AN ANALYSIS ON THE FACTORS THAT IMPACTING FOOD SECURITY IN JAPAN

BY

ONG KAI FENG

A research project submitted in partial fulfillment
of the requirement for the degree of

BACHELOR OF ECONOMICS (HONOURS)
GLOBAL ECONOMICS

UNIVERSITI TUNKU ABDUL RAHMAN

FACULTY OF ACCOUNTANCY AND
MANAGEMENT
DEPARTMENT OF ECONOMICS

MAY 2024

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DECLARATION

We hereby declare that:

(1) This undergraduate research project is the end result of our own work and that due acknowledgement has been given in the references to ALL sources of information be they printed, electronic, or personal.

(2) No portion of this research project has been submitted in support of any application for any other degree or qualification of this or any other university, or other institutes of learning.

(3) Equal contribution has been made by each group member in completing the research project.

(4) The word count of this research report is __________________________.

Name of Student:	Student ID:	Signature:
1. Ong Kai Feng	2002371	

Date: 2/5/2024

ACKNOWLEDGEMENT

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DEDICATION

During my college career studying at Universiti Tunku Abdul Rahman (UTAR), I met a lot of people and learned a lot of knowledge, especially from the Final Year Project (FYP). During this period, I received help from many people and gained a lot of professional guidance from mentors, which benefited me a lot. Therefore, I would like to dedicate this research project to all the people who mean a lot to me. I would like to dedicate this research paper to my supervisor, classmates, and study. Thank you for their support during this time.

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GFSI	Global Food Security Index (GFSI)
FAO	Food and Agriculture Organization
FPI	Food Production Index (2014-2016 = 100)
GDP	Gross Domestic Product per capita (constant 2015 US$)
FI	Food Import (% of merchandise imports)
EIA	Employment in Agriculture (% of total employment) (modeled ILO estimate)
AL	Agricultural Land (% of land are)
FC	Fertilizer Consumption (kilograms per hectare of arable land)
H0	Null Hypothesis
HA	Alternative Hypothesis
BLUE	Best Linear Unbiased Estimator
VECM	Vector Error Correction Method
VAR	Vector Autoregression
ADF	Augmented Dickey-Fuller
PP	Phillips-Perron
VIF	Variance Inflation Factor

PREFACE

In my impression, Japan has always been a developed country and a target that Malaysia wants to learn from. Therefore, when I discovered that Japan has less agricultural land, a gradually decreasing agricultural labor force, and is highly dependent on imports, it aroused my curiosity about Japan’s food supply and food security issues. Therefore, after much thought, I decided to research this topic in my Final year Project. In addition, people often pay attention to the country's economy but food security is often ignored by the public. Therefore, this article will discuss the factors affecting Japan's food security and provide some suggestions to policymakers and investors to reduce the potential problems caused by food insecurity in Japan.

ABSTRACT

Food has always been the foundation for the progress of human civilization and the basic purpose of human survival. Although Japan ranks prominently in the Global Food Security Index (GFSI), much of this is due to its strong economic fundamentals. However, food systems that rely solely on economic strength are vulnerable to external influences. Due to the current external situation, people have increased concerns about the possible disruption of Japan's food supply during an emergency and whether Japan can maintain strong agricultural self-sufficiency and food security. Therefore, this study will examine the relationship between different independent variables such as Japan's GDP per capita, food imports, agricultural employment, agricultural land, fertilizer consumption, and food production index (dependent variable), and evaluate the extent to which these factors affect to Japan's food production by using the vector error correction model method (VECM). According to the results from the VECM of this study, the food production index (FPI) and employment in agriculture (EIA) are cointegrated, which also means that there is a long-term relationship between the two. In addition, in the short term, per capita GDP, food imports, agricultural employment, and agricultural land will have a corresponding positive impact on the food production index (FPI), indicating their importance in affecting Japan's food production and security. This study attempts to identify areas for improvement and propose effective policy recommendations to ensure food security and a stable food production supply in Japan, thereby creating a more reliable food production system.

Keywords: Japan, food security, food production system, VECM

CHAPTER 1: RESEARCH OVERVIEW

1.0 Introduction

In chapter 1 will establish the foundational context for the research conducted on "An analysis of the factors influencing food security in Japan." This chapter will outline the study's topic, present a problem statement delineating the issue's significance and the necessity for the study, and discuss the study's importance, hypotheses, and the research's goals and inquiries. The concluding chapter will serve as a roadmap for the following chapters.

1.1 Research Background

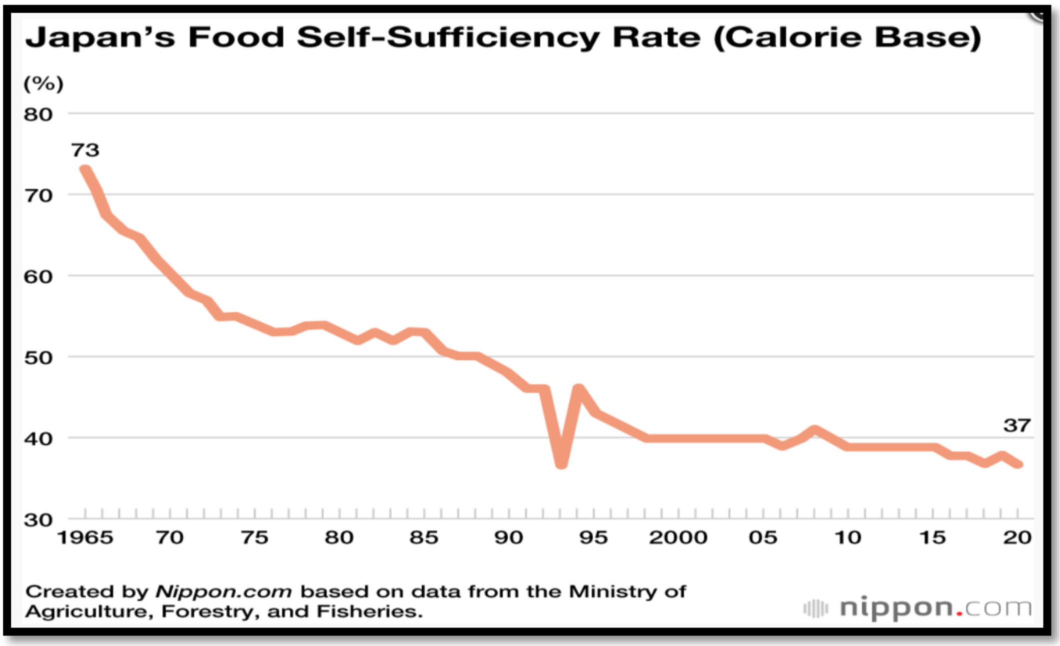
Food has always been essential to human civilization's progress and is the basic tenet of our survival. No matter is the Modern world and ancient historical records highlight the important practice of releasing stored grain during the famine, underscoring the enduring concern for food security. This owing to the fact that attaining food security is among the fundamental requirements for any nation to flourish and expand, particularly for nations like Australia, New Zealand, and others that rely mostly on advancements in the agricultural sector (Fernandes & Samputra, 2022). According to projections and assessments by the United Nations (n.d.) estimated that more than 600 million people worldwide will face hunger and without access to enough food in 2030. This highlights the huge challenge in achieving the goal of zero hunger. Therefore, food security is one of the important topics that requires the focus of global attention.

Food security refers to a nation's or region's state of food supply and a household's capacity to acquire, afford, and buy enough food. Furthermore, over time, definitions of food security have increasingly emphasized needs and access issues. Based on the World Food Summit (1996) stated that, the food security is to guarantee people's continued physical, social, and financial access to enough amounts of food that are safe, nourishing, and meet their dietary needs to maintain an active and healthy lifestyle. Conversely, food insecurity denotes unpredictable or restricted availability of safe, nutrient-dense food (Andersen, 1990). Furthermore, a thorough evaluation of society's food circumstances must primarily take into account the four aspects of food security: stability, availability, accessibility, and utilization (World Bank, n.d.).

Food plays a fundamental role in every aspect of society, directly impacting people's lifestyles by supplying vital nutrients including proteins, carbs, vitamins, and minerals necessary for physiologic function and overall health maintenance. People continually need food to maintain their daily labor levels, food production can become a significant component affecting the nation's economic position in addition to supplying food for the people and enhancing food security. In general, the higher a country's labor force participation rate, the more it can contribute to the national economy. If food security is not taken seriously for a long time, it may lead to an increase in the incidence of many chronic diseases, causing people to be unable to work and thus causing losses in economic activities for individuals and the country. Therefore, to ensure the development of the country and people's living standards, it is very important to ensure the continuity and stability of food security (Elmes, 2018). In many nations, the agricultural sector is essential and has become one of the key foundations of economic activity. A great deal of individuals can find work in it, from producing food to gathering raw materials, preparing food, and packaging final goods. This has significantly impacted the employment and income levels of the nation. However, technology continues to advance and increase the food supply over time. There is still no way to stop hunger, and there are food crises and potential problems in many parts of the world (Prosekov & Ivanova, 2018).

However, the issues with food security and associated hazards are unique to Japan compared to most of the world. Japan stands among the world's most significant economic powers. However, compared with its economic position on the global stage, it faces challenges in maintaining strong agricultural self-sufficiency and food security. Japan is an island nation made up of over 6,800 small islands as well as Hokkaido, Honshu, Shikoku, and Kyushu with a total land area of 37.97 square kilometers and a population of 125.5 million (Bureau, 2022). Most of Japan is mountainous, with a limited and fragmented region used for cultivation. It is a typical nation with a large population and limited land. In recent years, as Japan's population aging problem has become increasingly serious, the rural agriculture labor force has been decreasing year by year, which may have adverse effects (Dong, 2018).

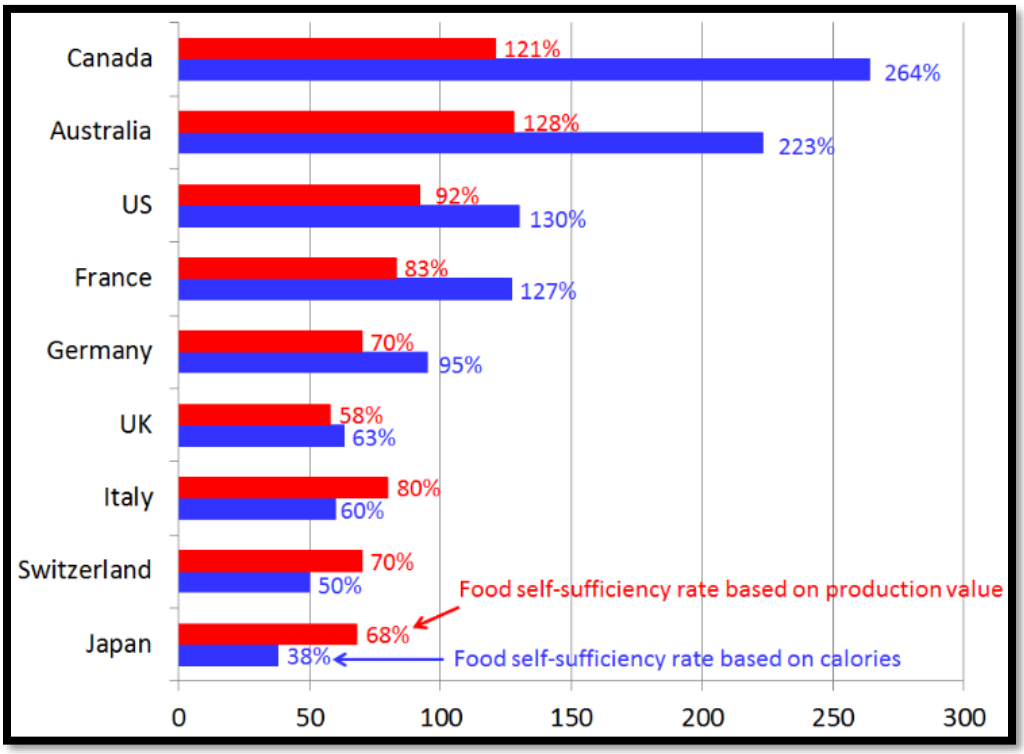
Figure 1.1: Japan's Food Self-Sufficiency Rate (Calorie Base)



Source: Nippon.com

Besides, according to Kako (2009) also stated that achieving food security in Japan entails boosting domestic output to become more self-sufficient. However, although Japan maintains a high supply of traditional consumer foods like rice, but food supply with Western-style meals such as wheat, beef, and dairy products is not enough. This is because shifting economic conditions have led to Japanese people liking Western-style meals. For example, Japan has only a 38% food self-sufficiency rate (calorie base) and Japan is also facing the problem of diminishing the rate of self-sufficiency since 1965.

Figure 1.2: Food Self-Sufficiency Rates Across Developed Countries



Source: Ministry of Agriculture, Forestry and Fisheries of Japan

According to figure 1.1.2, Japan has one of the lowest rates of food self-sufficiency (38%) among developed nations; by contrast, the food self-sufficiency rates (calorie basis) of other developed nations, like the US, Canada, France, and others are approaching or more than 100%. Furthermore, food self-sufficiency and food security in Japan are declining, despite the fact that these indicators are rising in many affluent nations (Kako, 2009). Japan's low degree of self-sufficiency indicates a greater reliance on imported food, which could make the country more subject to the effects of the outside world and the global food market. This has an impact on food security stability and raises the possibility of food insecurity (Higashi, 2022).

