

Impact of the Ukraine Conflict on Food Security: A Comprehensive Analysis Using Propensity Score Matching and Difference in Difference

Zhixing Chen¹ Jitong Yao²

1. William A. Shine - Great Neck South High School, Shenzhen, Guangdong, 518000, China

2. Drean Get Education Inc., Shenzhen, Guangdong, 518000, China

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ABSTRACT

This paper explores the significant impact of the Ukraine conflict on local food security, employing a robust methodological framework that integrates Propensity Score Matching (PSM) and Difference-in-Differences (DiD) estimation, supplemented by placebo tests and the synthetic control method. By examining panel data from 2014 to 2022, the study reveals a causal relationship between the conflict and a notable deterioration in Ukraine's food security index. The conflict, characterized by direct damages to agricultural production and infrastructure, alongside indirect economic and social disruptions, has led to a substantial decline in food security. This research contributes to understanding the dynamics of how war affects food security and provides actionable insights for policy formulation and response strategies to mitigate such impacts in similar conflict scenarios. Through a comprehensive analysis, it highlights the urgent need for international cooperation and humanitarian aid to address the challenges posed to food security by the war, emphasizing the broader implications for global food markets and prices.

1. Introduction

The core importance of food security lies in its fundamental impact on the quality of human life. Food security is not just about nutritional adequacy but is also the foundation of health and well-being. In 2021, approximately 139 million people globally were in a state of food crisis or severe insecurity, with war and instability being the primary driving ^[1]. Against this backdrop, the outbreak of the war in Ukraine has not only caused a local humanitarian disaster but also posed a severe challenge to global food security.

The full-scale military invasion of Ukraine by Russia on February 24, 2022, resulted in civilian casualties and damage to key infrastructure, followed by extensive sanc-

tions imposed on Russia by Western countries. The direct consequences of this war are not only a humanitarian crisis in Ukraine but also shocks to the global food and energy markets, particularly with prices remaining high until the end of 2024, further threatening global food security ^[2].

The outbreak of the war has exacerbated global concerns about food security. Ukraine and Russia, serving as the "breadbasket of the world," play significant roles in the global food and fertilizer industry. Both countries are major producers and exporters of agricultural products, minerals, fertilizers, and energy, with their resources being rich and typically concentrated in a few countries ^[3]. Therefore, the war in Ukraine has had a significant impact on the global food market and prices, especially against

*Corresponding Author:

Jitong Yao,

Male, Bachelor of Sociology, University of California;

Research direction : Sociology

Email:

the backdrop of supply chain disruptions caused by the COVID-19 pandemic, strong global demand, droughts, and poor harvests in South America ^[3].

Four months after the outbreak of the war, Ukraine's exports came to a halt, and future harvests became uncertain, leading to soaring global agricultural product prices and potentially plunging millions into hunger and poverty. Price increases and trade disruptions could also limit the supply of humanitarian aid for the prevention and treatment of acute malnutrition, increasing the number of malnourished individuals. The World Food Programme estimates that the number of people facing severe hunger will increase by 47 million compared to the pre-war baseline, with 323 million people expected to face severe food insecurity in 2022 ^[4]. The World Bank estimates that for every percentage point increase in food prices, 10 million people are pushed into severe poverty ^[5].

The purpose of this study is to investigate the direct impact of the war in Ukraine on local food security. Employing the PSM-DID method, combined with placebo tests and the synthetic control method for robustness checks of regression results, this study aims to reveal the causal relationship between the war and the local food security index in Ukraine. Through this approach, the specific impact of the war on food security in Ukraine can be more accurately determined, providing policy recommendations and response strategies for similar conflicts that may occur in the future.

2. Literature review

The direct impacts of war on food security are profound, with the most noticeable being disruptions to the harvesting and transportation of agricultural products, directly affecting staple supply and prices. The war has compromised Ukraine's ability to transport agricultural products both domestically and internationally, especially when port facilities and railways are damaged ^[6]. In fact, the war has caused a disruption to 95% of Ukraine's grain exports, primarily corn, especially during spring and early summer. Due to the lack of an effective railway system, even though alternative transportation routes, such as exporting through Poland or Romania, are feasible, these paths face many challenges, such as differing railway gauges and limited storage capacity. Additionally, increased insurance costs in the Black Sea region further exacerbate transportation costs, affecting food import prices ^[7].

