

FOOD SECURITY WITHIN COVID-19 PERIOD

BY

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LIST OF ABBREVIATIONS

BLUE	Best Linear Unbiased Estimator
BP-LM	Breusch and Pagan's Lagrange Multiplier
CFPI	Consumer Food Price Index
CLRM	Classical Linear Regression Model
CPI	Consumer Price Index
DFID	Department for International Development
ECM	Error Correlation Model
EIU	Economist Intelligence Unit
FAO	Food and Agriculture Organization
FEM	Fixed Effect Model
FIES	Food Insecurity Experience Scale
FS	Food Security
GDP	Gross Domestic Product
GFSI	Global Food Security Index
GMM	Generalized Method of Moments
GSCPI	Global Supply Chain Pressure Index
GWR	Geographically Weighted Regression
HPS	Household Pulse Survey
ILO	International Labour Organization
IMF	International Monetary Fund
lnGDP	GDP per capita

OECD	The Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
PCSE	Panel-Corrected Static Error
PGR	Population Growth Rate
POLS	Pooled Ordinary Least Square
PPP	Purchasing Power Parity
REM	Random Effect Model
RFP	Rising Food Prices
SCD	Supply Chain Disruption
SNAP	Supplemental Nutrition Assistance Program
UEMP	Unemployment Rate
UNSD AMA	United Nations Statistics Division National Accounts Estimate of Main Aggregates
WHO	World Health Organization

PREFACE

Covid-19 pandemic brought unprecedented challenges to global food security. The lockdown and movement restrictions for the purpose of preventing the spread of the pandemic brought negative effects to the food system of the countries worldwide. Movement restrictions, supply chain disruptions, and economic slowdowns have significantly affected food availability, accessibility, and affordability. As a result, food security has become a global concern. Before the pandemic, food insecurity showed an upward trend. Covid-19 further exacerbated global food insecurity and made this issue remain the global concern. This research focuses on moderate food security countries with a score ranging from 50% to 79.9% because these countries are rarely discussed in the existing literature.

This research aims to examine the relationship between unemployment rate, supply chain disruptions, rising food prices, and food security of the moderate GFSI countries from 2018 to 2022. By including the period before and after the pandemic, this research can provide a more comprehensive understanding of how economic conditions and market disruptions affect food security of the countries during the pandemic.

I hope that the findings of this study will contribute to the academic discussion on food security on food security under the Covid-19 context and provide useful insights for policymakers to design strategies to strengthen food system resilience to better deal with future global disruptions.

ABSTRACT

Food Security is important to both health and economy. Since the number of people who face food security is showing an upward trend, food security has become a global concern. The Covid-19 pandemic exacerbated global food security by increasing the unemployment rate, disruption in food supply chains, and rise in food prices. As a result, this study aims to examine the relationship between unemployment rate, supply chain disruptions, rising food prices, and food security in countries with moderate Global Food Security Index (GFSI) scores ranging from 50% to 79.9% from 2018 to 2022. Food security is the dependent variable, unemployment rate, supply chain disruptions, and rising food prices are the independent variables, while GDP per capita and population growth rate serves as the control variables. This study employed quantitative research and panel data methodology. All the data are collected from official sources such as the EIU, World Bank, Federal Reserve Bank of New York, IMF, and OECD. The results of this study indicate that the rising food prices and GDP per capita has a significant and positive relationship with food security. However, the unemployment rate, supply chain disruptions, and population growth rate do not have a significant relationship with food security, which means that these variables do not affect the food security of the observed countries during the pandemic. The findings can provide guidance to the governments worldwide to improve food security in their countries.

Keywords: food security, Covid-19, GFSI, unemployment rate, supply chain disruptions, food prices

CHAPTER 1: RESEARCH OVERVIEW

1.0 Introduction

This chapter provides an overview of this research. It serves as an introduction to the research topic and provides the context for the topic. This shapes the foundation of the entire research.

1.1 Research Background

According to the Food and Agriculture Organization (FAO), food security is defined as all people have physical, social, and economic accessibility to obtain sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996). Food security is built out from four dimensions which include availability, access, utilization, and stability. Food availability represents the availability of sufficient quantities of food that fulfills suitable quality. Food access indicates the accessibility of people to sufficient resources to obtain adequate food for a nutritious diet. Utilization identifies the achievement of nutritional well-being through the sufficient diet, clean water, sanitation and health care to utilize food. Stability defines that an individual, household or a population must always have access to sufficient and healthy food regardless of economic shocks, climate events, or periodical events (Food and Agriculture Organisation, 2006).

Food security brings serious threats to global health, affecting global economic and social well-being. Individuals who are facing hunger have a risk of poor physical and mental health issues which include malnutrition, stagnant growth, infectious disease, depression, and even the worst deaths (Gallegos, 2025). Health issues can occur across children, adults, and elderly. In another perspective, food security plays a critical role in economic stability. When people have enough nutrients, they have full physical and mental potential to conduct their work and increase their productivity which in turn

contributes to economic growth (Powell, 2023). Conversely, individuals who are facing food insecurity may suffer from poor health status which affects their ability to work. This may cause the loss of their income and affect their ability to purchase secure food. This scenario can create a vicious cycle where low-income people limit access to food, push more people to poverty and further bring bad effects to the economy. In the long term, food insecurity can slow down the development of the country.

Global food security is threatened by the increase in food demand and the inability of food production to meet climate change (Rahut, Aryal, Manchanda & Sonobe, 2022). The increase in food demand increases burden to the existing food systems, which many of them already find difficult to provide sufficient food to people. While climate change events such as droughts, floods, and heatwaves reduce the crop yields and disrupt food production, the existing food systems are further being exacerbated. The disruptions in food supply cause the price of food to increase and cause vulnerable populations unable access to food. To make matters worse, the outbreak of Covid-19 brings effects such as supply chain disruptions and economic downturn exacerbating the food system, which further worsens the global food insecurity. As a result, global food security has become a growing global concern, especially after Covid-19.

To prevent the transmission of Covid-19, countries worldwide implemented restricted movement and border closure. Although these restrictions were required for public health, these caused significant disruption in economic activity and the food system. Food production was disrupted due to labor shortages that are caused by restricted movement and social distancing, along with import limitations (Pereira & Oliveira, 2020). By this, the supply of food decreases and causes food supply chain disruptions, which leads to the rise in food prices. People's anxious feeling of a decrease in food production increases their demand for food and also causes food prices to increase. At the same time, the pandemic leads to a global economic downturn. This increases the unemployment rate and causes a decline in people's income. As a result, many individuals and households experience a decline in purchasing power, which reduces their ability to access sufficient and nutritious food. Besides that, the rising food prices

can exacerbate food insecurity, especially in the unemployment and poverty populations. Therefore, the Covid-19 exacerbated food insecurity in the world.

This study focuses on countries with Global Food Security Index (GFSI) scores ranging from 50% to 79.9% that indicate a moderate food security environment. Most of the countries are categorized as middle- to low-income countries. They have their own food systems, some of them rely on food imports, whereas some of them rely on domestic agricultural production. As these countries have inherent risks in their food system, they are vulnerable to the food system shocks. Thus, it is important to study these moderate food security countries to gain valuable insight into how the pandemic affects their food security. Furthermore, the countries with high GFSI scores ranging from 80% to 100% indicate that they may have a good food system and high level of economic development (Izraelov & Silber, 2019). In contrast, the countries with low GFSI scores ranging from 0% to 49.9% indicate that the countries have low levels of economic development (Izraelov & Silber, 2019) and poor food systems. As a result, the increase in unemployment rate, supply chain disruptions, and rising food prices may have insignificant and significant effects on these countries' food security. This will make the data less comparative in the analysis. Therefore, this research focuses on the moderate GFSI countries, rather than focusing on low or high GFSI countries.

1.2 Research Problem

Food security remains a global issue as it brings serious impacts to public health and economic stability. When people cannot access sufficient nutrients, they will have some health issues, which reduce their work productivity (BOR, 2020) and ultimately affect the Gross Domestic Product (GDP) and economic growth of the country. The Covid-19 pandemic exacerbated food security worldwide and caused more countries to face more challenges in overcoming food security. In 2019, an estimated 2 billion people worldwide did not have regular access to secure, nutritious, and adequate food. A record of close to 750 million people in the world were facing severe levels of food insecurity this year (FAO, 2020). However, a record 2.37 billion people in the world did not have

access to sufficient food in 2020 which increased almost 320 million people compared to 2019. In 2020, 928 million people experienced severe food insecurity which is more than 148 million people in comparison to 2019 (FAO, 2021). The increased number of people who cannot access sufficient food and faced severe food insecurity in 2020 as part resulted from the Covid-19 pandemic. The main causes of food insecurity such as economic slowdowns, conflicts, and climate change are exacerbated by Covid-19 pandemic (FAO, 2021).

Unemployment rate is a socioeconomic issue that brings negative effects to people and even the economy of a country. When individuals lose their jobs, their income is affected and causes a decline in their purchasing power. This can limit their ability to afford sufficient and nutritious food. As a result, unemployment rate can cause food insecurity among unemployed people. This situation seems the same for the household. For the households that rely on one person as their main income source, the unemployment of the people will increase the food insecurity of the whole family. Covid-19 further exacerbated this problem because the unemployment rate during this period was high. In 2020, when the year the pandemic occurred, the global unemployment rate had a record of 6.5%, which was an increase of 1.1% compared to 2019 (United Nations, 2022). This was due to the global economy being unstable and the movement restrictions imposed by governments. This upward trend can affect the food security of the countries.