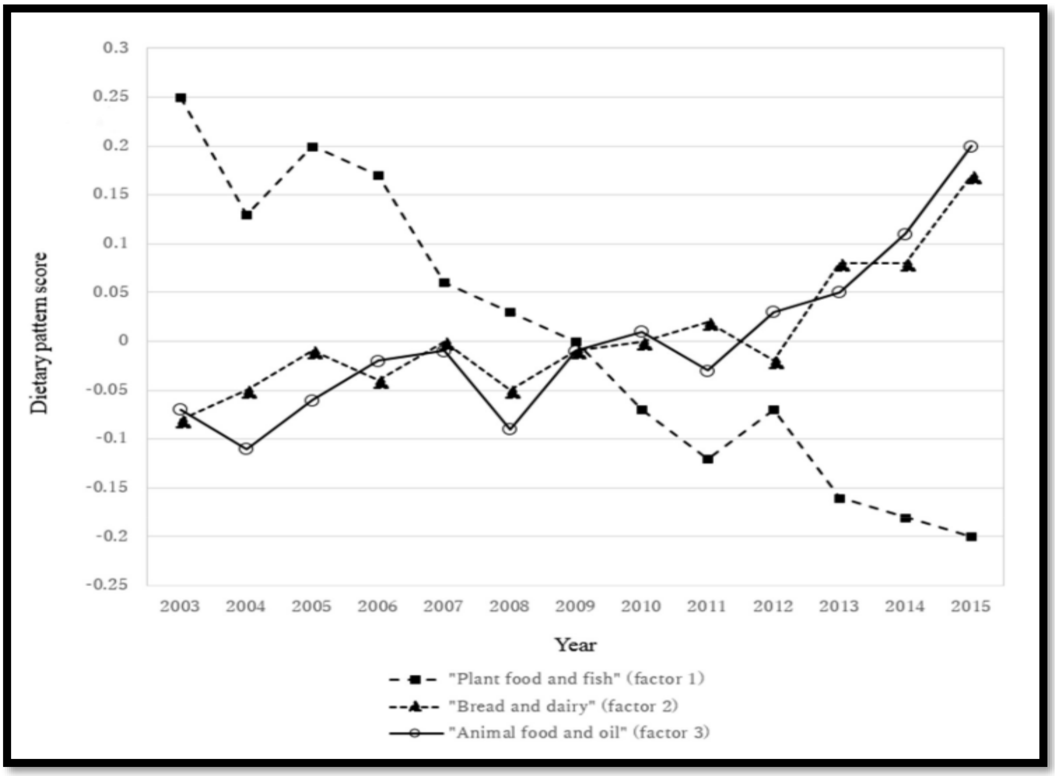
Take the effects of changes in global markets and interruptions to the supply chain, for instance. In addition, issues such as land resource limitations, the ability of food imports, and population aging (agricultural labor force decreasing) may also cause problems for Japan's food security and production. Despite having a robust economy, Japan's reliance on imported food exposes the country's weak food security (Linder, 2024). These problems may make Japan's food supply unstable, thus affecting domestic food security. Therefore, the food security situation in Japan is not optimistic, and policies and strategies to ensure food security and stable supply, as well as agricultural development, are top priorities.

Consequently, to avoid problems like inadequate food supply and food insecurity. The food production index serves as the dependent variable in this research, which focuses on guaranteeing food security and a sufficient food supply in Japan. In addition, various factors affecting Japan's food security will be studied using GDP per capita, food imports, employment in agriculture, agricultural land, and fertilizer consumption as independent variables.

1.2 Problem Statement

Japan's accomplishments and expertise in agricultural development have always drawn interest and knowledge from throughout the globe. Due to some internal and external factors, Japan's agricultural development is facing difficulties, and problems and potential risks that may endanger its country's food security have also emerged.

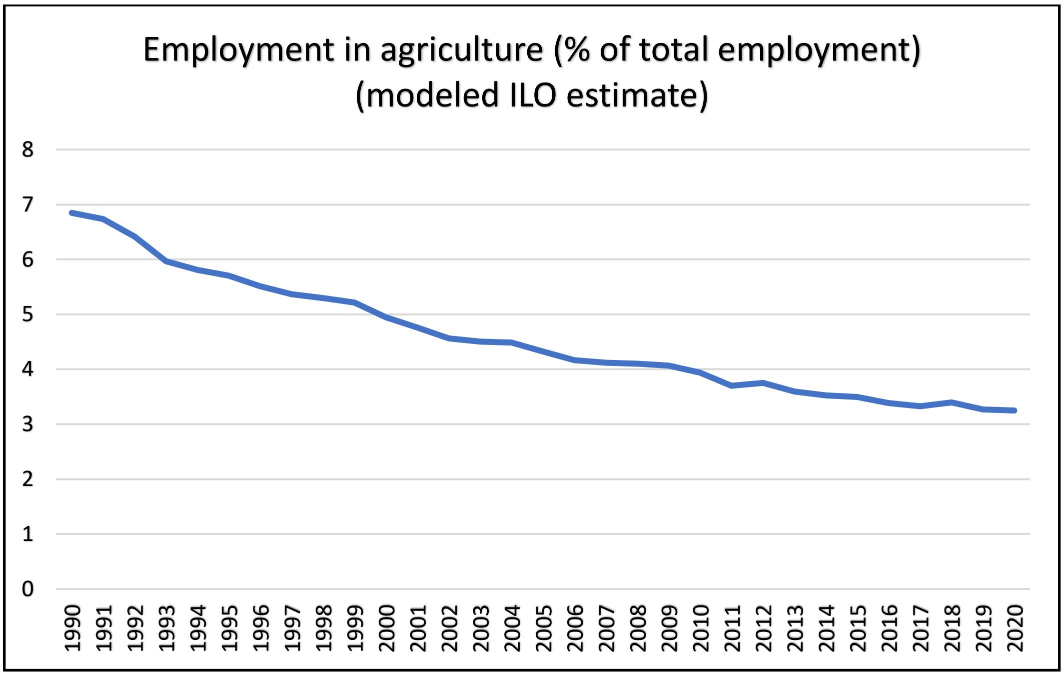
Figure 1.3: Trends in Dietary Patterns of Japanese



Source: (Murakami et al., 2018) .

From Figure 1.2.1 above, the intake of "plant foods and fish" by Japanese people steadily declines with time, while their intake of "bread and dairy products" and "animal foods and oils" increases gradually. This is because Japan began the process of industrialization during the Meiji Restoration and finished it in the early 1960s. The country's economy started a period of fast expansion (Ohno, 2018). According to research by Kagawa (1978), the traditional Japanese diet has drastically changed, with a decrease in the intake of rice and fish and an increase in the consumption of bread and meat due to Japan's economic growth. This change is particularly evident among the younger generation, the wealthy, and urban dwellers. The demand for traditional foods, particularly rice, which Japan produces on its own, has decreased as a result of this shift. Rather, it increased the demand for food prepared in the Western style, and Japan started importing food to satisfy this demand. This is because factors such as urbanization, globalization, and the rise of the economy and income will allow people to have more financial control over their purchases and to choose more diverse and high-quality foods (Pingali, 2007). This has led to increased imports of certain foods by Japan (Sasaki et al., 2022).

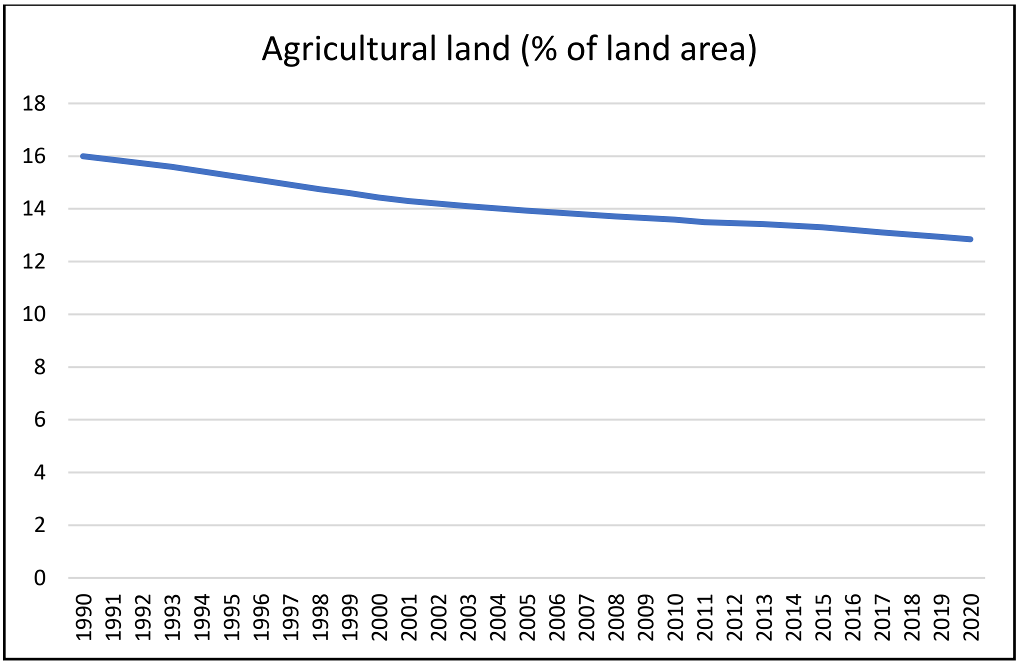
Figure 1.4. Employment in agriculture (% of total employment)



Adapted from: World Development Indicators (World Bank)

Furthermore, during Japan's period of rapid economic growth, the growing demand for labor driven by the surge in manufacturing and exports prompted a shift of workers from agriculture to industrial sectors, consequently resulting in a decline in the agricultural population. The agricultural and rural economic structures in Japan were greatly impacted by this period and process, which resulted in a notable fall in the importance of agriculture to the national economy (Ohno， 2018). Moreover, the labor force in agriculture is also getting older as a result of the relatively poor efficiency of agricultural operations and the significant loss of young and middle-aged workers. While 33% of Japan's employed people worked in agriculture in 1960, the country's agricultural output only made up 9% of its GDP. Moreover, as the economy develops quickly, the agriculture progressively falls behind other sectors of the economy. Japan has seen a decline in both agricultural income and total agricultural output value since 1984. As of 2013, the value of all agricultural output contributed just 1% of GDP, while 4 percent of all employed people were in the agricultural sector. Japan's agricultural population fell from 4.14 million in 1995 to 2.39 million in 2010, while the country's average age rose from 59.1 to 65.8 years. In 2013, the proportion of agricultural laborers who were 60 years of age or older was 75.8%, while the proportion of those who were 70 years of age or older was 48.6% (Dong, 2018). Although the government has implemented several initiatives aimed at promoting agriculture among young and middle-aged workers but in the face of the aging of the agricultural labor force, the new young and middle-aged labor force has had little effect.

Figure 1.5: Agricultural Land (% of land area)



Source: World Development Indicators (World Bank)

Moreover, Japan is a mountainous island country with limited domestic land resources. Over the previous few decades, just thirty percent of the overall land area has been deemed appropriate for agricultural and urban development. With the advancement of industrialization and urbanization, cultivated land resources have become scarcer, causing the cultivated land area to decrease by 25%. In 2014, the land area in Japan was composed of 66.3% forest, 3.1% residential space, and 12.0%

agricultural land (Bureau, 2017). Japan's limited agricultural land is now one of the biggest barriers to the country's agricultural growth (Hamdy & Aly, 2014). A significant contributing cause to the decline in the amount of land under cultivation in Japan is the annual conversion of a certain percentage of agricultural land to residential, commercial, industrial, or public facilities, despite the country's enactment of legislation regulating such changes (Bureau, 2017). Although Japan has issued laws restricting the change of agricultural land use, a certain proportion of agricultural land is still converted to residential, public facilities, industrial, or commercial land every year, which has become an important factor leading to the reduction of cultivated land.

Although Japan ranks prominently in the Global Food Security Index (GFSI), this is dependent on its strong economic base. However, a food system solely reliant on economic prowess is susceptible to external influences. The food prices have remained high due to the COVID-19 pandemic's logistical delays, which have caused disruptions in the world's food supply systems. In addition, the conflict between Russia and Ukraine has also affected the price of commodities and animal feed. Concerns over possible interruptions to Japan's food supply in times of emergency have increased due to the current circumstances, and we must use the Ukrainian crisis as a trigger for reassessing the global and Japanese states of food security (Higashi, 2022). Therefore, the significance of a country having a greater level of self-sufficiency never decreases. By investigating and filling the research gap, this study will examine the relationship between different independent variables such as GDP per capita, food imports, employment in agriculture, agricultural land, and fertilizer consumption and food production index (dependent variable) in Japan, assessing the extent to which these factors affect food production in Japan.

1.3 Research Questions

1. What is the connection between Japan's GDP per capita, employment in agriculture, land use for agriculture, food imports, fertilizer consumption, and food production index?
2. How much do these factors affect Japan's food production?
3. What particular policy initiatives can the government and pertinent organizations take to strengthen Japan's current food production system, boost its food security, and lessen its vulnerability to changes in international trade as well as foreign incidents?

1.4 Research Objectives

1.4.1 General Objective

This research attempts to pinpoint the areas that require improvement and propose effective policy recommendations to ensure food security and a steady food production supply in Japan, thereby creating a more reliable food production system.

1.4.2 Specific Objectives

1. Examine the relationship between the Japan Food Production Index (the dependent variable) and the GDP per capita, food imports, employment in agriculture, agricultural land, and fertilizer consumption (the independent variables).
2. Investigate the factors affecting Japan's Food Production to understand the extent to which these factors affect Japan's food production.
3. Examines ways to improve Japan's food production and existing food production system.

1.5 Hypotheses of the Study

These five hypotheses examine the significance or insignificance of the relationships between GDP per capita, food import, employment in agriculture, agricultural land and fertilizer consumption concerning the food production index make up the summary of our hypothesis testing. These hypotheses form the basis of our research questions and will be tested to gain insights into the impacts of these factors on the food production index in Japan.

Hypothesis 1

H_0: There is no significant relationship between GDP per capita (GDP) and food production index (FPI).

H_A: There is a significant relationship between GDP per capita (GDP) and food production index (FPI).

Hypothesis 2

H_0: There is no significant relationship between food import (FI) and food production index (FPI).

H_A: There is a significant relationship between food Import (FI) and food production index (FPI).

