Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of economics

Bachelor Thesis

The Analysis of Food security and Related Macroeconomic Indicators in the US

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BACHELOR THESIS ASSIGNMENT

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Thesis title

The Analysis of Food Security and Related Macroeconomic Indicators in a selected country

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Objectives of thesis

The World faced multiple crises in the recent years: a global pandemic, a climate crisis, and a number of local military conflicts. All these adverse events have heightened the urgency with which food security issues are discussed.

The main aim of the present Bachelor thesis is to disclose the relationship between national food Security and selected macroeconomic indicators on the example of a selected country.

To achieve this goal the following research questions will be raised, discussed and gradually answered:

1. How the very concept of Food security is defined?
2. What aspects does Food security include?
3. Which organizations/institutions deal with the issues of achieving and maintaining Food security (at a national and global level)?
4. Which indicators are used to measure different aspects of Food security?
5. What macroeconomic indicators can be referred to as core ones for characterizing any economy?
6. Is there any statistically significant relationship between macroeconomic indicators and food security proxies?

Methodology

Theoretical part of the Bachelor thesis will rest on the analysis and synthesis of relevant literature comprised of selected study books, scientific articles, legal documents and some electronic sources.

Having collected all the necessary information and data, the analysis of trend functions will be applied to identify the type of trend in the data, the results will allow to select an adequate technique for correlation analysis, which in turn will help in selecting explanatory variables for building a regression model. Estimation of a latter will shed light on the relationships between selected macroeconomic indicators and food security proxy variables. The results of the conducted analysis will help to get an idea of how macroeconomic situation in a country contributes to Food security maintaining. Based on the theoretical findings and outcomes of the Practical part, the conclusion and recommendations will be framed.

The proposed extent of the thesis

40-60

Keywords

Food Security; Macroeconomic Indicators; Comparative analysis; Statistical inference

Recommended information sources

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Prague on 12. 03. 2024

Declaration

I declare that I have worked on my bachelor thesis titled "The Analysis of Food Security and Related Macroeconomic Indicators in the US" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break any copyrights.

In Prague on 15.03.2024   _____

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I would like to thank Mgr. Elena Kuzmenko, Ph.D., and all other persons, for their advice and support during my work on this thesis.

Food Security and Related Macroeconomic Indicators in the US

Abstract

In recent years, global pandemics, climate change, and local military conflicts have led to multiple crises. All these adverse events have heightened the urgency with which food security issues are discussed. This bachelor thesis focuses on the very concept of food security and the macroeconomic indicators associated with it, using the example of the United States of America. The main goal of the thesis is to conduct a thorough analysis of food security in the United States and to disclose the relationship between it and selected macroeconomic indicators (GDP per capita, unemployment, inflation, and real interest rate) that may affect food security. Having analyzed the main pillars of the latter the following proxies were selected: food production index, poverty rate, prevalence of stunting, and food imports. The collected data cover the period from 2000 to 2021. The methodology used in the bachelor thesis rests on the analysis of descriptive statistics, trend functions, Spearman and Pearson correlation coefficients, statistical significance, and regression modeling. Basic econometric tests, namely the normality test, the autocorrelation test, and the heteroskedasticity test, were used to evaluate the validity of the regression model. Among the most atypical is the assumption that the growth of poverty is facilitated by more affordable loans for the population. The results obtained based on the analysis show the existing relationship between macroeconomic indicators and food security indicators.

Keywords: Food Security, macroeconomic, United States of America, linear regression, Spearman correlation, trend function, Pearson correlation, GDP per capita, unemployment, inflation, real interest rate, food production index, poverty rate, prevalence of stunting, food imports, descriptive statistics.

Potravinová bezpečnost a související makroekonomické ukazatele ve Spojených státech

Abstrakt

V posledních letech vedly globální pandemie, změny klimatu a lokální vojenské konflikty k několika krizím. Všechny tyto nepříznivé události zvýšily naléhavost, s jakou jsou diskutovány otázky potravinové bezpečnosti. Tato bakalářská práce se zaměřuje právě na koncept potravinové bezpečnosti a makroekonomické ukazatele s ním spojené, na příkladu Spojených států amerických. Hlavním cílem práce je provést důkladnou analýzu potravinové bezpečnosti ve Spojených státech a odhalit vztah mezi ní a vybranými makroekonomickými ukazateli (HDP na obyvatele, nezaměstnanost, inflace a reálná úroková sazba), které mohou ovlivnit potravinovou bezpečnost. Po analýze hlavních pilířů byly vybrány následující proxy: index produkce potravin, míra chudoby, prevalence retardace růstu a dovoz potravin. Sbíraná data pokrývají období od roku 2000 do roku 2021. Metodologie použitá v BP spočívá v analýze deskriptivních statistik, trendových funkcí, Spearmanových a Pearsonových korelačních koeficientů, statistické významnosti a regresního modelování. Základní ekonometrické testy, konkrétně test normality, autokorelace a test heteroskedasticity, byly použity k posouzení platnosti regresního modelu. Mezi nejatypičtější patří předpoklad, že růst chudoby je usnadněn dostupnějšími úvěry pro obyvatelstvo. Výsledky získané na základě analýzy ukazují existující vztah mezi makroekonomickými ukazateli a ukazateli potravinové bezpečnosti.

Klíčová slova: Bezpečnost potravin, makroekonomický, Spojené státy americké, lineární regrese, Spearmanova korelace, trendová funkce, Pearsonova korelace, HDP na obyvatele, nezaměstnanost, inflace, reálná úroková sazba, index produkce potravin, míra chudoby, prevalence zakrnění, dovoz potravin, popisná statistika.

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List of abbreviations

GDP　　　　　Gross Domestic product

FAO　　　　　 Food and Agriculture Organization

US　　　　　　United States of America

SNAP　　　　　Supplemental Nutrition Assistance Program

NSLP　　　　　 National School Lunch Program

WFP　　　　　World Food Programme

GFSI　　　　　 Global Food Security Index

FPI　　　　　　 Food Production Index

WIC　　　　　　Special Supplemental Nutrition Program for Woman, Infants, and Children

1   Introduction

Food security is the most important concept today since the world situation is not stable. There are wars and epidemics, and the issue of food security becomes especially acute. Food security is responsible for ensuring that every person receives adequate quality and healthy nutrition. This is crucial because human health and well-being depend on it. This concept has a broad meaning and affects every resident of the country. However, for clarity, the thesis will focus on the example of the United States. The US is a developed country, and problems with food insecurity exist even with a high level of economic development. Which once again emphasizes the relevance of this topic. When considering macroeconomic aspects, attention will be given to factors, in this case those that affect food security. Inflation: how much inflation affects food prices and how food prices change over time. Gross Domestic Product (GDP): GDP is the most important thing that can be used in a thesis. GDP gives a complete picture of the wealth and standard of living of the population, which accordingly can have an impact on food security. Unemployment is the most significant indicator because it demonstrates the situation in the labor market and the ability of people to provide themselves with essential needs and food. It is especially important to consider that unemployment affects not only the individual but their family in general. Additionally, macroeconomic indicators such as interest rates will be considered.

The theoretical section of the bachelor's thesis will include examples from reliable sources (such as scientific articles and official databases), where analysis and interpretation of the data will be carried out using different methods. The practical part will employ correlation methods to demonstrate the influence of macroeconomic indicators on food security, as well as linear regression. Additionally, the thesis will include descriptive statistics, trend functions, Pearson correlation analysis, Spearman correlation analysis, and linear regression.

2 Objectives and Methodology

2.1 Objectives

The World faced multiple crises in the recent years: a global pandemic, a climate crisis, and a number of local military conflicts. All these adverse events have heightened the urgency with which food security issues are discussed.

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To achieve this goal the following research questions will be raised, discussed and gradually answered:

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2.2 Methodology

The theoretical part of the bachelor thesis will rest on the analysis and synthesis of relevant literature comprised of selected study books, scientific articles, legal documents, and some electronic sources.

Having collected all the necessary information and data, the analysis of trend functions will be applied to identify the type of trend in the data, the results will allow to select an adequate technique for correlation analysis, which in turn will help in selecting explanatory variables for building a regression model. An estimation of the latter will shed light on the relationships between selected macroeconomic indicators and food security proxy variables. The results of the conducted analysis will help to get an idea of how the macroeconomic situation in a country contributes to food security maintaining. Based on the theoretical

findings and outcomes of the practical part, the conclusion and recommendations will be framed.

2.2.1 Descriptive statistics

Descriptive statistics will be used in this work to identify trends and patterns in the data. Two types of statistics will be employed: measures of central tendency and measures of dispersion.

Central tendency

Measures of central tendency, such as means and medians, will be used to identify the average value in the data distribution.

Median: "Median is the value which occupies the middle position when all the observations are arranged in an ascending/descending order. It divides the frequency distribution exactly into two halves" (Manikandan, 2011).

$$\tilde{X} = \frac{n+1}{2} \tag{1}$$

Mean: "Arithmetic mean (or, simply, "mean") is nothing but the average. It is computed by adding all the values in the data set divided by the number of observations in it. If we have the raw data, mean is given by the formula" (Manikandan, 2011).

$$\bar{X} = \frac{\sum x}{n} \tag{2}$$

Measure of dispersion

"Standard deviation (SD) is the most commonly used measure of dispersion. It is a measure of spread of data about the mean" (Manikandan, 2011).

$$SD = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}} \tag{3}$$

2.2.2 Correlation analysis

Correlation analysis will be needed to find correlations between existing factors, i.e., macroeconomic indicators and food security indicators. This will be necessary to determine

the dependence of some data on others. Pearson and Spearman correlations will be used for these purposes.

Pearson correlation

"The Pearson correlation coefficient is typically used for jointly normally distributed data (data that follow a bivariate normal distribution)" (Schober, 2018).

Based on Schober the term correlation is used in the context of a linear relationship between two continuous variables.Correlation means a relationship between two variables. As one variable increases, the value of the other variable also increases. Or, when the value of 1 variable increases, the second variable decreases. When p = 0, it means that there is no relationship between the variable and when the coefficient approaches -1 or +1, the relationship increases. (Schober, 2018).

This can be clearly seen in the figure below.

Figure 1 Correlation
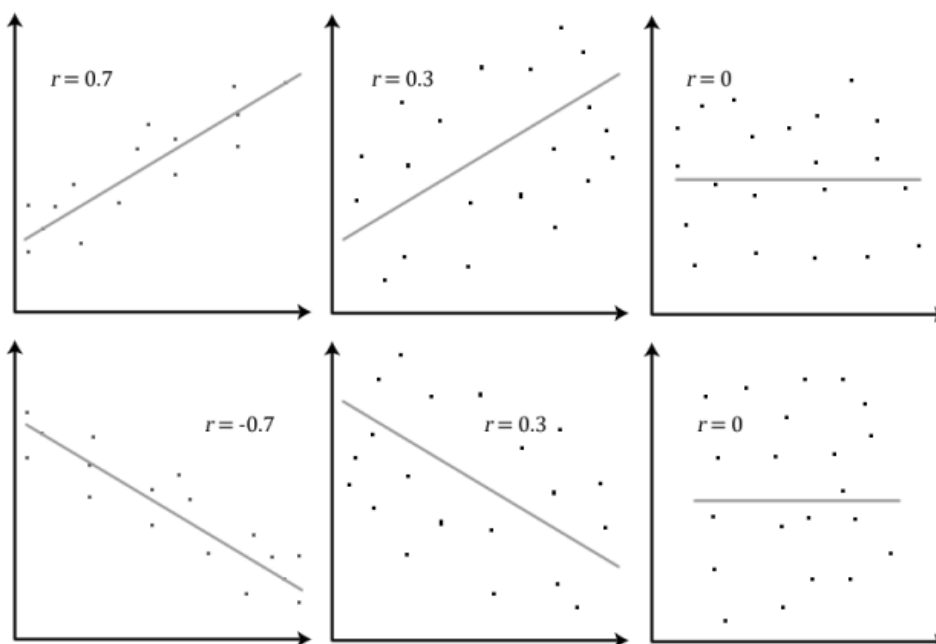
Source: Statsmethods, 2013

Pearson correlation coefficient will be used to analyze and understand the relationship between two variables. This will help to understand how much one variable affects another.

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2} \tag{4}$$

Spearman correlation

"Basically, a Spearman coefficient is a Pearson correlation coefficient calculated with the ranks of the values of each of the 2 variables instead of their actual values. Because ordinal data can also be ranked, use of a Spearman coefficient is not restricted to continuous variables" (Schober, 2018).

$$p = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)} \tag{5}$$

T-ratio

The t-ratio will be used to assess the significance of the correlation data obtained. The amount of data collected on macroeconomic and food security indicators will determine the critical value and degree of freedom needed to evaluate the significance of the data obtained.

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} \tag{6}$$

2.2.3 Linear regression

After Pearson and Spearman correlation, linear regression is used for more in-depth analysis. Linear regression will allow to estimate the relationship (if any) between food security proxies and selected macroeconomic indicators.

"In statistics, linear regression is an approach to modeling the relationship between a scalar dependent variable y and one or more explanatory variables denoted X" (Grob, 2003).

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_n X_n + \varepsilon \tag{7}$$

After estimating a model, three post-estimation tests will be conducted to check the possible presence of undesirable phenomena in residuals (autocorrelation, heteroscedasticity, and non-normality). For this purpose, the following three tests will be applied: the Breusch-Godfrey test, the White test, and the Jarque-Bera test, respectively. All the results will be considered at a 5% significance level.

3 Literature Review

3.1 Food Security concept

The role of food security is to provide the country's population with the quality nutrition necessary for a healthy existence, excluding such social problems as hunger. Food security includes many factors influenced by social and economic problems.

Here follows an analysis of the role of food security, based on verified sources, and a more detailed analysis of the concept itself and what it means. And its impact is not only on economic aspects but on the world as a whole.

Zhichkin states that the concept of food security is crucial to a country's economy. This concept is based on the country's ability to meet the population's needs, including an adequate supply of agricultural products for daily activities. To ensure that residents can carry out their daily activities, the state must provide an adequate volume of food products that not only meets the required quantity but also corresponds to the cultural and climatic characteristics of the region (Zhichkin, 2021).

Another author, Leroy, gives a more detailed answer to the definition of food security. Food security is when all people, at any time, have physical and economic access to sufficient and safe food while fully meeting their nutritional needs for an active lifestyle. According to the authors, this definition encompasses various aspects of food security, such as the ability to choose and consume culturally acceptable and preferred foods, as well as establishing connections between key health and productivity indicators (Leroy, 2015).

To understand the definition of food security, it is important to be aware of its levels. Warr describes four levels of food security. It exists at the global, national, household, and individual levels.

Global level

The global level of food security is related to whether global supplies are sufficient to meet global needs. The quantity of food is estimated to be sufficient for everyone, but there is a problem of distribution among people.

National level

Food security at the national level is determined by the balance between supplies and needs within a country. International trade can impact these national indicators without necessarily altering global balances.

Household level

Food security in the household presupposes having sufficient access to food at that level. This implies not only sufficient food for today but also for the future.

Individual level

Food security at the individual level involves the distribution of food within the household. In cases where there is insufficient food, individual members may experience different consequences (Warr, 2014).

