

Ph.D. thesis

Supervisors:

Attila Jámbor DSc

professor

Judit Nagy PhD

associate professor

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Sustainability Management Program – Agricultural Economics

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Table of Contents

1. RELEVANCE OF THE RESEARCH SUBJECT 4
2. METHODOLOGY 4
2.1. Research Questions, Sub-Questions, and Hypotheses 4
2.2. Data and Methods 6
3. RESEARCH RESULTS 9
3.1. Bibliometrics 9
3.2. Results published in Publication 1 9
3.3. Results published in Publication 2 11
3.4. Results published in Publication 3 13
4. CONCLUSIONS, SUMMARY OF RESULTS 14
5. Contribution to existing literature 18
6. MAIN REFERENCES 19
7. OWN PUBLICATIONS ON THE TOPIC 21

1. RELEVANCE OF THE RESEARCH SUBJECT

Food security remains a critically important issue, addressing one of the most fundamental human needs and characterized by a challenging cyclical pattern. Despite significant advances, each time stability seems within reach, new crises emerge to undermine progress. However, the efforts to enhance food security yield remarkable benefits, lifting millions of families from malnutrition and ensuring their daily access to sufficient and nutritious food. The importance of these efforts cannot be overstated, especially in light of recurrent crises. The COVID-19 pandemic and the conflict between Russia and Ukraine have escalated global challenges, contributing to a significant increase in undernourishment worldwide. In 2022, there were approximately 120 million more undernourished individuals than in 2019. Including both moderate and severe food insecurity, there is a surplus of almost half a billion people compared to 2019 (FAO et al., 2023). In 2024, amidst strong uncertainties in economic, geopolitical, and climate prospects, it's critical, without resorting to pessimism, to analyze the interplay between crises and food security. Such analyses can be vital not only to enhance our understanding and address current challenges but also to build greater resilience against future shocks.

2. METHODOLOGY

2.1. Research Questions, Sub-Questions, and Hypotheses

My research examines the impact of crises on food availability, accessibility, utilization and stability – i.e., on the 3+1 dimensions of food security – at regional, national, and household levels.

My approach to the topic has been shaped by identified gaps in the existing literature. I identified two methodology related research gaps and formulated my two main research questions (Q1, Q2) by reflecting on these gaps.

Existing studies lack a comprehensive analysis of all food security dimensions within a single crisis event. Most focus on one or two dimensions and a limited range of food system actors, often neglecting interactions critical for designing resilient food systems and effective crisis management. This gap informs my first research question:

Q1. **Could a comprehensive, 3+1 dimensions analysis contribute to discovering new results regarding crisis-caused impacts and their interplays in the food system?**

In the literature, I identified several studies that effectively employed statistical methods on panel data to determine the factors influencing food security (Demeke et al., 2011; Subramanyam et al., 2011; Mutisya et al., 2016; Dithmer and Abdulai, 2017; Affoh et al., 2022), however, I have not found studies which would apply these methods to examine whether crisis is a food security determinant. My second research question emerged from this methodological research gap:

Q2. Can well-established statistical methods – commonly used to identify food security determinants – be applied to assess the deterministic effect of crises on food security?

I divided my research into two parts along the two main research questions. As I narrowed the focus to specific crisis events and particular countries, regions, formulated further sub-questions (SQ1–3) and hypotheses (H1–10) (Table1).