Hypothesis 3

H_0: There is no significant relationship between employment in agriculture (EIA) and food production index (FPI).

H_A: There is a significant relationship between employment in agriculture (EIA) and food production index (FPI).

Hypothesis 4

H_0: There is no significant relationship between agricultural land (AL) and food production index (FPI).

H_A: There is a significant relationship between agricultural land (AL) and food production index (FPI).

Hypothesis 5

H_0: There is no significant relationship between fertilizer consumption (FC) and food production index (FPI).

H_A: There is a significant relationship between fertilizer consumption (FC) and food production index (FPI).

1.6 Significance of the Study

It is very important to analyze the variables that affect Japan's food security. This is because studying food production indices is crucial for developing targeted agricultural and food production policies, and access to adequate food production and supply is one of the main determinants of current food security in many countries. Therefore, in order to provide effective insights to investors and policymakers. This study will examine the impact of many factors on the food production index, including Japan's per capita GDP, food imports, agricultural employment, agricultural land, and fertilizer consumption.

This study will provide policymakers with a better understanding of opportunities, challenges, and recommendations for enhancing food security in Japan by understanding the relationship between these factors and food production indices. In addition, the research results will also provide some suggestions on how Japan can enhance its food self-sufficiency to reduce its sensitivity to fluctuations in international trade and external events.

1.7 Chapter Layout

In Chapter 2, theories about the relationships between the variables will be offered, along with a review of earlier study literature. Chapter 3's methodology section will address measurement scales, sample size, research design, data analysis methods, and data collection strategies. For chapter 4, which presents the test findings and their interpretation, covers the data analysis section. Lastly, the primary conclusions are covered in the chapter 5 section titled "Discussion and Conclusions."

1.8 Conclusion

This chapter serves as an introduction to the impending study. It starts by outlining the study background and the present food issues that Japan is facing. It also looks at how factors like agricultural employment, GDP per capita in Japan, food imports, exports, and agricultural land interact with Japan's food production index. This part contains an overview of the study's direction and scope, serving as a road map for the upcoming chapters.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

Expanding upon the groundwork laid in Chapter 1, which addressed the problem statement, research objectives, research questions, significance of the study, research background, and hypothesis development. Moreover, Chapter 2 delves into an exhaustive examination of existing literature concerning "An analysis on the factors impacting food security in Japan." This chapter functions as a crucial synthesis of previous research, offering valuable insights into fundamental concepts, theories, and empirical discoveries that form the basis of the current study.

2.1 Review of the Literature

2.1.1 Food Production Index

When a significant portion of a nation's populace consistently has reliable access to sufficient nutritious food for maintaining a healthy lifestyle, it qualifies as achieving food security (Idachaba, 2004). A fundamental requirement for attaining food security is ensuring that the vast majority of the population can obtain and consume food that is fit for consumption (Samuel, 2018). Consequently, the approach to evaluating food production involves assessing the potential capacities of both food production and markets, as these factors directly impact food availability. Therefore, the food production index serves as a crucial indicator. The food production index encompasses the variety of nutritious crops considered suitable and beneficial for human consumption. However, coffee and tea are exceptions to this classification because, despite being edible, they lack significant nutritional value (Omodero, 2021).

2.1.2 Gross Domestic Product per Capita

Food production will be somewhat impacted by GDP per capita, this is because agriculture productivity and technology are directly impacted by economic development. The reason why food production will be somewhat impacted by GDP per capita is because the increase or the advancement of agriculture productivity and technology will be directly impacted by economic development. According to the research by Singariya & Sinha (2015), They investigated the connection between GDP per capita and agricultural and manufacturing output. They gathered India's time series data between 1970 and 2013 for a study and used various econometric methods, including the stationarity test, Johnson cointegration test, Johnson VECM model, impulse response function as well as variance decomposition analysis. The findings demonstrate a two-way causal relationship between per capita GDP and agriculture, suggesting that both the economic level and agriculture will have an impact on economic development. Moreover, based on Beckman et al. (2021) utilize a computable general equilibrium model to simulate the pre and post COVID-19 impacts on food security, food prices, and GDP. However, the findings found that in OECD countries, GDP per capita fell by 7.2% during the COVID-19 pandemic, leading to a 27.8% rise in the population experiencing food insecurity, while crop producers experienced a 9% decrease in income. The study's findings also suggest there is a positive correlation between food production and GDP per capita.

In addition, the research of Timmer (2004) also mentioned the long-term positive or negative relationship between economic growth and food security. This is because, in the process of national development, economic growth, and citizen income levels are very closely related to food security. This indicates that while the economy continues to grow, the government needs to pay attention to food production and supply to ensure national food security and people's quality of life. The authors also suggest that governments can try to invest and provide monetary incentives to encourage increases in agricultural output, irrigation, rural infrastructure, and agricultural research and extension thereby directly driving economic growth, reducing poverty, and maintaining economic stability. Therefore, the findings of this study mainly highlight the interconnections between economic development and food production and emphasize the importance of economic policies in promoting food security.

According to research by Burchi & De Muro (2016), most traditional views on food security only focus on food supply. However, this view is too concentrated on a single economic sector. Food security issues cannot be seen as unique to the agricultural sector; all economic sectors of the national economy are interrelated. This broader view recognizes that food insecurity is not limited to agricultural production, but also involves factors such as gross domestic product (GDP) and economic growth, rather than relying solely on food production capacity. This is because if a country uses strong market economic strength, it can solve domestic food security problems by importing food. In addition, the study also mentioned that the level of national income will also have a direct impact on food security outcomes. This is because low income can also lead to insufficient purchasing of necessary food.

2.1.3 Food Import

In today's globalized food trade landscape, nearly every nation must import food from abroad to satisfy internal consumption demands (Ahumada and Villalobos, 2009). Despite Japan's status as the world's fourth-largest economy, its self-sufficiency rate has remained relatively low (Saili et al., 2020), leading to significant reliance on imported products. Although Japan's food production data and food security index are satisfactory, they predominantly hinge on rice cultivation. The assessment of food imports can be approached from both demand and supply perspectives (Fader et al., 2013). In instances where a country's supply exceeds domestic demand, importing food becomes a critical channel to meet nutritional requirements. However, domestic food prices will decline as a result of food imports. This might reduce farmer incentives and domestic food production, which would eventually cause importing countries' food output to decline (FAO, n.d.). In addition, the research by Ugwu, Efuntade & Ehinomen (2022) analyzed the impact of Nigeria's food imports on food production and international balance of payments from 1960 to 2020. This study employs an autoregressive distributed lag (ARDL) constrained cointegration test procedure and finds that overreliance on food imports harms domestic food production in both the long and short term and that low-cost food imports may shrink the market for local agricultural products. This is because cheap imported food may cause domestic food prices to fall, meaning farmers and agribusiness employees will no longer have a high source of income (Nyangito, 2002). Moreover, according to research by Subramaniam et al. (2023), mentioned that the Food and Agriculture Organization believes that imports are very important for food security. Therefore, the above study analyzed the impact of imports from 56 low and middle income countries from 2011 to 2016. After detailed analysis, they found out that the impact of imports has a significant positive impact on food supply levels. However, in terms of the level of food accessibility, utilization levels, and stability, imports have a negative impact.

Besides, as Japan's dietary habits shift towards Westernization, there is a gradual decline in rice consumption, juxtaposed with a surge in demand for Western staples like milk, butter, cheese, meat, and eggs (Campo & Beghin, 2005). Consequently, Japan finds itself reliant on imports to satisfy its diverse culinary preferences, underscoring the indispensable role of food imports. However, while imports help bridge gaps in domestic demand, they also pose potential sustainability risks to food supplies. Given the evolving landscape of Japan's food market and increasing external influences, the significance of food imports continues to grow.

<u>2.1.4 Employment in Agriculture</u>

Ensuring food production is of immense importance to a country, especially for nations like Japan, characterized by a weak agricultural sector and low self-sufficiency rates. Consequently, one of the challenges Japan must address for the sustainable supply of food is its agricultural labor force. According to the research of Abdullah and Sulaiman (2013), it is stated that the younger generation currently shows a preference for employment in factories and commercial sectors rather than in agriculture. The shift of agricultural labor to non-agricultural industries could profoundly impact food security. This is because the continuous decline in agricultural labor would lead to a decrease in food production, and as agricultural labor transitions to non-agricultural sectors, their role shifts from food producers to food consumers, exacerbating the gap between food supply and demand (Zou & Guo, 2015). In addition, as Japan now also faces the problem of an aging population and low birth rate, this problem has affected many industries, including agriculture and based on Saili et al. (2020) study examined seven Japanese youth engaged in the agricultural sector who participated in a qualitative study employing a phenomenological approach to determine their socioeconomic characteristics and gauge the youth's perspectives on food in agricultural development. They highlighted that the average age of farmers is increasing, with few young individuals stepping forward to replace them, resulting in a decline in the number of farmers. Therefore, elderly farmers are predominantly viewed as the primary demographic managing and operating farmland, while the involvement of young farmers remains minimal. This situation poses a threat to Japan's future food security and sustainability.

2.1.5 Agriculture Land

Agricultural land serves as a crucial land use type supporting millions of households' food needs and means of subsistence while catering to the needs of a growing global population, both in terms of food and non-food systems. Nevertheless, based on Aboye et al (2023) the study examines the transition in agricultural practices from cropland use to woodland use using panel and cross-sectional data, viewing farming practices as essential to sustenance and farmland-use loss in the context of urban expansion. The result of the study stated that, the acceleration of economic growth and urbanization poses significant challenges and pressures on agricultural land resources. Urban expansion as countries develop is particularly worrisome because urban expansion and sprawl often invade on agricultural land, reducing the amount of land available for food production and potentially leading to food insecurity.

This problem has been exacerbated by rapid economic development and urbanization in many countries today, resulting in significant degradation or reduction of agricultural land cover (Güneralp et al., 2020). According to Saili et al. (2020), Japan also faces this type of problem due to the development and Japan itself also faces a serious shortage of agricultural land. While there are only 15% of Japan's territory is suitable for agriculture, all available land is used to grow and produce agricultural products. In this case, Japan boasts one of the highest crop yields per hectare globally. Therefore, the diminishing agricultural land area has raised concerns among many nations regarding its impact on food production. However, according to Tilman et al. (2011) stated that the expansion of agricultural land to all suitable available land is key to achieving growth in food production and contend that the increase in food production is directly linked to the expansion of agricultural land. Only better utilization and richer arable land resources can more easily meet people's demand for food, thereby reducing the need for food imports. (Tian et al., 2020). Moreover, research studies such as those by Hamdy & Aly (2014) have highlighted that the shrinkage of agricultural land and its degradation could significantly impact regional food security. This is attributed to the overall decrease in production, which consequently drives up food prices for consumers across the board. Moreover, it results in income loss for those reliant on agricultural land or labor. Hence, expanding the agricultural land area becomes imperative to safeguard and enhance food production (Reidsma et al., 2012).

2.1.6 Fertilizer Consumption

The need for food is growing in society along with the economy and population. Therefore, agricultural productivity must rise dramatically to fulfil and adapt to the demands of modern civilization. However, governments and farmers worldwide have decided to increase the use of diverse fertilizers as agricultural land becomes scarce and agricultural labor becomes less in demand (Motesharezadeh et al., 2017). Therefore, the usage of chemical fertilizers has become a crucial input in agricultural production and one of the major elements affecting food production to create enough food supplies to meet expanding demand. This is because fertilizers require ongoing farming cycles in the cleared area for a specific amount of time in the future, in addition to prolonging the shelf life of the food produced (Stewart et al., 2005). Moreover, Japan is widely recognized for its high rice yields and widespread usage of chemical fertilizers. The widespread use of chemical fertilizers has led to a notable rise in rice yields, particularly following World War II (Murayama & Noboru, 1975).

However, Asumadu-Sarkodie & Owusu's (2016) research indicates that chemical fertilizers may have unfavorable impacts if applied excessively. Chemical fertilizers are widely used because they are inexpensive and because rice is expensive. But while this approach might boost yields in the short run, an over-reliance on chemical fertilizers can have a detrimental long-term economic impact on the agricultural economy by reducing fertilization efficiency (Murayama & Noboru, 1975).

2.2 Review of Relevant Theoretical Models

Food issues have always been an aspect that people attach great importance to. Whenever food security issues are discussed or faced with famine, the ideas of food supply proposed by Malthus become popular (Kurniawan, 2016). Malthus believed that famine and other food insecurity problems were caused by insufficient food supply. Malthus believed that the continuous increase in population has led to an increase in food demand, but due to the reduction of agricultural land and the reality of limited food supply, it cannot cope with such a huge demand. This resulted in problems such as famine and food insecurity (Malthus, 1789). The decline in crop yields is an important factor in the reduction of food supply.