The war has also made it impossible for Ukrainian farmers to farm normally, with conscription and displacement causing labor shortages, thereby affecting agricultural activities. The lack of key agricultural inputs, such as fertilizers, exacerbates this issue, potentially disrupting

ongoing spring planting and the upcoming winter crop harvests. According to the Food and Agriculture Organization, by 2022, up to a third of crops and farmland may be unharvested or unfarmed ^[8].

On the other hand, the economic sanctions against Russia create uncertainty for Russian exports. While Russia's Black Sea ports remain temporarily open, financial sanctions have led to currency depreciation, which could hinder productivity and development, and ultimately raise the costs of agricultural output. Moreover, Russia's restrictions on exporting agricultural products and food to non-"friendly" countries will exacerbate global food supply shortages, raise prices, and weaken the food security of hundreds of millions ^[9].

The indirect effects of the Ukraine war cannot be overlooked either. First, the rise in prices of basic inputs, such as fertilizers, leads many farmers globally to switch to crops with lower fertilizer requirements, like soybeans, which may exacerbate the supply shortages of high fertilizer-demand crops like wheat and corn ^[1]. Second, many countries have implemented export restrictions to ensure local food supply, which, although may be effective in the short term, could have profound effects on global food pricing and security in the long term. Moreover, panic buying behaviors at the national and individual levels, especially during the COVID-19 pandemic, indicate high levels of concern for food security during crises ^[8].

The war could also affect the economy's ability to access food, especially against the backdrop of the global economy impacted by the COVID-19 pandemic. This could lead to an increase in the costs of food and energy, disproportionately affecting the poor and middle class. The rise in international prices affects those dependent on grain ^[9].

An important aspect when discussing the impact of the Ukraine war on food security is the consideration of endogeneity issues. In recent years, food security and its consequences have garnered widespread attention, with research primarily focused on the conceptual understanding of food insecurity, such as insufficient dietary energy supply and malnutrition, and how to mitigate these issues. Additionally, researchers and practitioners have begun to explore the impact of food insecurity on conflict, a relatively new but crucial field ^[10].

Food security issues vary across regions and societies, influenced by the type, intensity, and income levels of armed conflicts. Its impacts stem from multiple levels, including the nutritional and economic opportunities at the individual and household levels, which may directly affect the likelihood of engaging in antisocial behaviors (Briones Alonso, Cockx, and Swinnen, 2018). Moreover,

more macro-level factors, such as global food prices, policies, and wartime institutions, markets, governance, and climate conditions domestically and locally, also have significant impacts ^[11].

Especially at the individual level, food insecurity or its threat may stimulate material and immaterial motivations, prompting individuals to engage in antisocial behaviors. However, due to the complexity of motivations and the lack of empirical evidence, it is challenging to measure precisely. These motivations are often complex and difficult to measure empirically, and the presence of alternative mechanisms not directly associated with food insecurity (such as kidnapping, peer pressure, ideology, and sentiment) makes it difficult to distinguish empirically.

Charles P. Martin-Shields and Wolfgang Stojetz in 2019 ^[12] researched the causal relationship between food security and conflict, finding robust quantitative evidence of a bidirectional relationship between food security and violent conflict, which explains the endogeneity issues. They summarized existing evidence and identified limitations in both directions: (i) the impact of violent conflict on food insecurity; and (ii) the impact of food insecurity on violent conflict as discussed in section 3.3. They utilized the Russia-Ukraine conflict as an exogenous shock, effectively mitigating the bidirectional

3. Data and methodology

This paper employs the Difference-in-Differences (DiD) estimation method, referenced from Card and Krueger (2000) ^[13], to compare changes in the food security index over time between matched treatment and control groups, while considering both time and individual fixed effects. This approach helps isolate the causal impact of the Ukraine war on food security, controlling for both observable and unobservable confounding factors. The model is specified as follows:

$$Y_{it} = \beta_0 + \beta_1 * War_{it} + \beta_2 * Treat_{it} + \beta_3 * Post_{it} + \beta_4 * X_{it} + \alpha_i + r_t + \varepsilon_{it}$$

Where Y_{it} represents the food security score of country i at time t . Food security, the dependent variable in this study, is a multidimensional and flexible concept with multiple definitions. This paper adopts the definition proposed by the Food and Agriculture Organization (FAO) in 1996 and revised in 2001: "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" ^[13]. To measure food security, this paper utilizes the food security index data from The Economist Intelligence Unit, which covers aspects such as affordability, availability, quality and safety, sustaina-

bility, and adaptability.