3.1.1 Historical retrospective view

The purpose of this section will be to reveal the history of the concept of food security and how it has changed over time. The time period will be from the 20th to the 21st centuries. This section will help to better understand the development and formation of the concept of food security.

Belugin's work demonstrates that efforts to draw global attention to the connections between food production, hunger, and health issues predate the establishment of FAO in 1945. The origins of this movement can be traced back to Frank L. McDougall, who comprehensively examined the facts of food security. A document was presented to the League of Nations based on the findings of leading nutritionists from the United States. This document is considered the first step in communicating to the general public that the majority of the world's population does not have enough food. The basic approaches that underlie the modern understanding of food security were formulated during the Second World War. This was a time when most agricultural production was destroyed or repurposed for military needs. Subsequently, the development of ideas that subsequently formed the basis of the concept of food security was carried out under UN organizations. In 1974, a conference was held in Rome that was attended by 134 countries worldwide. It was during this conference that the concept of 'food security' was first formulated. During the 1970s, there was a focus on controlling the world's food supplies to enhance food security and reduce price fluctuations. This emphasis was aimed at ensuring stability in the food market. Modern notions of food security include not only the availability of food of the right quality but also the ability to obtain the necessary nutrients from what is available. Indicators of food security include anthropometric studies, which measure the weight and height of children to determine deficiencies based on age group and gender (Belugin, 2019).

3.1.2 Food security pillars

When considering the fundamental concept of food security, it is important to focus on its main components.

Aborisade's work points out that sustainable food security is a broad phenomenon that requires the influence of a wide range of factors. The main pillars of food security that practitioners believe are critical to achieving food security are food availability, access, utilization, and stability (Aborisade, 2014).

Availability

Burchi identifies the food availability approach as the oldest and most influential. This approach, dating back to 1588, was authored by the Venetian thinker Giovanni Botero. The main idea of this approach is to maintain a balance between population and food availability. Specifically, the level of food availability should not be lower than the level of population growth. In this context, food security refers to the total per capita availability of food, which depends on the production, supply, and trade of food products (Burchi, 2016).

WFP defines it as "The amount of food that is present in a country or area through all forms of domestic production, imports, food stocks and food aid" (WFP, 2009).

Access

WFP defines it as "A household's ability to acquire adequate amount of food regularly through a combination of purchases, barter, borrowings, food assistance or gifts" (WFP, 2009).

Simon explains in more detail and divides access to food into three elements: The physical aspect is tied to logistics. If food is produced in a country with limited or inadequate transportation infrastructure, it may not reach the areas where it is needed most. The financial aspect is that food is available where people need it, and households have the financial ability to purchase food according to their needs. The understanding that availability of products does not always mean affordability due to financial concerns has become more apparent recently. This has attracted the attention of food security analysts and practitioners to the market. The sociocultural aspect is that food may be available, physically close to the consumer who has enough resources to purchase it, but there may be sociocultural barriers that limit access to food for certain groups of the population (Simon, 2012).

Utilization

Simon explains the utilization aspect is crucial in ensuring that people have a nutritious diet. Availability of food alone does not guarantee this outcome. There are a number of issues such as food choice and nutrient absorption. Food should not only be available, but also be of high quality and safe. Food utilization is also related to clean water and sanitation. Based on this, food utilization refers not only to food but also to other elements that are associated with the processing and preparation of food products (Simon, 2012).

Stability

According to Devereux, the concept of stability refers to an aspect of food security in which food shortages may be temporary or chronic. Chronic food insecurity is the long-term inability to meet food needs. Temporary food insecurity is a short-term or temporary lack of food (Devereux, 2006).

3.1.3 Organizations dealing with food security

Consideration should be given to examining organizations involved in addressing food security. This stage will be divided into two levels: global and national. For national organizations, those from the US will be considered.

FAO

Based on the words of Pernet, the reason for the creation of this organization is the connection between agriculture and food. It began with the interwar economic crisis. The organization was founded during the Second World War, when the preservation of agricultural production was important. FAO was supposed to achieve relief from hunger and improve world nutrition through new methods in agriculture (Pernet, 2019).

According to Boliko, FAO's main goal now is to improve nutrition, increase agricultural productivity, improve the lives of rural people, and participate in the growth of the world economy. FAO shares information on ensuring food production in all areas (Boliko, 2019). The FAO organization itself formulates the following priorities that were identified by member countries:

1. Improving food security

2. Promotion of agricultural production.

3. Promoting natural resource management

4. Responding to the impacts of climate change and developing adaptation strategies

5. Preparedness for emergency situations in the region

Dabovic notes that this organization has achieved participation in the creation of a database of standards and rules related to production, labelling, and food safety, known as the Codex Alimentarius. The Codex Alimentarius comprises global standards for acceptable levels of food additives, toxins, and pesticides in food, as well as regulations for hygiene and medication in animal-origin products. Notable achievements in the field of food security include the creation of the Committee on World Food Security (CFS). It also established the Codex Alimentarius Commission, which, as of 2021, includes 189 members and 50 observers. The CFS was created to address short-term and long-term crises. The Committee reports to the Economic and Social Council of the United Nations. Additionally, in 2004, the FAO created the Right to Food Guidelines. The Right to Food Principles is a practical tool to help realize the right to adequate food in the context of national food security (Dabovic, 2022).

WFP

According to O'Connor, the World Food Programme (WFP) was established in 1961 as an experimental organization with the aim of providing food aid. It is jointly managed by the United Nations (UN) and the Food and Agriculture Organization (FAO) (O'Connor, 2017).

Clay contends that WFP's food assistance activities include:

1) Support economic and social development with an emphasis on countries in need

2) Prevention of natural disasters and willingness to help mitigate their consequences

3) Helping refugees with food needs

4) Services to bilateral donors, United Nations agencies, and nongovernmental organizations that are consistent with the goals of the WFP (Clay, 2003).

United States Department of Agriculture

The USDA was created in 1862 as part of a body of legislation that the Union was able to enact once free from the constraints of the southern states (Phillips, 2013).

According to Gosselin, the US Department of Agriculture (USDA) is a huge organization whose purpose is to manage commodities, conservation and nutrition programs, and nutritional guidelines (Gosselin, 2010).

As stated by Lusk, the USDA's mission has broadened beyond its traditional focus on supporting farmers and domestic agriculture. Its new objectives include nutrition, lending, food security, healthcare, and food assistance. USDA spending has increased dramatically since the 1960s. The increase was since spending on nutrition assistance increased. 70

percent of total revenues in 2014 were allocated to food assistance. In 2014, the USDA allocated $161 billion. Of this amount, 66,6 percent was allocated to the Food and Nutrition Service, which is responsible for the Supplemental Nutrition Assistance Program. Funds were also allocated to the Risk Management Agency, which provides crop insurance, and to the Commodity Credit Corporation, which is responsible for farm subsidies associated with price and income support programs (Lusk, 2016).

3.2 Food insecurity

Food insecurity (FIS), defined as improper or inconsistent access to high-quality or nutritious foods, is a major public health problem affecting upwards of 2 billion people worldwide as of 2020 (FAO, 2020).

"Food insecurity can affect health and well-being in many ways, with potentially negative consequences for mental, social, and physical well-being, even in the absence of measurable negative effects on nutritional status" (Coates, 2006).

Perez-Escamilla identifies methods for determining food insecurity. Each of these methods will be further explained based on Perez-Escamilla words.

The FAO method

This method helps to estimate the per capita calorie intake in a given country using food balance sheets derived from household income surveys. The method requires information on the total number of calories consumed over a period, the number of people, the coefficient of variation of calorie consumption, and the cut-off point. The advantage of this method is that most countries have the information needed to analyse and apply it. It is also relatively inexpensive. The disadvantages of this method include the fact that it does not provide complete data, i.e., it does not consider the overall quality of the diet but only calories. Additionally, the method suggests that calorie intake above a minimum threshold indicates food insecurity, which is not always the case. For example, obesity is a serious problem among the poor, and excessive calorie intake can be associated with mild to moderate levels of food insecurity.

Household income and expenditure surveys

The method is based on conducting interviews with households, where they provide data on their food expenditure. To delve deeper into this issue, it uses input data such as the amount of food consumed inside and outside the home, food received as payment for work, or as a

gift, and food grown by household members. The advantages of this method include the possibility of identifying households that have problems with food security among the local population. Next is the opportunity to collect dietary information about the quality of food products. This method can also be used to assess the national food supply. However, this method has limitations and constraints. The constraints are related to the availability of food at a given time but not necessarily to the amount of food consumed during the period of interest, such as food consumed by guests or food that has been spoiled. Additionally, assessing the quality of food consumed outside the home is challenging. Determining the exact number of calories a household obtains from their food intake is imprecise and often relies on guesswork, which can lead to errors in the results. The method is costly and demands the active involvement of interdisciplinary teams.

Anthropometry

Anthropometry is defined as the measurement of the height, weight, size, and proportion of the body. These indicators demonstrate how food security levels and people's health are linked. This method is most often used in national surveys that are based on the height and weight of infants, children, youth, and adults. The interpretation of the results is based on clearly defined threshold values. The advantages of this method include its low cost, which makes it popular all over the world. The thresholds used to interpret the data are based on evidence. It allows for the creation of a nutrition map based on specific needs. It also allows for tracking food security within a nation and understanding the consequences of malnutrition at the individual level. The method of anthropometric indicators has two main limitations. Firstly, these indicators are an implicit measure of food security, as they do not directly measure food security but rather health status, which may be influenced by the overall nutritional status of the body. Secondly, the relationship between food security and obesity is difficult to interpret.

Food insecurity experience-based measurement scales

This method, based on experience-based measurement scales, directly measures the phenomenon of food insecurity itself and how affected individuals perceive it. The scales used in this measurement method cover various aspects, such as psycho-emotional states and the quality and quantity of food consumed. The advantages of the method include that the collection and analysis of data are simple and cheap, which allows for the collection of information in a decentralized manner. The method can be used in any cultural

environment, obtaining reliable results. This method reflects not only the physical consequences of a lack of food security but also the psychological aspects. However, the scales used in the method do not provide information about access to water, and most do not include questions about food safety problems caused by microbes and other environmental pollutants. The reliability of the answers may also be lost if this method is used to determine eligibility for social assistance (Perez-Escamilla, 2008).

3.3   Macroeconomic indicators

Now, at this point, examine the concept of macroeconomic to gain a complete understanding of its meaning. This section provides an overview of macroeconomic indicators, their definition, and their relevance to the thesis. Additionally, the focus will be on those aspects of macroeconomic that will help in the research needed to identify the factors that influence food security.

GDP

Bakieva defines gross domestic product (GDP) as the total market value of all final goods or services produced within a country's borders over a specified period, using both national and foreign factors. It is important to examine the properties of GDP in more detail. GDP is a cumulative indicator that characterises the volume of production, representing total output. It includes only official transactions, that are registered. Therefore, the concept of GDP cannot include self-employment or unpaid work. GDP measures national output in monetary terms. Money is a universal tool that can estimate the cost of various goods and services (Bakieva, 2019).

Bystrova notes that GDP, or gross domestic product, is the most important indicator for the international system of national accounts. GDP shows a country's overall economic performance. GDP is calculated by adding up the total cost of products made in a given country by foreign or domestic manufacturers. The gross domestic product (GDP) has a significant impact on the economy. It shows the level of economic development and its growth rate and is used to analyse the economy as a whole. A lower GDP indicates a lower level of well-being for the population. Therefore, GDP is an essential indicator of the general well-being of a country (Bystrova, 2019).

Inflation

Kacheyants provided information on inflation. Inflation is a crucial indicator, as it directly affects the final cost of products and the changes in prices over time. This indicator reflects the consumer's purchasing power, and lower inflation rates make it easier for consumers to afford food, which is essential for food security (Kacheyants, 2010).

Sayfutdinov explains that inflation undermines a country's purchasing power as prices rise over time, reducing people's ability to buy goods, including food. This effect is felt regardless of the inflation rate, whether it is 2% or 4%. However, higher inflation rates result in a faster and greater loss of purchasing power. Compounding ensures that the overall price level increases over time, which disproportionately affects people with lower incomes. If you take a high-income consumer, they spend a lower percentage of their income on basic necessities than, say, low-income consumers, who have little protection against inflationary erosion of their purchasing power. Financial market participants tend to focus on core inflation, which excludes food prices because of their volatility, and which does not completely rule out inflationary trends in the future. But people with low incomes spend a large proportion of their budget on goods that they cannot afford to do without when prices rise. Property is a good hedge against inflation; the poor tend not to have assets of their own. But there are social security and other benefits that are somewhat protected against inflation because the cost of benefits is adjusted in line with the consumer price index (Sayfutdinov, 2023).

Unemployment

According to Byrne, the unemployment level is one of the most important indicators of the well-being of the labour market and the economy in general. The unemployment rate is theoretically simple, but there is difficulty in determining whether a person is employed or unemployed. A person is considered unemployed if he meets the following requirements:

1) "Without work" that is, did not engage in paid work.

2) "Currently available for work" i.e. had access to paid work for a certain period.

3) "Looking for work" are those who are consciously looking for work and have taken steps for this (Byrne, 2004).

Sabirzhanova revealed unemployment as a phenomenon and highlighted the concept of cyclical unemployment. The concept of unemployment will always be present in countries where there is a market economy. Unemployment is part of the labour market and does not hinder the development of the market economy. The state only deals with a certain type of

unemployment, which is called cyclical unemployment. Cyclical unemployment is unemployment that exceeds the natural level. Cyclical unemployment causes economic and social problems for citizens and society. The loss to the economy from cyclical unemployment is, on average, much higher than from other problems. The relationship between the deviation of actual output from the level of cyclical unemployment is expressed by Okun's law. According to this law, for every 2 percent deviation of actual output from potential GDP, the unemployment rate increases by 1 percent. This rule shows how GDP affects unemployment (Sabirzhanova, 2018).

Interest Rate

According to Khachatryan, the interest rate is the fee that the borrower pays to the lender. In return, the borrower receives a certain amount of money to use temporarily. The interest rate depends on many factors, such as supply and demand in the market, and depends on the amount of the loan. The interest rate is a complex instrument for regulating banking activities. The principle of constructing the interest rate scale also depends on inflation and the size of deposits. In almost all countries, the interest rate is regulated by the government (Khachatryan, 2018).

Based on the words Barimen, the rate is the amount of money the borrower takes from the lender for a certain period at a certain rate. The rate at which money is borrowed is called the interest rate. The interest rate is the basis of the traditional banking system that affects the economy. A lower interest rate means more investment. In theory, a low interest rate improves food security because it increases investment, which creates wealth that allows people to buy food or directs that investment into the food industry (Barimen, 2022).

3.4 The impact of macroeconomy on food security

Now turn to the economic indicators that affect food security. Timmer also highlights the strong link between food security and the economy. Countries with a high level of economic development, in other words, developed countries, have fewer problems with things like food shortages and poverty (Timmer, 2004).