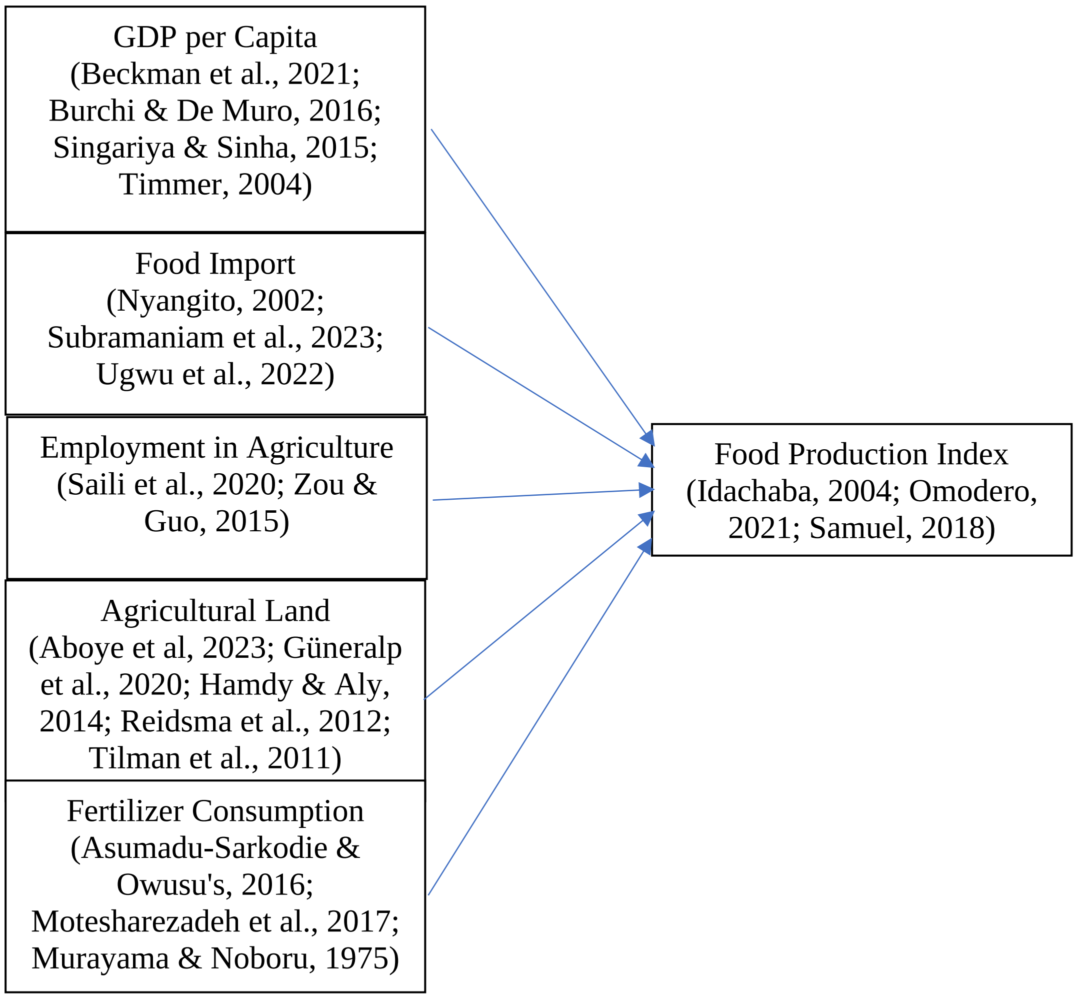
Moreover, other than Malthusian theory, Amartya Sen's rights approach to understanding famine focuses on access to food as a key issue. This theory is contrary to Malthusian theory, Amartya Sen believed that the problem of food security does not lie in the failure of food supply but in people's ability to obtain food (Devereux, 2001). Amartya Sen distinguishes between endowments (control over assets and resources) and rights (the ability to control packages of alternative goods in the society) and identifies four types of rights: trade-based, production-based, own labor-based, and inheritance-based /transfer. Famines occur when rights are lacking, such as due to natural disasters that limit access to food production, market food prices are high, market forces favor other areas, falling wages impact purchasing power, and food distribution is inadequate (Kurniawan, 2016).

Furthermore, the Demand theory can be said to be one of the core theories of economics. This theory primarily answers fundamental questions about how much people desire things and how income levels and satisfaction (utility) affect demand. With today's changing economic conditions causing Japanese people to prefer Western-style meals, higher demand for foreign food will be disturbing. To meet domestic demand, Japan can only increase its food imports, and over-reliance on food imports may threaten the sustainability of national food security, and the demand theory holds that if Japanese consumers regard imported food as ordinary commodities, or if there are fewer substitutes for imported food, then an increase in national income will lead to an increase in demand for imported food (Kurniawan, 2016). Therefore, in this case, there may be a positive relationship with GDP per capita. However, if local production provides a relative substitute for imported food, then a negative relationship may emerge between real income and food import demand (Narayan & Narayan, 2005).

In addition, the Heckscher-Ohlin model plays a key role in assessing the trade balance between two countries, especially when the two countries have different specialties and natural resources. This model provides an in-depth understanding of how trade operates under global resource imbalances. Not only that but this model can also be applied and provide insights into agriculture. According to the conceptual representation of the Heckscher-Ohlin model, each country specializes in the production of agricultural products based on its resource endowments such as labor and land. Therefore, if a country has abundant land resources but limited labor, it may be more inclined to plant land-intensive crops; conversely, if a country has sufficient labor but limited land, it may focus more on labor-intensive agricultural products. This choice of specialization is consistent with the theory of comparative advantage, which states that countries export by utilizing the abundant factors they possess and import the scarce factors they need. Over time, trade can help the prices of agricultural factors in various countries gradually become equal, which reflects the efficient allocation of resources. In addition, when Japan faces challenges such as limited agricultural land, shrinking labor force (due to aging), and changing national tastes, the government's import of food can indeed temporarily alleviate domestic demand problems.

2.3 Conceptual Framework

Figure 2.1: Conceptual framework of the variables influencing Japan's food production



Source: Developed for Research

The conceptual framework for this study, which was carried out in Japan, is shown in Figure 2.3.1. It consists of one dependent variable and five independent variables that were chosen to be examined in connection to the dependent variable.

Table 2.1: Dependent Variable and Independent Variables

FPI	Food production index (2014-2016 = 100)
GDP	GDP per capita (constant 2015 US$)
FI	Food imports (% of merchandise imports)
EIA	Employment in agriculture (% of total employment) (modeled ILO estimate)
AL	Agricultural land (% of land area)
FC	Fertilizer consumption (kilograms per hectare of arable land)

Source: Developed for Research

In this study, we will choose FPI which refers to the Food production index (2014-2016 = 100) as our chosen dependent variable. The independent variables selected are the GDP per capita (constant 2015 US$) (GDP), food imports (% of merchandise imports) (FI), employment in agriculture (% of total employment) (modeled ILO estimate) (EIA), agricultural land (% of land area) (AL) and fertilizer consumption (kilograms per hectare of arable land) (FC). Moreover, to prevent data sharpness, the model's variables are all translated into logarithm form, which is equation 1 at below.

$$LNFPI_t = \beta_0 + \beta_1 LNGDP_{t-1} + \beta_2 LNFI_{t-1} + \beta_3 LNEIA_{t-1} + \beta_4 LNAL_{t-1} + \beta_5 LNFC_{t-1} + \varepsilon \quad (1)$$

Table 2.2: Logarithm Form

LNFPR	Logarithm form of Food production index (2014-2016 = 100)
LNGDP	Logarithm form of GDP per capita (constant 2015 US$)
LNFI	Logarithm form of Food imports (% of merchandise imports)
LNEIA	Logarithm form of Employment in agriculture (% of total employment) (modeled ILO estimate)
LNAL	Logarithm form of Agricultural land (% of land area)

LNFC	Logarithm form of Fertilizer consumption (kilograms per hectare of arable land)

Source: Developed for Research

In equation 1, t represents the amount of time and ε is the error term. Additionally, the coefficients for GDP per capita, food import, employment in agriculture, agricultural land, and fertilizer consumption are β1, β2, β3, β4, and β5 respectively.

2.4 Hypotheses Development

Hypothesis 1 (GDP per capita)

H_0: There is no positive relationship between GDP per capita (GDP) and food production index (FPI).
H_A: There is a positive relationship between GDP per capita (GDP) and food production index (FPI).

Hypothesis 2 (Food Import)

H_0: There is no negative relationship between food import (FI) and food production index (FPI).
H_A: There is a negative relationship between food Import (FI) and food production index (FPI).

Hypothesis 3 (Employment in Agriculture)

H_0: There is no positive relationship between employment in agriculture (EIA) and food production index (FPI).
H_A: There is a positive relationship between employment in agriculture (EIA) and food production index (FPI).

Hypothesis 4 (Agricultural Land)

H_0: There is no positive relationship between agricultural land (AL) and food production index (FPI).
H_A: There is a positive relationship between agricultural land (AL) and food production index (FPI).

Hypothesis 5 (Fertilizer Consumption)

H_0: There is no negative relationship between fertilizer consumption (FC) and food production index (FPI).
H_A: There is a negative relationship between fertilizer consumption (FC) and food production index (FPI).

2.5 Conclusion

Chapter 2 provides a comprehensive analysis of the food security literature and highlights the variables that influence food security in Japan. In addition, Chapter 2 also briefly analyzes the importance of variables such as GDP per capita, food imports, agricultural employment, agricultural land use, and fertilizer use in determining food security outcomes. Next, Chapter 3 will outline the research methodology used to examine the relationship between the identified variables and food security in Japan. Chapter 4 will discuss the findings and results and explore policy implications and potential future research directions.

CHAPTER 3: METHODOLOGY

3.0 Introduction

The analytical techniques and methodological framework that will be applied in this study are mostly covered in Chapter 3. As mentioned above, this chapter will outline the research methodology used to examine the relationship between the identified variables and food security in Japan which also describe the research design, data collection, and analysis procedures for this study, and provide a detailed overview of the study's methodology.

3.1 Research Design

To ensure that the many elements of this paper are better integrated and the research questions are fully investigated. The research design of this study will be used to inform the analytical methods and strategies selected for this investigation. The research design of this study is to explore factors affecting Japan's food production index, such as per capita GDP, food imports, employment in agriculture, agricultural land, and fertilizer consumption. Additionally, this study is quantitative and causal. This study intends to identify the key factors affecting Japan's food production index through rigorous testing by analysis and explore strategies to improve the food production index and ensure Japan's national food security.

3.2 Data Collection Methods

This study will analyze variables affecting food security in Japan using quantitative methods as well as by collecting secondary data.

3.2.1 Secondary Data

The data used in this study are all secondary data and are collected from the World Development Indicators (The World Bank) which is the time series data and covers 1990 to 2020, a total of 31 years. In addition, all dependent variables and many independent variables in this study also come from the World Development Indicators data of the World Bank. These variables include independent variables and dependent variables such as per capita gross domestic product (GDP), food imports (FI), agricultural employment (EIA), agricultural land (AL), fertilizer consumption (FC), and food production index (FPI).

3.3 Research Instrument

EViews is a modern econometric, statistical, and forecasting software package. There are several econometric data types, such as time series, cross-sectional data, and panel data, that can be analyzed by using EViews. Besides, the EViews software also provides a wide range of analysis, forecasting, and modeling tools, allowing users to quickly and efficiently process data, perform statistical analysis and modeling, and produce high-quality charts and tables. With its cutting-edge user interface, which facilitates data entry and import as well as visualization, analysis, prediction, and model solving, EViews is built to streamline users' processes and because EViews offers numerous good features and tools, this leading many universities, corporations, and research institutes utilize it for econometric analysis and research. In this study, EViews is also suitable for secondary data and provides very good analysis tools. For example, descriptive analysis, correlation analysis, unit root test, VECM model, and other tests will be used in this study. Therefore, EViews is a very important statistical package for the analysis and finding outcome for this study.

3.4 Data Processing

The collection and transformation of data into information that is useful is known as data processing. Data processing is particularly significant for research. This is due to data processing can successfully prevent negative effects on the final data output. Furthermore, every variable from the World Development Indicators (World Bank) will be located and data on it will be gathered for this research. Moreover, this study requires long-term observations, spanning at least 30 years, and the number of observations for each variable must be the same during the data collection process. In addition, to analyze the obtained variable data. This study will use Eviews to run several tests such as the descriptive analysis, correlation analysis, unit root test, Johansen Cointrgrated Rank Test, Granger causality test, VECM, and residual diagnostic test to ensure that the data outcomes and avoid some mistakes. Moreover, the explanation and interpretation of this paper will be provided based on the Eviews and key test outcomes.

3.6 Data Analysis

In data processing part will describe the statistical techniques and tests that will be applied in this paper.

3.6.1 Descriptive Analysis

Descriptive analysis is a method of summarizing and characterizing data. Descriptive analysis allows us to better understand the characteristics, patterns, and trends present in the data set. Additionally, descriptive analysis is also a good way to provide conclusions about the distribution of study data and can help detect errors and outliers (Sarmento & Costa, 2017). Descriptive analysis is arguably one of the most critical stages in statistical data analysis and is usually the first step in most studies (Kaur et al., 2018).

Not only that, descriptive analysis can also help discover patterns between variables in the study, so as to prepare for subsequent statistical analysis to a certain extent. Descriptive analysis often involves creating visual representations such as histograms and scatter plots, as well as calculating things such as means, medians, standard deviations, and percentiles (Marshall & Jonker, 2010). Therefore, this study will utilize descriptive analysis to summarize the data and discover any significant patterns or trends that may exist within the data set.

3.6.2 Scale Measurement

There are five variables in this study. These include the food production Index (FPI), gross domestic product per capita (GDP), food imports (FI), agricultural employment (EIA), agricultural land (AL), and fertilizer consumption (FC).

Table 3.1: Scale Measurement Table

Variable(s)	Measurement of Data	Type	Data Source
FPI	Food production index (2014-2016 = 100)	DV	WDI
GDP	GDP per capita (constant 2015 US$)	IV	WDI
FI	Food imports (% of merchandise imports)	IV	WDI
EIA	Employment in agriculture (% of total employment) (modeled ILO estimate)	IV	WDI
AL	Agricultural land (% of land area)	IV	WDI
FC	Fertilizer consumption (kilograms per hectare of arable land)	IV	WDI

Source: Developed for Research

Food Production Index (FPI): The food crops that are deemed edible and contain nutrients are included in the food production index (2014-2016 = 100). Besides, Tea and coffee are not included. This is due to the perception that tea and coffee have lower nutritional value even though they can be consumed. In additional, the data on food production do not include unharvested sections or losses during the threshing and harvesting processes. They reflect the actual harvest from a field or orchard (World Bank, n.d.). The terms "food security" and "self-sufficiency" can alternatively be defined using the food production index. This is so because the quantity of food produced in a nation or region is reflected in the food production index. A place that produces enough food to cover its local needs and even exports excess is said to have a high food production index.