Supply chain disruption is another factor that can influence food security. Food supply chain disruption refers to the disruptions in the food supply chain activities that reduce the ability to transfer the food from production to consumer hand. This can affect food availability. The food supply chain during the pandemic was being affected because international trade and border activities were being restricted, border activities being affected and even closure, and logistics being interrupted. In different perspectives, the pandemic also caused labor shortages in the agricultural sector, leading to production shocks and decrease in food supply. The disruptions not only affect food availability but also increase the food prices and decrease the food access. For countries, especially

developed countries that rely on imported food from developing countries (Workie, Mackolil, Nyika, & Ramadas, 2020), the food supply chain disruptions decrease their accessibility to obtain sufficient food.

Furthermore, the rise in food prices also affects food security because inflation reduces the purchasing power and food affordability. Rising food prices force people to cut their food quantity and quality, thereby increasing their risks of hunger and malnutrition. Covid-19 exacerbated this situation. The restriction on border activities and decrease in food production makes the fear of the food market put pressure on food prices. Other than that, the disruption in the food supply chain also caused an increase in food prices. According to FAO (2022), the annual variation of global food consumer price index has increased from 6.3% in 2020 to 6.8% in 2021 due to the pandemic. This indicates that the global food price has recorded an increase of 6.8% compared to 2020. The rising food prices further affected the unemployed individuals, households, and vulnerable populations, especially poverty people by increasing their financial burden to access sufficient food.

In the existing literature, there are two inconclusive results on the effects of Covid-19 on food security issues. On the food supply chain disruptions aspect, a lot of research reported that this issue was caused by production disruptions as well as logistics and distribution problems. According to some research, food production was being affected due to labor shortages that are caused by movement restrictions and the fear of being infected (Barman, Das, & DE, 2021; Workie et al., 2020; Alabi & Ngwenyama, 2022). However, some literature also stated that food supply chain disruption was caused by the border restrictions (Workie et al., 2020; Alabi & Ngwenyama, 2022). While both factors are supported in the existing literature, it remains unclear whether the supply chain disruptions are primarily caused by production disruptions or logistics problems. Besides that, the existing literature also indicates that the supply chain disruptions cause an increase in food prices (Workie et al., 2020; Omotayo, Omotoso, Daud, Omotayo, & Adeniyi, 2022). However, a literature article argued that the decrease in GDP decreases the demand of agricultural products and causes a decrease in food prices

(Beckman, Baquedano, & Countryman, 2021). These two conflicting statements cause unclear understanding whether Covid-19 caused food prices to increase or decrease. These two inconclusive results cause the research gap in the existing research. As a result, this gap needs an empirical analysis to clarify.

1.3 Research Gap

In the existing research, there are many studies focused on the effects of Covid-19 on food security in countries such as Poland (Kowalska, Lingham, Maye & Manning, 2023; Dudek & Śpiewak, 2022), South Africa (Nel, 2024; Hart, Davids, Rule, Tirivanhu & Mtyingizane, 2022), Ghana (Apaliya, Kwaw, Osae, Alolga, , Aikins, , Otoo, Kaburi, Lamptey & Amo-Broni, 2022; Bukari, Aning-Agyei, Kyeremeh, Essilfie, Amuquandoh, Owusu, Otoo & Bukari, 2021), and European Union countries (Pawlak, Malak-Rawlikowska, Hamulczuk, & Skrzypczyk, 2024; Marcuță, Popescu, Tindeche, Smedescu & Marcuță, n.d.). However, there is limited research that specifically focuses on the moderate GFSI countries which get scores from 50% to 79.9% and how they have been affected during the pandemic. These countries may be vulnerable when facing Covid-19 and may have long-lasting impacts on food security that haven't been explored by the existing research. According to Szczepaniak & Olech (2025), there is evidence showing that Covid-19 dropped the country's GFSI ranking. The moderate GFSI score may have been dropped due to the pandemic and the vulnerability that these countries face may be underexplored in the existing literature. Another gap is the inconclusive findings regarding the supply chain disruptions and food prices. Therefore, this study focuses on addressing these two gaps by examining the relationships between independent variables such as unemployment rate, supply chain disruptions, and rising food prices and food security (dependent variable) in countries with the GFSI score from 50% to 79.9%. It is conducted by using panel data methodology to analyze the data from 2018 to 2022. The five-year range from 2018 to 2022 is used as these five years include the period before and after the pandemic.

1.4 Research Questions and Research Objectives

1.4.1 Research Questions

1. What is the relationship between unemployment rate and food security?
2. What is the relationship between food supply chain disruptions and food security?
3. What is the relationship between rising food prices and food security?

1.4.2 Research Objectives

1. To examine the relationship between unemployment rate and food security.
2. To examine the relationship between food supply chain disruptions and food security.
3. To examine the relationship between rising food prices and food security.

1.5 Research Significance

This study can provide valuable data and evidence to practitioners in moderate GFSI countries to enhance their food security. This study can provide guidance to governments and policymakers in designing effective policies to enhance their food security. These policies can provide preventive mechanisms for them when dealing with global events that bring disruptions to food systems. In addition, the findings of this research can provide information to stakeholders in the food industry such as farmers and distributors to understand the vulnerabilities caused by Covid-19 and motivate them to introduce new strategies to reduce future disruptions. Furthermore, this study can also provide a deep understanding to governments and policymakers about how the unemployment rates and rising food prices can affect people's affordability to safety and nutritious food. These understandings can assist them to develop more effective social protection interventions such as food subsidies,

unemployment aid, farmer subsidies, and financial aid for vulnerable populations to help them increase their ability to obtain sufficient food.

Other than that, this research also makes contributions to academics. This research focuses on filling the research gaps in moderate GFSI countries. While the existing literature major focuses on food security in specific countries such as Poland, South Africa, Ghana, and members of the European Union, this research focuses on the post-Covid food security challenges in countries with GFSI scores ranging from 50% to 79.9% that are overlooked in the existing studies. Moreover, this study provides empirical evidence on key variables that affect food security. By studying the relationship between unemployment rate, supply chain disruptions, and food prices with food security, this research provides valuable findings that can be used for future studies and analysis. In addition, this research also provides a framework for future research on crisis recovery in the context of food security. The findings of this study can become a reference model for future research on how global events can affect food security across different types of countries. This provides more information for academic discussion and further contributes more valuable insight into academia.

1.6 Conclusion

In conclusion, this chapter covers the background of this research and shows the evidence of the necessity of this study. It also explained how the factors such as unemployment rate, supply chain disruptions, and rising food prices affect food security. This chapter will serve as a guideline for the subsequent chapters.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

This chapter concludes the relevant reviews related to food security within Covid-19 period, which includes the underlying theories and the five variables that affect food security. By reviewing the theories and variables, it provides a comprehensive understanding and empirical evidence that forms the fundamentals of this research.

2.1 Underlying Theories

2.1.1 Amartya Sen's Entitlement Theory

Amartya Sen's Entitlement Theory is a theory proposed by Amartya Sen in 1981. This theory focuses on how the communities achieve food security, particularly through food accessibility. According to Amartya Sen, the definition of entitlements is the set of alternative goods bundles that an individual can obtain in society by exercising their rights and opportunities (Sen & Sen, 1997). The endowments can be the assets and resources such as labor power (Devereux, 2001). This approach focuses on the entitlement of each person to access a bundle of commodities that include food. Amartya Sen also stated that starvation is a result of losing entitlement to obtain food, not solely a result of food availability (Sen, 1982).

Under this theory, there are four legal ways to obtain food. First, trade-based entitlement, which is also known as exchange entitlement, is about an individual's ability to own something by trading with a willing party (Sen, 1982). In simple terms, it means the people's ability to sell and buy something for food (Kurniawan, n.d.). However, when the food supply declines, the food prices increase and negatively affect people's ability to exchange food, which causes them to face hunger. The unemployment during the pandemic caused people to lose their income also affected the exchange entitlement of people to purchase food. Second, the production-based

entitlement defines the ability of people to grow and produce food (Kurniawan, n.d.) by using the resources he or she owns or rents under agreed terms of trade (Sen, 1982). Third, the own-labor entitlement refers to the ability of people to sell their skill or labor power in exchange for income to purchase or produce food (Kurniawan, n.d.). Fourth, the inheritance and transfer entitlement define food transfer that can be accessed by the government, individuals, and society (Kurniawan, n.d.). Importantly, when one or more of the entitlements are lost, food insecurity happens. In this research, this theory can help to explain why the moderate GFSI countries experienced food insecurity within Covid-19 period by relating to the dependent variables.

2.1.2 Sustainable Livelihoods Framework

This framework was developed by the Institute for Development Studies in Universitas Sussex and Oxfam, The British Department for International Development (DFID). Its primary aim is to provide a framework for addressing poverty and vulnerability in the context of development and human vulnerability. The core idea of this theory is that when people have more access to social capital, human capital, physical capital, financial capital, and natural capital, they will have more right to increase revenue, which can improve living standards, reduce poverty and vulnerability, and in turn decrease food insecurity (Yuniarti & Purwaningsih, 2017).