Khramova notes that the country's food security is the result not only of agricultural and food policy but also of the country's macroeconomic development in general. The low income of the population affects the amount of food necessary for normal life support, and the high level of differentiation of the population by income level creates groups of people in the

country's population with malnutrition and risks to food security. It is also important to remember that the quality of the products themselves plays an important role in ensuring food security. If food is high in calories but lacks balance, it also poses a risk to public health, so programs that aim to ensure food security in the country must include recommendations on social policy and quality control (Khramova, 2001).

Unemployment affect

Now comes unemployment, an equally important macroeconomic indicator of food security. The full answer to this question is provided by the Raifman study, which highlights that unemployment creates problems, the most important of which is the lack of food. Government programs and various benefits are not always able to fully solve this problem. Without work, people are unable to provide their own food and are dependent on the state. The US deals with this problem through benefits and programs. Raifman conducted a national study which found that food insecurity decreased by 30% that there was a 42% decline in people eating less due to financial constraints among those who received unemployment insurance and had household earnings of less than $75,000 after losing their jobs during the COVID-19 pandemic. These results were even higher for people with low incomes. During this period, there was a significant impact on food insecurity due to the large unemployment benefit supplement of US$600. The evidence presented, that unemployment insurance reduces food insecurity, correlates with the fact that household expenditure increased immediately after the first unemployment insurance payments arrived in April 2020. 41 percent of people living in households with incomes below $75,000 reported unemployment between 1 April and 8 July 2020. 31 percent of households reported food insecurity, and 33 percent reported low food consumption. This was particularly pronounced among Hispanics and lone parents. Food insecurity declined over time among those receiving unemployment insurance. Eligibility for unemployment insurance and the amount received depend on the laws of the state in which the person lives. In March 2020, the share of unemployed people receiving unemployment insurance varied from 7.6% in Florida to 65.9% in Massachusetts, and the amount varied from 240$ US dollar per week in Arizona to 820$ US dollar in Massachusetts (Raifman, 2020).

GDP affect

At this point examine how GDP per capita affects food security using data from Swietlik research. The growth of the global economy from 2012 to 2015 increased the level of food

security in all regions. In poor countries, the growth of the global food security index was higher than in rich countries, which is an excellent indicator. The results of the analysis of food security in different regions show that territorial differentiation is due to differences in economic development, which means that it is influenced by gross domestic product. Countries with a low level of GDP were least well supplied with food, while countries with a high level of GDP had better access to food. The correlation between economic development and food security is more pronounced in more economically developed countries. Food security also increases as the level of GDP rises. The analysis found that changes in food security observed between 2012 and 2015 across regions and countries were highly correlated with changes in GDP per capita in those countries, with the most significant improvements in food security recorded in countries with the highest GDP growth rates. In 2015, the global food security index scored 55.8 points on a 100-point scale for 109 countries. The US ranked first with 89 points. This shows that the best performance in the GFSI analysis was achieved by countries with the highest GDP per capita, in this case the US (Swietlik, 2018).

Inflation

At this point, consider the impact of inflation on food prices and food security.Inflation is an important indicator because the price rises every year, and this has a significant impact on the ability to purchase certain products. It becomes more difficult for a person.

According to Nord, in conditions of rapidly changing inflation, food price increases may outstrip income growth for some households. Food price inflation creates food security problems, and food security can be affected by the level of food prices (Nord, 2014).

Further, Nord comments on the US inflation data. The price of all goods in 2012 was 4.37 percent higher than in 2005-2007 and this is estimated to have increased food insecurity by 2.55 percent. Changes in these two factors were partially offset by low inflation in 2012, which in turn reduced the prevalence of food insecurity by 0.51 percent. Food insecurity in 2012 is estimated to be 3.73 percentage points higher than in 2005-2007. When comparing the period from 2009-2010 to 2012, the rise in food insecurity was estimated at 0.52 percent and was associated with high inflation and food prices (Nord, 2014).

According to Gustafson, high prices can have serious consequences for overall welfare and food security, especially for vulnerable populations. The impact on poor households varies across countries. The more vulnerable the population, the greater the impact of price changes

on them. Gustafson builds on the work of the Committee on World Food Security, citing as an example a report on price volatility and food security. The report notes that food consumption is relatively price inelastic, requiring relatively large price changes to adjust. In addition, as incomes rise, the demand for food becomes less able to change prices because richer countries are willing to pay more to maintain the level of food consumption. but not everyone is able to do this. Two characteristics can be distinguished among vulnerable households: The first is that these households spend a large proportion of their income on food, especially cereals. This also applies to farmers who produce their own food. They are also net purchasers of food. Households in countries with high income levels, such as the United States, spend a small proportion of their income on food, in contrast to India and Tanzania. Poor households spend most of their income on food. Similarly, rich households spend a much smaller proportion of their income on food (Gustafson, 2013).

3.5 Overview of the United States economy and food security

This section will be divided into two parts. The first part will be about the general economic situation in the United States. The second part will be about the food security situation in the United States.

Figure 2 Infographic of the United States economy
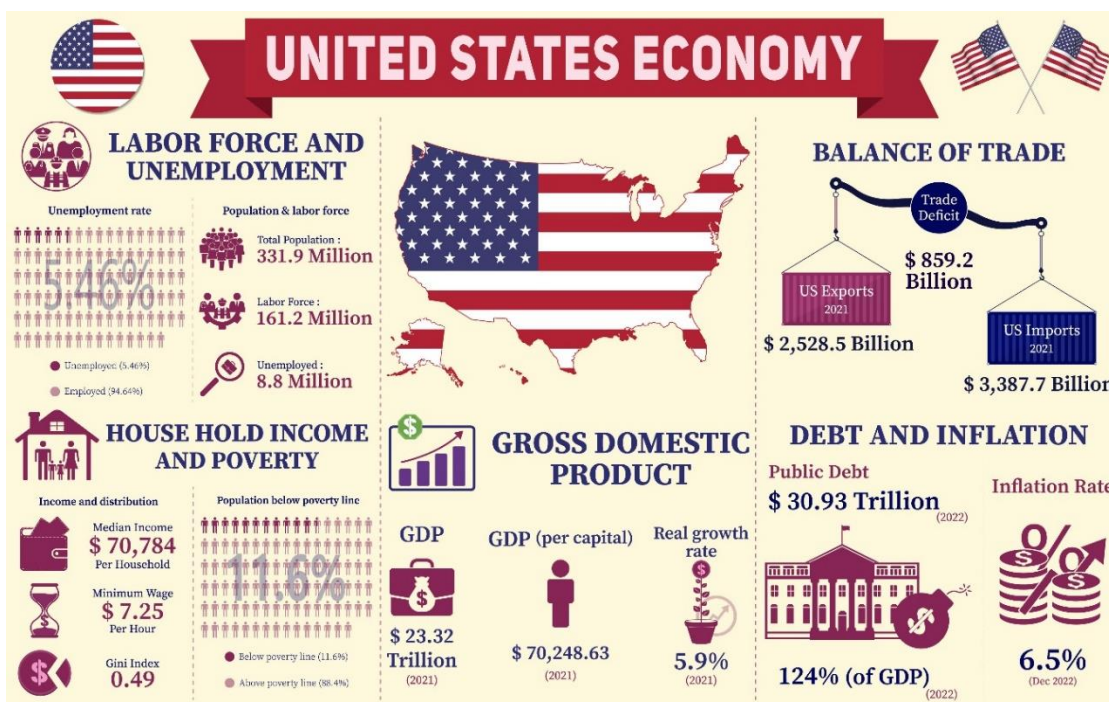
Source: Vecteezy, 2023

3.5.1   Economic situation in the US

The following information pertains to the United States: GDP level, inflation rate, and unemployment rate. The period from 2020 to 2022 was chosen, considering the situation with COVID-19.

GDP

Consideration will be given to the impact of the pandemic on GDP in the United States.

In compliance with the White House of the US, the impact of the COVID-19 pandemic on the economy can be seen through the GDP dynamics. All major economies experienced a decline in production, with the United States' GDP falling by 8.9% in 2020. In the second quarter of 2021, the US GDP increased and exceeded pre-pandemic levels, surpassing most other countries. It is important to note that while GDP does not reflect all the consequences of the pandemic, the US economy has made significant progress (White house, 2022).

Based on CEPAL information, the US had its highest GDP growth in 2021 since 1984. However, in 2022, the growth rate slowed to 2.1%, which is comparatively weak compared to the previous year. Growth resumed in the second half of 2022, following a slight decline in the first half of the year. The increase in consumer spending, exports, and private investments contributed to GDP growth in 2022. It is worth noting that imports, which are deducted when calculating GDP, also increased (CEPAL, 2023).

Inflation

As reported by Ball during the COVID pandemic, high inflation has become a significant economic issue in the US after four decades of low inflation. Monthly inflation fell to almost 10 percent in 2020 and reached 10 percent or higher in 2021 and 2022. Monthly inflation reached 17.1 percent in June 2022 and in September it amounted to 4.7 percent. High monthly figures in 2021 and early 2022 mean that 12-month inflation peaked at 9.1 percent in June 2022 and was 8.2 percent in September (Ball, 2022).

According to CEPAL, there is a trend towards a moderate increase in prices, judging by the graph, inflation peaked at 9.1% in 2022. The Consumer Price Index for Urban Consumers (CPI-U), which measures the cost of everyday goods and food, rose 5% in March 2023. This was the lowest figure since May 2021. In February 2023, prices increased by 5.5% compared to September 2022, excluding food and energy. Additionally, the food index experienced a 9.5% increase in February 2023. Inflation started with goods that were affected by supply problems. Last year, in 2022, supply problems eased, and prices for shipping and raw

materials fell. As a result, consumer spending shifted from goods to services. In March 2023, prices for basic goods increased by 1.5%, compared to 12.3% in February 2022. The economy is experiencing disruptions in supply chains and tightening credit policies, resulting in a reduction in excess demand and inflation. However, the turmoil in the banking sector complicates the path for monetary policy as the Federal Reserve is forced to balance high inflation with maintaining financial stability (CEPAL, 2023).

Unemployment

According to Barlow, there was a shock to the economy caused by the COVID-19 pandemic. The US unemployment rate has reached its highest level since World War II. At its peak in April 2020, US unemployment reached 14.7%, exceeding the 2008 unemployment rate during the global financial crisis (Barlow, 2021).

As stated by Kozicki, this analysis of the unemployment rate in 51 states showed leading values in the following states: Nevada - 28.3 percent, Michigan - 22.7 percent and Hawaii 22.3 percent. In the rest of the states, the unemployment rate was around 12.76%. The lowest unemployment rate was seen in Connecticut, at 8.1 percent. When examining the decrease in the unemployment rate in 51 US states from April to September 2020, the first places are Nevada at 15.1 percent, Michigan at 14 percent, Vermont at 10.8 percent, Indiana at 10.5 percent, Hawaii at 9.8 percent, and New - Hampshire at 9.8 percent. The remaining 45 states are hovering around 5.4 percent unemployment rates (Kozicki, 2021).

Based on CEPAL, the US labour market was strong in 2022, and the trend was the same in 2023, with a total of 399,000 jobs created per month in 2022 and 4.8 million per year. At the same time, the unemployment rate was minimal, at 3.5%. Economic forecasts suggest that interest rates will slow the economy and lead to higher unemployment in 2023. The unemployment rate is projected to be 4.6% in 2024 (CEPAL, 2023).

3.5.2   Food security in the US

In accordance with Rabbitt, 87.2 percent of US households were food secure in 2022. The remaining 12.8 percent, or a total of 17 million households, had food insecurity problems. Food insecurity was higher in 2022 than in 2021, which affected 13.5 million households, and in 2020, which affected 13.8 million households. In 2022, 5.1 percent of them, that is, 6.8 million households, have a very low level of food security, which is higher than in 2021 with 5.1 million households and in 2020 with 5.1 million households. Due to food insecurity, food consumption decreased, and normal dietary patterns were disrupted throughout the

year. In 2022, households with children experienced food insecurity in 8.8 percent of households, or 3.3 million households. In 2021, 6.2 percent of households with children were food insecure, or 2.3 million. In 2020, 7.6 percent, that is, 2.9 million households with children, were unable to provide children with sufficient food (Rabbitt, 2023).

4   Practical Part

4.1   Food Security programs in the US

SNAP program

Consistent with Hoynes, the SNAP program is a program that is not targeted at any group but is based on income and asset eligibility criteria. It is the most unlimited program and provides vouchers that can be used to purchase food products in stores and authorized retailers. The SNAP program is designed to provide a basic level of consumption to low-income families. As earnings increase, the benefit level decreases, this is called the benefit reduction rate. A research study of the SNAP program was conducted on health outcomes, including the impact on food insecurity and dietary quality. The research found that SNAP increases family capacity and leads to increased spending on food and goods. As a result, it reduces food insecurity and improves health at birth. Additionally, participation in the program at an early age leads to improved long-term health (Hoynes, 2015).

According to Short SNAP, it is by far the largest program at a cost of $74.2 billion in 2014. Nearly one in seven Americans participated in SNAP in 2014, and the program lifted 4.7 million people, including 2.1 million children, out of poverty in 2014 (Short, 2014).

Based on Rank, in 2010, the average monthly benefit was $288 per month for a family of four, with the maximum benefit for a family of that size being $668. The difference depends on the family's income in a given context. These benefits can represent a significant portion of the total income of low-income households. In terms of the number of people served, in 2010, the SNAP program covered about 40.3 million people each month, and the annual distribution of benefits was about $68.3 billion. That's a lot of money, and a significant portion of the population benefits from this program in the United States. Worst of all, a recent study found that nearly half of all American children will live in a household receiving food stamps by the time they reach age 20 (Rank, 2009).

NSLP

Based on Bhatia the National School Lunch Program (NSLP) was authorized by the National School Lunch Act (NSLA) in 1946. Since then, it has been operating in over 96,000 government and non-profit organizations, providing low-cost or free lunches to more than 31 million children. This program is a significant achievement for children's health and overall social justice (Bhatia, 2011).

According to Gundersen, more than 31 million students participated in the NSLP in 2010. Of these, most students (half) received free lunches, and one tenth received a discount on school lunches. Cash payments under this program exceeded $10 billion. Any child can participate in this program within the school. But unfortunately, children who are homeschooled cannot participate in this program. But it is also worth lifting the rules in more detail among children in these schools, families with incomes at or below the poverty level of 130% are eligible for free meals. Children living in a family with an income between 130% and 185% of the poverty level are eligible for reduced price meals, which cannot cost more than 40 cents. This is a great opportunity to provide children from low-income families with proper and balanced nutrition as part of their education (Gundersen, 2011).

WIC

"Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) was established in 1972, in order to enhance the nutritional status of these vulnerable groups" (Bitler, 2005).

"Special Supplemental Nutrition Assistance Program for Women, Infants, and Children (WIC), which provides vouchers to purchase basic food items (such as cereal, milk, and vegetables) to pregnant and breastfeeding people and children under age five" (Barnes, 2023).

Li states that WIC program research showed that nutrition interventions had a positive effect on the health of women and infants. There is evidence that the program has a positive effect on infant birth weight and reduces illness rates among children, as well as a reduction in food insecurity and a positive impact on nutrition among program participants. However, many program participants receive incomplete benefits as the benefits provided for food are only partially repaid (Li, 2021).