Table 1 Research structure

Research Part I. **Q1. Could a comprehensive, 3+1 dimensions analysis contribute to discovering new results regarding crisis-caused impacts and their interplays in the food system?** → 3+1-dimension analysis of a certain crisis event
• A systematic literature review limited to the COVID-19 pandemic crisis-related effects on food security, without geographical limitation. (Publication 1)
SQ1. What segments of food security have been affected by the COVID-19 lockdown and pandemic?
SQ2. Are the COVID-19-related food security problems temporary and "crisis specific" or are they rooted in structural weaknesses?
SQ3. Are new food security objectives needed to mitigate the negative effects of the pandemic and prepare for a possible future pandemic?
• A national-level statistical analysis of the impact of the food price surge in Hungary 2022–2023 on food security. (Publication 2)
H1. Despite the overall improvement in food security in Hungary between 2015 and 2020, significant differences in dietary quality persisted across households with different income levels.
H2. Food availability in Hungary remained stable even during the disruptions to food supply chains caused by the COVID-19 pandemic and the Russian-

Ukrainian war.
H3. The food price surge in 2022–2023 induced changes in food purchasing patterns through deteriorating affordability.
H4. The change in consumption is not reflected in a reduction in total energy intake but rather in a decrease in the consumption of micronutrients and dietary fiber.
H5. The gap between the dietary quality of the lowest and highest income groups increased in 2022–2023.
Research Part II. **Q2. Can well-established statistical methods—commonly used to identify food security determinants—be effectively applied to assess the deterministic effect of crises on food security?**
• Applying a panel data logistic regression model to detect food security determinants and the deterministic feature of crisis events on food security in East, South, and Southeast Asia between 2001 and 2021. (Publication 3)
H6. Higher performance of the agriculture sector decreases food insecurity.
H7. The growth of average economic size fosters food security.
H8. Open economic activities positively influence food security.
H9. Higher changes in average temperature are against food security.
H10. Crisis situations cause food security to decrease.

2.2. Data and Methods

The following table summarize the applied data and methods:

Table 2. Applied data and methods

Publication 1
Systematic literature review based on PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses, Page et al., 2020) guidelines.
Publication 2
Semi-structured interview based on the guidance of Gill et al. (2008).
Household survey to identify. - The questionnaire was shared via social media in November 2023. - 1st part: socio-demographic information about the household of the respondents; 2nd part: questions regarding changes in food purchasing and food consumption habits related to the food price surge (between January 2022 and November 2023).

- After cleaning the completed questionnaires, final sample size was n=300.

Descriptive statistical analysis on

- primary data: the data collected through the above-mentioned household survey;
- secondary data: income, expenditure, and consumption data by socio-economic groups and income deciles, and production of major cereal and meat products data from the Hungarian Central Statistical Office.

Spearman Rank Correlation based on the theoretical background of Schober et al. (2018)

- Formula of Spearman Rank Correlation, when $\boldsymbol{\rho}$ = Spearman Rank Correlation Coefficient, di = Difference of the ranks of each observation, n = number of observations:

$$\rho = 1 - \frac{6\Sigma\, d_i^2}{n(n^2-1)}$$

- Variables
  - Net income per capita by income deciles (HUF), Data source: Hungarian Central Statistical Office: Data table: Nr. 14.8.1.5.
    - Cereals; Meat and Meat Products; Fish and Fish Products; Fats; Fruits; Vegetables and Potatoes annual food consumption volume per capita by income deciles (kilogram), Data source: Hungarian Central Statistical Office: Data table: Nr. 14.1.1.27.

Pearson Correlation Coefficient based on the theoretical background of Schober et al. (2018)

- Formula of the Pearson Correlation Coefficient, when $\mathbf{r}$ is the Pearson Correlation Coefficient, and $\mathbf{x}$ and $\mathbf{y}$ are the sample means.

$$r = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2 \sum(y-\bar{y})^2}}$$

- Variables
  - Average monthly per capita income (HUF). Source: own household survey detailed above.
  - Food expenditure rate for different socio-demographic groups (age, sex, education, municipality type, employment status). Source: own household survey detailed above

Publication 3

Descriptive statistical analysis on

- secondary data from FAOSTAT: production, trade, and consumption of main food commodities; consumption of nutrients per capita.

