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Bachelor Thesis

Human Development Index in the Czech Republic

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Thesis title

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Objectives of thesis

This thesis aims to assess the Human Development Index in the Czech Republic to identify the diverse factors that influence it. The practical part will be presented with a statistical analysis of the selected aspects significantly affecting the Human Development Index. It will also aim to identify potential areas that offer prospects for improvement.

Methodology

The theoretical aspect of the thesis is the collection and analysis of observational data on the factors influencing the Human Development Index. The thesis's practical part focuses on conducting statistical analysis using time series. According to the main goal of the thesis, it is important to gain a comprehensive knowledge of the impact of socioeconomic, environmental and cultural factors on the Human Development Index in the Czech Republic. It is accomplished by regression and correlation analysis. The regression and correlation analyses will assess the relationships between factors and quality of life indicators.

The proposed extent of the thesis

30 – 40 pages

Keywords

Human development index, Czech Republic, quality of life, statistical analysis.

Recommended information sources

ATKINSON, A B. – MARLIER, E. Income and living conditions in Europe. Publications Office of the European Union, 2010. ISBN: 978-92-79-16351-7

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Declaration

I declare that I have worked on my bachelor thesis titled "Human Development Index in the Czech Republic" 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 14.03.2024 _____

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Human Development Index in the Czech Republic

Abstract

The focus of this bachelor thesis is the development of the Human Development Index (HDI) and the determination of the influence of macroeconomic indicators on the Index in the Czech Republic. The objective is to assess whether there is a significant relationship between Inflation, Gross Domestic Product (GDP), Unemployment and the HDI for the period from 1992 to 2021. The literature review focuses primarily on the presentation of the HDI and its ideas. The selection of macroeconomic indicators is then explained on the basis of scientific sources, and each of them is discussed in more detail. In order to determine the possible relationships between the HDI and each of the indicators, scientific articles from different countries around the world with similar analyses were also cited. The practical part is devoted to own research using statistical methods such as time series, correlation and regression analyses. As a result, the trend function for HDI is determined with high accuracy, correlation and regression analyses confirm a significant relationship between Inflation, GDP and HDI in the Czech Republic and refute the impact of Unemployment on the Index.

Keywords: Human Development Index, inflation, Gross Domestic Product, unemployment, Czech Republic

Index Lidského Rozvoje v České Republice

Abstrakt

Těžištěm této bakalářské práce je vývoj Indexu Lidského Rozvoje (HDI) a určení vlivu makroekonomických ukazatelů na tento index v České republice. Cílem je posoudit, zda existuje významný vztah mezi inflací, hrubým domácím produktem (HDP), nezaměstnaností a HDI za období 1992 až 2021. Přehled literatury se zaměřuje především na prezentaci HDI a jeho myšlenek. Výběr makroekonomických ukazatelů je pak vysvětlen na základě vědeckých zdrojů a každý z nich je podrobněji rozebrán. Za účelem zjištění možných vztahů mezi HDI a jednotlivými ukazateli byly rovněž citovány vědecké články z různých zemí světa s podobnými analýzami. Praktická část je věnována vlastnímu výzkumu s využitím statistických metod, jako jsou časové řady, korelační a regresní analýzy. Výsledkem je stanovení trendové funkce pro HDI s vysokou přesností, korelační a regresní analýzy potvrzují významný vztah mezi inflací, HDP a HDI v České republice a vyvracejí vliv nezaměstnanosti na index.

Klíčová slova: Index lidského rozvoje, inflace, hrubý domácí produkt, nezaměstnanost, Česká republika

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1 Introduction

This thesis aims to track changes in the Human Development Index (HDI) in the Czech Republic in the period from 1990 to 2021 and to define and describe the relationship between Inflation, Gross Domestic Product (GDP), Unemployment and the Human Development Index (HDI) in the Czech Republic for the period from 1992 to 2021. To examine the influence of macroeconomic indicators on the HDI, scientific articles with similar studies are used, which are reviewed in the theoretical part.

The Human Development Index (HDI) is of great importance as a global measure of human well-being, covering such key dimensions as health, education and living standards. It goes beyond conventional economic measures to provide a nuanced understanding of people's achievements and experiences. Despite its limitations, the HDI remains a widely recognised and popular tool, offering a valuable alternative to traditional indicators and serving as an important complement to global assessments of human development.

The indicators chosen, namely Gross Domestic Product (GDP), inflation rate and unemployment rate, are central to understanding and improving human development and living standards. GDP, as a measure of total income, is linked to employment opportunities, income levels and overall quality of life. Similarly, the inflation rate, which reflects the rate at which prices are rising, has a direct impact on the purchasing power of the population, affecting their ability to purchase necessities and, consequently, their standard of living. In addition, the unemployment rate, which indicates the proportion of the labour force without a job, is crucial in assessing financial stability and societal well-being. These indicators provide valuable insights for the design of effective policies aimed at improving the well-being of society and also contribute to possible variations in the HDI.

The practical part begins with a detailed analysis of the development of the HDI in the Czech Republic over the entire period of its existence. Then the focus of the work shifts to the main objective of the research - to determine the impact of inflation, GDP and unemployment on the HDI. Using multiple regression and correlation analysis, it is examined whether there is a relationship between the index and the indicators in the Czech Republic and, if so, how they correlate.

2 Objectives and Methodology

2.1 Objectives

The main objective of this thesis is to follow the development of the Human Development Index (HDI) and investigate the effect of Inflation, Gross Domestic Product (GDP) and Unemployment on the Index in the Czech Republic for the period from 1992 to 2021. The choice of these macroeconomic indicators is due to their recognition as essential measures for evaluating the health and vitality of a country's economy, and hence the economic well-being of its people. The aim is to test the following hypotheses:

1. Inflation has a significant relationship with the HDI in the Czech Republic.
2. GDP has a significant relationship with the HDI in the Czech Republic.
3. Unemployment has a significant relationship with HDI in the Czech Republic.

2.2 Methodology

2.2.1 Time Series

A time series is a set of data that is represented by numbers that are collected over time (Palma, 2016). The basic graphic representation of time series data is the time series plot, which provides a visual representation of many of the broad general features of a time series. This is just a graph of y_t versus the time period *t* for *t* = 1, 2, ... , *T*. Patterns such as randomness, trends, level shifts, periods or cycles, unusual observations, or a combination of patterns can be seen in time series plots (Montgomery, et al., 2007). For trend determination, it is necessary to calculate statistical indicators such as chain and base indices, which are part of the characteristics of time series.