Under this theory, there are five key assets that are owned by households. First, human capital includes education, skills, knowledge, health, nutrition and employment. In this research, the unemployment of people caused by the pandemic caused people to face hunger. Second, natural capitals include land, water forests, and air quality. Third, social capital includes social safety nets and access to opportunities within the community. Fourth, physical capital includes transportation, roads, buildings, and water supply facilities. By relating to this asset, the supply chain disruptions caused by border closures and transport restrictions limit the ability of people to access sufficient food. Fifth, financial capital includes savings and the flow of funds (Yuniarti & Purwaningsih, 2017). Unemployment reduces the financial capital of people to afford

sufficient and nutritious food. The decrease in financial assets further threatens people facing rising food prices. When individuals, households, and poverty populations utilize their assets well, they can obtain sufficient nutritious food and enhance their food security. As a result, they will be less vulnerable to the food crisis, which in turn contributes to their sustainable livelihoods. This theory can help this research to explain food security within Covid-19 period in moderate GFSI countries.

2.2 Review of Variables

2.2.1 Food Security

Food security is a flexible concept, as evidenced by the multiple attempts to define it in research and policy use (Peng & Berry, 2019). However, the widely accepted definition is defined as all people have physical, social, and financial accessibility to obtain sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996). In recent years, food security has become worse and become a global concern. Due to the pandemic, global food security is becoming more severe because food security's four dimensions are being disrupted.

Research conducted by Singh, Sunuwar, Shah, Sah, Karki & Sah (2021) aims to investigate the food insecurity among vulnerable communities and low-income families in Nepal's Province-2 during the pandemic. This research was conducted through semi-structured qualitative virtual interviews among the selected participants from both urban and rural areas at the Province-2. The interviews were conducted between July 2020 to August 2020, and the data was analyzed by using thematic network analysis. The interviews revealed that the low socioeconomic backgrounds families and vulnerable communities who worked on daily wages and rely on remittance had experienced an increase in food insecurity during the pandemic. It is because these populations have faced financial constraints to obtain sufficient food due to unemployment. Their unemployment also directly affected their family members'

food security. As their financial capability was already limited, the pandemic further diminished their ability to afford food. Factors such as limited food availability, market closure, border closure, disruption in transportation, rising food prices, local food production disruption, weak social networks and support systems also affected the food security of the low-income households and vulnerable communities. According to this research, their most common strategies to cope with food insecurity include borrowing money and food from landlords, consuming poor quality or limited-variety food, skipping meals, and reducing portions of the meals. These strategies exacerbated their food insecurity and affected their health.

2.2.2 Unemployment Rate

According to the research conducted by Milovanska-Farrington (2022), the research aims to examine how unemployment during Covid-19 affected families' food sufficiency. The paper investigates the effect of unemployment on food security of families and children, confidence about food security in the nearer future, as well as the change in the families' food sufficiency status during the pandemic in the United States. The data are obtained from the Household Pulse Survey (HPS) – Phase 2 that is collected by the Census Bureau in collaboration with other federal institutions. The sample consists of 413,976 people. This research applied the ordered Probit model as the methodology to analyze the data. The results of the research indicate that unemployment can cause greater food insecurity in the family, reduce the possibility of a family owning sufficient food, and deteriorate nutrition of children. In conclusion, the findings of this study stated that the unemployment during Covid-19 worsened food security, which presents a negative relationship.

Besides that, research conducted by Singleton, Fabusoro, Teran-Garcia & Lara-Cinisomo (2022) examines the relationship between changes in employment status that caused by the pandemic and household food insecurity among the sample of economically diverse Black and Latino adults in Illinois, US during the early stages of the pandemic. The data in this research are collected from 1,809 Black and Latino

adults in May and June or July 2020. This research also evaluated the significance of Supplemental Nutrition Assistance Program (SNAP) participation to investigate whether it will affect the relationship. Logistic regression is used as a research method to assess the significance of the relationship. The results of this research indicated that the individuals who faced unemployment during the pandemic had high possibility to experience food insecurity, with those who participated in SNAP being highly vulnerable. The results also revealed that the participants who were not receiving SNAP benefits and unemployed also have a high risk in experiencing food insecurity. As a result, this research shows that there is a negative relationship between unemployment and food insecurity of households.

Furthermore, research conducted by Mekonnen and Amede (2022) aimed to provide comprehensive empirical evidence on the food insecurity and unemployment caused by the dual Covid-19 crisis in sub-Saharan Africa. This research applied a systematic review approach as the methodology and started from the search for relevant literature in the global database such as Google Scholar, Science Direct and Web of Science. A total of 53 papers were included for the comprehensive review after the filtering process. The study results show that the pandemic worsens unemployment, food security, and nutrition of millions of people in the region, particularly the most vulnerable groups, migrants, and informal workers because unemployment causes the people to lose their income and in turn decreases their ability to obtain food. In conclusion, the results of this study indicate that the increase in unemployment during the pandemic brings negative effects to people's purchasing power in purchasing food, which increases the food insecurity in sub-Saharan Africa.

2.2.3 Supply Chain Disruptions

Research conducted by Alabi and Ngwenyama (2022) using two countries such as Canada and United States as the case studies to examine the effect of Covid-19 on food security and global food supply chains and provides the appropriate strategy or framework for creating a smarter and more resilient food supply chain in the past-

pandemic era. The research methodologies in this study are comprehensive literature review and analyzed the open data from Statistics Canada and the recent studies. The findings indicated that the pandemic has greater effects on the food security in Canada and US and global food supply chains because of the food supply chain disruptions. The findings also revealed how the pandemic causes the disruption in global food supply chains through poor economy, farm labor shortages, food accessibility limitation, restrictions in farm commodities transportation, and food trade policies restrictions to increase food insecurity in the two observed countries. In conclusion, this study provides evidence that supply chain disruptions due to the pandemic negatively affected food security.

In addition, the research conducted by Mahmood, Furqan, Meraj & Hassan (2024) aims to understand the dynamics relationships between the pandemic, food security, agricultural supply chains, and the environment by a comprehensive literature review. The relevant studies are found in Google Scholar and are from the period from 2019 to 2023. The findings of this research indicate that the global food supply chain disruptions caused by labor shortages, travel restrictions, agriculture input shortages, and changes in demand during the lockdowns of the pandemic further caused the increase in food prices and food insecurity. The findings also revealed that the disruptions in international transportation to protect against the spread of the pandemic led to lower food exports and imports, which particularly increased the food insecurity of the countries with less food self-sufficiency. In conclusion, the findings of this study show that prevention strategies to prevent the transmission of the pandemic decreased food availability on the market and caused food insecurity.

Furthermore, research conducted by Mostafa, Hussein, Elsheeta & Romagnoli (2024) aims to simulate the causes and effects of potential disruptions that might occur during the Covid-19 and the Russian-Ukrainian war, which include extended transportation time, shortages of goods, and increase in demand that caused by lockdowns and panic buying. The Baladi bread supply chain was modeled in this study by choosing East Cairo as a case study. This study used the anyLogistix software to model and analyze

the effect of unusual events on supply chains by using a discrete-event simulation model. The results of this study indicate that the supply chain was severely affected by the two events and caused the decrease in Baladi bread availability, unmet demand, extended lead times, and high backlogs of orders. Through the results, the supply chain disruptions can cause an increase in lead time for customers and the extent in shipping duration, which leads to the inability to fulfill increasing demand due to panic buying. In conclusion, this study shows that the supply chain disruptions can decrease the food supply and food availability on the market, which cannot fulfill people's increasing demands.

2.2.4 Rising Food Prices

According to the research conducted by Amolegbe, Upton, Bageant & Blom, (2021), this research uses panel data from Nigeria to examine the impacts of non-seasonal food price volatility, particularly the unexpected price increase, and food security of households. The data was gathered from the National Bureau of Statistics and the Nigeria Bureau of Statistics. The results of the study indicate that the increase in imported rice price caused damage to both dietary diversity and the proportion of food in consumption expenses, while the effects of price volatility in domestic rice are unclear. In conclusion, the results show that the increase in food prices can lead to a decrease in food security, which is a negative relationship.

In addition, the research conducted by Islam, Hossain, Shohag & Siddiquee (2025) aims to examine the food insecurity faced by urban slum households caused by high inflation and explore their coping mechanisms. The data collected are collected through the questionnaire at various slums located in Dhaka City Corporation, Bangladesh from November 2022 to January 2023. The respondents were being asked by using the Food Insecurity Experience Scale (FIES) survey module. This research used descriptive analysis and the Probit regression model as methodologies. The findings of this research stated that the rising food prices have significantly increased food insecurity, which disproportionately impacted the slum families with diverse socioeconomic

characteristics. The findings also indicate that the households who previously found food safety reported facing some extent of food insecurity due to the rising food prices. The probit regression result revealed that inflation reduced the real income of households and caused them to face increasing food insecurity. In conclusion, this research showed that the rising food prices decreased the disposable income of the households and caused more people to face food insecurity in the urban slums.