War_{it} represents the interaction term for the treatment group (Ukraine) and the post-treatment period (after 2022). $Treat_{it}$ is a binary variable indicating Ukraine (1 for Ukraine, 0 for others). $Post_{it}$ is a binary variable for the period after 2022. X_{it} includes control variables such as GDP, consumption, savings, secondary industry development, inflation CPI, the index of economic freedom, population, and arable land area. α_i and r_t represent country and year fixed effects, respectively. ε_{it} is the error term.

The index of economic freedom is calculated using the Principal Component Analysis (PCA) method, based on sub-indices such as property rights, integrity, fiscal freedom, government spending, business freedom, labor freedom, monetary freedom, trade freedom, investment freedom, and financial freedom. Data for all control variables are sourced from the United Nations Statistics Division, the World Bank database, and the International Monetary Fund database.

To further reduce endogeneity issues, this study combines the use of Propensity Score Matching (PSM) and DiD estimation. PSM matches Ukraine with other countries that have not experienced war, based on observable covariates such as GDP, consumption, savings, and secondary industry development, helping to reduce biases that may arise from unobserved differences between the treatment and control groups ^[14]. By matching countries that are similar in these characteristics, PSM helps to reduce bias.

The original dataset includes samples from 141 sovereign countries from 2014-2022. Given that war conflicts and food security are highly correlated with national characteristics, prone to selection bias, this paper matches control group firms closest to Ukraine in national characteristics using the Propensity Score Matching method to avoid the impact of selection bias on the accuracy of causal inference. Specifically, this study uses GDP and population as covariates, estimates propensity scores through logistic regression, and employs nearest neighbor matching to match each treated unit with 8 untreated units with similar propensity scores, constructing a comparable control group (Leuven & Sianesi, 2018). A caliper value of 0.05 is set to limit the difference in propensity score values between the control and treatment group samples. The matching results passed the balance test proposed by Rosenbaum and Rubin (1985). Figures 1 and 2 show the control group countries are essentially the same as Ukraine after matching.

Descriptive statistics are reported table 1 below, with the score being log-transformed. The mean and median are relatively close, indicating a normal distribution.