The chain index is calculated as follows:

$$\Delta_t^1 = y_t - y_{t-1}$$

where *t* = 2,3,..,n

The base index calculation is:

$$k_t = \frac{y_t}{y_{t-1}}$$

(Hindls, et al., 2006)

The definition of a trend greatly simplifies the modelling and forecasting of such a time series. This is done by fitting a regression model to the trend, describing its trend component in the data, and then subtracting it from the original observations. The result is a set of trend

free residuals. The trend model typically considered is a linear trend. The mean value of y_t is expected to move linearly with time, as follows:

$$E(y_t) = \beta_0 + \beta_1 t$$

or as a quadratic function of time:

$$E(y_t) = \beta_0 + \beta_1 t + \beta_2 t^2$$

or as an exponential function of time:

$$E(y_t) = \beta_0 e^{\beta_1 t}$$

(Montgomery, et al., 2007)

2.2.2 Correlation Analysis

An important aspect of studying the relationship between variables is correlation analysis. Correlation is a statistical tool that deals with the relationship between two or more variables. The measure of correlation is called the correlation coefficient and is calculated as follows:

$$r_{e_y e_x} = \frac{s_{e_y e_x}}{s_{e_y} s_{e_x}}$$

where $s_{e_y e_x}$ sample covariance of residuals for *y* and *x*

Correlation coefficients range from -1 to 1, with closer values to |1| indicating stronger correlations. (Hindls, et al., 2006)

2.2.3 Regression Analysis

Multiple linear regression is the model used in this research. According to Montgomery, Vining and Peck (Montgomery, et al., 2021) regression analysis is a statistical technique used to study and model the relationship between a dependent variable (*y*) and an independent or so-called explanatory variable (*x*). Multiple regression model is a regression model with more than one regressor. In this study, the dependent variable is the HDI and the independent ones are inflation, GDP and unemployment. The model of multiple regression is as follows:

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + \varepsilon$$

where the parameter β_0 is the intercept of the regression plane. The parameter β_1 indicates the expected change in response (*y*) per unit change in x_1, holding other variables constant. Similarly, the other β_k measure the expected change in y per unit change in x_k when other

independent variables are held constant. And ε is a random error component (Montgomery, et al., 2021).

3 Literature Review

3.1 Human Development Index

3.1.1 Idea behind the Index

In our world, the measurement of human well-being in various countries is a common topic of research. And such research is interesting because the standard of living is not something that can be measured in a simple or direct way. Before attempting to quantify it, a general operationalization and discussion of the concept must take place, followed by the selection of specific quality of life indicators. According to the research conducted by Mederly, Nováček, and Topercer, these indicators serve the purpose of comprehending numerical facts - namely, data encompassing variables, indices, and other derived quantitative characteristics - that bear a connection, either current or potential, to the quality of human life (Mederly, et al., 2004). The UN Commission on Sustainable Development's text discloses the role and importance of indicators, which have multiple functions. They simplify, clarify, and communicate consolidated information for informed decision-making. Additionally, they facilitate the integration of natural and social sciences in the decision-making process and aid in assessing the trajectory of sustainable development. Indicators are crucial for providing early warning of potential economic, social, and environmental threats. They are also essential tools for communicating messages and values (Potůček, 2002). The monitoring and evaluation of quality of life using a variety of indicators is undertaken by various global institutions and programmes. Examples include the United Nations Development Program (UNDP - Human Development Report), the World Bank (WB, World Development Indicators, Monitoring Environmental Progress), the World Health Organization (WHO Health For All database), United Nations DESA (Indicators of Sustainable Development), World Resource Institute (World Resources), United Nations FAO (FAOSTAT database), Eurostat (Pressure Indices Project), European Environment Agency (Yearly Indicator-Based Report), OECD (Organization for Economic Co-operation and Development, Core Set of Environmental Indicators), IUCN (now the World Conservation Union and its concept of the well-being of nations) and others (Heřmanova, 2012).

In 1990, UNDP presented the first Human Development Report (HDR) and launched the first version of the Human Development Index (HDI). This period marked a distinct era,

characterised by a global shift towards market fundamentalism and an emphasis on economic efficiency in both economic and development policies. Developing countries faced the challenges of oil shocks, collapsing terms of trade and ensuing debt crises and struggled with stabilisation and structural adjustment programmes. Economic growth took centre stage as the primary measure of development. Until 1997, the World Bank ranked countries by per capita income, emphasising the paramount importance of economic growth. Moreover, data on the performance of developing countries was poor, limited to a few indicators and not easily accessible. The scarcity of data led researchers to manually collect information from statistical annexes to reports. Flagship reports from development agencies were rare and eagerly awaited by a wide audience of academics, policymakers, and practitioners. This era was characterised by a distinctive global environment and a scarcity of broad and readily available development data. UNDP's 1990 HDR marked a paradigm shift in the development discourse. Moving away from a singular emphasis on economic efficiency and per capita income, it introduced the paradigm of human development, in line with Sen's capability approach (Sen, 1999). In contrast to previous challenges, this paradigm viewed economic resources as a means to improve people's lives (functionings) and freedoms (capabilities). During the construction of the index, the UNPD drew on earlier UN work to influence the development of the Human Development Index (HDI). A consensus emerged around three fundamental variables: life expectancy, literacy and GDP per capita. These variables were considered to be representative of the essential capabilities that are crucial for individuals to fully develop as human beings (Bagolin & Comim, 2008). The Human Development Index (HDI), a novel but fundamental measure, emerged as a robust indicator for tracking human development progress. Unlike previous indices, the HDI's success was due to its theoretical underpinning in the human development paradigm, its institutional support within an international organisation, and its global relevance beyond a focus on developing countries. This innovative approach provided a more durable and compelling framework for understanding and measuring development (Klasen, 2018).

Over time, a variety of indices have been developed to assess different aspects of human development, to identify groups that are falling behind in human progress and to monitor the distribution of progress. In 2010, three main indices - the Multidimensional Poverty Index (MPI), the Inequality-adjusted Human Development Index (IHDI) and the Gender Inequality Index (GII) - were introduced to measure poverty, inequality and gender empowerment along multiple dimensions. Since 2014, a Gender Development Index (GDI)

has been added. Twenty-eight years after the first HDR, today's challenges require focused measurement and analysis, particularly on inequality and sustainability (United Nations Development Programme, 2018).

3.1.2 Introduction to the HDI

According to UNDP, “The Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and having a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions.” (United Nations Development Programme, 2023). It sets a minimum and a maximum for each dimension, called targets, and then shows where each country stands in relation to these targets, expressed as a value between 0 and 1 (Human Development Report, 2020). In their research, Petr Mazouch, Kristýna Vltavská and Tomáš Staňek refer to the HDI as one of the most widely used indicators of the living conditions of the population (Mazouch, et al., 2016). In the work of Izete Pengo Bagolin and Flavio V. Comim (Bagolin & Comim, 2008), the HDI has been the main tool for the popularisation of the human development approach. This is what they wrote: "The HDI tries to measure the level of the Human Development and to represent human well-being at national, regional or municipal levels. By doing so, the HDI tries to provide a summary indicator of the basic needs and capability approach goals." Anand and Sen (Anand & Sen, 1994) highlight the evolution of the HDI, emphasising its purpose to provide an index that goes directly to the essence of people's lives - capturing their achievements and experiences. The HDI, as envisioned by Anand and Sen, seeks to answer fundamental questions about the well-being of individuals:” Do they have the capability to live long? Can they avoid mortality during infancy and childhood? Can they escape preventable morbidity? Do they avoid illiteracy? Are they free from hunger and undernourishement? Do they enjoy personal liberty and freedom?”