Moreover, the research conducted by Kunyanga, Byskov, Hyams, Mburu, Werikhe & Bett (2023) aimed to examine the effects of Covid-19 on food prices and commodities supplies to urban markets in Nairobi, Kenya. This study was conducted through mixed methods, which include qualitative data and quantitative data. The data was being analyzed by using descriptive, bivariate, and multivariate analysis. The findings of this study show a decrease in sales numbers for sellers in the observed markets and a decrease in consumption in households due to the rising food prices. The results also showed that the rising food prices have reduced the number of households that are able to maintain a continuous food consumption trend. The pandemic caused households to lose income and health care costs and caused them to face poverty, which directly increased their difficulty dealing with rising food prices. In conclusion, this study shows that the rising food prices reduced the food consumption of people and caused people, especially the poverty populations, to face food insecurity.

2.2.5 Gross Domestic Product per Capita

Gross Domestic Product per capita (GDP per capita), its distribution proportions and the material structure of consumption provide a comprehensive reflection of society's material living standards (Świetlik, 2018). The increase in GDP per capita reflects the improvement in citizens' material living standards, while the decrease reflects the decline in their economic well-being that affects their living standards (Świetlik, 2018).

According to Akbar, Rahim Darma, Imamul Mujahidin, & Andi Irawan (2022), the researchers use regression model to investigate the effect of economic recession that caused by Covid-19 on 4 aspects of food security such as availability, accessibility, stability, food utilization in Indonesia. The research uses GDP per capita based on purchasing power parity (PPP) as the indicator to represent food accessibility. The results showed that the negative GDP growth caused by the pandemic will reduce the 4 aspects of food security, ultimately affecting food security. This study also identifies that there the decline in GDP per capita can negatively affect food security.

Research conducted by Yao, Fan, Wu, Ouyang & Li (2023) investigated the impacts of the Covid-19, economic, climate, and their compound effects on three crop yields and food security worldwide. The data was collected from various sources such as World Health Organization (WHO), WorldPOP, and the United Nations Statistics Division National Accounts Estimate of Main Aggregates (UNSD AMA). This research used the global ordinary least squares model, geographically weighted regression (GWR), and multi-scale GWR as the research methodologies. The economic level worldwide is measured by using GDP and GDP per capita. The results of this research indicate that GDP per capita was the most important explanatory factor in explaining food security in most countries. This research highlights that the economic slowdown caused by the pandemic has exacerbated food insecurity in many developing countries as the reason for the loss in income. In conclusion, this research shows that the economic slowdown recorded a decrease in GDP per capita, which negatively affects the food security of the countries during Covid-19.

2.2.6 Population Growth Rate

According to Mozumdar (2012), global agriculture requires a significant increase to be able to fulfill the projected growing world population. If a country's national production cannot meet the increase in food demand caused by population growth, the undernourishment will increase (Molotoks, Smith & Dawson, 2020). As a result, countries that show the decline trend in population growth had higher food security,

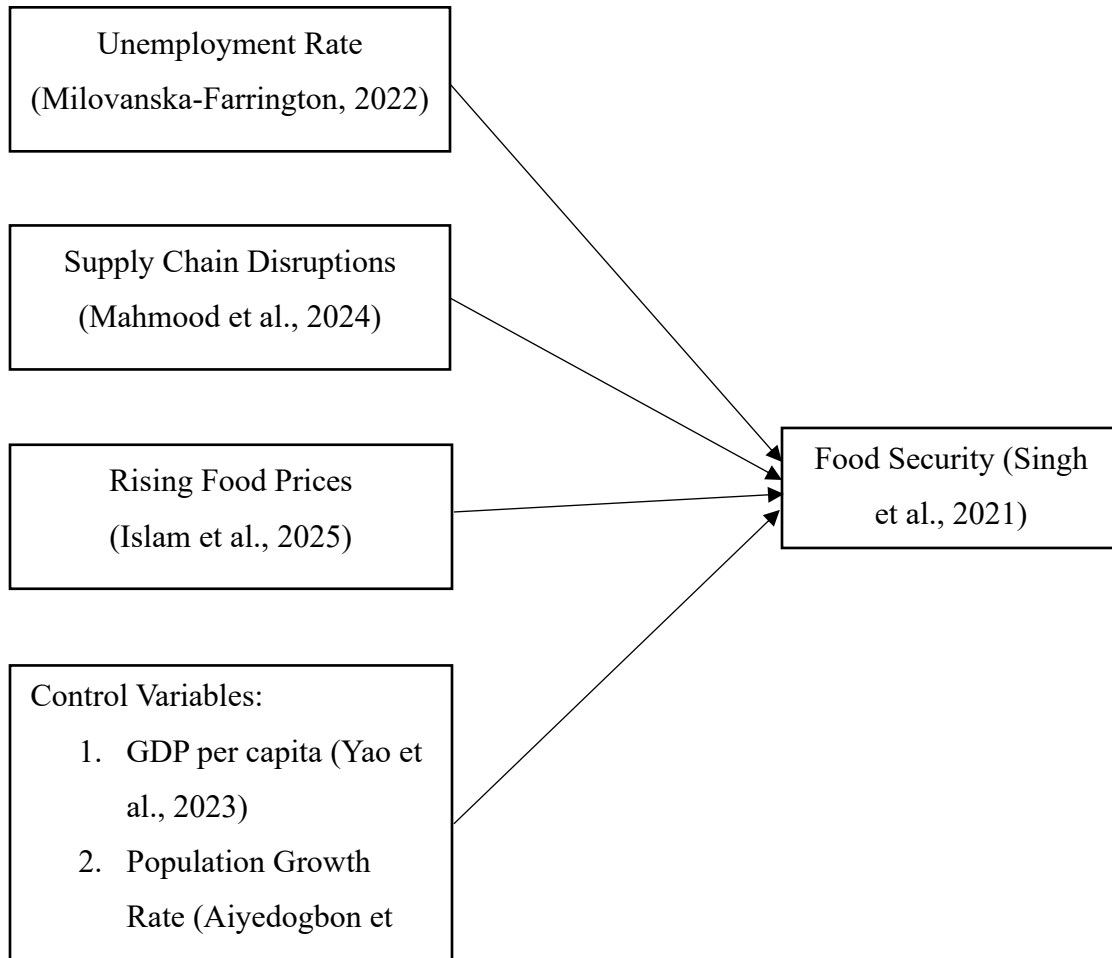
while the countries with the rapid growth in population had the worst food security (Molotoks et al., 2020).

Research conducted by Aiyedogbon, Anyanwu, Isa, Petrushenko & Zhuravka (2022) aims to investigate how the population growth affected food security in Nigeria with the data covering from 1986 to 2020. This study used linear regression models as the methodology to examine the relationship between population growth and food security on one hand and how these two variables affected Nigeria's economic growth on another hand. The data was collected from the Statistical Bulletin of the Central Bank of Nigeria and World Bank. The results of this study indicate that the population had a significant impact on Nigeria's agriculture output, which the absence of population would cause the agricultural sector to have negative productivity due to every sector, requiring labor. This result implies that the population growth can provide more labor power to the agriculture sector and in turn increase the agriculture production and food security of the country. The results also revealed that the population growth might be a good thing or bad depending on the ability of the economy to keep pace with the increase in food productivity. In conclusion, this research shows that population growth rate has a relationship with food security.

In Covid-19 context, population growth rate can affect food security. Rapid population growth, expanding urban housing, and limited natural resources provide large pressure to sustainable food supply (Khan, Akram, Janke, Qadri, Al-Sadi & Farooque, 2020). Covid-19 exacerbated the pressure of this sustainable food supply by disrupting the food supply chain. In the higher population growth countries that relied on food imports to fulfill the food demand, the disruption in supply chain can reduce food availability.

2.3 Conceptual Framework

Figure 2.1 Conceptual Framework



Source: Developed for the research.

This figure illustrates the relationship between the independent variables (unemployment rate, supply chain disruptions, and rising food prices), control variables (GDP per capita and population growth rate), and dependent variables (food security). This framework provides a conceptual foundation to examine how independent variables influence food security in moderate GFSI countries with a score ranging from 50% to 79.9%.

2.4 Hypotheses Development

H1: There is a negative relationship between unemployment rates and food security.

H2: There is a negative relationship between supply chain disruptions and food security.

H3: There is a negative relationship between rising food prices and food security.

2.5 Conclusion

This chapter includes the literature that explains the relationship between independent variables (unemployment rates, supply chain disruptions, and rising food prices), control variables (GDP per capita and population growth rate) and food security. The discussion showed how each factor influences food security. By summarizing all the existing knowledge, this chapter enables the researcher to develop hypotheses for testing.

CHAPTER 3: METHODOLOGY

3.0 Introduction

This chapter covers the research methodology that is used in this research. Research methodology provides guidance for how this research is conducted. This chapter includes elements such as research design, sampling design, data and sources, and proposed data analysis tools.

3.1 Research Design

The research design is formulated to examine the relationship between food security and the independent variables such as unemployment rate, supply chain disruptions, and rising food prices in countries with GFSI scores ranging from 50% to 79.9%. As a result, this research is adopted as causal research because it aims to examine the cause-and-effect relationships between independent and dependent variables. Other than that, this research is quantitative research that is used to explain the phenomena by collecting numerical data and thus, it needs to deal in numbers (Mohajan, 2020). The data are all measured in number and are collected on an annual basis. Since several economic concepts are relatively balanced over time, a static panel is suited for this research. By using panel data analysis to test the data from 2018 to 2022, this research design enables this research to examine the relationship between variables and explain the variations in food security among different countries within Covid-19 period.