Generalized least square random effects regression model

- Applied formula when *i:* given country, *t*: given year

$$POU_{it} = \alpha_0 + \alpha_1 POP_{it} + \alpha_2 GDP_{it} + \alpha_3 FDI_{it} + \alpha_4 EXCH_{it} + \alpha_5 CIDR_{it} + \alpha_6 AGREMP_{it} + \alpha_7 GPVAGRI_{it} + \alpha_8 PPRICEAGRI_{it} + \alpha_9 TEMPCHANGE_{it} + \alpha_{10} REFUGEE_{it} + \alpha_{11} DEATHS_{it} + \alpha_{12} PRICEBOOM_i + \alpha_{13} CRISES_i + \alpha_{14} DELAYEDCRISES_i + v_{ij} + \varepsilon_{ij} \quad (1)$$

- Variables:

Variable name	Variable description	Unit of measurement	Data source
• POU	Prevalence of undernourishment	%	FAOSTAT
• POP	Total population of the country	1000 people	FAOSTAT
• GDP	GDP (annual value)	Million $, 2015 prices	FAOSTAT
• FDI	FDI-inflow	Million $, 2015 prices	FAOSTAT
• EXCH	Exchange rate of local currency to USD	Local currency/$	FAOSTAT
• CIDR	Cereals import dependency ratio	%	FAOSTAT
• AGREMP	Share of agricultural employment in total employment	%	FAOSTAT
• GPVAGRI	Gross production value of agriculture	1000 $, 2014-2016	FAOSTAT
• PPRICEAGRI	Producer prices of agricultural products	%, 2014-2016 =100%	FAOSTAT
• TEMP-CHANGE	Temperature change on land	Celsius	FAOSTAT
• REFUGEE • Dummy: refugees	1= share of refugees in the host country's population bigger or equal to 0.01% in the given year 0= share of refugees in the host country's population smaller than 0.01%	Binary	World Bank
• DEATHS • Dummy: fatalities in battle	1= fatal casualties happened on battlefield on the territory of the country in the given year 0= no fatal outcomes of battle on the territory of the country in the given year	Binary	Uppsala Conflict Data Program
• PRICEBOOM • Dummy: foodprice boom in East, South, Southeast Asia	1= the years of remarkable food price increases in the three regions: 2007, 2008, 2011, 2014, 2019, 2020 0=rest of the years	Binary	-
• CRISES • Dummy: crises	1= years of the food price crisis in 2007, 2008, years of COVID19 in 2020, 2021 0= rest of the years	Binary	-
• DELAYED-CRISES • Dummy: delayed crises	1= dummy-crises+1 year 0= rest of the years	Binary	-

3. RESEARCH RESULTS

3.1. Bibliometrics

The research results have been published in the following three publications:

- Publication 1
    - Éliás, Boglárka Anna, and Jámbor, Attila. (2021). Food security and COVID-19: a systematic review of the first-year experience. *Sustainability*, 13(9), 5294; **https://doi.org/10.3390/su13095294**.
    - Ranking of journal in year of publishing:
        - Hungarian Academy of Science – IV. Section of Agricultural Sciences: A,
        - SJR Q1.
- Publication 2.
    - Éliás, Boglárka Anna (2024). Magyarország élelmezése válság idején. Gazdálkodás, 68(2), 103–125, [Food security of Hungary in times of crisis] https://doi.org/10.53079/GAZDALKODAS.68.2.t.pp_103-125.
    - Ranking of journal in year of publishing:
        - Hungarian Academy of Science – IV. Section of Agricultural Sciences: A,
        - Hungarian Academy of Science – IX. Section of Economics and Law: C.
- Publication 3
    - Jámbor, Attila and Éliás, Boglárka Anna (2024). Determinants of Food Security: A Comprehensive Analysis Across East, South, and Southeast Asia. *Journal of Sustainability Research*, *6*(2):e240030; https://doi.org/10.20900/jsr20240030.
    - Ranking of journal in year of publishing: SJR Q2.

3.2. Results published in Publication 1

SQ1. What segments of food security have been affected by the COVID-19 lockdown and pandemic?