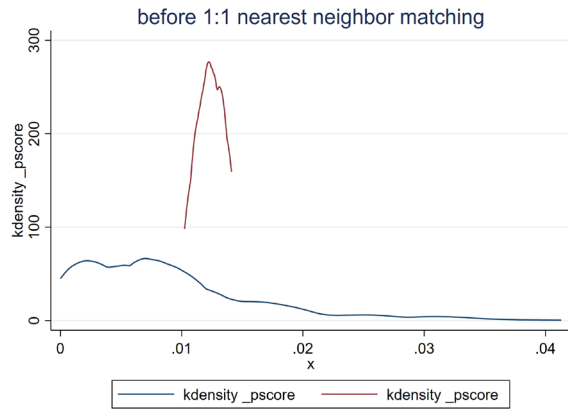


Figure 1. Before matching

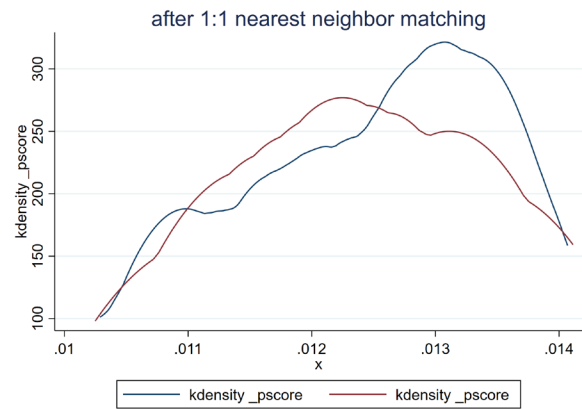


Figure 2. After matching

Table 1. Descriptive Statistic

Variable Name	Obs	Mean	Median	Min	Max	SD
score	50	4.050	4.032	3.525	4.406	0.196
treat	50	0.160	0.000	0.000	1.000	0.370
post	50	0.100	0.000	0.000	1.000	0.303
War	50	0.020	0.000	0.000	1.000	0.141
GDP	50	24.841	24.893	21.802	28.121	1.880
consumption	50	0.766	0.763	0.428	1.061	0.125
saving	50	0.004	0.002	-0.010	0.021	0.006
secondary	50	3.957	3.587	1.667	7.630	1.560
InflationCPI	50	9.329	5.023	4.473	23.163	7.089
EconFreeIndex	50	4.058	4.124	3.845	4.196	0.100
Population	50	1.250	1.255	0.870	1.675	0.220
AgrArea	50	12.981	13.019	12.497	13.019	0.107

4. Results

The results presented in the first column in table 2 illustrate the average impact of the Ukraine war on local food security in Ukraine, showing a significant decline in food security with a regression coefficient of -0.337 at the 1% significance level. This indicates that food security in Ukraine has significantly deteriorated following the war. The second column, which includes control variables on top of the first column’s model, shows a regression result of -0.263, significant at the 1% level. Columns three and four, which regress using robust standard errors on the ba-

sis of previous models, maintain consistency with the first and second columns, indicating a certain robustness in the regression results.

From an economic perspective, these results clearly demonstrate the destructive impact of war on a country’s food security. Particularly for Ukraine, the war has not only directly affected its agricultural production capacity but may also exacerbate food security issues through indirect means such as infrastructure damage, economic turmoil, and social instability. Therefore, policy measures and aid during and after the war are crucial for mitigating these negative impacts.

Table 2. Baseline regression

	(1)	(2)	(3)	(4)
	score	score	score	score
War	-0.337*** (-4.704)	-0.263** (-2.306)	-0.337*** (-6.658)	-0.263** (-2.515)
treat	0.220*** (3.273)	1.177 (1.589)	0.220*** (3.570)	1.177 (1.306)
post	0.000 (.)	0.167** (2.238)	0.000 (.)	0.167* (1.911)
GDP		0.007 (0.047)		0.007 (0.033)
consumption		-1.378* (-2.019)		-1.378 (-1.401)
saving		-3.949 (-1.189)		-3.949 (-0.791)
secondary		0.067 (1.399)		0.067 (1.588)
InflationCPI		0.138 (1.002)		0.138 (0.889)
EconFreeIndex		-0.022 (-0.089)		-0.022 (-0.071)
Population		0.001 (0.380)		0.001 (0.296)
AgrArea		0.000 (.)		0.000 (.)
_cons	3.765*** (50.523)	1.154 (0.292)	3.765*** (53.272)	1.154 (0.240)
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
N	50	50	50	50
r2_a	0.914	0.909	0.914	0.909

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5. Robustness Check

To further verify the robustness of the experimental results and address endogeneity issues, this paper employs three methods: parallel trend tests, placebo tests, and synthetic control methods to further examine the robustness of the regression results.

5.1 Parallel Trend Test

The parallel trend assumption is a prerequisite for employing DID in empirical papers. The target variable for both the treatment and control groups before the policy implementation (pre-treatment) must satisfy the parallel trend assumption for DID to be applicable. Conversely, if there are pre-existing differences between the treatment

and control groups before the policy, the DID results may not represent the net effect of the policy, as other factors could influence the changes in the dependent variable. Therefore, a parallel trend test is conducted first.

Figure 3 is a time trend graph showing that before the start of the Russia-Ukraine war (2022), the food security index trends of both the treatment and control groups were generally consistent and upward. However, during the two years of 2022, the directions of the target variable changes for the two groups diverged. Ukraine experienced a sharp decline after the war, while the synthetic control group continued an upward trend. Thus, it can be preliminarily judged that the parallel trend assumption before the Russia-Ukraine war is basically satisfied, and the difference in trend lines after 2022 is likely caused by the war. Howev-

er, this conclusion is not robust and requires further examination of the dynamic effects between the two groups.