GDP per Capita (GDP): Gross domestic product is divided by mid-year population and calculated in constant 2015 dollars to obtain GDP per capita (constant 2015 dollars). Furthermore, gross domestic product is the sum of gross value added by all citizens who are among the producers in the economy, plus any product taxes and minus any subsidies that are not deducted from the value of the products. Generally, gross domestic product calculations do not take into account the depreciation of manufactured assets or the depletion and deterioration of natural resources (World Bank, n.d.).

Food Import (FI): The live animals, beverages, tobacco, animal, vegetable oils, fats, oilseeds, oilsnuts, and kernels are included in the food imports (% of merchandise imports) gathered from the World Indicator Development (World Bank, n.d.).

Employment in Agriculture (EIA): Those of working age involved in agricultural activities that produce agricultural commodities or provide agricultural services for compensation or profit are referred to as employed in agriculture (% of total employment) (modelled ILO estimate). Furthermore, labor moves from agriculture and other labor-intensive primary activities to industry and ultimately the service sector as the economy grows, according to the World Bank (n.d.). Numerous workers progressively moved from rural to urban areas during this development phase.

Agricultural Land (AL): The percentage of land area that can be used for permanent pasture, permanent crops, and other agricultural uses is known as agricultural land (% of total land area). Land that has been utilised for feed for five years or more, whether cultivated and uncultivated, is considered a permanent pasture. According to the FAO, arable land includes areas used for temporary crops (double-cropped areas are counted once), land temporarily fallow, and land beneath vegetable gardens or markets. Furthermore, land used for intermittent farming is not included in this instead the permanent agricultural land is utilised to grow long-lasting crops like rubber, coffee, and cocoa that don't require replacement after each harvest. Furthermore, land under fruit trees, nut trees, vines, and blooming shrubs is included in this category; property under trees used for timber or timber cultivation is not (World Bank, n.d.).

Fertilizer Consumption (FC): The amount of plant nutrients utilised per unit of farmland is generally measured by fertiliser use, which is expressed in kilogrammes per hectare of arable land. This category of fertilizer products excludes general traditional nutrients like plant and animal fertilizers but does include potassium, nitrogen, and phosphate fertilizers. Although fertilizers significantly increase crop yields, excessive use of chemical inputs such as fertilizers and pesticides can cause environmental and health impacts, including soil salinization, increased pest populations, greenhouse gas emissions, and water pollution. In this case, finding the right balance of inputs depends on local conditions and crop type, highlighting the importance of food security and the need for sustainable agricultural practices (World Bank, n.d.).

3.6.3 Correlation Analysis

Correlation analysis is one of the important statistical techniques, mainly used to determine the direction and extent of the relationship between two variables. Correlation analysis is now widely used by many studies to investigate the strength of relationships between variables in various studies. Correlation analysis can effectively measure the degree of correlation between variables and discover whether these correlations are positive or negative. If a high correlation between variables is found according to the results of correlation analysis, it means that the correlation between the two variables is strong, and a low correlation means that the correlation between the two variables is weak. Not only that, if an increase in one variable causes an increase in another variable, there is a positive correlation between the two variables. Conversely, a negative correlation indicates that when one variable increases, the other decreases, and vice versa (Senthilnathan, 2019).

To summarize, correlation analysis is generally used to analyze and identify relationships, patterns, important connections, and trends between variables or data sets in a study. Therefore, in order to analyze and explore the relationship between the food production index (FPI) and the GDP per capita (GDP), food imports (FI), employment in agriculture (EIA), agricultural land (AL), fertilizer consumption (FC) and other variables, Relationship. This paper will also be analyzed through the use of correlation analysis, which will not only help to reveal any significant relationships between these variables but also provide insights into which independent variables will food production index (FPI).

Table 3.2: Strength of Correlations

Strength of Correlation Coefficient	**Correlation Value**
Very Weak	< 0.20
Weak	0.20 – 0.39
Moderate	0.40 – 0.59
Strong	0.60 – 0.79
Very Strong	0.80 – 1.00

Source: Evans (1996).

According to Akoglu, H. (2018) stated that the letter of the "r" can be used as the relationship between two variables and quantified with numbers. Typically this number ranges from -1 to +1. Thus, if r is 0, it indicates that the two variables have no correlation, and if r is 1, it indicates that the two variables have perfect correlation. In addition, a negative r suggests an inverse relationship between the variables. The association becomes stronger between 0 and +1 and between 0 and -1. It should be mentioned, nonetheless, that the correlation analysis may also be used to categorize the strength of the association between the variables using terms like "strong," "very strong," "strong," "moderate," "weak," and "very weak.". Very strong 0.80 – 1.00, strong 0.60 – 0.79, moderate 0.40 – 0.59, weak 0.20 – 0.39, and very weak <0.20 are the specific ranges.

3.6.4 Unit Root

The unit root test is a statistical technique used to measure and determine the presence of a unit root in a time series. Unit root means that the time series is non-stationary and will eventually tend to revert to the mean. Therefore, in order to evaluate whether the collected data is stationary, this article will also use the unit root test to evaluate the data. In general, the two most commonly used unit root tests are the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test. Both tests can be used to determine whether a unit root exists in time series data.

The ADF test is a widely used unit root test. The ADF test mainly checks the possibility of unit roots in a set of time series data and determines and explains the coefficient values of the differences between initial differences in non-stationary time series (Glynn et al., 2007). If the calculated coefficient is statistically significant and negative, the data probably has a unit root and is therefore non-stationary. Furthermore, the PP test is roughly equivalent to the ADF test, but the PP test also includes a correction factor that modifies the standard error of the test statistic. This adjustment factor helps improve the accuracy of the test when using small samples. In addition, according to Glynn et al. (2007), regression analysis and other statistical procedures need to be able to convert non-stationary data into stationary data, which can be achieved.

$$H_0 = The\ time\ series\ data\ is\ unit\ root\ and\ non-stationary$$

$$H_A = The\ time\ series\ data\ is\ no\ unit\ root\ and\ stationary$$

Furthermore, if the t-statistic variable in the ADF and PP test exceeds the t-statistic critical value, which has a significance level of 0.01, 0.05, or 0.10. Thus, reject the null hypothesis. The variables in the model are therefore stationary and do not have a unit root.

3.6.5 Co-integration Rank Test (Johansen Cointegration Test)

The Cointegration Rank Test helps to figure out if there are long-term connections between variables and the Maximum Eigenvalue test and the Trace test are the two tests used in the Johansen Cointegration Test process to ascertain the number of cointegration vectors. This indicates that there are two categories of test data presented, and the findings are testing for the number of cointegrating relations (cointegration rank). The maximum eigenvalue statistics are reported in the second block, while the so-called trace statistics are reported in the first (Asari et al., 2011). To determine whether the variables in this study has a long-term relationship, the co-integration test was used in this study. The null and alternative hypotheses are below,

$$H_0 = The\ variables\ do\ not\ have\ cointegrating\ and\ long\ run\ relationship$$

$$H_A = The\ variables\ have\ cointegrating\ and\ long\ run\ relationship$$

There are multiple cointegrating and long-term relationships between the variables, which can be explained by the Cointegration Rank Test (Johansen Cointegration Test). According to the results of the maximum eigenvalue test and trace test, if two cointegration equations are significant at the 0.01 level, it means that a long-term equilibrium has been reached between the variables.

3.6.6 Vector Correction Model (VECM)

The vector error correction model (VECM) is the core model of this study. In order to gain an in-depth understanding of whether there is a causal relationship between GDP per capita, food imports, agricultural employment, agricultural land and fertilizer consumption and the food production index. This study will examine the long-term and short-term relationships between GDP per capita, food imports, agricultural employment, agricultural land and fertilizer consumption, and food production index by using the Vector Error Correction Model (VECM) technique.

In addition, VECM can evaluate the short-term characteristics of cointegrated series because cointegration indicates the existence of a long-term equilibrium relationship between series. In addition, if cointegration does not exist, it indicates that VECM is no longer needed and the test of Granger causality can then be performed to determine the causal relationships between variables (Asari et al., 2011).

The vector error correction model (VECM) is constructed from an error correction term derived from a known cointegration relationship and a p-1 order VAR model through variable differences. Furthermore, the Vector Error Correction Method (VECM) model is a restricted vector autoregressive (VAR) design used with a non-stationary series of known cointegration, combining cointegration and VECM equations (Winarno et al., 2021). Therefore, the VECM model establishes the short-term relationship between variables and also corrects the deviation of the long-term linkage between variables. Furthermore, based on the research of Klian and Lütkepohl (2017), it is pointed out that the VECM model is a specific version of the vector autoregressive (VAR) model. The cointegration equations are included in the specification to constrain the long-run behavior of the endogenous variables and relate them to their cointegration relationships. If the residuals show a pattern and are stationary, then the variables in the cointegration equation are cointegrated and have a long-run relationship. All endogenous variables are simultaneously included in the VECM equation, allowing for short-term dynamic adjustment.

3.6.7 Granger Causality

Granger causality is a prediction-based statistical concept of causality. A statistical hypothesis test for determining whether one time series can be used to forecast another is the Granger causality test. If the probability value was less than that threshold at any α level, the hypothesis would be rejected (Wei, 2016). Furthermore, in accordance with Granger causality, past values of X1 should contain information that aids in predicting X2 above and above that which is contained in past values of X2 alone if a signal X1 "Granger-causes" (or "G-causes") a signal X2. Stochastic process modelling with linear regression is the foundation of its mathematical formulation. There are more intricate extensions to nonlinear instances, however putting these extensions into reality is frequently more challenging (Seth, 2007).

3.6.8 Residual Diagnosis

3.6.8.1 Normality Test

One of the most common statistical tests carried out on a significant continuous probability distribution with a bell-shaped density curve that may be represented by the mean and standard deviation is the normality test. The normality tests are an addition to the graphical assessment of normality (Ghasemi & Zahediasl, 2012). One of the main techniques for assessing normality is the Jarque-Bera test (Öztuna et al., 2006). This suggests that the Jarque-Bera test, a goodness-of-fit study, is employed in statistics to ascertain whether the skewness and kurtosis of sample data are consistent with a normal distribution. The skewness indicates the degree of distribution asymmetry, while the kurtosis indicates whether the data are neither heavy-tailed nor light-tailed (Kim, 2013). To be deemed regularly distributed, the distribution must also meet the requirements of 0 skewness and 3 kurtosis coefficients. Even though some research indicated that skewness and kurtosis are rarely important in the laboratory, the statistics can still be used as indications of normality because they are readily available. Below are the hypotheses of the normality test:

$$H_0 = The\ residuals\ are\ normally\ distributed$$

$$H_A = The\ residuals\ are\ not\ normally\ distributed$$

It is possible to conclude that there is evidence supporting the normal distribution of the data if the p-value is more than 0.05 or the Jarque Bera critical value is smaller than the statistic value of Jarque Bera. In these cases, the null hypothesis should not be rejected.

3.6.8.2 Heteroscedasticity Test

When the variance of the residuals is uneven throughout a range of measured values, this is referred to as heteroskedasticity. If the population employed in the regression has unequal variance if heteroskedasticity is present, thus the analysis's conclusions may not be true (Knaub, 2007). This is because highly heteroskedasticity data would inevitably result in grave effects, including disproportionately high or low significance testing of study findings, skewed standard errors, and lacking minimum variance (Tim, 2018). The reasons mostly may be causing the heteroskedasticity to occur are the variance is biassed, the t and unreliable F-statistic, the coefficient (β) has no lowest value, and the estimator is linear but not the best linear unbiased estimator (BLUE).

$$H_0 = The\ residuals\ do\ not\ have\ heteroscedasticity$$

$$H_A = The\ residuals\ have\ heteroscedasticity$$

The heteroscedasticity test, also known as the Breusch-Pagan Godfrey Test or BPG, will be used in this investigation to see if there is heteroscedasticity. As a result, if the prob value is more than 0.05. In this case, we reject the null hypothesis and demonstrate that there is heteroscedasticity between the residual.

3.6.8.3 Autocorrelation Test

The connection between a time series and its lag version throughout time is called autocorrelation, also known as serial correlation in the discrete-time case. Autocorrelation employs the same time series twice while being comparable to correlation. The main purpose of carrying out the serial correlation test is to make sure and identify that there is no systematic association between any two error term observations. Therefore, an accurate estimation of the standard errors of the coefficients will result from the presence of a systematic correlation.

$H_0 = The\ residuals\ do\ not\ have\ serial\ correlation\ (autocorrelation)$

$H_A = The\ residuals\ have\ serial\ correlation\ (autocorrelation)$

We will also perform a serial correlation test to see if there is a serial correlation between the residuals in this study. Therefore, if the prob value is more than 0.05. In this case, we reject the null hypothesis and indicate that there is a serial correlation between the residual.

<u>3.6.8.2 Multicollinearity Test</u>

A statistical phenomenon known as multicollinearity happens when there is a strong correlation between two or more independent variables in a regression model. In other words, multicollinearity suggests that the predictor variables have a strong linear relationship (Daoud, 2017).

$H_0 = The\ residuals\ do\ not\ have\ multicollinearity$

$H_A = The\ residuals\ have\ multicollinearity$

The variance of predictor coefficients is inflated when there is a correlation between the predictors, as indicated by an increase in the standard error of predictor coefficients. A useful technique for calculating how much the variance is overstated is the VIF. VIFs are often computed by the program during regression analysis, and the results will show up in the VIF column (Daoud, 2017). The table below applies the subsequent rule to interpret the value of VIF:

Table 3.3: VIF interpretation

VIF Value	Conclusion
VIF = 1	Not Correlated
1 < VIF < 5	Moderately Correlated
VIF > 5	Highly Correlated

Source: Daoud, (2017).

In addition to revealing whether the predictors are correlated, the square root of the VIF also shows how much bigger the standard error is. When a predictor's VIF is close to 9 or 10, it means that its standard error for the coefficient is three times higher than it would be if it did not correlate with other predictors (Daoud, 2017).