According to our findings, the COVID-19 pandemic and lockdowns have impacted all dimensions of food security, primarily affecting economic access to food mostly in line with previous literature (Laborde et al. 2020; Béné, 2020). Financial challenges, such as low household income (31.8% of the articles focusing on household food security reported this problem), income loss (43.2%), and rising food prices (4.5%), were the main reasons for increased food insecurity, particularly in low-income countries.

Dietary shifts included reduced consumption of healthy foods due to affordability issues (22.7%) and emotional stress (27.3%), leading to less nutritious eating habits, while some individuals adopted healthier diets for immunity (9.1%) or weight management (4.5%).

Physical access to food was also hindered by movement restrictions and fear of infection, leading to temporary food shortages in the households (6.8%).

The pandemic disrupted food production through decreased demand and sale prices (77.7% of the articles focusing on food availability/food production reported this problem) labor shortages (33.3%), increased costs (22.2%) and transportation difficulties (33.3%) but did not significantly reduce overall production levels.

SQ2. Are the COVID-19-related food security problems temporary and "crisis specific" or are they rooted in structural weaknesses?

Our review found some effects being temporary and expected to revert to pre-pandemic conditions once restrictions are lifted and case numbers decrease. Temporary effects include limited physical access to food due to panic buying, movement restrictions, or infection fears, and negative dietary changes driven by anxiety and loneliness, which are likely to improve after the restoration of social connections. For producers, the resolution of market access and labor mobility issues is also anticipated post-restrictions.

However, the review highlights that the most significant and persistent challenge is the low income of households. Low-income households, lacking sufficient savings and the ability to bulk purchase, face difficulties affording nutritious food due to income loss and rising prices, impacting demand for producers. This issue reflects a deeper, structural problem within global food security, underscoring low income as the core factor detrimentally affecting food security during the crisis.

SQ3. Are new food security objectives needed to mitigate the negative effects of the pandemic and prepare for a possible future pandemic?

We concluded that the primary lesson from the COVID-19 pandemic for food security is not the need for new global objectives but a heightened focus on poverty reduction and increasing the income of low-income households. This approach is deemed essential for preparing for future crises by ensuring that households have economic access to food through adequate wages, which enhances food security under normal conditions and builds resilience against various crises. The pandemic has shown that while it's possible to prepare for some disruptions, unforeseen challenges like COVID-19 present novel problems. Strengthening structural weaknesses, such as financial insecurity, can mitigate the broader impacts of crises on food security.

3.3. Results published in Publication 2

Gap-filling access and nutrition status analysis of Hungary between 2015–2020.

The last comprehensive food security analysis of Hungary was published in 2013 (Jankuné Kürthy et al., 2013), therefore, a new analysis was needed, the results of which could be used as a benchmark in testing the hypotheses of my research.

Physical access to food:

Small settlements have more grocery stores per capita, but they face issues like high prices and limited selection. There's a decline in small retail outlets and an increase in larger stores' average size, suggesting retail concentration. The concentration of larger stores in urban areas may limit access for those in smaller settlements, potentially raising food prices there due to reduced competition.

Economic access to food:

Hungarian households generally had low risk of food insecurity between 2015 and 2020, with an average food expenditure of 24.7% of total household expenditure. Certain groups, however, including active and inactive households in specific income quintiles, showed higher food expenditure shares, indicating greater vulnerability. From 2015 to 2020, food prices increased by 23.0, and net capita incomes increased by 60.7%. Despite some groups being more vulnerable (retired, inactive, low level of education), Hungary saw an overall increase in economic access to food.

Nutrition:

The most recent nutrient intake survey (OTÁP, 2019) highlights issues with the Hungarian diet, including high overweight and obesity rates, inadequate dietary fiber and vitamin intake, and excessive fat consumption.

H1. Despite the overall improvement in food security in Hungary between 2015 and 2020, significant differences in dietary quality persisted across households with different income levels. – Confirmed.