According to Hoynes, benefits from the WIC program differ from food stamps in that the benefit is not based on income and there is no benefit reduction factor. Participants in the WIC program are entitled to the full amount of the benefit. Products received under this program are selected by the WIC and contain a significant amount of protein, calcium, iron, and vitamins (Hoynes, 2015).

4.2 Macroeconomic situation in the US

The literature review provided the definitions and functions of each macroeconomic indicator. Additionally, in the literature review, a brief overview of the US economy was made using macroeconomic indicators, credible sources, and the opinions of other authors. In the practical part, there will be data that the author, using sources, collected independently for the period from 2000 to 2021, which will help answer questions and make the analysis that was noted in the methodology. Key macroeconomic indicators such as GDP, inflation, unemployment, and interest rates will be collected. GDP will be considered per capita. Inflation on consumer prices. Unemployment will be given as a percentage, and the interest rate will also be given as a percentage. The following is a description of each macroeconomic indicator separately and indicates the tables that are present.

First, an analysis of nominal GDP per capita from 2000 to 2021 in the United States will be given.

Figure 3 Nominal GDP per capita
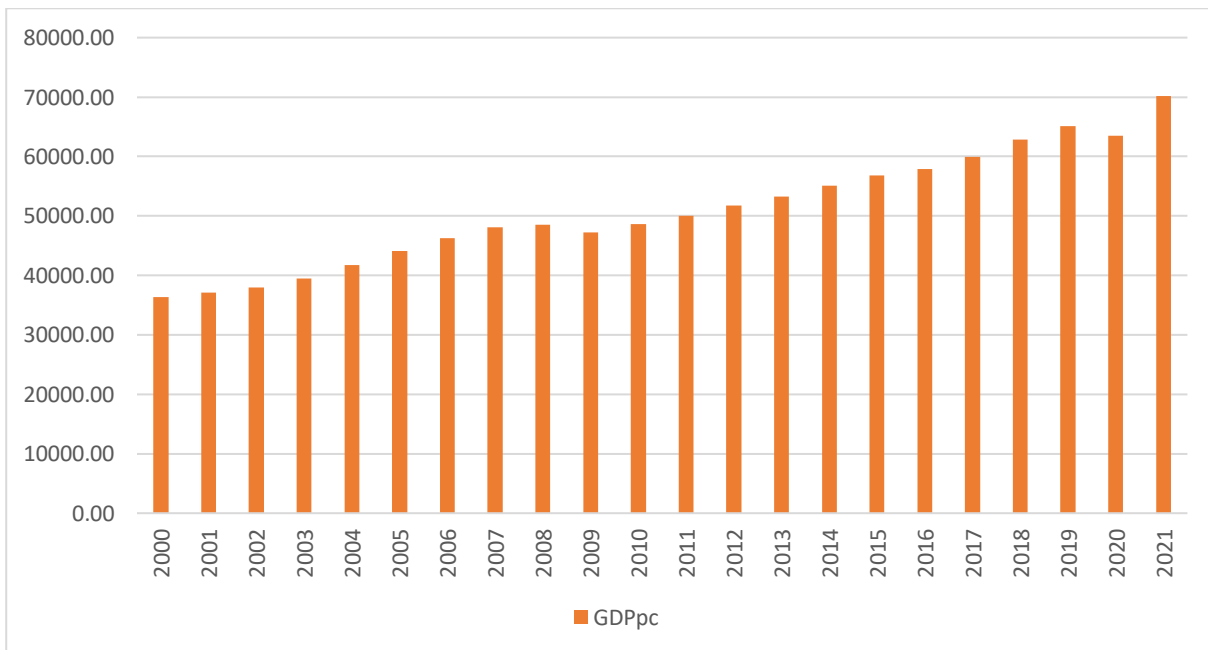
Source: own processing based on The World Bank data

Based on the data in the table, GDP per capita changes from 36329.96 to 70219.50. The lowest value was in 2000 and amounted to 36329.96, and the highest was in 2021, which amounted to 70219.50. Every year, the GDP per capita has grown, with each year showing a higher value than the previous year. With two exceptions, in 2008 the GDP per capita was

30

48570.05 and in 2009 it was 47194.94, which decreased by 1375.11 US dollars compared to last year. During this period, there was the beginning of the Great Recession, which affected the United States as well. But in 2010, GDP per capita was 48650.64, which is higher than in 2008 by 80.59 US dollars and higher than in 2009 by 1455.7 US dollars. Also, the second case was in 2019 when GDP per capita was 65120.40, and in 2020 it was 63528.60 where it decreased by 1591.80 US dollars compared to last year. During this period, there was just the world-famous COVID-2019 pandemic, which affected the economies in all countries of the world. Based on the above-mentioned GDP per capita in comparison with 2000, in 2021 it increased by 33889.54 US dollars.

Second, an analysis of inflation in consumer prices from 2000 to 2021 in the United States will be given.

Figure 4 Inflation in percent
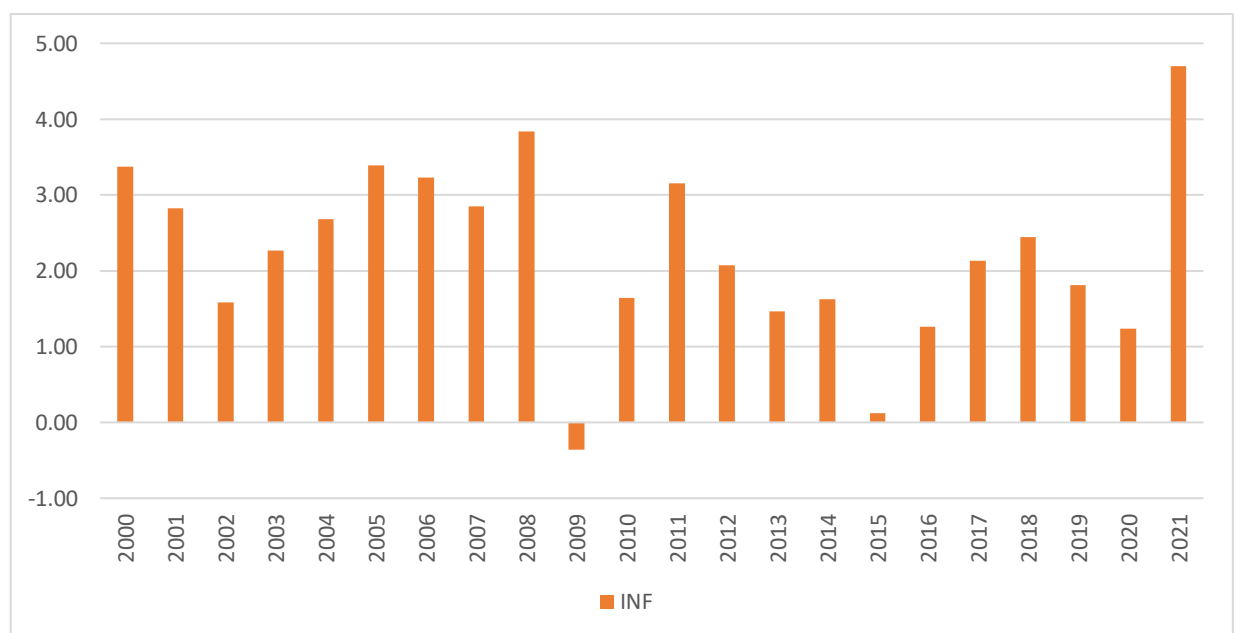
Source: own processing based on The World Bank data

Based on the data in the table, it is indicated that inflation in 2000 was 3.38 percent, while in 2021 it was 4.70 percent. Inflation values varied but ranged from a low in 2009 of -0.36 percent to a high in 2021 of 4.70 percent. In 2009, a negative value of -0.36 percent indicates deflation, that is, consumer prices, on the contrary, decreased. No other instances of deflation were observed from 2000 to 2021. Another low value for consumer price inflation was in

2015, which amounted to 0.12 percent, which is a record value in the data under review. Also, the highest inflation rate, with the exception of 2021, was recorded in 2005, which amounted to 3.39 percent.

Third, an analysis of unemployment in percent from 2000 to 2021 in the United States will be given.

Figure 5 Unemployment in percent
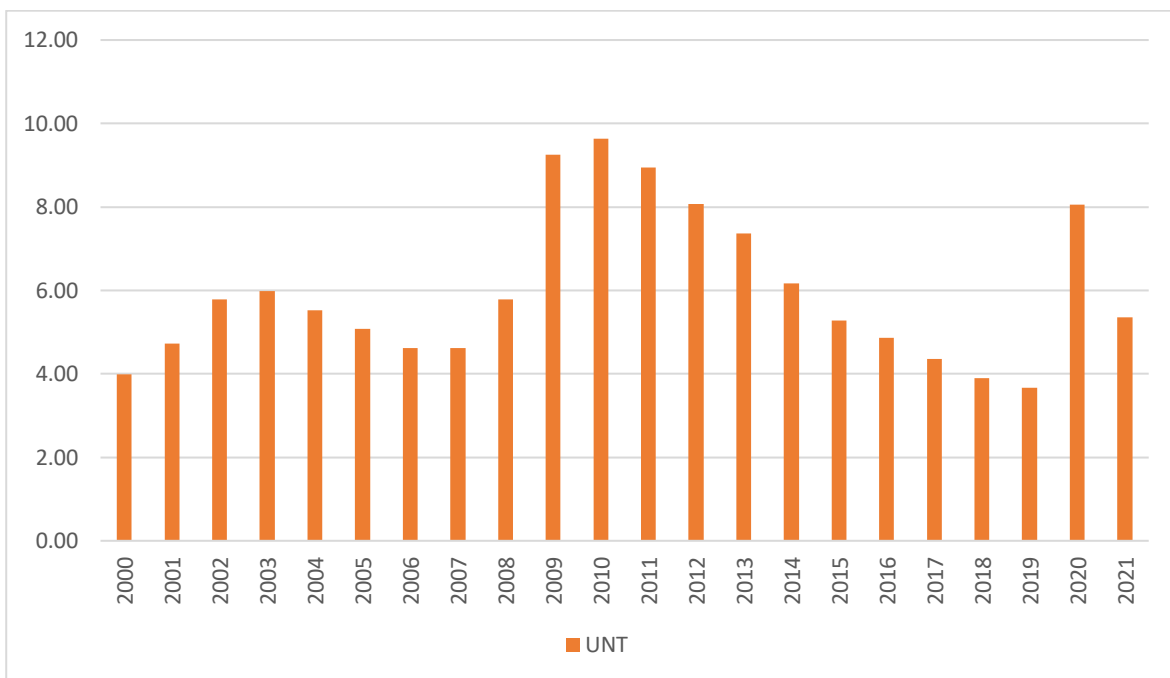
Source: own processing based on Statista

The unemployment rate has been measured as a percentage since 2000 at 3.99 percent and in 2021 at 5.35 percent. The lowest unemployment rate was recorded in 2019 at 3.67 percent. The highest unemployment rate was seen in 2010, at 9.63 percent. Not much more than in 2009, when the unemployment rate was 9.25 percent. Further, in 2011, unemployment was 8.95 percent, in 2012 it was 8.07 percent, in 2013 it was 7.37 percent, in 2014 it was 6.17 percent, and only in 2015 it was 5.28 percent, which is acceptable relative to the graph data. This was due to the financial crisis in 2008 and the subsequent decline in jobs. A similarly low unemployment rate was recorded in 2020 at 8.05 percent. Such a high unemployment rate was associated with the COVID-2019 pandemic, which changed the global economy and deprived people of a huge number of jobs. To understand the scale of changes, the

unemployment rate in 2020 compared to 2019, increased by 4.38 percentage points and by 4.15 percentage points when comparing 2020 to 2018.

Fourth, an analysis of real interest rate in percent from 2000 to 2021 in the United States will be given.

Figure 6 Real interest rate in percent
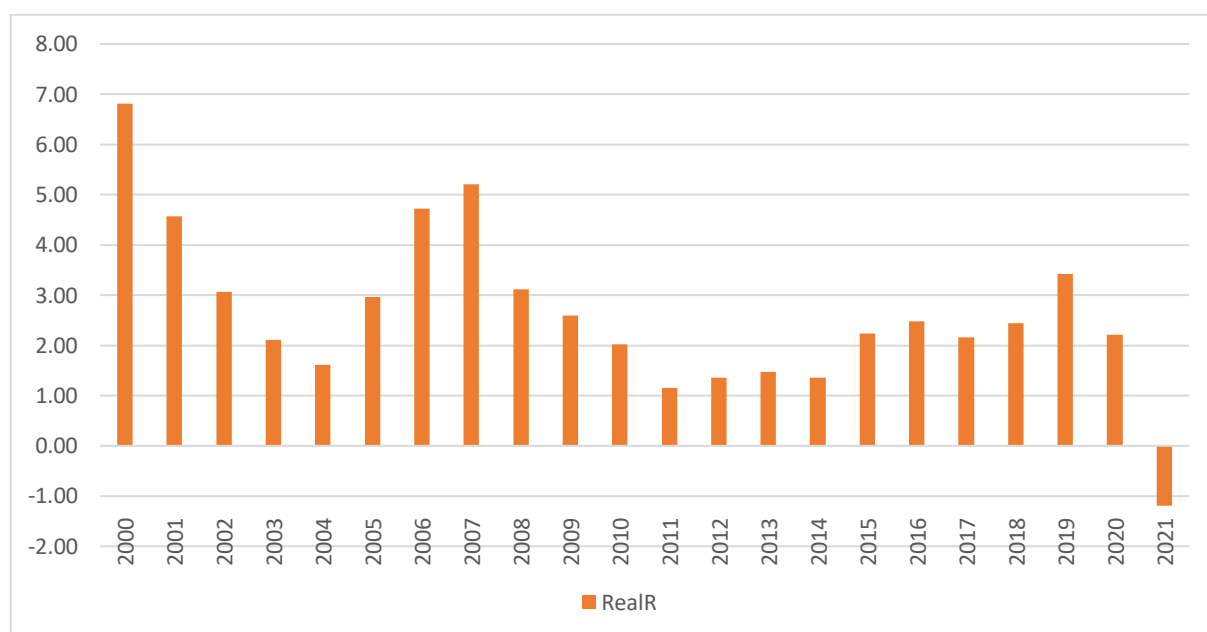
Source: own processing based on The World Bank data

Based on the data in the table, the highest value of the real interest rate was recorded in 2000, which amounted to 6.81 percent. The graph shows a negative value in 2021 of -1.19 percent. A negative real interest rate means that the interest rate excluding inflation is below the inflation rate. During the COVID-2019 pandemic, there were no significant changes in the real interest rate as the real interest rate, in 2018 was 2.44 percent, in 2019 was 3.43 percent, and in 2020 was 2.21 percent. The second highest real interest rate was in 2007, which was 5.21 percent.

Based on the collected data, a descriptive analysis of macroeconomic indicators will be given. The table with the obtained result is given below.