3.7 Conclusion

To sum up, this chapter will primarily address the procedures and approaches that will be utilized to carry out this research. The time series data utilized is secondary data collected from the World Bank's World Development Indicators during 31 years, from 1990 to 2020. Furthermore, Eviews will be used in this study as a measuring tool for several tests and analyses. For example descriptive analysis, correlation analysis, unit root test, Cointegrated Rank Test, VECM, residual diagnosis test, and others.

CHAPTER 4: DATA ANALYSIS

4.0 Introduction

The results of various tests and analyses conducted utilizing the interviews will be described and interpreted in this chapter.

4.1 Descriptive Data

Table 4.1: Descriptive Analysis

	LNFPI_2	LNAL_2	LNEIA_2	LNFC_2	LNFI_2	LNGDP_2
Mean	0.0007	0.0000	0.0004	-0.0002	0.0003	-0.0025
Median	0.0042	0.0000	0.0059	-0.0053	-0.0067	-0.0035
Maximum	0.1239	0.0040	0.0770	0.3251	0.2140	0.0985
Minimum	-0.0991	-0.0025	-0.0607	-0.4326	-0.3122	-0.0457
Std. Dev.	0.0431	0.0024	0.0314	0.1322	0.1164	0.0271
Skewness	0.2077	0.7722	0.0933	-0.7288	-0.2522	1.5936
Kurtosis	4.4299	4.6350	2.8932	6.2952	3.3247	7.8276

Source: Developed for the Research.

Table 4.1 data indicate that the food production index (FPI) has a mean of 0.0007 and a median of 0.0042. FPI has a maximum value of 0.1239 and a minimum value of -0.0991. The FPI's standard deviation is 0.0431, its skewness value is 0.2077, and its kurtosis value is 4.429861.

Moreover, the median value for agricultural land (AL) is -2.77E-05, whereas the mean value is 4.28E-05. For AL, the maximum and minimums are, respectively, 0.0040 and -0.0025. AL's values for skewness, kurtosis, and standard deviation are 4.6350, 0.7722, and 0.0014, respectively.

Besides, the mean and median values for employment in agriculture (EIA) are 0.0004 and 0.0059, respectively. For EIA, the maximum and minimums are 0.0770 and -0.0607, respectively. The EIA's values for skewness, kurtosis, and standard deviation are 2.8932, 0.0933, and 0.0314, respectively.

The median value for fertilizer consumption (FC) is -0.0053, while the mean value is -0.0002. For FC, the maximum and minimum values are, respectively, 0.3251 and -0.4326. FC has the following values for skewness, kurtosis, and standard deviation: 01322, -0.7288, and 6.2952, respectively.

The median value for the Food Import (FI) is -0.0067, while the mean value is 0.0003. For FI, the maximum and minimum values are, respectively, 0.2140 and -0.3122. FI's values for skewness, kurtosis, and standard deviation are 3.3247, -0.2522, and 0.1164, respectively.

GDP per capita (GDP) has a mean value of -0.0025 and a median value of -0.0035. GDP ranges from a minimum of -0.0457 to a maximum of 0.0985. The standard deviation, skewness, and kurtosis of GDP are 0.0276, 1.5936, and 7.8276.

4.2 Correlation Analysis

Table 4.2. Correlation Analysis

	LNFPI_2	**LNAL_2**	**LNEIA_2**	**LNFC_2**	**LNFI_2**	**LNGDP_2**
LNFPI_2	1.0000	0.0147	0.0958	0.0289	0.1068	0.0816
LNAL_2	0.0147	1.0000	0.3123	0.1226	0.0895	0.0985
LNEIA_2	0.0958	0.3123	1.0000	-0.0664	0.0825	-0.0232
LNFC_2	0.0288	0.1226	-0.0664	1.0000	-0.3256	0.3947
LNFI_2	0.1068	0.0895	0.0825	-0.3256	1.0000	-0.6737
LNGDP_2	0.0816	0.0985	-0.0232	0.3947	-0.6737	1.0000

Source: Developed for the Research.

Finding the direction and intensity of the linear relationship between two variables is the aim of this analysis. The range of the r value is -1 < 0 < 1. If the r value is negative, the variables are perfectly negatively linked. If the r value is positive, the variables are perfectly positively correlated. If the r value is zero, the variables are not related. According to the presented data, all independent variables such as GDP per capita, employment in agriculture, fertiliser consumption, and food imports have a positive connection with FPI.

4.3 Unit Root

Table 4.3. Unit Root Test

Variable	Augmented Dickey-Fuller (ADF)			Phillip-Perron (PP)		
	Level	1st Different	2nd Different	Level	1st Different	2nd Different
FPI	-1.9239	-8.7661***	-8.4479***	-2.2805	-8.7666***	-29.60852***
GDP	-1.7222	-4.7724***	-7.4401***	-1.8201	-4.7726***	-12.3262***
FI	-1.0633	-4.9930***	-8.5077***	-1.0395	-4.9778***	-13.8269***
EIA	-2.1324	-5.5965***	-7.8005***	-7.8992***	-5.5963***	-31.0920***
AL	-1.7852	-1.4383	-6.0156***	-1.4563	-3.1049**	-5.9925***
FC	-1.2660	-6.1100***	-7.4953***	-0.8501	-15.7800***	-26.5848***

Source: Developed for the Research.

Based on the findings, most of the variables exhibit stationarity when considering the second difference level (Δ2 data series). Therefore, it is recommended to employ the Vector Error Correction Model (VECM) as suggested by both the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests for modeling purposes.

4.4 Johansen Cointegration Rank Test

Table 4.4 Johansen Cointegration Rank Test (Trace and Maximum Eigenvalue)

First Block: Unrestricted Cointegration Rank Test - Trace

Hypothesized No. of CE(s)	Trace	Trace Statistic	0.05 Critical Value	Prob. **
None *	0.9425	291.6881	95.7537	0.0000
At Most 1 *	0.9159	211.7366	69.8189	0.0000
At Most 2 *	0.8212	142.4264	47.8561	0.0000
At Most 3 *	0.7676	94.2278	29.7971	0.0000
At Most 4 *	0.6810	53.3709	15.4947	0.0000
At Most 5 *	0.5339	21.3756	3.8415	0.0000

Second Block: Unrestricted Cointegration Rank Test - Maximum Eigenvalue

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob. **
None *	0.9425	79.9516	40.0776	0.0000
At Most 1 *	0.9159	69.3102	33.8769	0.0000
At Most 2 *	0.8212	48.1985	27.5843	0.0000
At Most 3 *	0.7676	40.8570	21.1316	0.0000
At Most 4 *	0.6810	31.9952	14.2646	0.0000
At Most 5 *	0.5339	21.7356	3.8415	0.0000

Source: Developed for the Research.

Finding the number and rank of cointegrating relations is the outcome of the Johansen cointegration rank test. Two types of test statistics—trace statistics (first block) and maximum eigenvalue statistics (second block)—are presented based on the generated findings. The findings of both statistics indicate that there are multiple cointegrating relationships between the variables. Six cointegrating equations were significant at the α 0.05 level, according to the findings of the two tests, indicating that the variables reached the long-term equilibrium.

4.5 Vector Error Collection Method Model (VECM)

4.5.1 The Cointegrating Equation for FPI

$-0.7473\Delta2FPI_t$ + 0.0005$\Delta2AL_t$ + 0.6326$\Delta2FC_t$ – 0.6980$\Delta2EIA_t$ – 1.0364$\Delta2FI_t$ – 0.0095$\Delta2GDP_t$ = 0

t-stat: [-3.2749**] [0.0547] [0.5896] [-4.2278**] [-1.4024] [-0.05194]

The variables of the food production index (FPI) and employment in agriculture are cointegrated between the variables in the food price index (FPI) cointegration equation. The statistical significance at the α 0.05 level indicates the long-term association between the variables, FPI and EIA. Moreover, for the other variables such as, agricultural land (AL), fertilizer consumption (FC), and food import (FI) variables do not cointegrate, indicating that there is no long relationship between them toward the food production index (FPI).

4.5.2 VECM Model Equation

$\Delta2FPI_t$ = 0.0025$_{t-1}$ + 7.1320$\Delta2AL_{t-1}$ + 0.5027$\Delta2EIA_{t-1}$ + 0.0129$\Delta2FC_{t-1}$ + 0.2145$\Delta2FI_{t-1}$ + 0.5558$\Delta2GDP_{t-1}$ -0.3035$\Delta2FPI_{t-1}$ + 0.0075$_{et}$

t-stat = [1.6863*] [2.3481**] [0.38154ns] [3.16278**] [2.0089**] [-1.6988*]

$R^2 = 0.8112$, $Adj\ R^2 = 0.7417$

The food production index (FPI) equation's variance was explained by the independent variables in 81.1% of cases, as per the FPI VECM model's result. Based on estimates, the relevant variables that are statistically significant at the α 0.05 level include agricultural land (AL), employment in agriculture (EIA), food import (FI), and GDP per capita (GDP). Therefore, assuming all other variables remain constant, an increase of 1 unit in agricultural land (AL) will, on average, have a positive influence on raising the food production index (FPI) by 7.1320 units, which is statistically significant at the α 0.05 level. Furthermore, assuming all other variables remain constant, an average increase of 1 unit in employment in agriculture (EIA) positively affects the FPI by 0.5027 units statistically significant at the α 0.05 level. Furthermore, assuming all other variables remain constant, an average increase of 1 unit in Food Import (FI) results in a statistically significant rise of 0.2145 units in the FPI at the α 0.05 level. Furthermore, when all other factors are held constant, an average 1 unit rise in GDP per capita (GDP) has a positive influence on raising the FPI by 0.5558 units, which is statistically significant at the α 0.05 level.

$\Delta 2AL_t = 0.0000102_{t-1} + 0.0128\Delta 2EIA_{t-1} + 0.0013\Delta 2FI_{t-1} - 0.005\Delta 2FPI_{t-1}$
$- 0.0013\Delta 2FC_{t-1} - 0.0162\Delta 2GDP_{t-1} - 0.6282\Delta 2AL_{t-1} + 0.0003_{et}$

t-stat = [1.5029*] [0.4937] [-0.7064]

[-0.7822] [1.4804] [-3.2599**]

$R^2 = 0.6423, Adj\ R^2 = 0.5105$

The agricultural land (AL) equation's variance was explained by the independent variables in 64.2% of cases, as per the AL VECM model's result. Based on estimates, the relevant variables that are statistically significant at the α 0.05 level include employment in agriculture (EIA). Therefore, assuming all other variables remain constant, an average increase of 1 unit in employment in agriculture (EIA) will positively impact the amount of agricultural land (AL) by 0.0128 units, which is statistically significant at the α 0.05 level.

$\Delta 2EIA_t = 0.0022_{t-1} + 0.3553\Delta 2FPI_{t-1} + 0.0074\Delta 2FC_{t-1} + 0.0169\Delta 2FI_{t-1} + 0.2364\Delta 2GDP_{t-1} - 9.9745\Delta 2AL_{t-1} + 0.0064\Delta 2EIA_{t-1} + 0.0054_{et}$

t-stat = [2.7496**] [0.2806] [3.4476**]
[1.1809] [-3.2597**] [0.0415]

$R^2 = 0.8065, Adj\ R^2 = 0.7353$

The employment of agriculture (EIA) based on the VECM model result showed that, there is 80.2% of the variation in the employment in agriculture (EIA) equation could be explained by the independent variables. Based on the equation, the agricultural land (AL) and the food production index (FPI) are the two major variables that are statistically significant at the α 0.05 level. Therefore, assuming the other variables remain constant, an average rise of 1 unit in the food production index (FPI) will increase employment in agriculture (EIA) by 0.3553 units, which is statistically significant at the α 0.05 level. Furthermore, when all other variables are held constant, an average 1 unit increase in food import (FI) positively affects the EIA by 0.0169 units at the α 0.05 level of statistical significance. Furthermore, assuming all other variables remain constant, an average increase of 1 unit in agricultural land (AL) has a negative impact on the EIA, reducing it by 9.974 units statistically significant at the α 0.05 level.

$\Delta 2FC_t = -0.00246_{t-1} + 38.6095\Delta 2AL_{t-1} - 0.3381\Delta 2FPI_{t-1} - 1.7649\Delta 2EIA_{t-1} - 0.1532\Delta 2FI_{t-1} - 2.4677\Delta 2GDP_{t-1} - 0.4697\Delta 2FC_{t-1} + 0.0352_{et}$

t-stat = [1.9416*] [-0.4025] [-1.7534*]
[-0.4803] [-1.8931*] [-2.7364**]

$R^2 = 0.5372, Adj\ R^2 = 0.36676$

The fertiliser consumption (FC) equation's variation was explained by the independent variables in 53.7% of cases, as per the FC VECM model's conclusion. Based on estimates, the variables that are statistically significant at the α 0.05 level are GDP per capita and agricultural land (AL). Therefore, assuming all other variables remain constant, an increase of 1 unit in agricultural land (AL) will, on average, have a positive effect on raising the fertiliser consumption (FC) by 1.7649 units that are statistically significant at the α 0.05 level. Furthermore, when all other variables are held constant, an average 1 unit rise in GDP per capita (GDP) has a negative effect on raising the FC by 2.4677 units statistically significant at the α 0.05 level.

$\Delta 2FI_t$= -0.0056_{t-1} + $1.1992\Delta 2EIA_{t-1}$ + $0.7652\Delta 2GDP_{t-1}$ $-0.0051\Delta 2FPI_{t-1}$ $13.2211\Delta 2AL_{t-1}$ $-0.2965\Delta 2FC_{t-1}$ $-0.5179\Delta 2FI_{t-1}$ + 0.0352_{et}

t-stat = [1.7297*] [0.8540] [-0.0087]

[-0.9653] [-2.5083] [-2.3583**]

$R^2 = 0.7277, Adj\ R^2 = 0.6273$

The food import (FI) equation's variation was primarily explained by the independent variables, as indicated by the FI VECM model's result, which gave 72.7% of the variance. Based on estimates, the relevant variable that is statistically significant at the α 0.05 level is employment in agriculture (EIA). Therefore, assuming all other variables remain constant, an increase of 1 unit in employment in agriculture (EIA) will, on average, have a positive influence on increasing food import (FI) by 1.1992 units, which is statistically significant at the α 0.05 level.