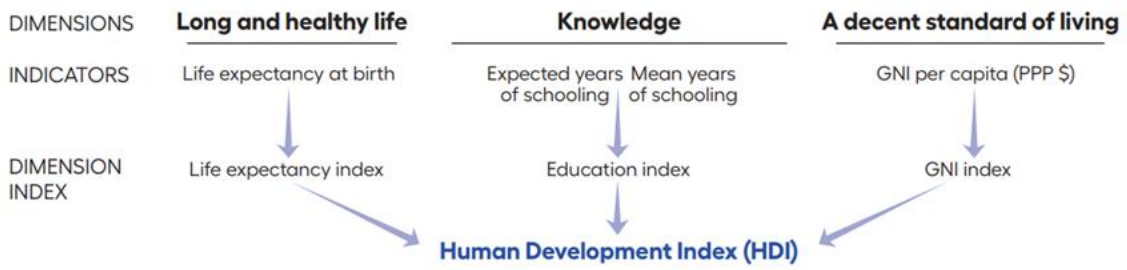
Proposed as an alternative to conventional measures of national development, such as income levels and economic growth rates, the HDI occupies a key position in the global Human Development Report (HDR). However, this central position does not mean that it represents the best way to measure Human Development. Although the index highlights important dimensions, it does not capture many aspects of life that people value and have reason to value, such as economic, social, and political freedom, and protection against violence, insecurity, and discrimination. It is important to note, however, that indices in

general, and HDIs specifically, continue to rank high in terms of popularity and recognition among development indicators and are seen as crucial complements or alternatives to per capita income and dollar-a-day poverty rates. This is due to their clarity and simplicity, their link to the popular capacity-based approach, and their past success as key development indicators.

3.1.3 Calculation of the HDI

Figure 1 demonstrates a graphical presentation of the HDI calculation used in current period. The length of a long and healthy life is measured by life expectancy at birth. This statistic shows the average age a newborn is expected to live to. The data source is UNDESA (United Nations Department of Economic and Social Affairs). Education has two measures. The first indicator is the expected number of years that school-age children are expected to spend in school. The second is the average number of years spent in school by a person over the age of 25. The data comes from CEDLAS (The Center of Distributive, Labor and Social Studies) and World Bank, UNESCO Institute for Statistics, UNICEF (United Nations Children`s Fund), ICF Macro Demographic and Health Surveys, and OECD (Organization for Economic Cooperation and Development). A decent standard of living is measured in terms of gross national income per capita converted to purchasing power parity. GNI per capita data source: World Bank, UNDESA, IMF (International Monetary Fund), United Nations Statistics Division (Human Development Report, 2020).

Figure 1 Calculating the human development index - graphical presentation



Source: (Human Development Report, 2020)

Calculating HDI values involves two steps. The first step is the construction of the dimension indices. Minimum and maximum values (goalposts) are set in order to transform the indicators expressed in different units into indices between 0 and 1. These goalposts act as "natural zeros" and "aspirational targets" respectively, from which the component

indicators are standardised. Once the minimum and maximum values have been defined, the dimension indices are calculated as follows:

$$Dimension\ Index = \frac{actual\ value - minimum\ value}{maximum\ value - minimum\ value}$$

In a second step, the HDI is calculated as the geometric mean of these three sub-indices: health, education, and income. The formula is as follows:

$$HDI = (I_{Health} \times I_{Education} \times I_{Income})^{1/3}$$

Table 1 from the Technical Report (Human Development Report, 2020) shows the four categories of human development that have been introduced in the reports for the year 2014. The world's countries have been classified into four groups based on their level of human development. Countries with a very high level (HDI ≥ 0.800), those with a high level (0.799 ≥ HDI ≥ 0.700), those with a medium level (0.699 ≥ HDI ≥ 0.550), and those with a low level of development (HDI < 0.550).

Table 1 Human development categories

Very high human development	0.800 and above
High human development	0.700–0.799
Medium human development	0.550–0.699
Low human development	Below 0.550

Source: (Human Development Report, 2020)

3.1.4 Review of HDI critiques and potential improvements

In recent decades, the HDI has been criticised for its structure and components. On the other hand, there has been an argument that the index should be extended to more dimensions. Despite legitimate concerns, the UNDP considers its goal is not to create an "indisputable indicator of well-being". "But the objective … is to redirect attention towards human-centred development and to promote debate over how we advance the progress of societies" - the UNDP states in its annual report (United Nations Development Programme, 2010). Thinking about what should be included in the HDI, addressing the challenge of grouping different categories, giving meaning to each and improving the quality of the data, moves away from the narrow focus on growth that has dominated development thinking.

Bagolin and Comim (Bagolin & Comim, 2008) concluded their critique of the HDI by admitting that the Index has shown remarkable resilience, maintaining its original ideas and dimensions while adapting to criticisms and methodological advances. Despite technical modifications, some criticisms remain, particularly in relation to data quality and aggregation procedures. However, compared to earlier one-dimensional indicators, the HDI represents a significant advance in characterising the multidimensional nature of development. The claim that it introduces a new paradigm focused on promoting human ends rather than means, in their opinion, remains controversial. Nevertheless, all dimensions of the HDI are considered essential for the development of human capabilities.

And while the Index continues to be recognised as important after much criticism, the UNDP itself is not resting on its laurels and is discussing further ways to improve it. As the report (United Nations Development Programme, 2018) says: “From a human development viewpoint, true progress can be achieved only by ensuring quality - in education, health and beyond”. Progress in human development should go beyond quantitative indicators such as life expectancy or years of schooling. It should include qualitative aspects as well. Were the years lived filled with real joy or marred by prolonged illness? Did children not only go to school but also acquire the skills and knowledge necessary for a fulfilling life? Do jobs allow people to thrive, or do most people labour in insecure and unstable conditions? Do people actively participate in shaping the environment or are there barriers to their participation? There is a sense that UNDP is still under the influence of Anand and Sen's ideas.