Figure 7 Descriptive statistics of macroeconomic indicators

	Mean	Median	Standard deviation	Minimum	Maximum
GDP per capita	51002,82	49358,30	9631,29	36329,96	70219,50
Inflation	2,24	2,20	1,18	-0,36	4,70
Unemployment	5,96	5,44	1,80	3,67	9,63
Real interest rate	2,63	2,34	1,65	-1,19	6,81

Source: own calculations based on The World Bank data and Statista

The results were obtained using (1), (2), (3) formulas, which were noted in the methods. The median, mean, standard deviation, minimum and maximum values of the data obtained are given. The maximum value indicates the highest value of the selected data. For example, for GDP per capita, the maximum value is 70219.50. When as minimum value indicates the lowest value of the selected data. For GDP per capita, the minimum value is 36329.96. The standard deviation indicates the variability of a value over a period relative to its mean value. For GDP per capita, the standard deviation is 9631.29. The mean of GDP per capita considering all values, while the median indicates the middle point in the data. The mean value for GDP per capita is 51002.82, while the median is 49358.30. All the values in the table are positive, except for the minimum values for inflation and the real interest rate.

Figure 8 Macroeconomic indicators
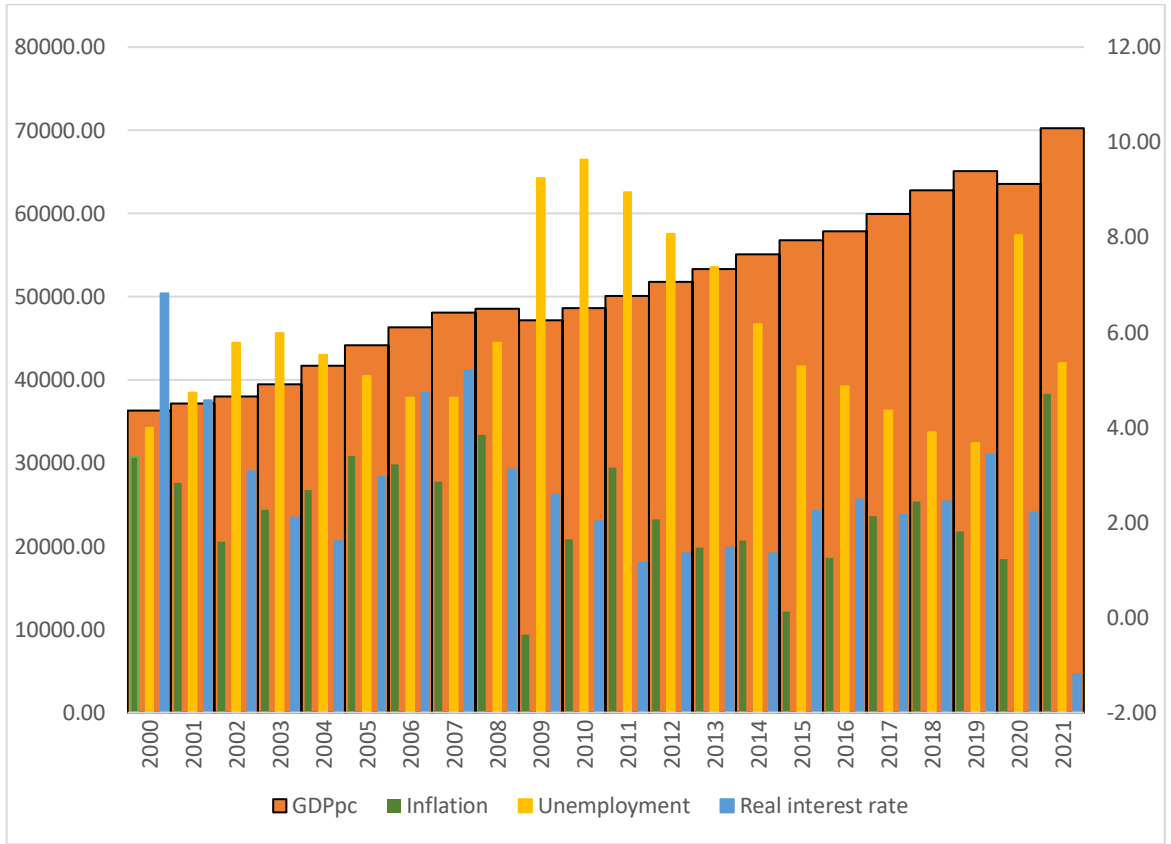
Source: own processing based on The World Bank data and Statista

Figure 8 combines all the macroeconomic indicators under consideration. On the left side are values for GDP per capita, on the right side are values for inflation, unemployment, and real interest rates. The starting point for inflation, unemployment, and real interest rates starts at -2. When the starting point for GDP per capita starts from zero.

4.3 Overview of Food Security indicators in the US

The literature review identified four main pillars of food security. From each of these pillars, one indicator will be selected and considered in practical work, using the USA as an example. The practical section contains data from 2000 to 2021, necessary for future analysis as noted in the methodology. The food production index indicator will be used for food security availability, while the poverty rate will be used as a percentage for food security access. To measure food security utilization, the percentage of children under 5 years old

who are stunted (height for age) will be used. And for food security stability food imports will be used as a percentage. Below is a description of each indicator separately, along with a table.

First, an analysis of the food production index from 2000 to 2021 in the United States will be given.

Figure 9 Food Production Index
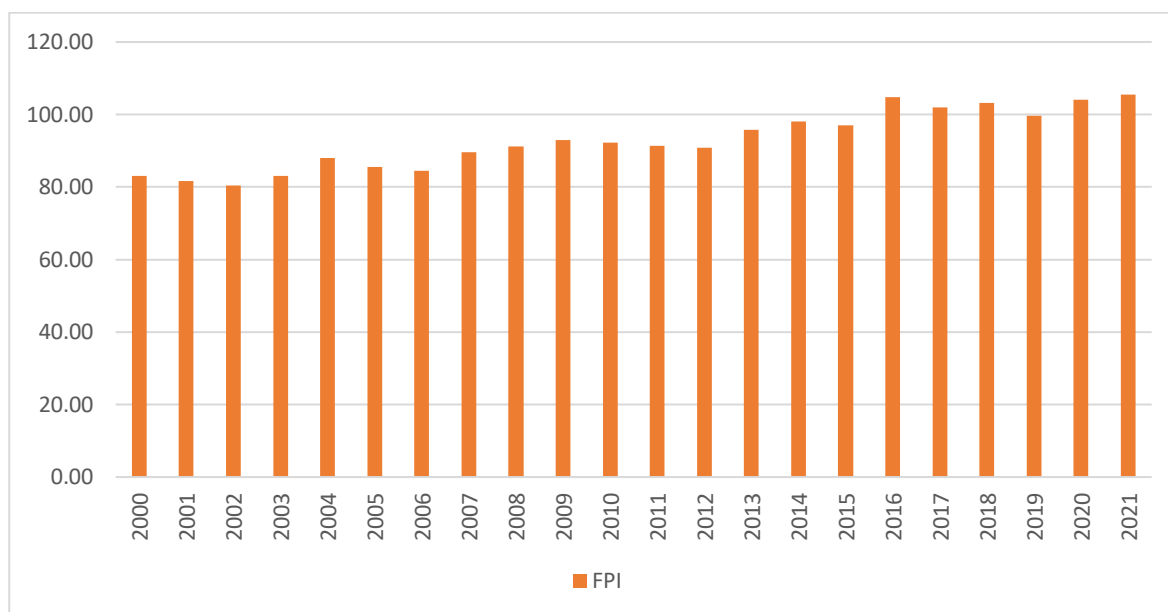
Note: Measurement index relative to an average of 100 for the period 2014-2016. High values indicate an increase in production, while low values indicate a decrease in production.

Source: own processing based on The World Bank data

The food production index belongs to the first pillar, availability of food security. The food production index value changes every year. The highest value was in 2021, which was 105.46, and the lowest value was in 2002, which was 80.43. Based on the chart data, the highest values after 100 were in 2016 in the amount of 104.86, in 2017 in the amount of 101.96 and in 2018 in the amount of 103.20; however, they decreased to 99.65 in 2019. But FDI increased to 104.05 in 2020.

Second, an analysis of poverty in percent from 2000 to 2021 in the United States will be given.

Figure 10 Poverty rate in percent of the total population
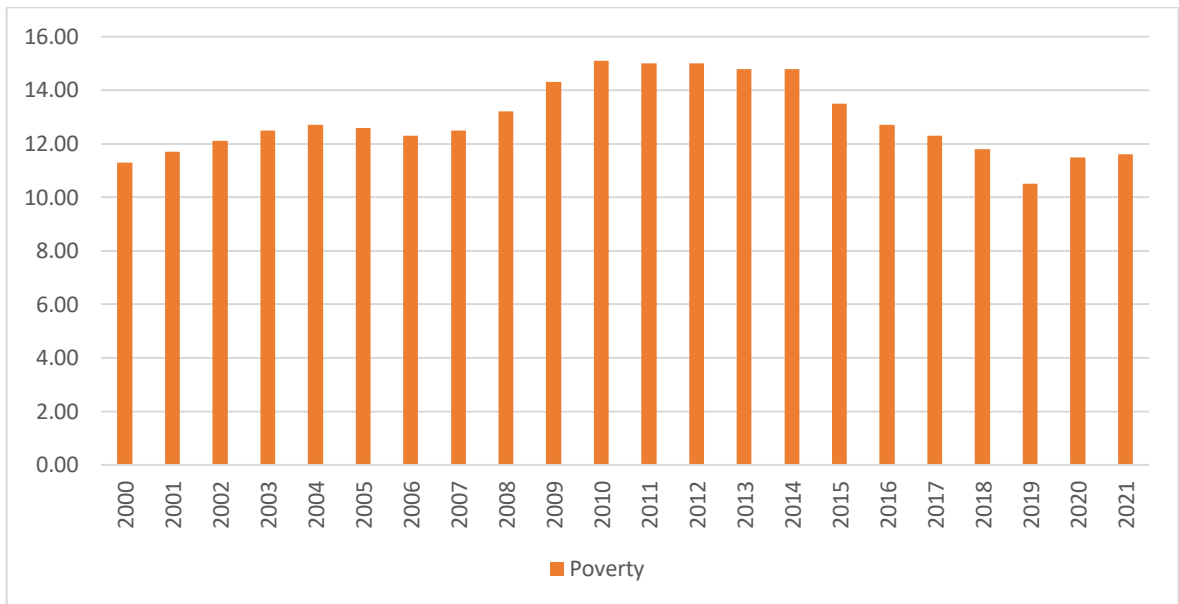
Source: own processing based on Statista

The poverty rate belongs to the second pillar, access of food security. The poverty rate remained relatively stable between 2000 and 2021, with the lowest rate recorded in 2019 at 10.50 percent. After 2019, the lowest rate was in 2000 at 11.30 percent and in 2001 at 11.7 percent. The highest rate of poverty was in 2010 in the amount of 15.10 percent and in 2012 in the amount of 15.00 percent. The same value of the poverty rate as in 2012 was in 2013, which also amounted to 15.00 percent.

Third, an analysis of the percentage of children under 5 years old who are stunted (height for age) from 2000 to 2021 in the United States will be given.

Figure 11 Prevalence of stunting, height for age (modeled estimate, % of children under 5)
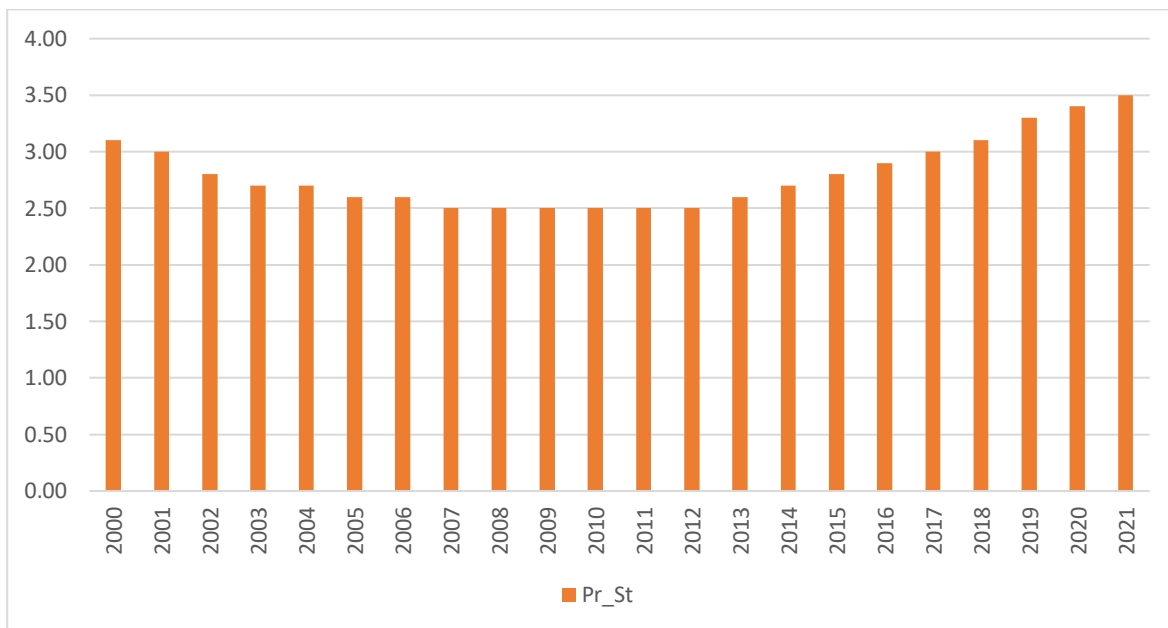
Source: own processing based on The World Bank data

The prevalence of stunting belongs to the third pillar, utilization of food security. The graph indicates that there were relatively small differences in the percentage prevalence of stunting between the dates. The highest recorded value was 3.50 percent in 2021, while the lowest was 2.50 percent in 2007. However, the same value of 2.50 percent persisted from 2007 to 2012, and in 2013, it slightly increased to 2.60 percent. Taking into account the initial starting points starting in 2000, the prevalence of stunting stood at 3.10 percent, while in 2021, the highest value reached 3.50 percent.

Fourth, an analysis of the percentage of stability food imports from 2000 to 2021 in the United States will be given.