3.2 Sampling Design

The target population of this study consists of 48 countries with moderate GFSI scores ranging from 50% to 79.9% during 2018 to 2022. The reason for selecting the countries between these moderate GFSI scores is because there is a lack of coverage of these countries in the existing literature on the context of food security within Covid-19 period. The moderate GFSI also has moderate vulnerability when dealing with the

pandemic that has not been explored by the existing literature. Therefore, this research selects these 48 moderate GFSI countries can fill the research gap and investigate the actual variables that affect their food security during the pandemic. The sampling frame is derived from the Global Food Security Index 2022 database from the Economist Intelligence Unit (EIU). The observed moderate GFSI countries in this research are selected based on their 2018 GFSI score range between 50% to 79.9%. The same group of countries then continue to be observed across 2018 to 2022 to ensure consistency in panel data analyses. The sampling technique that applied in this study is non-probability purposive sampling because the observed countries are purposely selected based on the criteria of GFSI scores ranging from 50% to 79.9%.

According to the 2018 GFSI score ranging from 50% to 79.9%, a total of 59 countries are included. However, the final sample consists of 48 countries, which covers the developed and developing countries and the regions such as Asia, Africa and Europe. The reason for not using all the 59 countries is because the data of the remaining 11 countries is incomplete as there is a large amount of missing data. Furthermore, one of the country's 2019 GFSI scores over the observed range. In conclusion, the 48 countries that are taken into consideration are listed as the table below:

Table 3.1: The observed countries

1. India	25. Bulgaria
2. Honduras	26. South Africa
3. Bolivia	27. Belarus
4. Nicaragua	28. Mexico
5. Algeria	29. Russia
6. El Salvador	30. Bahrain
7. Sri Lanka	31. Malaysia
8. Ecuador	32. Argentina
9. Morocco	33. Costa Rica
10. Ukraine	34. Slovakia
11. Vietnam	35. Greece
12. Egypt	36. Saudi Arabia
13. Jordan	37. Hungary
14. Paraguay	38. Oman
15. Dominican Republic	39. Kuwait
16. Kazakhstan	40. Chile
17. Azerbaijan	41. Poland
18. Thailand	42. South Korea
19. Serbia	43. Czech Republic
20. Botswana	44. Italy
21. Tunisia	45. Spain
22. Panama	46. Israel
23. Colombia	47. Portugal
24. Turkey	48. Japan

Source: Developed for the research.

3.3 Data and Sources

This research is conducted using quantitative methods and collecting secondary data on an annual basis for the 48 observed countries. To measure the relationship between the different independent variables and food security among these countries, each variable is measured using different units. The data are collected from the Economist Intelligence Unit (EIU), World Bank, Federal Reserve Bank of New York, International Monetary Fund (IMF), and The Organisation for Economic Co-operation and Development (OECD). All the data collected are covered from 2018 to 2022, a total of 5 years. The data collection in this study is an unbalanced panel. As a result, this research will use a special method to fix this unbalanced panel problem. By collecting data from these sources, the results of this research are correct and credible because these sources are official sources and internationally recognized. As a result, these sources are reliable, suitable, and adequate. Other than that, these sources provide the full set of data, which saves the researcher's time and money in the data collection process. Below is the list of independent, dependent, and control variables, their unit of measure, and data sources.

Table 3.2: List of Variables, Their Measure Unit, and Sources

Abbreviation	Variables	Measure Unit	Sources
<u>Dependent Variable:</u>			
FS	Food Security	Global Food Security Index (GFSI)	Economist Intelligence Unit (EIU)
<u>Independent Variables:</u>			
UEMP	Unemployment Rate	Unemployment, total (% of total labor force) (modeled ILO estimate)	World Bank

SCD	Supply Chain Disruptions	Global Supply Chain Pressure Index (GSCPI)	Federal Reserve Bank of New York
RFP	Rising Food Prices	Consumer Price Index (CPI)	International Monetary Fund (IMF) & The Organisation for Economic Co-operation and Development (OECD)
<u>Control Variables:</u>			
lnGDP	Gross Domestic Product per capita	GDP per capita (constant 2015 US\$)	World Bank
PGR	Population Growth Rate	Population growth (annual %)	World Bank

Source: Developed for the research.

Variable Specification:

Food Security (FS)

Food security is the dependent variable of this research and is measured by Global Food Security Index (GFSI). It represents the food security differential of the countries with GFSI scores ranging from 50% to 79.9% from 2018 to 2022. GFSI is a composite index created by the Economist Intelligence Unit (EIU) in 2012 (Nel, 2024), to evaluate the food security environment in 113 countries based on four key pillars, namely affordability, availability, quality and safety, and sustainably and adoption (The Economist Group, 2022).

Unemployment Rate (UEMP)

The unemployment rate represents the proportion of unemployed people in the labor market that are actively seeking a job. This unit is calculated as the percentage of unemployed people to the total labor force that is estimated by the International Labour Organization (ILO).

Supply Chain Disruptions (SCD)

Supply chain disruptions are hard to measure directly. As a result, this research uses Global Supply Chain Pressure Index (GSCPI) as a proxy measure unit to measure this variable. This indicator developed by the Federal Reserve Bank of New York and integrates the transportation cost, air freight cost, and the supply chain-related components to measure the global supply chain conditions (*Global Supply Chain Pressure Index*, n.d.). Since this index is a global index, the same GSCPI values are applied to each observed country in the same year.

Rising Food Prices (RFP)

Rising food prices use the consumer food price index (CFPI) of the country's consumer price index (CPI) to measure. CFPI measures the relative changes in food prices during a certain period. IMF serves as the primary source. However, as the IMF dataset does not provide complete data of the observed countries, the supplementary data is collected from OECD.

Gross Domestic Product per capita (lnGDP)

GDP per capita is measured by GDP per capita (constant 2015 US\$). It is calculated by the Gross Domestic Product (GDP) divided by midyear population. In this research, this variable is named lnGDP, which is the logarithm form. As GDP per capita is a large value, logarithms can log the numbers to normal size and make the distribution more symmetric and normal (Cameron & Trivedi, 2022).

Population Growth Rate (PGR)

Population growth rate represents the annual percentage of population growth of a country. Population is calculated based on the de facto definition of population that includes all the residents regardless of the legal status or citizenship (*Glossary | DataBank*, n.d.-b).

3.4 Data Analysis Tool

In this study, the computer programs used to analyze the collected data is Stata. Stata is a commercial statistical software developed especially for data manipulation, analysis, management, visualization, and reporting. It is a tool that is commonly used in research that applies panel data methodology. Stata comprises few tests such as Pooled Ordinary Least Square (POLS), Fixed Effect model, Random Effect model, Breusch and Pagan Lagrangian Multiplier test, Hausman test, and Diagnostic test.

3.4.1 Static Panel

3.4.1.1 Pooled Ordinary Least Squares (POLS)

POLS is the basic way to estimate a regression model with panel data. This model assumes that all the data have the same underlying characteristics and ignore any heterogeneity between the countries and time differences. As a result, it is effective to combine all the data into a cross-sectional data set. The formula presented in the following equation:

$$Y_{it} = \beta_0 + \beta_1 X1_{it} + \beta_2 X2_{it} + \beta_3 X3_{it} + \beta_4 X4_{it} + \beta_5 X5_{it} + \mu_{it} \quad (1)$$

According to the above equation, POLS identify the parameter of independent variables (Xs). In this research, the dependent variable (Y) evaluated is food security in countries with GFSI scores ranging from 50% to 79.9%, and the independent variables (X) that use to test the relationship are unemployment rate (X1), supply chain disruptions (X2),

rising food prices (X3), log GDP per capita (X4), and Population Growth Rate (X5). The symbol β_0 indicate the constant, while μ_{it} indicate the equation error. The it symbol is defined as the panel data that we use to conduct this research. Ordinary Least Squares produces efficient and consistent parameters estimation under the assumption of homogeneity and ignores individual effects. Other than that, POLS consider the Best Linear Unbiased Estimator (BLUE), which excludes all the linear unbiased estimators that are possible.

Thus, the integrated equation will be formed as the following:

$$FS_{it} = \beta_0 + \beta_1 UEMP_{it} + \beta_2 SCD_{it} + \beta_3 RFP_{it} + \beta_4 \ln GDP_{it} + \beta_5 PGR_{it} + \mu_{it} \quad (2)$$

3.4.1.2 Fixed Effect Model (FEM)

The second estimation method is applied when individual particular effects are time invariant because of a person-specific intercept. In other words, it is concerned with unique characteristics of each nation. Thus, every country has distinctive interceptions and slope coefficients are similar across countries. The advantage of applying this model is that it generates consistent estimating regardless of whether there is the existence of a connection between the explanatory variable and the unit-specific effect.

The estimated models are shown as:

$$Y_{it} = \beta_0 + \beta_1 X1_{it} + \beta_2 X2_{it} + \beta_3 X3_{it} + \beta_4 X4_{it} + \beta_5 X5_{it} + \alpha_i + \mu_{it} \quad (3)$$

With an estimation of within-transform:

$$(Y_{it} - \bar{Y}_i) = \beta(X_{it} - \bar{X}_i) + \varepsilon_{it}$$

(4)

$$\text{Where } \bar{Y}_i = \frac{1}{T} \sum_t Y_{it} \text{ and } \bar{X}_i = \frac{1}{T} \sum_t X_{it}, \text{ and } \varepsilon_{it} = (Y_{it} - \bar{Y}_i - \beta_1 \bar{X}_i)$$

Y_{it} represent dependent variable, and X_{it} represent independent variables, where i is the entity and t is an annual time series. Then, α_i ($i = 1 \dots n$) define as the unknown intercept for each entity, which is heterogeneity under a specific effect (n entity-specific intercepts). The coefficients of the equation will be identified as β_s .