According to Spearman's rank correlation coefficient, there is a very strong relationship between income level and the consumption of healthier foods like fruits (r_s=0.988), fish (r_s=0.976), vegetables and potatoes (r_s=0.964), while consumption of cereals (r_s=0.673), fats (r_s=0.600) and sugar (r_s=0.406) is more evenly distributed across income groups between 2015 and 2020.

H2. Food availability in Hungary remained stable even during the disruptions to food supply chains caused by the COVID-19 pandemic and the Russian-Ukrainian war. – Confirmed.

The statistical analysis of the production of major cereals and meat between 2018 and 2022, along with the available daily nutrient volume per capita in 2022, suggests that food availability remained stable. Hungary continues to maintain food self-sufficiency for key cereals and meat products, with production levels consistently exceeding domestic consumption.

H3. The food price surge in 2022–2023 induced changes in food purchasing patterns through deteriorating affordability. – Confirmed.

A significant increase in food prices was noted between 2022 and 2023 (+58.6%), while incomes increased by 33.2%, challenging the previously positive trends in economic access. 71.7% of respondents reported changing their food shopping habits due to rising food prices. Only 6.3% of the respondents reported that there were only small shops in their area whose prices they could not afford or could barely afford, however, unexpectedly only one-third of them were rural residents, and half of them were from the capital, putting the findings of the questionnaire in tension with the implications of the previous literature and data.

H4. The change in consumption is not reflected in a reduction in total energy intake but rather in a decrease in the consumption of micronutrients and dietary fiber. – Rejected.

The household survey revealed that since the beginning of 2022, a significant portion, 34% of respondents reported buying less food associated with a *healthy diet* due to affordability issues. Price increases led to a reduction in the purchase of nutrient-rich foods like fruits, nuts, fish, and vegetables, particularly among lower-income respondents. However, 3.3% of the respondents cannot afford to buy a *sufficient amount* of food, while they could afford it prior to 2022. Therefore, the hypothesis cannot be confimred.

H5. The gap between the dietary quality of the lowest and highest income groups increased in 2022–2023. – Confirmed.

The survey results suggest that the gap in diet quality between low and high-income households has widened further with the food price increases in 2022–2023. Higher-income households (13–27% higher income than sample average) have been able to maintain or increase their consumption of high nutritional quality foods, while lower-income households (7–14% lower income than sample average) have had to reduce their consumption of these essential nutrient sources (fruits, vegetables, fishes, oil seeds and nuts).

Further implications regarding the food security status of Hungary:

Given that the average financial situation of the respondents is above the national average by 32.9%, it can unfortunately be concluded that food security in Hungary has been affected by

the food price increase even more severely than the level presented in the analysis of the survey results. More than 3.3% of the respondents reported not being able to purchase a sufficient amount of food, which implicates severe insecurity, and this proportion is above the previous data (<2.5%).

3.4. Results published in Publication 3

Due to the results of our GLS random effects regression model (357 observations from 17 countries between 2001 and 2021; independent variable: Prevalence of Undernourishment, *PoU*), population size (+), economic growth (+), the value of agricultural production (–), agricultural employment (+), the cereal imports dependency ratio (–/+), and the number of deaths in battle were statistically significant (+), while foreign direct investment, exchange rate, annual temperature change, dummy of refugees, economic crisis, and food price surge dummy variables were not.

H6. Higher performance of the agriculture sector decreases food insecurity – Confirmed.

Our analysis also supports the theory that agriculture plays a pivotal role in food security, as evidenced by the influence of agricultural employment and production value on PoU, emphasizing the importance of efficient and profitable agricultural sectors. This observation is consistent with the notion that in developed nations with advanced agricultural technologies and various social factors, agricultural employment tends to be low, whereas the opposite is true in less developed countries.

H7. The growth of average economic size foster food security – Partially confirmed.

In line with previous research (Applanaidu and Baharudin, 2014; Kovljenič and Raletič-Jotanovič, 2020; Aiyedogbon et al., 2022) we found a positive relationship between population size and PoU, though the impact was less significant than in other studies, due to outliers such as China, Japan, and Mongolia, underscoring the demographic challenges to food security.