Figure 12 Food Imports (% of merchandise imports)
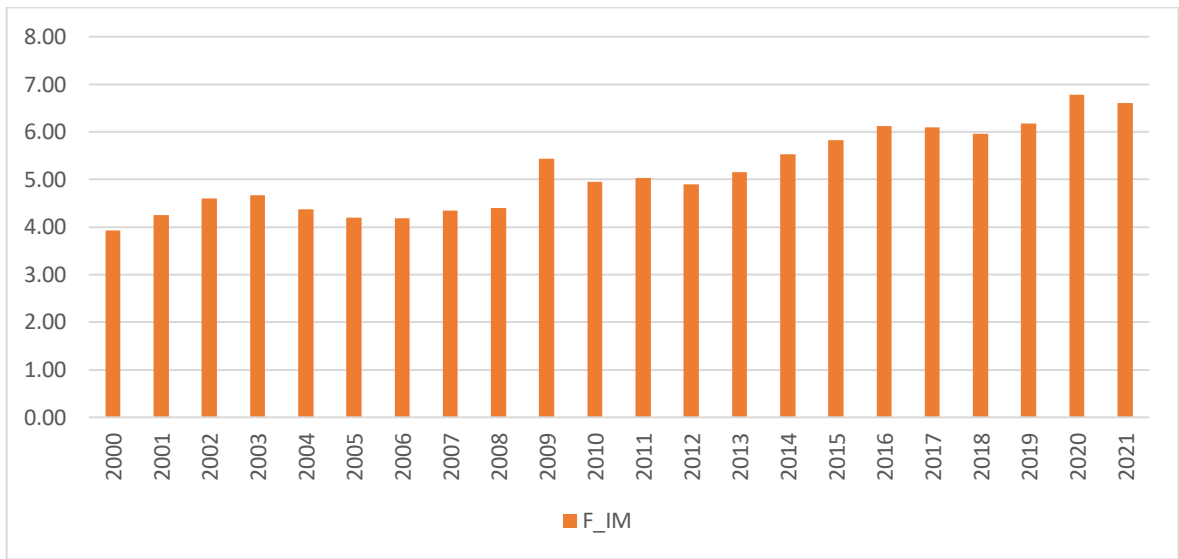
Source: own processing based on The World Bank data

Food imports belong to the fourth pillar, stability of food security. Following the graph data, it is clear that the lowest value was in 2000, from the beginning of the reference date. The value of food imports in 2000 was 3.93 percent. There was a significant increase in 2020 compared to last year. In 2020, food imports amounted to 6.77 percent, while in 2019, they was 6.18 percent. The highest value was also in 2020, which amounted to 6.77 percent, which does not contrast much with 2021, where food imports amounted to 6.61 percent. Based on the collected data, a descriptive analysis of food security indicators will be given. The table with the obtained result is given below.

Figure 13 Descriptive analysis of food security indicators

	Mean	Median	Standard deviation	Minimum	Maximum
FPI	92,94	91,80	8,04	80,43	105,50
Poverty	12,90	12,55	1,37	10,50	15,10
Prevelance of stunting	2,81	2,70	0,31	2,50	3,50
Food imports	5,16	4,99	0,86	3,93	6,77

Source: own calculations based on The World Bank data and Statista

The results were obtained using (1), (2), (3) formulas that were noted in the methodologies. The median, mean, standard deviation, minimum and maximum values of the data obtained are given. The maximum value indicates the highest value of the selected data. For example, for FPI, the maximum value is 105,50. When the minimum value indicates the lowest value of the selected data. For FPI, the minimum value is 80,43. The standard deviation indicates the variability of a value over a period relative to its mean value. For FPI, the standard deviation is 8,04. The mean considering all values, while the median indicates the middle point in the data. The mean value for FPI is 92,94, while the median is 91,80. All the values in the table are positive.

Figure 14 Food security indicators
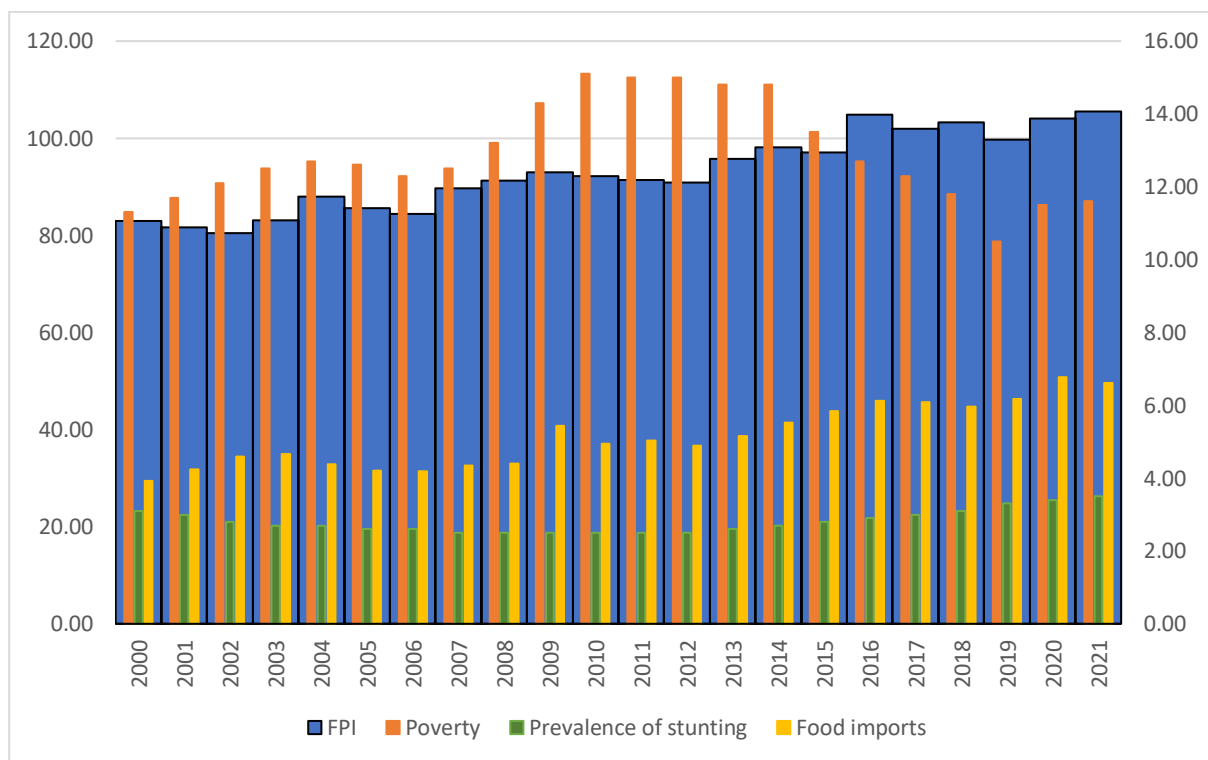
Source: own calculations based on The World Bank data and Statista

Figure 14 combines all the food security indicators under consideration. On the left side are values for FPI, on the right side are values for poverty, prevalence of stunting, and food imports.

4.4 Trend functions analysis

Data on trend functions for macroeconomic indicators and food security indicators will be provided here.

Figure 15 Macroeconomic indicators
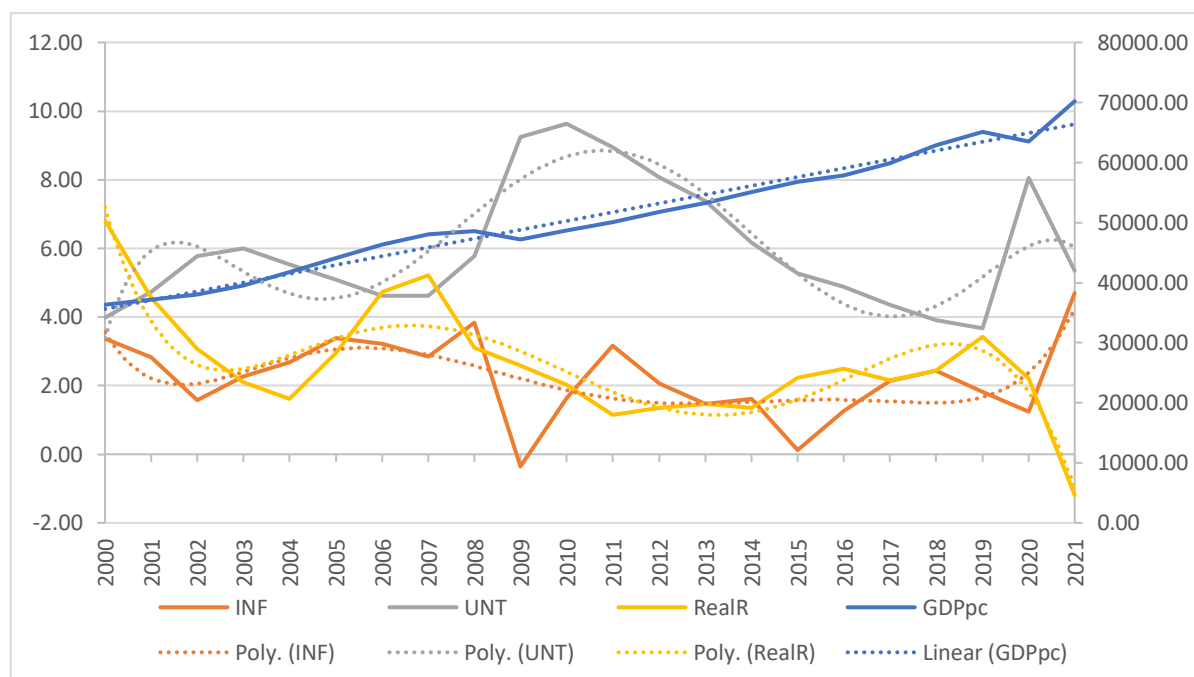
Note: Inf- Inflation, UNT-Unemployment, RealR-Real interest rate, GDPpc-GDP per capita

Source: own processing based on The World Bank data and Statista

An equation was drawn up for each of the macroeconomic indicators and the coefficient of determination was identified.

Unemployment: $y = -3E-05x^6 + 0{,}3291x^5 - 1654{,}6x^4 + 4E+06x^3 - 7E+09x^2 + 5E+12x - 2E+15$; $R^2 = 0{,}7577$

GDP per capita: $y = 1464{,}9x - 3E + 06$; $R^2 = 0{,}9754$

Real interest rate: $y = 3E-06x^6 - 0{,}0409x^5 + 206{,}56x^4 - 556074x^3 + 8E+08x^2 - 7E+11x + 2E+14$; $R^2 = 0{,}8449$

Inflation: $y = 1E-05x^6 - 0{,}1347x^5 + 677{,}35x^4 - 2E+06x^3 + 3E+09x^2 - 2E+12x + 7E+14$; $R^2 = 0{,}4289$

The chart below displays the food security indicators.

Figure 16 Food security indicators
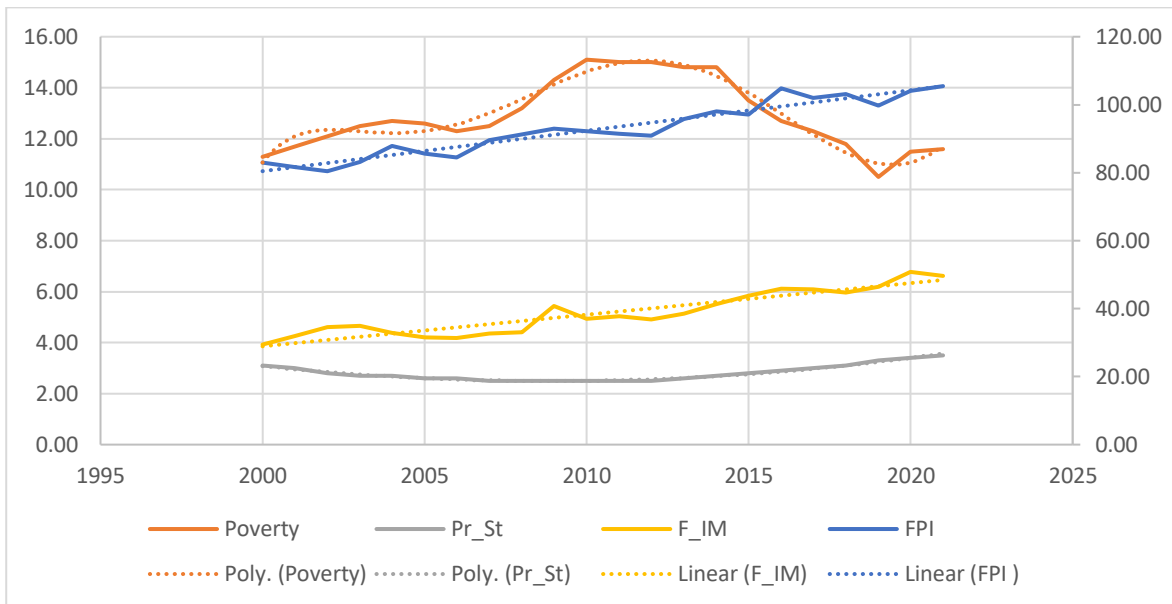
Note: Pr_St-Prevalence of stunting, F_IM-Food imports, FPI-Food Production Index

Source: own processing based on The World Bank data and Statista

An equation was drawn up for each of the food security indicators and the coefficient of determination was identified.

Poverty: $y = -4E\text{-}06x^6 + 0,0537x^5 - 270,16x^4 + 725260x^3 - 1E\text{+}09x^2 + 9E\text{+}11x - 3E\text{+}14$; $R^2 = 0,9433$

FPI; $y = 1,1903x - 2300,2$; $R^2 = 0,9243$

Food imports: $y = 0,1239x - 243,97$; $R^2 = 0,8707$

Prevalence of stunting: $y = 0,0074x^2 - 29,691x + 29826$; $R^2 = 0,987$

The graphs of GDP per capita, food production index and food imports follow linear trend functions, while the remaining indicators (poverty, prevalence of stunting, inflation, unemployment, real interest rate) follow polynomial trend functions. Therefore, for the accuracy of the analysis, in addition to the Pearson correlation analysis, Spearman correlation analysis will also be used.

4.5   Correlation analysis

The correlation analysis is ready to commence. The data for this analysis has already been collected and includes macroeconomic and food security indicators from 2000 to 2021.

Figure 17 Pearson Correlation Matrix

	GDP per capita	Inflation	Unemployment	Real interest rate	FPI	Poverty	Prevalence of stunting	Food imports
GDP per capita	1							
Inflation	-0,09	1						
Unemployment	-0,04	-0,36	1					
Real interest rate	-0,54	0,06	-0,43	1				
FPI	0,94	-0,21	0,009	-0,53	1			
Poverty	-0,10	-0,31	0,75	-0,40	-0,02	1		
Prevalence of stunting	0,53	0,14	-0,43	-0,08	0,49	-0,74	1	
Food imports	0,90	-0,34	0,06	-0,57	0,92	-0,12	0,61	1

Source: own calculations based on The World Bank data and Statista

After obtaining the Pearson correlation matrix, the Spearman correlation matrix will be made. Key values will be highlighted later.

Figure 18 Spearman Correlation Matrix

	GDP per capita	Inflation	Unemployment	Real interest rate	FPI	Poverty	Prevalence of stunting	Food imports
GDP per capita	1							
Inflation	-0,27	1						
Unemployment	-0,05	-0,35	1					
Real interest rate	-0,43	0,17	-0,60	1				
FPI	0,94	-0,33	0,000565	-0,43	1			
Poverty	-0,04	-0,26	0,70	-0,51	0,004	1		
Prevalence of stunting	0,37	-0,03	-0,54	0,08	0,366	-0,808	1	
Food imports	0,90	-0,51	0,1	-0,47	0,916	-0,066	0,457	1

Source: own calculations based on The World Bank data and Statista

Both matrices contain correlations of macroeconomic indicators with other macroeconomic indicators. The analysis requires only those data from both correlation matrices that show the correlation values between macroeconomic indicators and food security indicators. The t-ratio will be calculated for both correlation matrices only for those data required for analysis. To assess the presence and significance of correlations, a critical value of 2.09 and

degree of freedom 20 are set to be used. To calculate the t-coefficient, formula (6) from the methodology will be used.