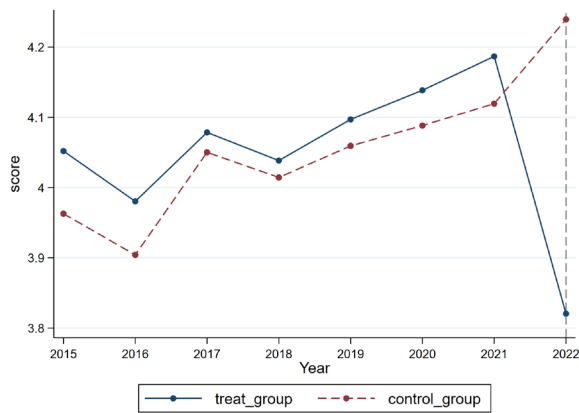


Figure 3. Parallel trend test

Figure 4 is a dynamic effect test graph, where the vertical capped short lines perpendicular to the horizontal axis represent the 95% confidence intervals of the regression coefficients of the interaction terms with the treatment group dummy variable for each period. Before period 0 (2022), the pre-war coefficients are not significant (the 95% confidence intervals do not cross the coefficient = 0 horizontal line), whereas the coefficients after the war are generally significant.

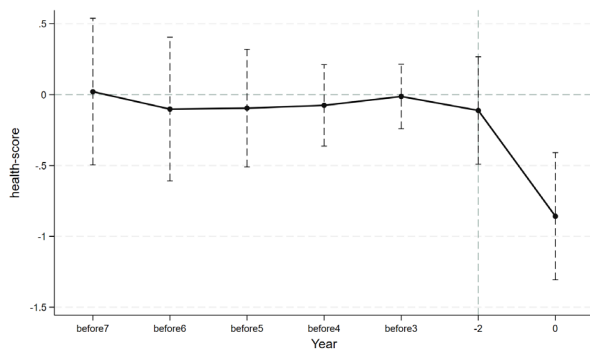


Figure 4. Dynamic effect test

5.2 Placebo Test

The placebo test, following the approach of Xu Si et al. , is employed to rule out the influence of time trends and ensure that the deterioration in food security is not due to local policies or other random factors, but rather a consequence of the war. To exclude this potential possibility, the study randomly selects individuals as the treatment group and repeats this process 100 times to test whether the coefficients of the “pseudo-policy dummy variables” are significant. The graph displays the distribution of the 100 “pseudo-policy dummy variable” estimation coeffi-

cients and their corresponding p-values, where the x-axis represents the t-values of the regression of the constructed pseudo-experimental group dummy variable on food security, the y-axis represents density values, and the curve is the kernel density distribution of the estimated-coefficients. The red dots represent the p-values of the estimated coefficients, the vertical dashed line represents the real estimated value of the DID model (-0.171), and the horizontal dashed line represents the significance level of 0.1. From the graph, it is evident that the estimated coefficients are mostly concentrated around zero, with most of the estimated values having p-values greater than 0.1 (not significant at the 10% level). This indicates that the estimation results are unlikely to be obtained by chance and are thus unlikely to be influenced by other policies or random factors.

This placebo test provides robust evidence supporting the validity of the original findings by demonstrating that the observed effects on food security are indeed attributable to the impact of the war, rather than being driven by other time-varying unobserved confounders. This strengthens the argument that the war has had a significant negative effect on food security in Ukraine, reinforcing the need for targeted policy interventions and support to address these challenges.