$\Delta 2GDP_t$ = -0.0001_{t-1} + $0.1601\Delta 2EIA_{t-1}$ + $0.1086\Delta 2FC_{t-1}$ $-0.0218\Delta 2FI_{t-1}$$-0.0271\Delta 2FPI_{t-1}$ $-0.1864\Delta 2AL_{t-1}$ $-0.7371\Delta 2GDP_{t-1}$ + 0.006_{et}

t-stat = [1.9416*] [-0.4025]

[-1.7534*] [-0.4803] [-1.8931*] [-2.7364**]

$R^2 = 0.6594, Adj\ R^2 = 0.53395$

The GDP VECM model result showed that 65.9% of the variation in the GDP per capita equation could be explained by the independent variables. Based on estimates, the variables that are statistically significant at the α 0.05 level include agricultural land (AL), food imports (FI), and employment in agriculture (EIA). Hence, if all other variables remain same, an average 1 unit increase in employment in agriculture (EIA) will result in a 0.1601 unit statistically significant rise in GDP per capita (GDP) at the α 0.05 level. Furthermore, if all other variables remain constant, an average increase of 1 unit in food import (FI) will result in a 0.0218 unit statistically significant decrease in GDP per capita (GDP) at the α 0.05 level. Furthermore, assuming all other variables remain constant, an average increase of 1 unit in agricultural land (AL) will result in a 0.8164 unit statistically significant decrease in GDP per capita (GDP) at the α 0.05 level.

4.6 Granger Causality Test

Table 4.5: Granger Causality Test

	F Statistics	**Prob**
AL does not Granger Cause FPI	2.0659	0.1630
FPI does not Granger Cause AL	0.09512	0.7603
EIA does not Granger Cause FPI	1.3676	0.2533
FPI does not Granger Cause EIA	0.2485	0.6225
FC does not Granger Cause FPI	0.0068	0.9346
FPI does not Granger Cause FC	0.4014	0.5321
FI does not Granger Cause FPI	0.2568	0.6167
FPI does not Granger Cause FI	2.7890	0.1074
GDP does not Granger Cause FPI	0.1015	0.7527
FPI does not Granger Cause GDP	0.0616	0.8061

Source: Developed for the Research.

The Granger causality test indicates that there is neither a cointegrated nor a long-term equilibrium relationship between the independent variables and FPI at the α 0.05 level of statistical significance. Due to its dependence on other factors, the food price index (FPI) may not be able to demonstrate the causal relationship between dependent and independent variables.

4.7 Residual Diagonosis Tests

In this study, the residual diagnosis test consisted of serial correlation (autocorrelation), heteroscedasticity, multicollinearity, and normality tests. The test resulted in the table below:

Table 4.6: Residual Diagnosis Test

Diagnostic Tests	Results	Hypothesis	Decision
Normality Test (Jarque Test)	Jarque Bera: 0.0828 P–value: 0.9594	H_0 : Residuals are normally distributed H_A : Residuals are not normally distributed.	Since P-value (0.9594) > α 0.05. Do not reject $H0$. Thus, residuals are normally distributed.
Heteroscedasticity Test	P-value: 0.5880	H_0 : Residuals are no heteroscedasticity H_A : Residuals are heteroscedasticity	Since P-value (0.5880) > α 0.05 Do not reject $H0$. Thus, residuals are not heteroscedasticity.
Multicollinearity Test	VIF = 1/ (1-R^2) = 1/ (1-0.8112) = 5.2966	H_0 : Residuals are no multicollinearity H_A : Residuals are multicollinearity	VIF (5.2966) > 5 Reject $H0$. Thus, residuals multicollinearity.
Serial Correlation Test	P – value: 0.0001	H_0 : Residuals are no autocorrelation	Since P-value (0.0001) < α 0.05 Reject $H0$.

		H_A : Residuals are autocorrelation	Thus, residuals autocorrelation.

Source: Developed for the Research.

Regarding the normality test, the p-value is 0.9594 and the Jarque-Bera value is 0.0828, both of which are greater than the α 0.05 level. Since there is evidence that the residuals are regularly distributed, the null hypothesis should not be rejected. The heteroscedasticity test's p-value is 0.5880, which is higher than the α 0.05 level. Therefore, it is not appropriate to reject the null hypothesis because there is evidence indicating that there is no heteroscedasticity. Furthermore, 5.2966, a VIF number which greater than 5. Thus, this shows that there is multicollinearity in this model and that the null hypothesis must be rejected. Moreover, since the p-value for the LM test is 0.0001, which is less than 0.05, reject H0 for the serial correlation test. This also indicates that there is autocorrelation in the residuals.

4.8 Summary of Hypothesis Testing

Table 4.7 Summary of Hypothesis Testing

Hypothesis	**Decision**	**Supported / Rejected**
H_0 : There is no relationship between agricultural land and food production index. H_A : There is a relationship between agricultural land and food production index.	T – Statistic Value: 1.6863* Rejected H_0	Supported
H_0 : There is no relationship between employment of agriculture and food production index.	T – Statistic Value: 2.3481** Rejected H_0	Supported

H_A : There is a relationship between employment of agriculture and food production index.		
H_0 : There is no relationship between fertilizer consumption and food production index. H_A : There is a relationship between employment in agriculture and food production index.	T – Statistic Value: 0.3815 Do not reject H_0	Rejected
H_0 : There is no relationship between food import and food production index. H_A : There is a relationship between food import and food production index.	T – Statistic Value: 3.16278** Rejected H_0	Supported
H_0 : There is no relationship between GDP per capita and food production index. H_A : There is a relationship between GDP per capita and food production index.	T – Statistic Value: 2.0089** Rejected H_0	Supported

Source: Developed for the Research.

Based on the results in Table 4.7 show that the agricultural land, employment in agriculture, food import, and GDP per capita are statistically significant. Therefore, need to reject the null hypothesis which indicates that the agricultural land, employment in agriculture, food import, and GDP per capita have a relationship toward the food production index. However, fertilizer consumption do not have statistically significant. Therefore, no need to reject the null hypothesis which indicates that fertilizer consumption do not having a relationship with the food production index (FPI).

4.9 Conclusion

This chapter includes the results and interpretation of the results including descriptive analysis, correlation analysis, unit root, cointegration rank test, VECM, Granger causality, and residual diagnostics. The next chapter, Chapter 5, will provide more complete and comprehensive research results and will provide some suggestions to Japanese policymakers, government and investors.

CHAPTER 5: DISCUSSION, CONCLUSION AND IMPLICATIONS

5.0 Introduction

This chapter will summarise the key ideas from the other chapters and wrap up this study in chapter 5. The major discoveries will also be highlighted, based on how the dependent and independent variables relate to each other. Furthermore, the policy's implications and the study's limitations will be covered and in this chapter will offer some suggestions for future investigations to address the limitations of researchers who would like to research this subject. Finally, this chapter will bring all the major points to a close.

5.1 Summary of Statistical Analyses

Based on the results shown by the correlation analysis, all the independent variables such as GDP per capita, employment in agriculture, fertilizer consumption, and food imports have are very weak positive connection with FPI.

Moreover, the results from the ADF and PP tests of unit root show that, most of the variables exhibit stationarity when considering the second level of difference (Δ2 data series).

In addition, according to the results displayed by the Johansen cointegration rank test, 6 cointegration equations are significant at the α0.05 level, indicating that the variables have reached long-term equilibrium.

Moreover, based on the residual diagnosis test results indicated that, there are two different residual diagnoses that appear in this research which are multicollinearity and serial correlation.

Finally, for the relationship between variables. In summary, agricultural land, agricultural employment, food imports, and GDP per capita are statistically significant. This also means in addition to fertilizer consumption. Other variables such as agricultural land, agricultural employment, food imports, and per capita GDP are related to the food production index.

5.2 Discussion of Major Finding

Based on the Model of the VECM, the food price index (FPI) cointegration equation, there is a cointegration between the food production index (FPI) and agricultural employment variables. In addition, this equation also shows that the variables FPI and EIA have a long-term relationship. This result is consistent with Abdullah & Sulaiman, 2013; Zou & Guo, 2015). Furthermore, the cointegration equation according to FPI shows that there is no cointegration between agricultural land (AL), fertilizer consumption (FC), and food import (FI) variables, which means that there is no long-term relationship between these three variables.

5.2.1 GDP per Capita

Based on the equation of VECM. The results of the FPI VECM model, per capita gross domestic product (GDP) is an important variable that is statistically significant at the α 0.05 level and has a short-term positive correlation with FPI. This result is consistent with (Beckman et al., 2021; Burchi & De Muro, 2016; Singariya & Sinha, 2015; Timmer, 2004). This is because, usually when a country's economy is growing, the government will receive better revenue to ensure the country's food production and supply issues (Timmer, 2004). In addition, if a country takes advantage of its strong market economy, it can solve domestic food security problems by importing food. The level of national income will also have a direct impact on food security outcomes, because low income can also lead to insufficient purchase of necessary food (Burchi & De Muro, 2016).

5.2.2 Food Import

According to the equation of VECM. The results of the FPI VECM model, food import (FI) is an important variable that is statistically significant at the α 0.05 level and has a short-term positive correlation with FPI. This result is only consistent with (Suramaniam et al., 2023), but not inconsistent with Nyangito, 2002 and Ugwu et al., 2022). With the development of Japan's economy. The dietary habits of Japanese people have also begun to gradually become Westernized, with rice consumption gradually declining, while the demand for Western staple foods such as milk, butter, cheese, meat, and eggs has surged (Campo & Beghin, 2005). Japan's food production mainly focuses on traditional Japanese food. According to Subramaniam et al. (2023) imports are not only very important for food security, but imports can also make up for food supply levels. Therefore, Japan relies on imports to satisfy its diverse culinary preferences and and maintain their food availability, highlighting the indispensable role of food imports.

5.2.3 Employment in Agriculture

According to the equation of VECM. The results of the FPI VECM model, Employment in Agriculture (EIA) is an important variable that is statistically significant at the α 0.05 level and has a short-term positive correlation with FPI. This result is consistent with (Saili et al., 2020; Zou & Guo, 2015). This is because agricultural labor has always been the largest contributor to agricultural production besides technology. The continuous decrease of agricultural labor force will lead to the decrease of food production, while the continuous increase of industrial labor force will also lead to the increase of food production. If more and more agricultural laborers transition to the non-agricultural sector, this will lead to the emergence of more food consumers, exacerbating the gap between food supply and demand (Zou & Guo, 2015). In addition, as Japan is facing a serious aging population problem, the average age of farmers is increasing, and most young people are unwilling to participate in agricultural work, resulting in a decline in the number of farmers. This situation poses a threat to Japan's future food security and sustainability (Saili et al., 2020).

5.2.4 Agricultural Land

According to the results of VECM, agricultural land (AL) is also an important variable, which is statistically significant at the α 0.05 level and has a short-term positive relationship with FPI. This result is consistent only with (Aboye et al., 2023; Güneralp et al., 2020; Hamdy & Aly, 2014; Reidsma et al., 2012; Tilman et al., 2011). This is because expanding agricultural land to all suitable available land is key to achieving growth in food production. In addition, the more abundant agricultural land resources are, the higher the possibility of meeting the population's demand for any kind of food and reducing the potential threats posed by food imports (Tian et al., 2020).

5.2.5 Fertilizer Comsumption

According to the equation of VECM results, unfortunately the results show that fertilizer consumption (FC) does not seem to have a significant impact on the food production index. This means that there is no short-term relationship between fertilizer consumption (FC) and food production index (FPI). This result is different from the results shown in many earlier studies such as (Asumadu-Sarkodie & Owusu's, 2016; Motesharezadeh et al., 2017; Murayama & Noboru, 1975). This may be based on local environmental issues in Japan, where excessive use of chemical fertilizers can lead to water pollution and other environmental problems due to a lack of agricultural land or the desire for chemical fertilizers to increase food production. Therefore, the Japanese government may enact regulations or voluntary measures to limit the use of chemical fertilizers and promote sustainable agricultural practices resulting in Fertilizer consumption (FC) that does not appear to have a significant impact on food availability and food production.

5.3 Implications of Policy

After the model in this study is successfully generated, it demonstrates that the factors that significantly affect Japan's food production and food security are GDP per capita, food imports, agricultural employment, and agricultural land. Consequently, the following are some implications of the policy that the Japanese government or policymakers can use to lower the danger of food insecurity:

First of all, the government and policymakers can focus on and continuously promote Japan's agricultural science and technology innovation. Although Japan's current progress in agricultural science and technology cannot be underestimated, but governments and policymakers can still continue to develop new technologies. Therefore, governments and policymakers can further invest in innovative agricultural technologies. This is because advanced technologies and sustainable practices can not only effectively increase agricultural productivity, but also avoid excessive resource consumption and reduce negative impacts on the environment. In addition, new agricultural technology can also help Japan overcome its own constraints of insufficient agricultural land and an aging and shrinking rural labor force.

Moreover, the governments and policymakers can develop effective policies or benefits to attract more young workers to join the agricultural industry. For example, governments and policymakers can address the problem of reducing the agricultural labor force (the challenge of an aging workforce) and ensure food supply levels by eliminating people's stereotypes of agriculture as hard, low-wage work and implementing increase the income and subsidies for agricultural sector workforce. The Japanese government can also carry out agricultural promotion work and provide job opportunities that should not be limited to agricultural jobs but should cover the entire agricultural sector to provide diversified choices.