The table below shows the t-ratio for the Pearson correlation matrix.

Figure 19 T-ratio for Pearson Correlation coefficients

	GDP per capita	Inflation	Unemployment	Real interest rate
FPI	**13,17267**	-0,98201	0,043118	**-2,84857**
Poverty	-0,4685	-1,49933	**5,136309**	-1,95301
Prevalence of stunting	**2,834715**	0,650168	**-2,17596**	-0,38075
Food imports	**9,588085**	-1,64574	0,293836	**-3,14137**

Source: own calculations based on The World Bank data and Statista

The table below shows the t-ratio for the Spearman correlation matrix.

Figure 20 T-ratio for Spearman Correlation coefficients

	GDP per capita	Inflation	Unemployment	Real interest rate
FPI	**13,17348**	-1,60127	0,002527	**-2,14192**
Poverty	-0,21519	-1,21314	**4,466339**	**-2,68374**
Prevalence of stunting	1,801228	-0,15874	**-2,93954**	0,385219
Food imports	**9,329519**	**-2,69061**	0,449467	**-2,44291**

Source: own calculations based on The World Bank data and Statista

In Figure 19 and Figure 20 those data that correspond to the critical value of 2.09 and degrees of freedom 20 will be important for the study because they are statistically significant are highlighted in red. Based on this, Figure 21 and Figure 22 below were compiled. Figure 21 and Figure 22 are also intended to visualize the relationship between macroeconomic indicators and food security indicators. Where in Figure 21 is the important Person correlation data and where in Figure 22 is the important Spearman correlation data.

Figure 21 Significant Pearson correlations
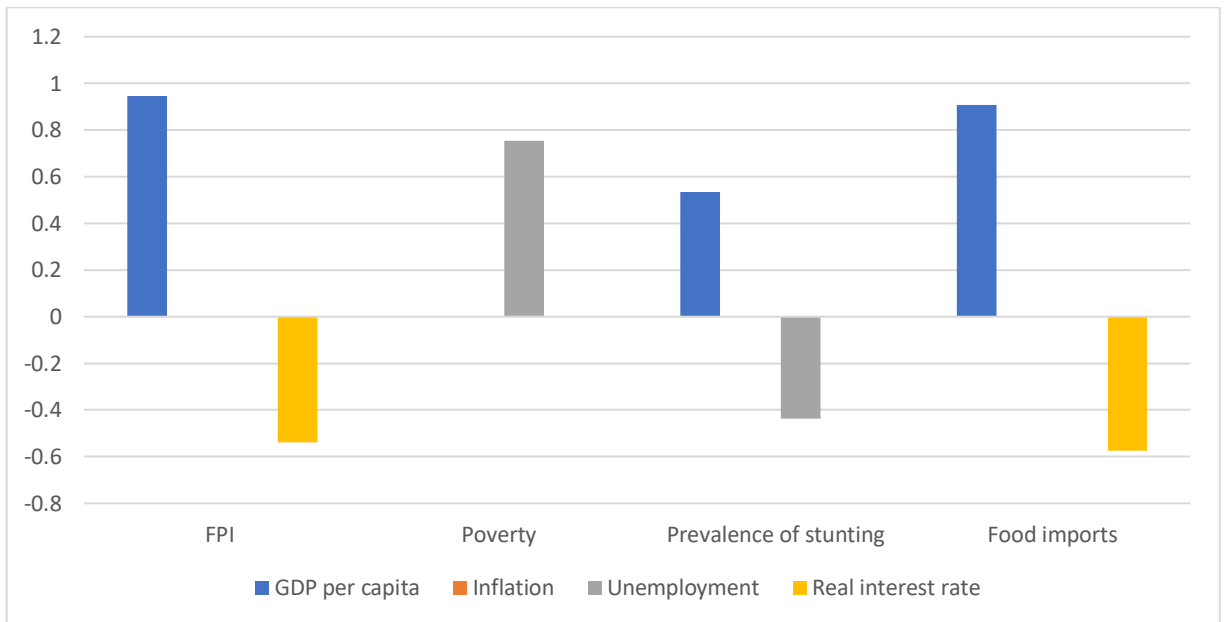
Source: own calculations based on The World Bank data and Statista

Figure 22 Significant Spearman correlations
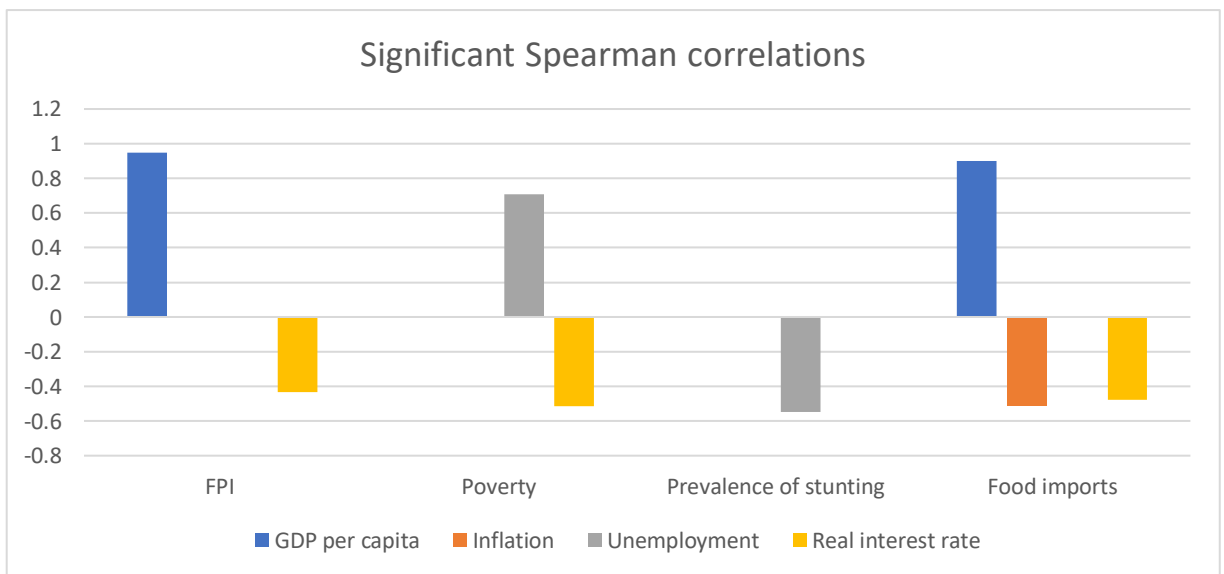
Source: own calculations based on The World Bank data and Statista

The table data reveals a correlation between macroeconomic indicators and food security indicators. Figures 21 and 22 are statistically significant and fit the critical value of 2.09. For the analysis of Pearson correlation, only GDP per capita, food production index, and food imports will be used since they are linear functions and can be reliable for Pearson

correlation, while other indicators (poverty, prevalence of stunting, inflation, unemployment, and real interest rate) are polynomial functions. The Pearson and Spearman correlations indicate a strong correlation between FPI and GDP per capita. Additionally, the Spearman correlation shows a negative correlation between the FPI indicator and the real interest rate, with a coefficient of -0.43. The Spearman correlation shows a negative relationship of -0.51 between the real interest rate and the poverty indicator. The Spearman correlation demonstrates a relationship between the poverty indicator and unemployment rate with coefficients of 0.70. The Spearman correlation shows a negative correlation between unemployment and the prevalence of stunting indicators with coefficients of -0.54. Regarding the food imports indicator, both Pearson and Spearman correlations show a strong connection with GDP per capita. The Spearman correlation indicates a negative correlation between food imports and inflation, with a correlation coefficient of -0.51. Similarly, food imports have a negative correlation with the real interest rate, with a correlation coefficient of -0.47.

4.6 Linear regression analysis

Available data on macroeconomic indicators and food security indicators have different units of measurement. A regression modeling is used to determine the strength of the relationships between indicators. Since not all the time series follow the linear trend, all the data were transformed using natural logarithms. In addition, this transformation will allow to interpret all the regression coefficients in percentages. All model estimations will be made for the significant indicators that were found through Spearman correlation analysis. The regression model that aims to describe the relationships between food security indicator (Poverty rate) and selected before, with the use of correlation analysis, macroeconomic indicator (Unemployment) is given below. To ensure that the regression coefficient provides the best linear unbiased estimates, the following three post-estimation tests with regard to the model residuals must be conducted: Test of Normality, Test for the absence of Autocorrelation, and Heteroskedasticity Test. The results have shown that there is no autocorrelation, the residuals are normally distributed, and the errors are homoscedastic. Gretl has been used for calculations.

Figure 23 Linear regression model

```
Model 11: OLS, using observations 2001-2021 (T = 21)
Dependent variable: l_Poverty

                  coefficient   std. error    t-ratio   p-value
  -------------------------------------------------------------------
  const             0.539130     0.154088       3.499    0.0026    ***
  l_UNT             0.165552     0.0244638      6.767    2.43e-06  ***
  l_Poverty_1       0.675593     0.0654753     10.32     5.50e-09  ***

Mean dependent var    2.557923    S.D. dependent var     0.104222
Sum squared resid     0.014088    S.E. of regression     0.027976
R-squared             0.935152    Adjusted R-squared     0.927947
F(2, 18)            129.7862      P-value(F)             2.03e-11
Log-likelihood       46.92544     Akaike criterion     -87.85087
Schwarz criterion   -84.71730     Hannan-Quinn         -87.17081
rho                   0.291870    Durbin's h             1.402120

Log-likelihood for Poverty = -6.79096

White's test for heteroskedasticity -
  Null hypothesis: heteroskedasticity not present
  Test statistic: LM = 7.04123
  with p-value = P(Chi-square(5) > 7.04123) = 0.217592

Test for normality of residual -
  Null hypothesis: error is normally distributed
  Test statistic: Chi-square(2) = 3.38034
  with p-value = 0.184489

LM test for autocorrelation up to order 1 -
  Null hypothesis: no autocorrelation
  Test statistic: LMF = 1.70683
  with p-value = P(F(1, 17) > 1.70683) = 0.208797
```

Source: Own calculations in Gretl based on The World Bank data

Based on Figure 23, White's test for heteroscedasticity was carried out, obtaining a P-value of 0.217592, which indicates that there is no heteroscedasticity in residuals since the null hypothesis cannot be rejected. This, in turn, means that the error variance remains stable. A test for normality of the residuals was carried out, obtaining a P-value of 0.184489, which indicates that the errors in the model are normally distributed, the null hypothesis about their normal distribution cannot be rejected. An autocorrelation test was performed, and the P-value is 0.208797, so the null hypothesis cannot be rejected, indicating that there is no autocorrelation in residuals of the model. This suggests that the errors are not temporally dependent. The R-squared is 0.935152. Based on this value, the model fits the data and strongly explains the change in the dependent variable. Calculations for other highlighted indicators are detailed in the Appendix.

Figure 24 The summary of modelling results

variables	Models:						
	1.	2.	3.	4.	5.	6.	7.
	FPI		Food imports		Poverty		PrSt
GDPpc	**0.432** (0.000)	-	-	**-1.973** (0.002)	-	-	-
Real interest rate	-	**-0.021** (0.049)	-	**-0.016** (0.075)	-	**-0.070** (0.020)	**-0.028** (0.021)
Unemployment	-	-	-	-	**0.165** (0.000)	-	**-0.207** (0.011)
Inflation	-	**-**	**-0.016** (0.000)	-	-	-	**-0.002** (0.786)
Lag of dep.var.	No	No	Yes	Yes	Yes	Yes	No
Lags of indep.var.	No	No	No	Yes	No	Yes	No
R^2	0.90	0.17	0.91	0.93	0.93	0.86	0.43
Heteroscedasticity	No	No	No	No	No	No	No
Non-normality	No	No	No	No	No	No	Yes
Autocorrelation	No	Yes	No	No	No	No	Yes

Note: p-values are given in parentheses; PrSt - Prevalence of stunting

Source: Own calculations in Gretl based on The World Bank data and Statista

The data in Figure 24 provide the summary results of all the estimated regression models (the very models, their screenshots are given in the appendix). Every 1 percent increase in GDP per capita is associated with the food production index increase by 0.432 percent, ceteris paribus. For a 1 percent increase in real interest rate, the food production index changes by -0.021 percent. When unemployment increases by 1 percent, poverty changes by 0.165 percent. If looking at negative values, then when the real interest rate changes by 1 percent, poverty changes by -0.07 percent. When unemployment increases by 1 percent point, the prevalence of stunting changes by -0.207 percentage points. While real interest rate and inflation change by 1 percent, prevalence of stunting changes by -0.028 for real interest rate and -0.002 for inflation. In the case of food imports, there is a 1 percent change in GDP per capita, food imports shift by -1.973 percent. When both inflation and the real interest rate change by 1 percent, food imports change by -0.016 percent. The p-values for each coefficient are indicated in parentheses.

5 Results and Discussion

The results will provide a complete overview and analysis of the work carried out. How the questions were answered and what issues were raised in the bachelor thesis.

The first question: how the very concept of Food security is defined?

Based on the research and literature analysis, the concept of food security has a broad meaning. Food security reveals not only access to food but also high-quality and necessary amounts of nutrition for a healthy and active life. Food security is divided into global, national, and household levels, which respectively indicate the sufficiency of food at the global, country, and household levels. The final aspect to consider is the level of food security at the individual level. These terms are supported by authors such as Warr and Leroy.

The second question: What aspects does Food security include?

Based on the study, food security includes main aspects such as availability, access, utilization, and stability. Considering the situation in the USA, this country has problems with food security, but there are many programs such as SNAP, NSLP, and WIC that help in solve problems related to food security. The United States is actively addressing the issue of food insecurity and providing benefits to those who lack access to quality nutrition. The example of the SNAP program shows the participation of the state and the huge funds that are allocated to solve problems related to food security. According to data for 2014, 4.7 million people participated in the program, of which 2.1 million were children. Participation in the lives of children is also visible through the NSLP program, which in turn provides children with school meals at free or reduced prices depending on the income of family members. The WIC program solves the problem of illnesses in children that may be due to a lack or improper nutrition. The voucher system helps new mothers and provides food for healthy children.

The third question: Which organizations/institutions deal with the issues of achieving and maintaining Food security (at a national and global level)?

At the global level, the Food and Agriculture Organization (FAO) is responsible for establishing global standards and regulations related to food production, labeling, and safety. Also, at the global level, there is an organization that is noted in the literature review called WFP, which is helping refugees with food needs. At the national level, the United States Department of Agriculture (USDA) is responsible for food safety regulations within the

United States. This is an established organization with a foundation dating back to 1862. Its purpose is to manage commodities, conservation, and nutrition programs.

The fourth question: What indicators are used to measure different aspects of food security?

One indicator was selected for each food security pillar. The FPI indicator data was selected for availability, the poverty rate indicator data was selected for access, data from the prevalence of stunting, height for age indicator was selected for utilization, and the food imports indicator was chosen for the last pillar of food security stability. All data was collected from 2000 to 2021 for the United States. The mean, median, minimum, and maximum values, as well as the standard deviation for the collected data on food security indicators, were identified.

The fifth question: What macroeconomic indicators can be referred to as core ones for characterizing any economy?