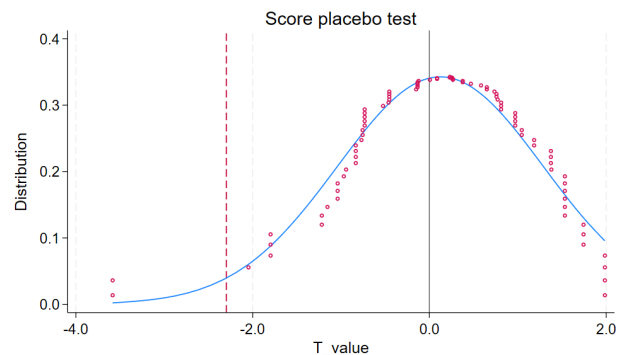


Figure 5. Placebo test

5.3 Synthetic Control Method

To further validate the results of this study, we employed the Synthetic Control Method (SCM) proposed by Abadie and Gardeazabal (2003) ^[15] for the final robustness check. Using the original sample of 141 sovereign countries and further selecting samples that did not experience war from 2014 to 2022, we chose a set of control units from countries that were not affected by war intervention. Then, through a data-driven approach, weights were assigned to these control units to construct a “synthetic Ukraine.” This synthetic Ukraine’s pre-war characteristics

are as similar as possible to the real Ukraine, but it did not undergo the same policy changes during and after the war. The graph shows the food security trend of synthetic Ukraine compared to Ukraine, with the dashed line representing synthetic Ukraine closely following the trend of Ukraine. However, after the outbreak of the war in 2022, the food security of synthetic Ukraine declined, but not as severely as in Ukraine. This method reduces errors from subjective selection and effectively avoids endogeneity issues in policy. It allows us to simulate the target entity (i.e., Ukraine) before policy implementation through the weighting of multiple control units. This not only clearly reflects each control entity's contribution to constructing the "counterfactual" scenario but also avoids the problem of excessive extrapolation.

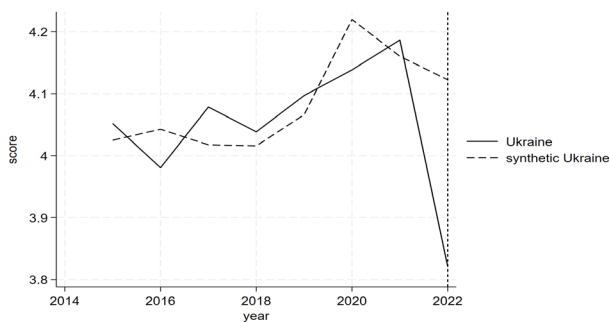


Figure 6. SCM

6. Conclusion

This study, using panel data from 2014 to 2022 years, delves into the direct impact of the war in Ukraine on local food security, revealing the causal relationship between the war and Ukraine's food security index. By integrating the Propensity Score Matching (PSM) and Difference-in-Differences (DiD) estimation methods, along with placebo tests and the synthetic control method for robustness checks, this research offers a new perspective on how war affects food security and proposes policy recommendations and response strategies for similar conflicts that may occur in the future^[16].

The findings indicate that the war in Ukraine has had a significant negative impact on its food security, with a significant decline in the food security index by 0.3. This finding is not only statistically significant but also carries important economic implications. The war has directly destroyed agricultural production and infrastructure and indirectly caused economic turmoil and social instability, further weakening food security.

The methodological framework employed in this study provides an effective tool for quantifying and analyzing the impact of similar international conflicts on food secu-

urity. With the PSM-DiD method, we were able to construct a comparable control group, effectively reducing bias from unobserved differences. Moreover, by conducting parallel trend tests, placebo tests, and applying the synthetic control method, the results of this study demonstrate good robustness, adding credibility to our conclusions.

However, this study has limitations. First, it only covers the short-term impact of one year after the war. This may limit the statistical power of the analysis and increase the risk of Type II errors (false negatives). Secondly, due to the limited time range of the data, this paper does not provide an analysis of the long-term effects of the war on Ukraine's food security. Future research could explore this area further for a more comprehensive understanding of the long-term impacts of war.

Finally, this study emphasizes that mitigating the negative impacts of war on food security requires the collective efforts of the international community, including providing humanitarian aid, improving agricultural production conditions, and enhancing international cooperation. These efforts are crucial for securing food security in war-torn regions and globally. We hope this research can provide reference for understanding and responding to the impacts of similar conflicts on food security in the future, and promote the development of more effective policies and strategies.