Thus, the integrated form of the equation can be written as below:

$$FS_{it} = \beta_0 + \beta_1 UEMP_{it} + \beta_2 SCD_{it} + \beta_3 RFP_{it} + \beta_4 \ln GDP_{it} + \beta_5 PGR_{it} + \alpha_i + \mu_{it}$$
(5)

3.4.1.3 Random Effect Model (REM)

Random Effect Model is also known as the error component model. Moreover, it acts as a solution in order to avoid the difficulties that arise both time and cross-section. REM handles the intercept term, where β_0 is a random variable that can be expressed as:

$$Y_{it} = \beta_0_{it} + \beta_1 X1_{it} + \beta_2 X2_{it} + \beta_3 X3_{it} + \beta_4 X4_{it} + \beta_5 X5_{it} + \varepsilon_{it} + \mu_{it}$$
(6)

The error term W_{it} comprise of two elements: the cross-section error component, ε_i , and the combination of cross-section and time series error components, μ_{it} . The assumptions of Error Correlation Model (ECM) are shown as the following:

$$\varepsilon_i \sim N(0, \sigma^2)$$

$$\mu_{it} \sim N(0, \sigma^2)$$

$$E(\varepsilon_i \mu_{it}) = 0 \quad E(\varepsilon_i \varepsilon_j) = 0 \quad (i \neq j)$$

$$E(\mu_{it} \mu_{is}) = E(\mu_{it} \mu_{it}) = E(\mu_{it} \mu_{js}) = 0 \quad (i \neq j; t \neq s)$$

The classical linear regression model (CLRM)'s assumptions that state that the errors are zero mean and constant variance were followed by both error components. The time-series and cross-sectional units are uncorrelated with each other, same for the individual error components. The advantage of this model is that it can produce efficient results while remaining consistent in the absence of correlation between the explanatory variable and the unit-effect. Furthermore, this model can also integrate the time invariant variables.

Hence, the equation will be rewritten as the following:

$$FS_{it} = \beta_0 + \beta_1 UNEM_{it} + \beta_2 SCD_{it} + \beta_3 RFP_{it} + \beta_4 \ln GDP_{it} + \beta_5 PGR_{it} + \varepsilon_{it} + \mu_{it} \quad (7)$$

3.4.2 The Selection of Panel Data Models

To select the most suitable model among POLS, FEM, and REM, the Breusch and Pagan Lagrangian Multiplier Test (BP-LM) and Hausman Test will be conducted.

3.4.2.1 Breusch and Pagan Lagrangian Multiplier (BP-LM) Test for REM

Breusch and Pagan Lagrangian Multiplier Test (BP-LM) will be applied to determine the most suitable module between POLS and REM. Trevor Breusch and Pagan developed this test in 1979. When the p-value is less than 1%, 5% and 10% level of significant (α), H_0 will be rejected. As a result, the REM model performs better than POLS. The hypothesis is shown as the following:

H_0 : Poolability Test

H_1 : Non-Poolability Test

3.4.2.2 Hausman Test

The Hausman Test is conducted to identify the best model between FEM and REM by comparing the estimator of random effect and fixed effect. This test was created by Jerry Hausman in 1978, and he named it as Hausman Test. When the FEM performs better than REM, H_0 will be rejected. Due to the statistical inferences of the case, the ε_i in the sample will be conditional. The hypothesis is shown as below:

H_0 : REM is more preferred

H_1 : FEM is more preferred

3.4.3 Diagnostic Test

3.4.3.1 Autocorrelation

Another name of autocorrelation is serial correlation. It explains the correlation between the proximity of variables and the observations over different time periods. Autocorrelation is calculated using the mean and variance function. The issue of Autocorrelation frequently occurs in time series data, where if the covariance of the function is not equal to zero, the error terms of the data are relatively correlated. The hypothesis is written as below:

H_0 : The residuals have no autocorrelation

H_1 : The residuals have autocorrelation

3.4.4 Panel-Corrected Static Panel

Panel-Corrected Static Error (PCSE) is usually used to examine the time-series-cross-section data that typically show heteroscedasticity and contemporaneous correlation, which cause the inference from OLS standard error incorrect (Bailey & Katz, 2011). If residual issues in OLS such as heteroscedasticity and serial correlation exist, PCSE can be used to estimate the correct standard errors. As a result, the cluster REM model under PCSE is performed in this research. The standard errors generated by PCSE solve the residual issue. The formula shown below is the equation of PCSE that was specifically developed for panel data.

The panel-corrected standard error can be used to calculate the square roots of the diagonal terms.

$$cov(b) = (X'X)^{-1}(X'(\phi \otimes I_T)X)(X'X)^{-1} \quad (8)$$

Where,

$\phi = N \times N$ matrix along the $(i, j)^{th}$ component determined through:

$$\frac{(\sum_t^T = 1 \hat{e}_{i,t} \hat{e}_{j,t})}{T} \quad (9)$$

3.4.5 Inferential Analysis

In this research, inferential analysis is used. In this study, panel data regression models such as POLS, FEM, and REM will be carried out to conduct parametric inferential analysis because the regression models rely on parametric assumptions such as

normality, linearity, and homoscedasticity. Furthermore, statistical hypothesis tests and significance tests are parts of inferential analysis. This research conducts hypothesis testing by interpreting the P-Value. The null hypothesis is being rejected often if the P-Value is smaller than 0.10, 0.05 and 0.01 significant level (α). By applied hypothesis testing, this research is able to test the proposed hypotheses and draw conclusions on whether the changes in independent variables will significantly affect food security.

3.5 Conclusion

This chapter outlines the research methodology that will be applied in this research. The data in this research is a panel dataset which is collected on yearly basis from 2018 to 2022, a total of 5 years. All the data are collected from the EIU, World Bank, Federal Reserve Bank of New York, IMF, and OECD. This research used Stata software to conduct several tests and data analyses. Besides that, every model and technique that will be carried out in this research have been elaborated in this chapter.

CHAPTER 4: DATA ANALYSIS

4.0 Introduction

This chapter shows the results of the model that have been discussed in Chapter 3 and analyses the results to test the research questions and hypotheses proposed. Also, the static panel will be used as the basis for this analysis.

4.1 Results of Descriptive Analysis

Table 4.1: Summarize Statistic

Variables	Observations	Mean	Std. Dev	Min	Max
FS	240	66.2442	7.2637	50.1	79.9
UEMP	239	7.7362	5.8089	0.716	34.007
SCD	240	1.4696	1.1417	-0.0382	3.0778
RFP	231	290.6577	953.7797	62.1308	8048.022
lnGDP	240	9.1055	0.8253	7.4991	10.6577
PGR	240	0.6516	1.2323	-7.6193	5.1132

Source: Developed via STATA for research purpose.

Based on the results shown in the table above, the unemployment rate of the countries has an average of 7.7362 with a minimum of 0.716 and a maximum of 34.007. Besides that, the supply chain disruption has a mean of 1.4696, with a minimum of -0.0382 and a maximum of 3.0778. Apart from that, the rising food prices have the highest mean value of 290.6577, with a minimum of 62.1308 and a maximum of 8048.022. Furthermore, the average GDP per capita of the countries is 9.1055, with a minimum of 7.4991 and a maximum of 10.6577. In addition, the population growth rate has the lowest mean value of 0.6516, with a minimum of -7.6193 and a maximum of 5.1132.

4.2 Static Panel (POLS, FEM, REM)

4.2.1 Result of Estimated Model

Three different estimating approaches are used to analyze the data. This study used Pooled Ordinary Least Squares (POLS), Fixed Effect Models (FEM), Random Effect Models (REM), and Panel Corrected Standard Error (PCSE) to examine the effect of independent variables on food security of countries. In Section 4.3, the Breusch and Pagan's Lagrange Multiplier (BP-LM) test and Hausman test, which are being used to determine which model is most suitable, show that the REM model is more preferred. Since autocorrelation exists in REM, the panel-corrected static panel is being used as the final model in this research.

Based on the panel-corrected static panel result, only Rising Food Prices (RFP) and log GDP per capita (lnGDP) are significant with the positive sign. The results show that the **RFP** has a statically significant result with a positive sign, with a 1% increase in food prices, on average has a positive relationship impact on increasing the FS by 0.04% with statically significance at the level of 0.05, while holding constant with other variables. This means that rising food prices can increase the food security during Covid-19. However, this result is not consistent with the existing literature. The research conducted by Pawlak et al. (2024) and Erinle, Ogbu, Evivie, Zaheer, Ogunyemi & Adeniran (2021) stated that the governments' intervention policies are effective in mitigating the negative effects of rising food prices. Thus, rising food prices during Covid-19 may increase countries' food security due to governments intervention.