Although life expectancy has increased significantly in most countries over the last three decades, life expectancy at birth does not provide the necessary insight into the quality of healthcare. Measures such as access to physicians and hospital beds would be more appropriate for a better understanding of the state of the health care system. There are 24.7 physicians per 10,000 people in Europe and Central Asia, 7.8 in South Asia and 1.9 in Sub-Saharan Africa. The average number of hospital beds per 10,000 people is 58 in countries with a high level of human development, compared with 9 in countries with a medium level of human development and 13 in countries with a low level of human development. Another measurement solution would be healthy life expectancy and lost health expectance. Healthy life expectancy lags behind total life expectancy by 12.0%, meaning that, on average, people worldwide spend 88.0% of their lives in relatively good health, but face health challenges in their later years. There are significant disparities, with countries with very high levels of human development having a healthy life expectancy of 69.9 years, as opposed to countries

with low levels of human development, where it is only 53.3 years (United Nations Development Programme, 2018).

Educational progress is evident, with school-age children in the Czech Republic now spending 4.4 more years in school than in 1990. However, the challenge remains to make sure that this time in school translates into improved skills. Inequalities remain, with low human development countries having three times more primary school pupils per teacher than very high human development countries (41 versus 14), and medium human development countries having 11 more pupils per teacher than high human development countries (29 versus 18). Teacher training also plays a key role in the quality of education, with around 76 percent of primary school teachers in low and medium human development countries having received some form of training, although there are variations. In addition, the integration of communication technologies can have an impact on the quality of education, but modernising schools requires substantial investment, which is a challenge in most developing regions (United Nations Development Programme, 2018).

And as the UNDP states in their report (United Nations Development Programme, 2018), today's world is witnessing increased life expectancy, better education and greater access to goods and services. It is noteworthy that even in countries with a low level of human development, there have been significant improvements in human development. A critical look, however, reveals that there are considerable deficits in the quality of human development. Longer life does not guarantee more years of enjoyment, and more schooling does not necessarily mean better skills. The emphasis on the quality of human development is therefore of crucial importance for the monitoring and promotion of future progress.

3.2 Macroeconomic indicators

When it comes to exploring the determinants of human well-being, we are immersed in the complex elements that define our immediate environment. From a country's economic performance to access to basic necessities, all of these factors affect people's daily lives in complex ways. Identifying these factors is crucial not only for analysing the quality of life of a population, but also for designing policies that can improve the well-being of society. Human well-being is a complex concept consisting of many components. Its multifaceted nature makes statistical representation a challenging task. As a result, statistical analyses often focus on quantifying individual components. Each of these components is so diverse that it cannot be expressed in a single natural unit. Living conditions are viewed from

different perspectives - economic, socio-economic or socio-psychological. From the economic point of view, the assessment of living standards is mainly from a material perspective, especially at the state level. This assessment is based on macroeconomic factors, which play an important role in shaping the living conditions of people in society. They serve as indicators that reflect the health and vitality of an economy and hence affect the daily lives of its citizens. In the field of economic analysis, economists use various data to assess the health of the economy. Among the many indicators available, Mankiw (Mankiw, 2010, 2007, 2003) identified three macroeconomic variables that are of particular importance: gross domestic product (GDP), inflation rate and unemployment rate.

GDP is used to measure the total income of individuals in an economy. A high GDP is often associated with increased employment opportunities, higher income levels and a better quality of life. A high GDP may indicate a country's economic strength, therefore should lead to increase in the HDI but if the population is large, the benefits may not be evenly distributed. Conversely, a country with a lower GDP should have a correspondingly lower HDI.

Inflation rate measures the speed of price increase is another indicator that has a direct impact on living conditions. While moderate inflation is considered normal, excessive inflation undermines the purchasing power of the population, making it difficult to acquire necessities. This can lead to a decline in the overall quality of life. Fluctuations in these indicators directly affect employment opportunities, income levels and the overall cost of living, which ultimately shape the living conditions of people in a society. Therefore, the following proposals can be made: a country with high inflation should have a lower HDI, than a country with a low inflation rate.

Another important indicator that affects living conditions is the unemployment rate, that indicates the proportion of the labour force currently without work. High unemployment not only leads to financial instability for individuals, but also contributes to insecurity and stress in society, that can be correlated with a lower HDI. Conversely, low unemployment can contribute to economic stability by providing citizens with a more secure financial footing, which indicates a higher HDI.

Macroeconomists study how these variables are determined, why they change over time and their interactions. An understanding of these indicators is essential in order to be able to deal with the challenges and opportunities that arise in a dynamic economic environment. In this chapter, each of the indicators and their measurement in the Czech

Republic are discussed in detail. It also presents studies related to the Index and the indicators. These studies are used to determine what relationships may exist between them and whether they coincide with the logical conclusions drawn above.

3.2.1 Inflation

Inflation refers to the rate at which prices have risen over a given period. It is usually a broad measure, such as the increase in the cost of living in a country. However, it can also be calculated more narrowly, either for specific goods or for services. The purpose of measuring inflation is to determine how much more expensive a set of goods and/or services has become over a certain period, usually a year (Oner, 2017). Mankiw (Mankiw, 2010, 2007, 2003) describes inflation as one of the main problems faced by economists and politicians - an increase in the general price level.

3.2.1.1 Causes of Inflation

Prolonged periods of high inflation typically result from lax monetary policy. When the money supply exceeds the size of the economy, the purchasing power of the currency declines, causing prices to rise. This relationship, known as the quantity theory of money, is a long-standing concept in economics (Oner, 2017). In its meticulous analysis and forecasting, the Czech National Bank carefully considers these various triggers of inflation. Among the many causes of inflation, they can generally be divided into three broad categories:

- Demand-pull inflation. It is the result of shifts and changes in the demand side of the economic spectrum. It reflects the interaction between consumer behaviour, market developments and aggregate demand forces (Reserve Bank of Australia, 2018). A good example is the situation of a demand shock, such as a stock market rally. Investors become optimistic about the future and consumer confidence rises when the stock market experiences a strong rally. As a result, people have a tendency to spend more money on goods and services. This increased consumer demand can outstrip the economy's ability to produce, leaving manufacturers and service providers struggling to meet the sudden increase in orders. In response to high demand and limited supply, prices can rise, leading to demand-pull inflation (Oner, 2017).

- Cost-push inflation. This factor is triggered by the impact of rising input costs on the supply side of the economic equation. Rising costs for producers and manufacturers exert inflationary pressure and affect the overall price level in the economy (Reserve Bank of Australia, 2018). The example of high oil prices is given. Across a range of industries, a rise in oil prices can have a domino effect on production costs. When oil prices rise due to geopolitical tensions or supply disruptions, companies face higher costs for transportation, manufacturing and energy consumption. In the form of higher prices for goods and services, these higher costs are often passed on to consumers. In this scenario, the inflationary pressure will be driven by the rising costs of production, which reflects cost-push inflation (Oner, 2017).
- Inflation expectations. The psychological aspect is introduced by the intangible force of "inflation expectations". This factor depends on the perceptions and forecasts of households and firms regarding future price dynamics. It is noteworthy that individuals' perceptions of future price dynamics can have a tangible impact on actual inflation outcomes (Reserve Bank of Australia, 2018). An example is the situation where workers, expecting an increase in the cost of living, demand a wage increase when their contract is renewed. Employers, recognising these inflationary expectations, agree to the wage increase. As the agreed wage increase takes effect, firms face higher labour costs, forcing them to raise the prices of goods and services. This interaction between inflationary expectations affecting wages and contractual adjustments creates a self-fulfilling cycle that leads to inflationary inertia (Oner, 2017).