Besides, there are also several key strategies that governments and policymakers can engage in through structural transformation to reduce over-reliance on Japanese imports and enhance food security. For example, by increasing the production and utilization of domestic resources, using compost and sludge to make fertilizers, establishing supply chains, and stocking up on imported raw materials. Futhermore, promoting domestic feed production, connecting crop and livestock farmers, and implementing energy-saving technologies across various agricultural sectors are also key steps.

Secondly, Japan government and policymakers must get rid of over-reliance on imports, including increasing dryland wheat and soybean production, converting irrigated fields to dryland, supporting domestic rice production and using rice flour to replace imported wheat flour. Additionally, encouraging food companies to prioritize domestic raw materials over imported ones complements the strategy. In terms of production side. The government and policy makers of Japan can better plan the way agricultural land is used and if possible Japan can also try to grow or introduce foods that local citizens consume more to grow and produce meat products.

5.4 Limitations of the Study

The aspects of the design or methodology that will have an impact on how the study's findings are applied or interpreted are known as the study's limitations. Most studies may have limitations, and this study is no exception. Therefore, in this part, what are the limitations encountered in this study. First, the first limitation is that there may be inconsistencies between journals and expected signals and Japan. This is because the research object of this study is Japan, but the journals and expected signals of previous scholars founded mostly observe foreign situations. Therefore, these situations and the theory may not be fully applicable to Japan. Then there are statistical or data limitations. This study may be affected by statistical or data limitations. This is because this study was conducted with a rather small sample size of only 31 to explain the results. This issue may have weakened the power of the results and led to a slight lack of accuracy/precision in the interpretation of the results. Moreover, there might be many factors that may affect Japan's food security. This study only collected five factors including GDP per Capita (GDP), Food Import (FI), Employment in Agriculture (EIA), Agricultural Land (AL), and Fertilizer Consumption (FC). This is not enough to explain everything, so more variables need to be collected and studied to find better results. Finally, because the dependent variable used in this study is food production index. However, most of the problem statements mentioned in this study focus more on the potential food security issues caused by Japan's food self-sufficiency rate. Therefore, using food production index as the dependent variable of this study may causing some inconsistencies.

5.5 Recommendation for Future Research

First of all, future scholars who are interested in Japan’s food security and self-sufficiency issues can collect or refer to journals and research results published by previous scholars that are more in line with Japan’s local conditions. This is to avoid that the theory is not fully applicable to Japan because most of the referenced journals and expected signals are based on observations of foreign situations. Moreover, future studies can look into more variables or factors which impact Japan's food security. Future researchers can examine Japan's food security or self-sufficiency by employing a large sample size and adding more significant variable(s) to the study in order to increase the accuracy of the conclusions and outcomes. Furthermore, researchers with an interest in self-sufficiency rate (SSR) and food security in Japan can think about utilising SSR as the dependent variable in their studies. This is due to the self-sufficiency rate (SSR) may be determined whether a nation's agricultural output is adequate to fulfil domestic demand and computes the percentage of food produced and eaten domestically.

5.6 Conclusion

Through this research, the purpose is to study and analyze the factors that affecting to Japan's food security. There is a long-term relationship between the variables FPI and EIA and GDP per capita, food imports, employment in agriculture, agricultural land, and fertilizer consumption all having a positive relationship with the food production index of Japan. Moreover, in this research also provided some recommendations for the government and policymakers of Japan to reduce the risk of food insecurity that they are currently facing with.

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APPENDICS

Appendix 4.1: Descriptive Analysis

	FPI2	AL2	EIA2	FC2	FI2	GDP2
Mean	0.000717	4.28E-05	0.000392	-0.000187	0.000298	-0.002465
Median	0.004216	-2.77E-05	0.005853	-0.005281	-0.006658	-0.003505
Maximum	0.123883	0.004038	0.077007	0.325057	0.213968	0.098475
Minimum	-0.099091	-0.002537	-0.060654	-0.432633	-0.312165	-0.045690
Std. Dev.	0.043080	0.001393	0.031420	0.132150	0.116404	0.027056
Skewness	0.207654	0.772229	0.093328	-0.728830	-0.252209	1.593583
Kurtosis	4.429861	4.635025	2.893180	6.295194	3.324671	7.827602
Jarque-Bera	2.678854	6.112544	0.055886	15.68789	0.434818	40.43538
Probability	0.261996	0.047063	0.972444	0.000392	0.804601	0.000000
Sum	0.020806	0.001241	0.011381	-0.005411	0.008652	-0.071485
Sum Sq. Dev.	0.051965	5.43E-05	0.027641	0.488978	0.379396	0.020497

Appendix 4.2: Correlation Analysis

	FPI2	AL2	EIA2	FC2	FI2	GDP2
FPI2	1.000000	0.014728	0.095827	0.028872	0.106805	0.081632
AL2	0.014728	1.000000	0.312254	0.122575	0.089496	0.098529
EIA2	0.095827	0.312254	1.000000	-0.066435	0.082540	-0.023204
FC2	0.028872	0.122575	-0.066435	1.000000	-0.325559	0.394682
FI2	0.106805	0.089496	0.082540	-0.325559	1.000000	-0.673689
GDP2	0.081632	0.098529	-0.023204	0.394682	-0.673689	1.000000

Appendix 4.3: Johansen Cointegration Rank Test

Date: 03/29/24 Time: 17:52
Sample (adjusted): 4 31
Included observations: 28 after adjustments
Trend assumption: Linear deterministic trend
Series: FPI2 AL2 EIA2 FC2 FI2 GDP2
Lags interval (in first differences): No lags

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.942468	291.6881	95.75366	0.0000
At most 1 *	0.915868	211.7366	69.81889	0.0000
At most 2 *	0.821180	142.4264	47.85613	0.0000
At most 3 *	0.767573	94.22783	29.79707	0.0000
At most 4 *	0.681039	53.37085	15.49471	0.0000
At most 5 *	0.533928	21.37561	3.841465	0.0000

Trace test indicates 6 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.942468	79.95156	40.07757	0.0000
At most 1 *	0.915868	69.31022	33.87687	0.0000
At most 2 *	0.821180	48.19853	27.58434	0.0000
At most 3 *	0.767573	40.85698	21.13162	0.0000
At most 4 *	0.681039	31.99524	14.26460	0.0000
At most 5 *	0.533928	21.37561	3.841465	0.0000

Max-eigenvalue test indicates 6 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Appendix 4.4: VECM Model Equation

Vector Error Correction Estimates
Date: 03/29/24 Time: 15:42
Sample (adjusted): 5 31
Included observations: 27 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
FPI2(-1)	1.000000
AL2(-1)	-5.427421 (2.96415) [-1.83102]
EIA2(-1)	1.428309 (0.20361) [7.01496]
FC2(-1)	0.078031 (0.06369) [1.22511]
FI2(-1)	0.485790 (0.06817) [7.12650]
GDP2(-1)	1.168006 (0.32507) [3.59305]
C	0.002169

Error Correction:	D(FPI2)	D(AL2)	D(EIA2)	D(FC2)	D(FI2)	D(GDP2)
CointEq1	-0.747327 (0.22820) [-3.27488]	0.000495 (0.00906) [0.05462]	-0.697976 (0.16509) [-4.22774]	0.632634 (1.07294) [0.58963]	-1.036372 (0.73901) [-1.40237]	-0.009460 (0.18213) [-0.05194]
D(FPI2(-1))	-0.303450 (0.17863) [-1.69877]	-0.005010 (0.00709) [-0.70641]	0.355338 (0.12923) [2.74962]	-0.338060 (0.83987) [-0.40251]	-0.005123 (0.57848) [-0.00886]	-0.027069 (0.14257) [-0.18987]
D(AL2(-1))	7.132035 (4.22938) [1.68631]	-0.628155 (0.16793) [-3.74047]	-9.974505 (3.05980) [-3.25986]	38.60954 (19.8855) [1.94159]	-13.22113 (13.6966) [-0.96529]	-0.186393 (3.37559) [-0.05522]
D(EIA2(-1))	0.502690 (0.21408) [2.34813]	0.012775 (0.00850) [1.50285]	0.006431 (0.15488) [0.04152]	-1.764869 (1.00656) [-1.75337]	1.199168 (0.69329) [1.72968]	0.160059 (0.17086) [0.93676]
D(FC2(-1))	0.013928 (0.03651) [0.38154]	-0.001134 (0.00145) [-0.78221]	0.007409 (0.02641) [0.28055]	-0.469663 (0.17164) [-2.73636]	-0.296525 (0.11822) [-2.50826]	0.108631 (0.02914) [3.72842]
D(FI2(-1))	0.214500 (0.06782) [3.16278]	0.001329 (0.00269) [0.49368]	0.169156 (0.04907) [3.44758]	-0.153156 (0.31887) [-0.48030]	-0.517949 (0.21963) [-2.35827]	0.021797 (0.05413) [0.40268]
D(GDP2(-1))	0.555832 (0.27669) [2.00886]	-0.016264 (0.01099) [-1.48036]	0.236388 (0.20018) [1.18090]	-2.462773 (1.30093) [-1.89308]	0.765220 (0.89605) [0.85400]	-0.737060 (0.22084) [-3.33760]
C	0.002505 (0.00748) [0.33471]	1.20E-05 (0.00030) [0.04036]	0.002182 (0.00541) [0.40293]	-0.002459 (0.03519) [-0.06989]	0.005638 (0.02423) [0.23263]	-0.000139 (0.00597) [-0.02324]
R-squared	0.811236	0.642302	0.806598	0.537245	0.727654	0.659421
Adj. R-squared	0.741691	0.510519	0.735345	0.366756	0.627316	0.533945
Sum sq. resids	0.028635	4.51E-05	0.014987	0.633015	0.300307	0.018241
S.E. equation	0.038821	0.001541	0.028086	0.182528	0.125720	0.030984
F-statistic	11.66497	4.873920	11.32015	3.151200	7.252037	5.255347
Log likelihood	54.14974	141.2581	62.88982	12.35549	22.42229	60.23783
Akaike AIC	-3.418500	-9.870967	-4.065912	-0.322629	-1.068318	-3.869469
Schwarz SC	-3.034548	-9.487015	-3.681961	0.061323	-0.684366	-3.485517
Mean dependent	0.003359	-1.80E-06	0.002169	-0.000272	0.004068	-0.000928
S.D. dependent	0.076384	0.002203	0.054594	0.229374	0.205938	0.045386

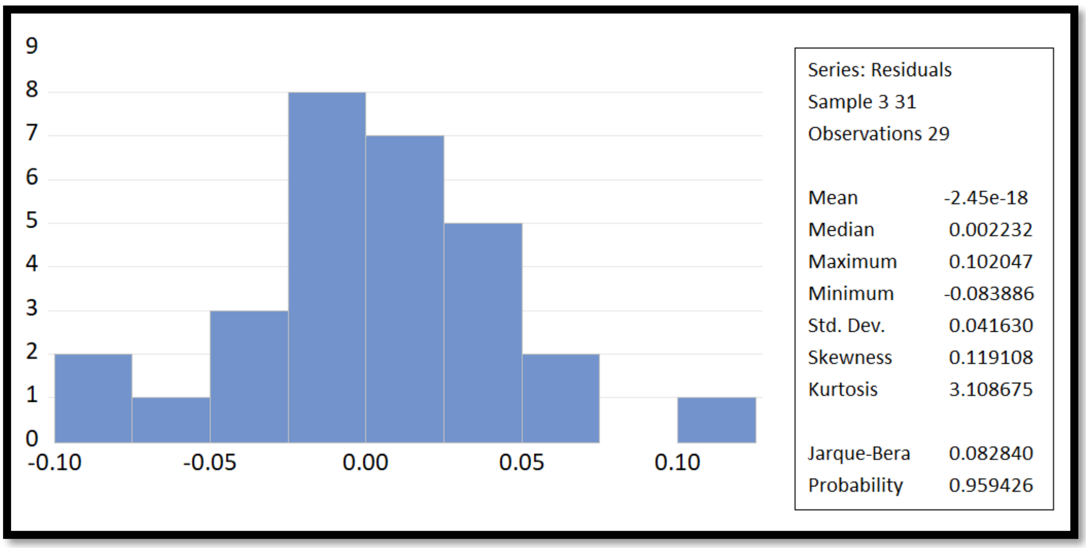
Determinant resid covariance (dof adj.)	5.57E-20
Determinant resid covariance	6.77E-21
Log likelihood	397.1053
Akaike information criterion	-25.41521
Schwarz criterion	-22.82354
Number of coefficients	54

Appendix 4.5: Granger Causality Test

Pairwise Granger Causality Tests
Date: 03/29/24 Time: 15:42
Sample: 1 31
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
AL2 does not Granger Cause FPI2	28	2.06590	0.1630
FPI2 does not Granger Cause AL2		0.09512	0.7603
EIA2 does not Granger Cause FPI2	28	1.36760	0.2533
FPI2 does not Granger Cause EIA2		0.24851	0.6225
FC2 does not Granger Cause FPI2	28	0.00682	0.9348
FPI2 does not Granger Cause FC2		0.40138	0.5321
FI2 does not Granger Cause FPI2	28	0.25683	0.6167
FPI2 does not Granger Cause FI2		2.78902	0.1074
GDP2 does not Granger Cause FPI2	28	0.10146	0.7527
FPI2 does not Granger Cause GDP2		0.06157	0.8061

Appendix 4.6: Normality test



Appendix 4.7: Heteroskedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	0.759560	Prob. F(5,23)	0.5880
Obs*R-squared	4.109898	Prob. Chi-Square(5)	0.5337
Scaled explained SS	2.725652	Prob. Chi-Square(5)	0.7422

Appendix 4.8: Serial Correlation Test

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 1 lag

F-statistic	21.29962	Prob. F(1,22)	0.0001
Obs*R-squared	14.26546	Prob. Chi-Square(1)	0.0002