Besides that, the **lnGDP** has a statically significant result with a positive sign with 1% increase in the GDP per capita, on average has a positive relationship effect of increasing the FS by 7.4335 units with statically significance at the level of 0.01, while holding constant with other variables. This means that the high GDP per capita can increase food security due to the increase in affordability. This result is consistent with the existing literature, in which the increase in GDP per capita will be followed by an

increase in food security level (Świetlik, 2018). The country with the increase in GDP per capita indicates that people's material living standard increases. As a result, people have more ability to purchase enough food and increase their food security. The results of POLS, REM, FEM, and Panel-Corrected Static Panel show that lnGDP has a significant and positive relationship with food security, which means that the relationship is strong. The log form of GDP per capita logs the big number to normal size and makes the distribution more symmetric. As a result, these characteristics make the result more reliable.

Other than that, according to the result, the variables such as UEMP, SCD, and PGR are all insignificant to food security because their p-value is higher than the significance level of 0.01, 0.05, and 0.10. Thus, food security is not sensitive to the unemployment rate, supply chain disruptions, and population growth rate of moderate GFSI countries.

Table 4.2: The Result of Estimated Model

Estimated Model				
Variables	(1) POLS	(2) REM	(3) FEM	Panel Corrected
UEMP	-0.0356 (0.0465)	-0.0109 (0.0713)	0.2575 (0.2055)	-0.0109 (0.0807)
SCD	0.0221 (0.2329)	0.0286 (0.1812)	-0.0881 (0.1961)	0.0286 (0.2132)
RFP	0.0002 (0.0003)	0.0004 (0.0004)	0.0016 (0.0016)	0.0004** (0.0002)
lnGDP	7.2538*** (0.3389)	7.4335*** (0.5423)	11.2994* (6.0246)	7.4335*** (0.4550)
PGR	-0.5279** (0.2496)	-0.2153 (0.2405)	-0.0511 (0.2624)	-0.2153 (0.1698)
Constant	0.5982 (3.2397)	-1.5443 (5.1204)	-39.2207 (55.7294)	-1.5443 (4.2254)

Observations	230	230	230	230
Number of groups	-	48	48	48
R-squared	0.7011	0.6981	0.6575	0.6981
Breusch-Pagan LM test	69.01 (0.0000)***		-	-
Hausman test	-	4.60 (0.4668)		-
Serial Correlation (F-stat)	-	-	33.792 (0.0000)***	-

Source: Developed via STATA for research purpose.

Note: The result is generated from Panel Corrected Standard Error (PCSE)

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

4.3 The Selection of Panel Data Models

To choose the best model between POLS, FEM, and REM, the Breusch and Pagan Lagrangian Multiplier Test (BP-LM) and Hausman Test will be used.

4.3.1 Breusch and Pagan Lagrangian Multiplier (BP-LM) Test for REM

This test is used to determine the best model between POLS and REM. The result is shown in Table 4.3.

Table 4.3: The Estimated Result of BP-LM Test

	Estimated Model	
	Var	SD = sqrt (Var)

FS	52.6305	7.2547
e	9.3410	3.0563
u	6.8214	2.6118
Var (u) = 0		
	chibar2 (01) = 69.01	
	Prob > chibar2 = 0.0000	

Source: Developed via STATA for research purpose.

According to Table 4.3, the estimated model indicates that the p-value of the chibar-square is 0.0000. As the p-value is less than 0.01 level of significant, H_0 is being rejected. As a result, the REM model performs better than POLS.

4.3.2 Hausman Test

The Hausman Test is applied to identify the best regression model between FEM and REM. The outcome is present in Table 4.4.

Table 4.4: Result of Hausman Test

Estimated Model	
chi2 (5)	= 4.60
Prob > chi2	= 0.4668

Source: Developed via STATA for research purpose.

According to Table 4.4, the estimated model shows that the p-value of chi-square is 0.4668. Since the p-value is higher than the significance level of 0.10, the H_0 is failed to be rejected. As a result, the REM model is preferred.

In conclusion, the results of BP-LM Test and Hausman Test indicate that the REM model is more preferred in the estimated model. Thus, REM models will be used to find diagnostic problems.

4.4 Diagnostic Test

4.4.1 Autocorrelation

Table 4.5: The Result of Autocorrelation

Wooldridge test for autocorrelation in panel data
Estimated Model for REM
F (1, 45) = 33.792
Prob > F = 0.0000

Source: Developed via STATA for research purpose.

Table 4.5 shows the result of Wooldridge test on random effect regression model to determine whether there is autocorrelation between the variables in panel data. According to the result of the estimated model REM, the p-value of F-statistic is 0.0000. Since the p-value is less than the 0.01 significance level, the H_0 is being rejected. As a result, this provides evidence that the residuals have autocorrelation.

4.5 Conclusion

Based on the result of the Hausman Test, the REM is chosen to be the model of this research. Since there are autocorrelations in the REM model, the panel-corrected static panel is ultimately being used as the model for research. This research has found that the rising food prices and GDP per capita have a positive and significant effect on food security. Moreover, the unemployment rate, supply chain disruptions, and population growth rate do not have a significant relationship with food security.

CHAPTER 5: DISCUSSION, CONCLUSION AND IMPLICATIONS

5.0 Introduction

This section will discuss and analyze the findings of the results in the previous chapter. The implications and the limitations of the study will also be covered. The recommendations will also provide for future research to make improvements. Lastly, the conclusion will be discussed at the end of this research.

5.1 Discussions of Major Findings

According to the results of BP-LM Test and Hausman Test, the REM model is preferred. For the diagnostic test, the result of autocorrelation Wooldridge test shows that the residuals have autocorrelation. To solve this issue, Panel-corrected Standard Error was used as the final model. According to the panel-corrected static panel, only the rising food prices (RFP) and Gross Domestic Product per capita (lnGDP) have shown a significant and positive relationship with food security (FS), while the unemployment rate (UEMP), supply chain disruptions (SCD), and population growth rate (PGR) do not have the significant relationship with food security (FS).

Based on the research results, the rising food prices have shown a significant and positive relationship with food security. However, this result is not consistent with the existing literature. This result rejects the hypothesis of this research that stated the negative relationship between rising food prices and food security. One of the reasons that causes rising food prices to increase food security is governments' interventions. According to Mouloudj, Bouarar & Fechit (2020), the agriculture and trade ministries of Algeria respond to the rising food prices caused by panic buying through intensified control measures and rebalancing the market. By this, food availability and accessibility increase. Other than that, the rising food prices can be offset by the

increase in disposable incomes with the support of social policy transfers (Pawlak et al., 2024). For example, unemployment insurance was provided to the affected populations to overcome food insecurity in the US. Household spending on food increases immediately after receiving unemployment insurance, which reduces food insecurity (Raifman, Bor & Venkataramani, 2021). From this finding, unemployment insurance increased the financial ability of households, which can help them to purchase food even if the food price is increasing. In addition, the removal of export bans and taxes can be used to promote cross-border trade among developing countries can minimize the increase in food prices (Erinle et al., 2021). Therefore, the rising food prices can cause governments to implement intervention policies to stabilize the prices, which are able to increase the food security of the countries.

Moreover, the Gross Domestic Product per capita is positively and significantly associated with observed countries' food security. This result is consistent with Świetlik (2018), which stated that the increase in GDP per capita will be followed by the increase in the country's food security. The increase in GDP per capita represents the growth in economics and improvement in living standards. During Covid-19, the GDP per capita of countries declined and people may have difficulties purchasing enough food due to decrease in purchasing power. Thus, the increase in GDP per capita will increase countries' food security.

Furthermore, the unemployment rate does not have a significant relationship with food security. However, this result is not consistent with the existing literature. This result rejects the hypothesis of this research that stated the negative relationship between unemployment rate and food security. One possible reason that can explain this insignificant relationship is the social safety nets. According to Mishra and Rampal (2020), economic growth and unemployment do not completely determine the hunger level in a country. Food security can be increased by social safety nets including cash and food transfer. During Covid-19, governments of the countries provided social transfers to unemployed individuals for the purpose of reducing their food insecurity. Raifman et al. (2021) stated that unemployment insurance increased the households

spending and reduced food insecurity. This proves that unemployment insurance increases the financial ability of the households to purchase enough food. As a result, these social safety nets can decrease the unemployment effect on food security and thus do not have a significant relationship with food security.

In addition, another key finding of this research is that supply chain disruptions do not have a significant relationship with food security. However, this finding is not consistent with the existing literature. Thus, the hypothesis of this research stated that there is a negative relationship between supply chain disruptions and food security is being rejected. One possible reason to explain this insignificant relationship is supply chain resilience. According to Hobbs (2020), the short-term shortages and stockouts in the market are being mitigated because the supply chains rapidly adjust to customer market demand signals by increasing the product flows during the pandemic. This shows that the supply chain with high resilience can absorb the pandemic shocks and maintain the activities during that period. In this research, the moderate GFSI countries may have certain supply chain resilience that can help them to deal with the pandemic. As a result, the supply chain disruptions can be mitigated by the countries' inherent resilience, which caused the insignificant relationship with food security.

5.2 Implications of Study

5.2.1 Practical Implications

The results of this study provide empirical evidence that rising food prices can increase the food security level of the countries. One of the reasons that causes this result is government support. Policymakers can use this finding to refine the existing food security strategies. For example, when food prices rise, policymakers can provide government support programs and enhance social protection programs such as cash transfer and food assistance programs to people, especially the poor populations. Other than that, governments can reinforce food price monitoring systems and implement market intervention strategies to stabilize food prices when price volatility. By

executing these two strategies, policymakers can ensure that people can access food at a more stable price. These two strategies can also enable governments to be well-prepared to deal with the future global events that have the opportunities to cause food prices to increase.