However, our hypothesis cannot be completely accepted as our results question several long-held beliefs on the relationship between GDP-growth and food security status. Contrary to the expected negative relationship, we discovered a positive link between GDP and undernourishment, indicating that economic expansion is not a sole predictor of food security, a finding that deviates from common belief and calls for further scrutiny.

H8. Open economic activities positively influence food security. – Rejected.

Similarly, the impact of open economy factors such as the cereal import dependency ratio and foreign direct investment (FDI) on PoU revealed unexpected patterns. The lack of a consistent negative effect of high cereal import dependency on food security challenges the idea that dependence on food imports is inherently harmful. Additionally, the minimal influence of FDI on PoU disputes the notion that FDI is a straightforward solution to enhancing food security through economic growth and agricultural innovation.

H9. Higher changes in average temperature are against food security. – Rejected.

Another surprising discovery was the insignificance of temperature change on food security, suggesting that climate change's expected adverse effects on agriculture and food supply might be offset by other variables, such as adaptive strategies or economic progress in the regions studied.

H10. Crises situations cause food security to decrease. – Partially confirmed.

The "deaths in battle" dummy variable showed a significant impact on the food security of the countries in the three examined regions. However, other crisis-related dummies ("refugees", food price boom, economic crises) had no significant impact on food security in model. This indicates that while geopolitical and societal stability are essential, their direct influence on undernourishment is more complex than assumed, pointing to the necessity for a deeper exploration of resilience mechanisms.

It's important to note that PoU is a measurement of extreme food insecurity. The lack of significant findings for crisis variables suggests that future research could benefit from examining more nuanced indicators like dietary diversity, although such data is scarce in the regions of interest; thus, different geographical scope might be needed for that research.

4. CONCLUSIONS, SUMMARY OF RESULTS

Based on the studies conducted in the two research parts, conclusions can be drawn regarding the two main research questions.

Q1. Could a comprehensive, 3+1 dimensions analysis contribute to discovering new results regarding crisis-caused impacts and their interplays in the food system?

Publication 1 investigated the effects of the supply chain and economic crises triggered by lockdowns, travel bans, and transportation restrictions following the COVID-19 outbreak, using a systematic literature review at a global scale. The selected articles reported empirical findings on both the consumer side (access and utilization) and the supply side (availability) of the food system. The analysis of physical access to food during the pandemic revealed

significant causal relationships among the physical access, availability, economic access, and utilization/nutrition dimensions. Physical access to food was hindered in two primary ways during this period. First, consumers autonomously chose to limit food purchases due to fear of infection. Second, political measures, such as curfews and movement restrictions, further restricted access. The decline in food purchases led to temporary food shortages in certain households, reducing their nutritional status. Simultaneously, decreased food demand resulted in lower sales prices for agricultural commodities, which caused income losses for rural agricultural households. This, in turn, reduced their ability to purchase food from markets, a critical factor in mitigating the impacts of crises on food security for rural population, as noted by Vlassenroot and Raesmaekers (2004) and Wineman et al. (2017). Additionally, movement and border restrictions caused temporary income losses for agricultural workers and led to shortages of labor and other inputs for agricultural production. These findings underscore the importance of considering the entire food system when implementing restrictions to address future crises. Decision-makers must account for the interconnected impacts on food access, availability, and utilization to minimize disruptions and enhance resilience.

Publication 2 examined the impact on food security of the food price crisis in Hungary, which was the result of COVID-19 and the Russian-Ukrainian war, as well as domestic economic and political dynamics. To answer the research question, I examined all 3+1 food security dimensions pre-crisis and amid crisis, applying both secondary national data and primary household survey data. The simultaneous examination of the 3+1 dimensions made it possible to detect an interplay between physical access, economic access, and utilization dimensions. I discovered an effect of food price surge, where food consumers seeking better offers tend to shift from smaller local stores to larger supermarkets, hypermarkets, and discount stores, thereby enhancing market concentration, and potentially contributing to further price increases. Those who are not able to regularly visit larger, cheaper stores far from their home turned out to be the most vulnerable, as they had to decrease the diversity of their diet and, in some cases, even the amount of energy they intake.