3.2.1.2 Measurement of Inflation

So, inflation is defined as the process of constantly rising prices and falling purchasing power of money. Therefore, the consumer price index (CPI) is the logical unit of measurement for the living expenses of ordinary people. This index measures average changes in a basket of consumer goods and services over time and its purpose is to maintain stable purchasing power. The approach is based on a cost of goods index that tracks the purchasing power or expenditure required to buy a basket of goods, reflecting only price changes and not changes in the quality of goods (Höflmayr, 2022). CPIs were initially introduced in many countries to measure changes in living costs faced by workers, enabling wage increases to be related to changing price levels. However, over time, their scope has

widened, and they are now widely used as a macroeconomic indicator of inflation. Governments and central banks use them as a tool for monetary policy and monitoring price stability, and they serve as indexers and deflators in national accounts. The CPI is used to adjust benefits, including wages, rents, interest, social security, pensions, and other benefits, for the impact of inflation (International Labour Office, International Monetary Fund, Organisation for Economic Co-operation and Development, European Union, United Nations, World Bank, 2020).

The CPI is a crucial metric in the range of price indices calculated in the Czech Republic. It accurately measures the dynamics of changes in final consumer prices for goods and services, considering the full range of expenditures of the population, including taxes. Indices reflecting the cost of living play a vital role in assessing inflation in the Czech Republic. The methodology used to construct these indices is regularly updated. Changes primarily concern the adjustment of weights, the sampling strategy for elementary aggregates, and the calculation of price indices. The weights are adjusted every two years to improve timeliness, and the selection of elementary aggregates and methodology are adapted annually. These adjustments are made in line with the changing needs and standards of the European Union. In 2021, the weighting system underwent a revamp. As of January 2022, the updated weights are based on the average household expenditure from 2019 to 2021, sourced from national accounts statistics. The elementary aggregate weights were revised using data from the Household Budget Survey, supplemented by other relevant sources (Prices Statistics Department, 2023).

For the CPI calculation by Laspeyres formula constants weights are used:

$$I = \frac{\sum \frac{p_1}{p_0} \times p_0 q_0}{\sum p_0 q_0} \times 100$$

I – index for the reference period to base period (base index),

p_1 – price for goods (services) in the reference period (current) period,

p_0 - price for goods (services) in base period,

$p_0 q_0$ – constant weight – household expenditure on goods (services) in the base period (Prices Statistics Department, 2023).

For the correct interpretation of any price index, it is important to know what period it is for. There are often different numbers given, but all of them are correct. The prerequisite for this is a precise definition in terms of content, space, and time. This means that the period

for which the inflation rate is given (the reference period) and the base period against which the reference period is compared should be clearly stated.

- The most used inflation rates are:
- Inflation rate as an increase in average annual CPI;
- Inflation rate as an increase in CPI compared with the corresponding month of preceding year;
- Inflation rate as an increase in CPI compared with preceding month;
- Inflation rate as an increase in CPI compared with the base period (year 2015 = 100).

As of January 2017, all consumer price indices, crucial for gauging inflation rates across distinct timeframes, undergo calculation using base indices anchored to a base period (with the average of 2015 = 100 set as the base). The methodology applied ensures that inflation rates are expressed through the overarching consumer price index for total households (Czech Statistical Office, 2023).

The methodology used to process the Consumer Price Index considers Eurostat's harmonization requirements and incorporates feedback from the Consulting Commission for Consumer Price Statistics. From January 2018, the computation of consumer price indices has adopted a new approach using the ECOICOP classification (European Classification of Individual Consumption according to Purpose). This classification allows for a more detailed analysis of the consumer basket while still categorising products and services into 12 divisions. These divisions include food and non-alcoholic beverages; alcoholic beverages and tobacco; clothing and footwear; housing, water, electricity, gas, and other fuels; furnishings, household equipment and routine household maintenance; health; transport; communication; recreation and culture; education; restaurants and hotels; miscellaneous goods and services (Prices Statistics Department, 2023).

3.2.1.3 Inflation policy in the Czech Republic

Since January 1998, the CNB has adopted an inflation targeting system, which aims to keep inflation close to a set target under normal external economic conditions. This system provides a direct focus on the control of inflation, a crucial variable that influences consumption, investment, and savings decisions. The inflation target serves as a well-understood commitment of the central bank and helps to establish inflation expectations. However, despite careful monetary policy decisions, inflation can deviate from the target, often due to unpredictable external variables such as world commodity and food prices,

global sentiment affecting the exchange rate and external demand for Czech exports. These uncertainties contribute to the country's relatively volatile inflation history. The CNB acknowledges the potential for temporary non-achievement of the inflation target, particularly in situations where it is economically justified, and emphasises the importance of suppressing secondary effects, which may arise as unwanted inflationary consequences of primary shocks. An example is the deliberate non-response to the first-round price effects of the war in Ukraine in 2022, which led to a surge in global energy, commodity, and food prices (Czech National Bank, 2023).

3.2.1.4 How the HDI relates to inflation

In order to understand what relationships are generally possible between the HDI and Inflation, several studies have been reviewed.

First of all, the work of Y. Yolanda (Yolanda, 2017) was considered. Among the problems for his further research was the following: “What is the impact of inflation on the Human Development Index in Indonesia?”. Based on his multiple regression results, inflation has a significant and positive effect on the HDI in Indonesia. His model shows that the increase/decrease in inflation will lead to the increase/decrease in HDI. Furthermore, the influence of the inflation variable on the HDI is 22.38%, while 77.62% is influenced by other variables. Yolanda concludes that his research shows that inflation is a disease in a country's economy that affects all economic activities.

Next, the work of H. Herman (Herman, 2021) was examined. The purpose of his study was to find out what impact inflation and minimum wage in the city have on the human development index in Pekanbaru city. From the results of the study, it can be partially concluded that inflation has no effect on human development index. At the same time, inflation and minimum wage in the city affect the human development index. And the magnitude of the effect of inflation and minimum wage of the city on human development index in Pekanbaru is 98.8%, the remaining 1.20% is due to other variables that are not included in this study.