Furthermore, the result also indicates that increase in GDP per capita significantly improves food security in the observed countries. Policymakers should focus on the strategies to improve the GDP per capita that can enhance the household purchasing power. Most of the observed countries are categorized in middle- to low-income countries, which generally have a lower GDP per capita than the high-income countries. To enhance the food security of the observed countries, policymakers can enhance households' economic status through income generation activities that provide stable income to households to enable them to survive from threats posed by future food security crises. According to Omia (2024), the income generation activities in Adavi, Nigeria such as crop production, cloth weaving, crops selling, and hair weaving created chances for households to become self-reliant and earn money independently, which in turn improved food security. As a result, policymakers can imitate this policy to ensure households can rely on their labor power to earn income. Other than that, policymakers can also increase the minimum wages and promote more job opportunities. In this way, people have more disposable income to purchase sufficient food.

5.3 Limitations of Study

While analyzing the results, some limitations should be considered. First, Global Supply Chain Pressure Index (GSCPI) is global level data rather than country-level data. This may not fully capture a country's actual supply chain disruptions, which can affect the accuracy of the result. Second, this research only covers 48 countries out of 59 countries according to the GFSI score in 2018. This is because there is a lot of missing data in the remaining 11 countries and one of the country's GFSI ranges over the observed range. This may cause difficulty understanding the food security issue of the moderate GFSI countries in depth and comprehensively as the remaining 11

countries may have different policies and actions to deal with food security across the observed years. Third, during the data collection process, a full set of consumer food price index cannot be collected from only one source because the primary source does not provide full coverage data. To ensure the coverage of the observed countries to improve the accuracy of the panel data analysis, this research fills in the gap from the alternative source. However, this may cause inconsistencies in the results. Although there are limitations in this study, these limitations do not invalidate the significance of the results. These limitations provide the foundations for future research.

5.4 Recommendations for Future Research

First, future research can involve dynamic static panel models such as Generalized Method of Moments (GMM). Since some variables may be endogenous and thus cause the OLS model to become biased and inconsistent, future research could conduct dynamic static panel models because this model can solve issues such as endogeneity, unobserved heterogeneity, and dynamic relationships. This can provide more reliable results for the studies.

Second, future research can cover another group of countries with high GFSI countries or low GFSI countries. By this, future research can have a more comprehensive understanding of the effects of Covid-19 on food security in different countries with different GFSI scores. Not only that, the new findings can also make the research on this topic more complete and diversified and add value insight to the academic.

Besides that, future research can include more variables that may affect food security during Covid-19. As this research only observed 5 variables, there are still a lot of variables that may have relation with food security being ignored. Future research can include more variables from different perspectives such as trade restrictions, logistics restrictions, and poverty rate. By including more variables, future research can provide more evidence and significant results on this topic.

5.5 Conclusion

In conclusion, this research is conducted to identify the factors that affect food security after Covid-19 in countries with moderate GFSI scores ranging from 50% to 79.9%. Rising food prices and GDP per capita are found to be the main factors that affect the countries' food security within Covid-19 period. The result of rising food prices is not consistent with the existing literature and hypothesis made in the earlier chapter is being rejected. However, the result of GDP per capita is consistent with the existing literature. Besides that, the unemployment rate, supply chain disruptions, and population growth rate do not have a significant relationship with food security. The hypotheses that examine the relationship between unemployment rate, supply chain disruptions and food security are also being rejected.

The observed countries' policymakers are encouraged to refine existing food security strategies such as enhancing social protection programs, reinforce food price monitoring systems, and implement market intervention to stabilize the food prices. Besides, policymakers are encouraged to provide income generation activities, increase minimum wages, and promote more job opportunities in order to enhance households' economic access to food.

Last but not least, there are some limitations in this study which include the GSCPI is global level data rather than country-level data, only covers 48 countries out of 59 countries due to the remaining 11 countries has a lot of missing data, as well as using multiple sources for one variable due to the primary source do not provide full coverage data. Hence, recommendations are given as advice to further improvement for future study.

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APPENDICES

Appendix 4.1: Descriptive Statistics

Variable		Mean	Std. dev.	Min	Max	Observations
FS	overall	66.24417	7.263681	50.1	79.9	N = 240
	between		6.75716	54.46	78.62	n = 48
	within		2.804641	56.52417	72.70417	T = 5
UEMP	overall	7.736213	5.808894	.716	34.007	N = 239
	between		5.718713	.947	30.3732	n = 48
	within		1.208017	4.028613	13.53061	T = 4.97917
SCD	overall	1.469628	1.141665	-.0382	3.077764	N = 240
	between		0	1.469628	1.469628	n = 48
	within		1.141665	-.0382	3.077764	T = 5
RFP	overall	290.6577	953.7797	62.13075	8048.022	N = 231
	between		935.3039	72.14032	6589.86	n = 48
	within		130.8905	-507.2951	1748.82	T = 4.8125
lnGDP	overall	9.10546	.8253009	7.499147	10.65765	N = 240
	between		.831133	7.56812	10.59278	n = 48
	within		.0435974	8.919969	9.207129	T = 5
PGR	overall	.651616	1.232267	-7.61932	5.113181	N = 240
	between		.8863618	-2.030897	1.990701	n = 48
	within		.8637093	-4.936807	4.799359	T = 5

Appendix 4.2: Pooled Ordinary Least Squares (POLs)

Source	SS	df	MS	Number of obs	=	230
Model	8449.32449	5	1689.8649	F(5, 224)	=	105.06
Residual	3603.0502	224	16.0850456	Prob > F	=	0.0000
				R-squared	=	0.7011
				Adj R-squared	=	0.6944
Total	12052.3747	229	52.6304572	Root MSE	=	4.0106

FS	Coefficient	Std. err.	t	P> t	[95% conf. interval]	
UEMP	-.0355713	.0465355	-0.76	0.445	-.1272745	.056132
SCD	.0221041	.2329435	0.09	0.924	-.436937	.4811452
RFP	.0001951	.000285	0.68	0.494	-.0003666	.0007568
lnGDP	7.253758	.3388646	21.41	0.000	6.585987	7.921528
PGR	-.5279308	.2496418	-2.11	0.036	-1.019878	-.035984
_cons	.5982493	3.239667	0.18	0.854	-5.785874	6.982373

Appendix 4.5: Cluster Code for REM

```

Random-effects GLS regression           Number of obs   =       230
Group variable: id                     Number of groups =        48

R-squared:                               Obs per group:
  Within = 0.0161                          min =          1
  Between = 0.8151                         avg =         4.8
  Overall = 0.6981                          max =          5

corr(u_i, X) = 0 (assumed)                Wald chi2(5)    =       277.60
                                           Prob > chi2     =        0.0000

```

(Std. err. adjusted for 48 clusters in id)

FS	Coefficient	Robust std. err.	z	P> z	[95% conf. interval]	
UEMP	-.0108848	.0806814	-0.13	0.893	-.1690175	.1472479
SCD	.0285954	.2131549	0.13	0.893	-.3891805	.4463712
RFP	.0003793	.000187	2.03	0.043	.0000127	.0007459
lnGDP	7.433508	.4550152	16.34	0.000	6.541694	8.325321
PGR	-.2153146	.1697838	-1.27	0.205	-.5480847	.1174554
_cons	-1.544328	4.225356	-0.37	0.715	-9.825874	6.737218
sigma_u	2.6117744					
sigma_e	3.0562978					
rho	.42205356 (fraction of variance due to u_i)					

Appendix 4.6: Breusch and Pagan Lagrangian Multiplier Test for Random Effects

Breusch and Pagan Lagrangian multiplier test for random effects

$$FS[id,t] = Xb + u[id] + e[id,t]$$

Estimated results:

	Var	SD = sqrt(Var)
FS	52.63046	7.254685
e	9.340956	3.056298
u	6.821365	2.611774

Test: Var(u) = 0

chibar2(01) = 69.01
 Prob > chibar2 = 0.0000

Appendix 4.7: Hausman Test

	— Coefficients —			sqrt(diag(V_b-V_B)) Std. err.
	(b) fixed	(B) random	(b-B) Difference	
UEMP	.2574798	-.0108848	.2683646	.1927695
SCD	-.0881255	.0285954	-.1167209	.0748921
RFP	.0016293	.0003793	.00125	.001563
lnGDP	11.29941	7.433508	3.865904	6.000136
PGR	-.0511495	-.2153146	.1641651	.1049324

b = Consistent under H₀ and H_a; obtained from **xtreg**.
 B = Inconsistent under H_a, efficient under H₀; obtained from **xtreg**.

Test of H₀: Difference in coefficients not systematic

chi2(5) = (b-B)'[(V_b-V_B)⁽⁻¹⁾](b-B)
 = 4.60
 Prob > chi2 = 0.4668
 (V_b-V_B is not positive definite)

Appendix 4.8: Autocorrelation Test

Wooldridge test for autocorrelation in panel data

H₀: no first order autocorrelation

F(1, 45) = 33.792
 Prob > F = 0.0000