Consequently, the answer to the first research question (Q1) is yes, a comprehensive, 3+1-dimension analysis can contribute to new results by discovering interplays of crisis impacts between different food security dimensions.

Q2. Can well-established statistical methods – commonly used to identify food security determinants – be effectively applied to assess the deterministic effect of crises on food security?

In Publication 3, we searched for determinants of prevalence of undernourishment at a super-regional level (East, South, and Southeast Asia), with a relatively high number of observations through a logistic regression model, in which we used dummy variables representing different types of crises: years when the share of refugees in the host country's population was higher or equal to 0.01%; years when fatal casualties happened on the battlefield on the territory of the country; the years of remarkable food price increases in the three regions: 2007, 2008, 2011, 2014, 2019, 2020; years of the food price crisis in 2007, 2008, years of COVID-19 in 2020, 2021; years of food crisis + 1.

Aside from battlefield deaths, crisis-related factors have not significantly affected food security. This suggests that, although geopolitical and societal stability are crucial, their direct impact on undernourishment is more intricate than previously assumed, highlighting the need to explore resilience mechanisms further. It's important to remember that the PoU (Prevalence of Undernourishment) reflects extreme food insecurity, and the absence of significant results for crisis variables indicates that future studies may need to focus on more sensitive indicators, such as dietary diversity. The conclusion that in East, South, and Southeast Asia, PoU is no longer a reliable indicator to examine changes in food security indicates a positive development in regard to the food security status of these three regions; however, this poses difficulty for further panel data analysis since data for more nuanced indicators are rarely available for longer periods.

The above detailed results are concisely presented in Table 3:

Table 3. Summary of research questions, sub-questions, and hypotheses

Research Part I.	
Q1. Could a comprehensive, 3+1 dimensions analysis contribute to discovering new results regarding crisis-caused impacts and their interplays in the food system?	Yes, it can. The research published in Publications 1 and 2 proved that a 3+1 dimension approach can reveal otherwise neglected interplays and causalities between food security dimensions and between the components of the food system.
Publication 1: a systematic literature review limited to the COVID-19 pandemic crisis-related effects on food security, without geographical limitation.	
SQ1. What segments of food security have been affected by the COVID-19 lockdown and	All 3+1 dimensions have been affected, but primarily the economic

pandemic?	access dimension.
SQ2. Are the COVID-19-related food security problems temporary and "crisis specific" or are they rooted in structural weaknesses?	Most of the impacts are temporary, however the biggest problem proved to be income loss combined with previous low income.
SQ3. Are new food security objectives needed to mitigate the negative effects of the pandemic and prepare for a possible future pandemic?	The most important objective remains poverty reduction to build resilience against food security crises.
Publication 2: a national-level statistical analysis of the impact of the food price surge in Hungary 2022–2023 on food security.	
H1. Despite the overall improvement in food security in Hungary between 2015 and 2020, significant differences in dietary quality persisted across households with different income levels.	Confirmed.
H2. Food availability in Hungary remained stable even during the disruptions to food supply chains caused by the COVID-19 pandemic and the Russian-Ukrainian war.	Confirmed.
H3. The food price surge in 2022–2023 induced changes in food purchasing patterns through deteriorating affordability.	Confirmed.
H4. The change in consumption is not reflected in a reduction in total energy intake but rather in a decrease in the consumption of micronutrients and dietary fiber.	Rejected.
H5. The gap between the dietary quality of the lowest and highest income groups increased in 2022–2023.	Confirmed.
Research Part II.	
Q2. Can well-established statistical methods — commonly used to identify food security determinants — be effectively applied to assess the deterministic effect of crises on food security?	Research Part II (presented in Publication 3) failed to fully assess the deterministic effects of all crisis variables. However, I suggest that this limitation arose not from the chosen method (random effects regression model) but rather from the selection of the independent variable (PoU).
Publication 3: applying a panel data logistic regression model to detect food security determinants and the deterministic feature of crisis events on food security in East, South, and Southeast Asia between 2001 and 2021.	
H6. Higher performance of the agriculture sector decreases food insecurity.	Confirmed.