References

- [1] T. Ben Hassen and H. El Bilali, 'Impacts of the Russia-Ukraine War on Global Food Security: Towards More Sustainable and Resilient Food Systems?', *Foods*, vol. 11, no. 15, Art. no. 15, Jan. 2022, doi: 10.3390/foods11152301.
- [2] 'Ukraine: Civilian Deaths from Cluster Munitions | Human Rights Watch'. Accessed: Feb. 08, 2024. [Online]. Available: <https://www.hrw.org/news/2023/07/06/ukraine-civilian-deaths-cluster-munitions>
- [3] OECD, OECD Economic Outlook, Interim Report March 2022: Economic and Social Impacts and Policy Implications of the War in Ukraine. in OECD Economic Outlook. OECD, 2022. doi: 10.1787/4181d61b-en.
- [4] WFP, 'War in Ukraine Drives Global Food Crisis'. World Food Programme Rome, Italy, 2022.
- [5] 'Remarks by World Bank Group President David Malpass to the U.S. Treasury's Event on "Tackling Food Insecurity: The Challenge and Call to Action"', World Bank. Accessed: Feb. 08, 2024. [Online]. Available: <https://www.worldbank.org/en/news/speech/2022/04/19/remarks-by-world-bank-group>

- president-david-malpass-to-the-u-s-treasury-s-event-on-tackling-food-insecurity-the-challeng
- [6] R. E. Mbah and D. F. Wasum, 'Russian-Ukraine 2022 War: A review of the economic impact of Russian-Ukraine crisis on the USA, UK, Canada, and Europe', *Advances in Social Sciences Research Journal*, vol. 9, no. 3, pp. 144–153, 2022.
- [7] Beirut Lebanon, 'War in Ukraine will lead to a record of about 126 million poor in the Arab region', *United Nations Economic and Social Commission for Western Asia*. Accessed: Feb. 08, 2024. [Online]. Available: <http://www.unescwa.org/news/war-ukraine-will-lead-record-about-126-million-poor-arab-region>
- [8] C. Arndt, X. Diao, P. Dorosh, K. Pauw, and J. Thurlow, 'The Ukraine war and rising commodity prices: Implications for developing countries', *Glob Food Sec*, vol. 36, p. 100680, Mar. 2023, doi: 10.1016/j.gfs.2023.100680.
- [9] N. Yazbeck, R. Mansour, H. Salame, N. B. Chahine, and M. Hoteit, 'The Ukraine-Russia War Is Deepening Food Insecurity, Unhealthy Dietary Patterns and the Lack of Dietary Diversity in Lebanon: Prevalence, Correlates and Findings from a National Cross-Sectional Study', *Nutrients*, vol. 14, no. 17, p. 3504, Aug. 2022, doi: 10.3390/nu14173504.
- [10] E. Briones Alonso, L. Cockx, and J. Swinnen, 'Culture and food security', *Global Food Security*, vol. 17, pp. 113–127, Jun. 2018, doi: 10.1016/j.gfs.2018.02.002.
- [11] Simon Maxwell, 'Food security: a post-modern perspective - ScienceDirect'. Accessed: Feb. 08, 2024. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S0306919295000747>
- [12] D. Card and A. B. Krueger, 'Minimum Wages and Employment: A Case Study of the Fast-Food Industry in New Jersey and Pennsylvania: Reply', *American Economic Review*, vol. 90, no. 5, pp. 1397–1420, Dec. 2000, doi: 10.1257/aer.90.5.1397.
- [13] FAO, 'Declaration on world food security', *World Food Summit*. FAO Rome, Italy, 1996.
- [14] A. Abadie and J. Gardeazabal, 'The economic costs of conflict: A case study of the Basque Country', *American economic review*, vol. 93, no. 1, pp. 113–132, 2003.
- [15] Koren, O., Bagozzi, B.E. From global to local, food insecurity is associated with contemporary armed conflicts. *Food Sec.* 8, 999–1010 (2016). <https://doi.org/10.1007/s12571-016-0610-x>
- [16] Heckman, J. J., Ichimura, H., & Todd, P. E. (1997). Matching as an Econometric Evaluation Estimator: Evidence from Evaluating a Job Training Programme. *The Review of Economic Studies*, 64(4), 605–654. <https://doi.org/10.2307/2971733>