The last study reviewed is by Koyuncu and Yalcinkaya (Koyuncu & Yalcinkaya, 2022). In their study, using a time series dataset over the period 1990-2021 and ARDL method, they try to examine the short-run and long-run effects of inflation on human development and poverty in Turkey. The results of the cointegration test show that inflation and human development are cointegrated. Long-run coefficient estimates reveal a negative

statistically significant relationship between inflation and human development and a positive statistically significant relationship between inflation and poverty. More specifically, a 1% increase in inflation has a 0.1088% and 0.1101% decrease in human development in two different models.

Thus, the studies reviewed demonstrate all three possible correlations between between inflation and the HDI: a positive relationship, no relationship and a negative relationship. The next hypotheses to be tested are based on the problem formulation in the introduction:

1. There is positive relationship between the HDI and Inflation in the Czech Republic.
2. There is no relationship between the HDI and Inflation in the Czech Republic.
3. There is negative relationship between the HDI and Inflation in the Czech Republic.

In the practical part, it will be clarified how the inflation-index relationship develop in the Czech Republic.

3.2.2 Gross Domestic Product

Gross Domestic Product (GDP) is commonly regarded as the primary indicator of economic performance. It aims to summarise the complex network of economic activities into a single numerical value, representing the dollar value of economic activity within a specific time frame. GDP is significant from two perspectives: one interprets it as the aggregate income of all economic participants, while the other views it as the total expenditure on the economy's output of goods and services. GDP serves as a vital gauge of economic vitality, aligning with people's concerns about their incomes and an economy's capacity to fulfil diverse demands from households, businesses, and the government. The role of GDP as a measure of both income and expenditure is based on the principle that, for the entire economy, income must match expenditure. This linkage arises from the symmetry in economic transactions. Each dollar spent by a buyer becomes a dollar of income for a seller. The interdependence of income and expenditure in the GDP framework reflects a fundamental economic reality, illustrating the complex nature of financial transactions that drive economic performance (Mankiw, 2010, 2007, 2003).

3.2.2.1 GDP calculation methods

To calculate GDP for a complex economy that involves the production and sale of numerous goods and services, a precise definition is necessary. As stated by N. Gregory Mankiw:

“Gross domestic product (GDP) is the market value of all final goods and services produced within an economy in a given period of time.” Economists and policymakers focus not only on the volume of goods and services produced by the economy but also on how this output is distributed across various uses. The national income accounts capture the intricacies of this distribution by dissecting GDP into four overarching spending categories:

- Consumption (C),
- Investment (I),
- Government purchases (G),
- Net exports (NX).

This gives us the formula, representing GDP with the variable Y:

$$Y = C + I + G + NX$$

This equation is a fundamental assertion grounded in the definitions of these variables, emphasizing the inherent relationship between the components of economic activity. Consumption refers to the purchase of goods and services by households, which can be categorized into three types: nondurable goods, durable goods, and services. Nondurable goods, such as food and clothing, have a short lifespan, while durable goods, such as cars and TVs, last longer. Services involve work provided by individuals and firms, such as haircuts and doctor visits. Investment, on the other hand, involves acquiring goods for future use and is divided into business fixed investment, residential fixed investment, and inventory investment. Business fixed investment refers to the purchase of new plant and equipment by firms. Residential investment involves the acquisition of new housing, while inventory investment refers to changes in firms' inventories. Government purchases include goods and services acquired by federal, state, and local governments, but exclude transfer payments such as Social Security and welfare, which are not considered part of GDP. Finally, net exports account for international trade, reflecting the value of exports minus imports. Positive net exports indicate a surplus, while negative values imply a deficit, which can affect the income of domestic producers (Mankiw, 2010, 2007, 2003).

On the official website of the Czech Statistical Office (Czech Statistical Office, 2022), which is responsible for calculating GDP in the Czech Republic, it states “Gross domestic product (GDP) is a monetary expression of the total value of goods and services newly created in a given period in a certain territory; it is used to determine the performance

of the economy. It can be defined or calculated in three ways: (1) the production approach, (2) the expenditure approach, and (3) the income approach."

In the production method, GDP is calculated by adding the gross value added of individual sectors and activities, along with net taxes on products. This serves as a balancing item in the national economy's production account, accounting for output on the resources side and intermediate consumption on the uses side. Gross value added represents the difference between output and intermediate consumption, with the resources side further incorporating taxes minus subsidies on products (Czech Statistical Office, 2022).

$$GDP = Output - Intermediate\ Consumption + Taxes\ on\ product - Subsidies\ on\ product$$

In the expenditure method, GDP is calculated by totalling the final use of products and services by resident units, encompassing real final consumption and gross capital formation, along with the balance of exports and imports. Actual final consumption involves social transfers in kind from households, government, and non-profit institutions. Gross capital formation is segmented into gross fixed capital formation, inventory changes, and net acquisition of valuables (Czech Statistical Office, 2022).

$$GDP = Final\ Consumption\ Expenditure + Gross\ Capital\ Formation + Export\ of\ goods\ and\ services - Import$$

The income method computes GDP as the sum of primary incomes for the national economy. These include compensation of employees, taxes on production and imports (net of subsidies), gross operating surplus, mixed income, and consumption of fixed capital (Czech Statistical Office, 2022).

$$GDP = Compensation\ of\ Employees + Taxes\ on\ production\ and\ import - Subsidies + Net\ Operating\ Surplus + Net\ Mixed\ Income + Consumption\ of\ Fixed\ Capital$$

3.2.2.2 How the HDI relates to GDP

In order to get a picture of the possible relationship between the HDI and GDP in general, a number of different studies have been analysed.

Roshaniza and Selvaratnam's paper (Roshaniza & Selvaratnam, 2015) was reviewed. In their study, they discuss the relationship between the growth of domestic products (GDP), the human development index (HDI) and the poverty rate in Malaysia from 1990 to 2012. In the long run, HDI and GDP have a negative relationship, according to the results of this

study. Meanwhile, in the short term, HDI and GDP have no relation. But based on this research topic, which aims to investigate the relationship between Gross Domestic Product (GDP) and Human Development Index (HDI) in Malaysia, the authors expected that there are positive relationships between both variables. The previous research conducted by Shome and Tondon (Shome & Tondon, 2010) had stated that the increase in each of the parameters in HDI will lead to increase in GDP. Their research was conducted for the economic growth of ASEAN5 countries including Malaysia.

So, the studies reviewed provide evidence of all three possible relationships between the HDI and GDP: a negative influence, no influence and a positive influence of GDP on the Index. Hypotheses for testing:

1. There is positive relationship between the HDI and GDP in the Czech Republic.
2. There is no relationship between the HDI and GDP in the Czech Republic.
3. There is negative relationship between the HDI and GDP in the Czech Republic.

In the practical part, it will be analysed which development the relationship between HDI and GDP will follow in the Czech Republic.