Four macroeconomic indicators have been used. These are GDP, inflation, unemployment, and interest rates. The definitions and the impact of each indicator on the country's economy were given. Data was collected for the United States from 2000 to 2021. The mean, median, minimum, maximum, and standard deviation were determined for the collected data on macroeconomic indicators. The indicators are suitable for developing the topic and have been used to find links between macroeconomic indicators and food security indicators.

The sixth question: Is there any statistically significant relationship between macroeconomic indicators and food security proxies?

An analysis was made that showed the correlation of these indicators with macroeconomic indicators. For this purpose, Pearson and Spearman correlation matrices were carried out. Based on the data obtained, the t-ratio was checked, and important indicators were identified for both methods of correlation analysis. Trend functions were found for each of the macroeconomic indicators and food security indicators based on which only three indicators, such as GDP per capita, FPI, and food imports, are linear, the study will heavily rely on Spearman correlation analysis. Based on the data obtained using the Spearman correlation method, a strong correlation was observed between GDP per capita and FPI in both methods of correlation analysis. Although correlation does not imply causation, it may indicate that a high level of FPI is likely to indicate a higher level of overall economic development. This is also relevant and was confirmed by the Pearson correlation method since both indicators

are linear. Both Pearson and Spearman correlation analyses showed a strong positive correlation between the food import indicator and GDP per capita. This suggests that a higher GDP per capita leads to an increased demand for food and, consequently, food imports. The Spearman correlation matrix shows that the FPI has a negative correlation with the macroeconomic indicator of the real interest rate. It can be assumed that this may indicate a relationship where a decrease in the level of production stimulates an increase in the real interest rate. Next will be the poverty rate indicator, which, based on Spearman's correlation analysis, shows a positive correlation with unemployment. It can be assumed that there is a connection between a lack of work and an increase in poverty due to the inability to provide oneself with a regular income. There is also a negative correlation between poverty and the real interest rate. Which may indicate that increasing the availability of credit contributes to the growth of poverty. Returning to food imports in Spearman's correlation analysis, it is important to note the negative correlation with inflation. This suggests that an increase in food imports could lead to a reduction in food prices, making them more affordable for the average consumer. Additionally, there is a negative correlation between food imports and the real interest rate. This suggests that an increase in food imports could potentially decrease the demand for borrowed funds, resulting in a decrease in the real interest rate. As previously stated, correlation only indicates a statistical relationship between indicators and does not imply a cause-and-effect relationship. Correlation evaluates only the degree of relationship between variables. Linear regression was then carried out to confirm the results obtained from the significant Pearson correlation analysis. Gretl has been used for modeling regression functions. Three tests namely normality test, autocorrelation test and heteroskedasticity test to evaluate the significance of the regression model. What is not obvious is that, for example, when the real interest rate increases by 1 percent, poverty decreases, which suggests that the availability of credit leads to unjustified debt and poverty, which confirms the correlation data obtained with the Spearman method. It should be noted that a 1 percent increase in unemployment decreases the prevalence of stunting in children. As the data was collected in the United States, it is important to note that there are several programs available to assist unemployed individuals and families facing food insecurity. For example, a program like the WIC, which, based on Lee research, reduces the incidence rate among children and through this program. It can be assumed that the unemployed become active participants in this program and due to this, fewer children suffer from the prevalence

of stunting. As previously stated, linear regression and correlation analysis do not imply a cause-effect relationship. However, assumptions can be made based on this data.

6 Conclusion

To conclude, all the goals were addressed, and each question was answered. Each question was answered, and the topic was covered from the point of view of the indicators used. The definitions and methods of analysis that will be used in the practical part, such as Pearson and Spearman correlation analysis, linear regression, and descriptive analysis, are disclosed in the methodology.

The literature review provided a definition of food security. Four pillars of food security, such as availability, access, utilization, and stability, are analyzed and disclosed. which indicators were subsequently identified and described in more detail in the practical part. The history of the concept of food security is given, and organizations that are struggling with this problem are shown. Global organizations include FAO and WFP; USDA was chosen for the national one. The concept of lack of food security is revealed, and methods that help determine the lack of food security are highlighted. Each definition or piece of information has been used in conjunction with reliable sources. Later, each macroeconomic indicator is revealed, which was later used in the practical part. The macroeconomic indicators considered include GDP, inflation, unemployment, and the interest rate. These indicators were chosen because they are capable of revealing the economic situation and are the main macroeconomic indicators. Based on reliable sources, the influence of macroeconomic indicators and food security indicators, which have been confirmed in practical terms, was considered. Later, infographics were given in the USA, and the economic situation in this country and how the USA is fighting the lack of food security were revealed. Based on the information received, the United States is a developed country with a strong economy, and even in such countries, there are problems related to food security.

In the practical part, analysis methods such as descriptive statistics, trend function, Pearson and Spearman correlation analysis, and linear regression were used. The practical part included programs that exist in the United States to reduce food insecurity. There are programs like SNAP, NSLP, and WIC that have proven to be effective, and the government provides full support to those people who are faced with nutrition problems. The main macroeconomic and food security indicators for the period from 2000 to 2021 were given. Descriptive statistics were carried out for the collected indicators. Trend functions were found, and on their basis, it was concluded that the Spearman correlation is statistically

significant for the study. To confirm the Spearman correlation, linear regression was performed on significant values. It is important to note that studies have shown that with more preferential lending, there is a potential increase in the percentage of poverty among the population. Based on the Pearson and Spearman correlation, the inflation indicator is not statistically significant for such indicators of food security as FPI, poverty, and prevalence of stunting. It is also not obvious that, based on Spearman correlation analysis, a negative correlation was noticed between unemployment and the prevalence of stunting. Which was also confirmed by linear regression. It can be assumed that unemployment leads to the use of programs such as WIC, which provides high-quality nutrition for mothers, essential for the healthy development of children. Food security remains an important aspect of human life. An adequate level of nutrition and, most importantly, nutrition that meets international standards and promotes a healthy and active lifestyle remain priorities.Based on the research conducted in the bachelor's thesis, it can be confidently stated that there is a connection between macroeconomic indicators and food security indicators.

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Appendix

```
Model 2: OLS, using observations 2000-2021 (T = 22)
Dependent variable: l_FPI

              coefficient   std. error   t-ratio    p-value
   --------------------------------------------------------------
   const       -0.150714     0.342590     -0.4399    0.6647
   l_GDPpc      0.432349     0.0316508    13.66      1.33e-011  ***

Mean dependent var    4.528371    S.D. dependent var    0.086642
Sum squared resid     0.015261    S.E. of regression    0.027623
R-squared             0.903192    Adjusted R-squared    0.898352
F(1, 20)              186.5951    P-value(F)            1.33e-11
Log-likelihood        48.79171    Akaike criterion      -93.58343
Schwarz criterion    -91.40134    Hannan-Quinn          -93.06939
rho                   0.105855    Durbin-Watson          1.717695

Log-likelihood for FPI = -50.8324

White's test for heteroskedasticity -
  Null hypothesis: heteroskedasticity not present
  Test statistic: LM = 0.378383
  with p-value = P(Chi-square(2) > 0.378383) = 0.827628

Test for normality of residual -
  Null hypothesis: error is normally distributed
  Test statistic: Chi-square(2) = 1.67689
  with p-value = 0.432383

LM test for autocorrelation up to order 1 -
  Null hypothesis: no autocorrelation
  Test statistic: LMF = 0.213621
  with p-value = P(F(1, 19) > 0.213621) = 0.649193
```

```
Model 4: OLS, using observations 2000-2021 (T = 22)
Dependent variable: l_FPI

              coefficient   std. error   t-ratio    p-value
   --------------------------------------------------------------
   const        4.54039      0.0180879    251.0      1.82e-036  ***
   l_RealR     -0.0211692    0.0101320    -2.089     0.0497     **

Mean dependent var    4.528371    S.D. dependent var    0.086642
Sum squared resid     0.129400    S.E. of regression    0.080436
R-squared             0.179160    Adjusted R-squared    0.138118
F(1, 20)              4.365285    P-value(F)            0.049666
Log-likelihood        25.27810    Akaike criterion      -46.55620
Schwarz criterion    -44.37412    Hannan-Quinn          -46.04217
rho                   0.804143    Durbin-Watson          0.344865

Log-likelihood for FPI = -74.3461

White's test for heteroskedasticity -
  Null hypothesis: heteroskedasticity not present
  Test statistic: LM = 1.65556
  with p-value = P(Chi-square(2) > 1.65556) = 0.437019

Test for normality of residual -
  Null hypothesis: error is normally distributed
  Test statistic: Chi-square(2) = 1.11387
  with p-value = 0.572961

LM test for autocorrelation up to order 1 -
  Null hypothesis: no autocorrelation
  Test statistic: LMF = 54.8751
  with p-value = P(F(1, 19) > 54.8751) = 5.15141e-07
```

```
Model 9: OLS, using observations 2001-2021 (T = 21)
Dependent variable: l_F_IM

              coefficient   std. error    t-ratio    p-value
   ---------------------------------------------------------------
   const        0.106287     0.111509      0.9532     0.3531
   l_INF       -0.0162705    0.00394747   -4.122      0.0006    ***
   l_F_IM_1     0.950483     0.0687619    13.82       5.02e-011 ***

Mean dependent var    1.639852    S.D. dependent var     0.158538
Sum squared resid     0.042078    S.E. of regression     0.048349
R-squared             0.916294    Adjusted R-squared     0.906994
F(2, 18)             98.51951     P-value(F)             2.02e-10
Log-likelihood       35.43631     Akaike criterion      -64.87262
Schwarz criterion   -61.73905     Hannan-Quinn          -64.19256
rho                   0.194091    Durbin's h             0.937182


Log-likelihood for F_IM = 0.99941


White's test for heteroskedasticity -
  Null hypothesis: heteroskedasticity not present
  Test statistic: LM = 1.26177
  with p-value = P(Chi-square(5) > 1.26177) = 0.938816

Test for normality of residual -
  Null hypothesis: error is normally distributed
  Test statistic: Chi-square(2) = 1.56347
  with p-value = 0.457612

LM test for autocorrelation up to order 1 -
  Null hypothesis: no autocorrelation
  Test statistic: LMF = 0.748997
  with p-value = P(F(1, 17) > 0.748997) = 0.398843
```

```
Model 10: OLS, using observations 2001-2021 (T = 21)
Dependent variable: l_F_IM

              coefficient   std. error    t-ratio    p-value
   ---------------------------------------------------------------
   const       -1.29414      1.19379      -1.084      0.2955
   l_GDPpc     -1.97290      0.535129     -3.687      0.0022    ***
   l_GDPpc_1    2.14132      0.499968      4.283      0.0007    ***
   l_RealR     -0.0158362    0.00827302   -1.914      0.0749    *
   l_RealR_1    0.00389599   0.0250142     0.1558     0.8783
   l_F_IM_1     0.730797     0.149187      4.899      0.0002    ***

Mean dependent var    1.639852    S.D. dependent var     0.158538
Sum squared resid     0.030688    S.E. of regression     0.045231
R-squared             0.938951    Adjusted R-squared     0.918602
F(5, 15)             46.14100     P-value(F)             1.40e-08
Log-likelihood       38.75047     Akaike criterion      -65.50093
Schwarz criterion   -59.23380     Hannan-Quinn          -64.14080
rho                  -0.003225    Durbin's h            -0.020250


Log-likelihood for F_IM = 4.31356

Excluding the constant, p-value was highest for variable 19 (l_RealR_1)

White's test for heteroskedasticity -
  Null hypothesis: heteroskedasticity not present
  Test statistic: LM = 13.1483
  with p-value = P(Chi-square(10) > 13.1483) = 0.2155

Test for normality of residual -
  Null hypothesis: error is normally distributed
  Test statistic: Chi-square(2) = 4.19029
  with p-value = 0.123053

LM test for autocorrelation up to order 1 -
  Null hypothesis: no autocorrelation
  Test statistic: LMF = 0.00034029
  with p-value = P(F(1, 14) > 0.00034029) = 0.985543
```

```
Model 22: OLS, using observations 2001-2021 (T = 21)
Dependent variable: l_Poverty

               coefficient   std. error   t-ratio   p-value
  ------------------------------------------------------------
  const         -0.167606     0.328712     -0.5099   0.6167
  l_RealR       -0.0700416    0.0273516    -2.561    0.0203    **
  l_RealR_1      0.105615     0.0322146     3.278    0.0044    ***
  l_Poverty_1    1.05069      0.121540      8.645    1.25e-07  ***

Mean dependent var    2.557923    S.D. dependent var    0.104222
Sum squared resid     0.029639    S.E. of regression    0.041755
R-squared             0.863567    Adjusted R-squared    0.839490
F(3, 17)             35.86766    P-value(F)             1.43e-07
Log-likelihood       39.11563    Akaike criterion     -70.23127
Schwarz criterion   -66.05318    Hannan-Quinn         -69.32451
rho                  -0.034485    Durbin's h           -0.190273


Log-likelihood for Poverty = -14.6008

White's test for heteroskedasticity -
  Null hypothesis: heteroskedasticity not present
  Test statistic: LM = 11.2113
  with p-value = P(Chi-square(9) > 11.2113) = 0.2615

Test for normality of residual -
  Null hypothesis: error is normally distributed
  Test statistic: Chi-square(2) = 0.147372
  with p-value = 0.928963

LM test for autocorrelation up to order 1 -
  Null hypothesis: no autocorrelation
  Test statistic: LMF = 0.0220067
  with p-value = P(F(1, 16) > 0.0220067) = 0.883923

Model 27: OLS, using observations 2000-2021 (T = 22)
Dependent variable: l_Pr_St

               coefficient   std. error   t-ratio   p-value
  ------------------------------------------------------------
  const         1.40545       0.131281     10.71     3.10e-09  ***
  l_RealR      -0.0283404     0.0112828    -2.512    0.0218    **
  l_UNT        -0.207320      0.0732435    -2.831    0.0111    **
  l_INF        -0.00259565    0.00941637   -0.2757   0.7860

Mean dependent var    1.027203    S.D. dependent var    0.107644
Sum squared resid     0.138492    S.E. of regression    0.087715
R-squared             0.430853    Adjusted R-squared    0.335995
F(3, 18)              4.542086    P-value(F)             0.015402
Log-likelihood       24.53122    Akaike criterion     -41.06245
Schwarz criterion   -36.69828    Hannan-Quinn         -40.03438
rho                   0.534013    Durbin-Watson          0.896211


Log-likelihood for Pr_St = 1.93275

Excluding the constant, p-value was highest for variable 19 (l_INF)

White's test for heteroskedasticity -
  Null hypothesis: heteroskedasticity not present
  Test statistic: LM = 7.42361
  with p-value = P(Chi-square(9) > 7.42361) = 0.593105

Test for normality of residual -
  Null hypothesis: error is normally distributed
  Test statistic: Chi-square(2) = 10.3576
  with p-value = 0.00563469

LM test for autocorrelation up to order 1 -
  Null hypothesis: no autocorrelation
  Test statistic: LMF = 41.6523
  with p-value = P(F(1, 17) > 41.6523) = 5.94469e-06
```