H7. The growth of average economic size fosters food security.	Partially confirmed.
H8. Open economic activities positively influence food security.	Rejected.
H9. Higher changes in average temperature are against food security.	Rejected.
H10. Crisis situations cause food security to decrease.	Partially confirmed.

Source: Own compilation.

5. Contribution to existing literature

Besides answering the research questions and adding new conceptual and methodological approaches to the research on the crisis-impacts on food security, each research phase produced several results, which contribute to the literature on a wide range due to the diversity in methodology and approaches. Number of results:

a.) conclusions based on the qualitative analysis of the systematic literature review: 21;

b.) statistical results based on primary data: 128;

c.) statistical results based on secondary data: 183.

Many of these findings align with previous research; however, several challenge the existing literature or highlight unresolved research gaps.

Although mental distress during crisis events as a cause of negative dietary shifts has received some attention lately (Bakaloudi *et al.*, 2022; Shamir-Stein *et al.,* 2024), during my review of the theoretical and empirical literature, I have not encountered studies that would express that the psychological well-being of the food consumers is not only affecting their own nutrient intake but has an impact on the whole food system. As I presented above by answering my first research question (Q1), in Publication 1, we concluded that anxiety caused disruption in physical access, which means lower food demand which affects the producer, transportation, and retail components of the food system. Therefore, in the future, it is important to consider the psychological well-being of individuals when planning communication strategies for crisis management, since the mental distress of food consumers impacts the whole food system and has economic consequences.

After an 11-year hiatus, Publication 2 completed a comprehensive food security overview of Hungary, including an analysis of income, consumption, and nutrient intake for the period 2015–2020 and a household survey and analysis for the food price crisis of 2022–2023. The latter also filled a void in the literature, as previous publications of these surveys

took place during the COVID-19 crisis when households encountered different difficulties compared to the 2022–2023 food price surge.

The unexpected findings in Publication 2 were that the proportion of people unable to buy enough food was higher than international malnutrition rates for Hungary and that the phenomenon of only small and expensive grocery stores being available near the household is significant among urban and even capital city residents, not just in small villages as I had assumed relying on previous literature and national statistical data.

According to the previous findings of the literature, food retail concentration leads to higher prices, thus endangering food security (Aalto-Setälä, 2002; Hovhannisyan et al., 2019). However, it has not been pointed out before that in case of a food price crisis, the consumers' coping strategy – shifting from smaller nearby grocery shops to discount stores and supermarkets for current lower prices – can enhance further retail concentration, thus prolonging the ongoing crisis (Publication 2). Political decision-makers might consider this phenomenon in their crisis-management strategy.

In Publication 3, several unexpected results emerged. It confirmed the assumption that agricultural development and smaller populations predict stronger food security. However, despite the findings of Subramanyam et al. (2011), Applanaidu and Baharudin (2014), Warr (2014), and Aziz et al. (2021), we found a negative relationship between economic growth and food security. The weak influence of import dependency of cereals, the insignificance of FDI, and temperature change are unexpected results as well and contribute to the prevailing theories in the literature as valid exceptions.

Another surprising result was that despite the South Asian region – one of the most food insecure regions in the world – was included in the research, PoU did not prove to be a sufficiently sensitive independent variable to statistically confirm the impact of crises on the food security of the region. This suggests that the food security of the South Asian region has improved significantly over the past two decades, highlighting the need for more sensitive indicators to track changes in the region's food security status.

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