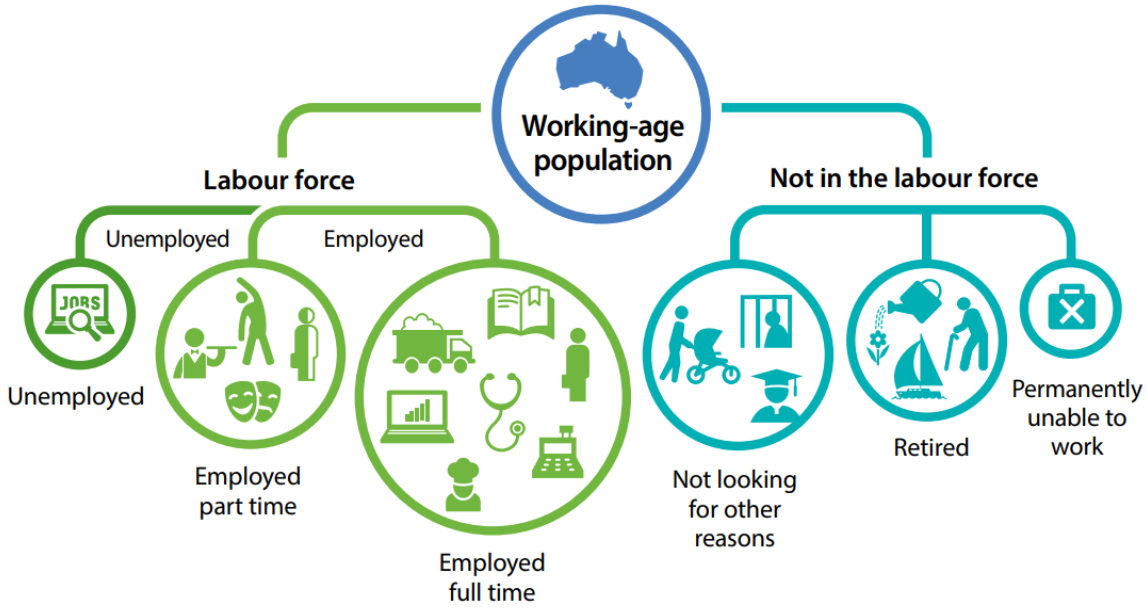
3.2.3 Unemployment

"Like any other market, the labour market consists of a supply side and a demand side. The labour supply of the population, referred to as the economically active population or labour force, has two components: employed persons and unemployed persons. The labour demand of enterprises and other production units, too, can be broken down in two components: jobs (filled posts) and job vacancies (unfilled posts)." – This is the beginning of Ralf Hussman's work on the measurement of employment, unemployment and underemployment (Hussmanns, 2007). The author provides a brief overview of the labour market, highlighting the inherent dynamics of supply and demand and distinguishing between the components of labour supply (employed and unemployed) and labour demand (occupied jobs and vacancies).

In order to measure the unemployment rate, it is necessary to identify who is in the labour force. The unemployment rate is derived from a detailed household survey. On the basis of the answers received, each adult aged 15 and over in the household is classified into one of distinct categories, all types of which are detailed in Figure 2. There are three main groups described by Mankiw (Mankiw, 2010, 2007, 2003):

- Employed: Includes persons in paid employment, self-employed or working as unpaid labour in a family member's business. This category also includes those who are temporarily absent from work due to factors such as holidays, illness or adverse weather conditions.
- Unemployed: Includes those who are currently unemployed, have been actively looking for work in the past four weeks and are available for work. It also includes those waiting to return to a job from which they were previously dismissed.
- Not in the labour force: This includes persons who do not fall within the parameters of the previous categories, such as full-time students, housewives or retired persons.

Figure 2 Groups in the Labour Market



Source: (Reserve Bank of Australia, 2018)

As defined by the Czech Statistical Office (Czech Statistical Office, 2024) on the basis of internationally comparable methodology, persons aged 15 years and over, residing in the observation area and fulfilling the three ILO conditions during the reference week are classified as unemployed:

- were not employed,
- were ready to start work immediately or within 14 days at the latest for paid employment or self-employment,
- during the last 4 weeks they actively looked for a job.

The category of unemployed also includes those who have found a job but have not yet started work within a maximum of three months from the time of the assessment. The

detailed criteria for classifying individuals as employed, unemployed or inactive provide a basis for understanding the labour market. This makes a smooth transition to examining how to measure unemployment.

3.2.3.1 Measurement of Unemployment

The unemployment rate is defined as the percentage of the unemployed in the labour force, which includes both the unemployed and those in paid or self-employment (OECD, 2013). The formula for calculating the unemployment rate is therefore:

$$Unemployment\ Rate = \frac{Unemployed}{Labour\ force} \times 100\%$$

Unemployment rates are influenced by changes in both the number of unemployed individuals (numerator) and the size of the labour force (denominator). These changes can be attributed to various factors, including demographic shifts, educational level, age, and active labour market policies. Additionally, cyclical factors, such as economic downturns, and structural factors in the economy can also contribute to changes in unemployment rates. During times of high unemployment, individuals may lose motivation and cease actively seeking employment, resulting in their exclusion from the labour force. As a result, the unemployment rate may appear to decrease or remain stagnant despite no actual improvement in the labour market (Reserve Bank of Australia, 2018).

3.2.3.2 Czech policy to combat Unemployment

The Czech government is actively combating unemployment through a series of measures that apply to Czech citizens as well as other European Union (EU) citizens or foreigners with permanent residence in the Czech Republic. All EU citizens who have recently been employed or self-employed in the Czech Republic are entitled to unemployment benefit and assistance in finding a job. The amount of the benefit depends on the person's previous income. Czech and other nationals who have recently been employed in the Czech Republic and are unemployed can claim unemployment benefit and help finding work. In addition, people who have returned from working abroad can claim unemployment benefit in the Czech Republic if this was their country of residence when they were working abroad. After registering with the regional employment centre in their place of residence, jobseekers have access to job search assistance and information on available vacancies in the Czech Republic. The government promotes retraining programmes that take into account

the experience, skills and age of the jobseeker and the prevailing labour market conditions. Registered jobseekers or persons expressing an interest in employment can apply for a retraining allowance, reflecting the government's commitment to proactive and individualised solutions to unemployment (European Commission, 2023).

3.2.3.3 How the HDI relates to Unemployment

To gain a general understanding of the possible relationships between the index and unemployment, a number of studies have been analysed. Most of them come to similar conclusions, so only a few are presented here.

The first study reviewed was by Priambodo (Priambodo, 2021). The purpose of this study is to analyse the impact of unemployment and poverty on the economic growth and the human development index in the regency of Purbalingga. This study is an associative, which is an analysis of the relationship between variables, and uses multiple correlation data analysis. The results show that unemployment and poverty have a negative impact on economic growth and human development index in Purbalingga Regency. Therefore, with the increase of unemployment and poverty, there is a decrease in economic growth and HDI.

The next paper by Wahyuningrum and Soesilowati (Wahyuningrum & Soesilowati, 2021) investigated whether economic growth rate and open unemployment rate affect human development index in East Java Province. Based on the results of testing the influence of population growth rate, population and open unemployment rate on human development index in 38 districts or cities in East Java in the period 2014 to 2018 using regression panel data, the following conclusions were obtained: Economic growth rate and open unemployment rate have no significant influence on human development index (HDI).

Consequently, the studies reviewed show only two of three possible relationships between unemployment and the HDI: a negative correlation and no correlation. So, there are hypotheses to test:

1. There is no relationship between the HDI and Unemployment in the Czech Republic.
2. There is negative relationship between the HDI and Unemployment in the Czech Republic.

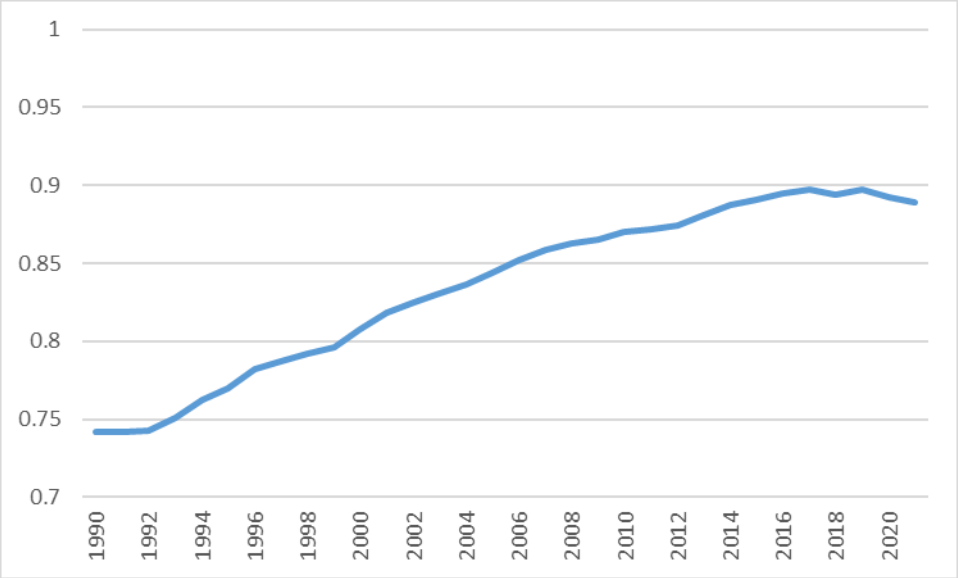
How the relationship between unemployment and the HDI evolves in the Czech Republic is examined in the practical part.

4 Practical Part

4.1 Time Series analysis of the HDI

The study of the Human Development Index (HDI) in the Czech Republic begins with an examination of its trend over the years. Using data from the official UNDP website, Figure 3 shows a clear picture of a steady increase in the HDI value until recently.

Figure 3 Time series of the Human Development Index (HDI) in the Czech Republic for the period 1990-2021



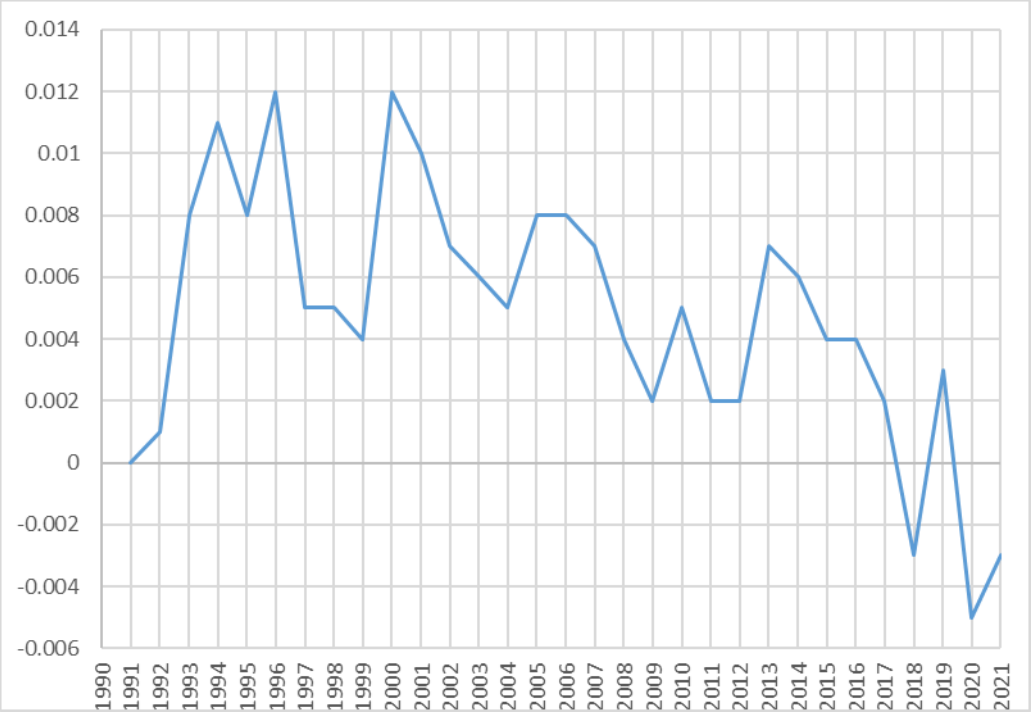
Source: (United Nation Development Programme, 2024)

Significant progress in improving living conditions in the Czech Republic is evidenced by the continuous rise in the HDI values. A key driver of the index growth is the increase in life expectancy from 71.4 years to an impressive 79 years. Possible reasons for this jump include advances in healthcare, improved lifestyles, and effective public health initiatives. There has also been a significant increase in the expectation of years of schooling, from 11.8 to 16.9 years. At the same time, mean years of schooling increased from 9.1 to 12.9 years. These gains demonstrate a strong commitment to education and reflect both increased access and improved quality of education systems. The economy is also experiencing growth, as evidenced by the dramatic increase in gross national income per capita, which has risen from $19,864 to $38,745. This economic prosperity, characterised by rising income levels, has undoubtedly been a factor in the overall improvement in living standards. In 2018, however, the index falls by 0.003 compared to the previous year. The decline is then repeated in 2020 and 2021. In 2018, the fall caused a decrease of 0.6 in expected years of schooling compared to the previous year, other indicators remained unchanged and GNI per capita even increased

by $1,041. After 2019, life expectancy began to decline. In three years, it fell from a high of 79.2 to 77.7 years. The other indicators remain at the same level. GNI per capita falls by $955 in 2020 but returns to surplus in 2021.

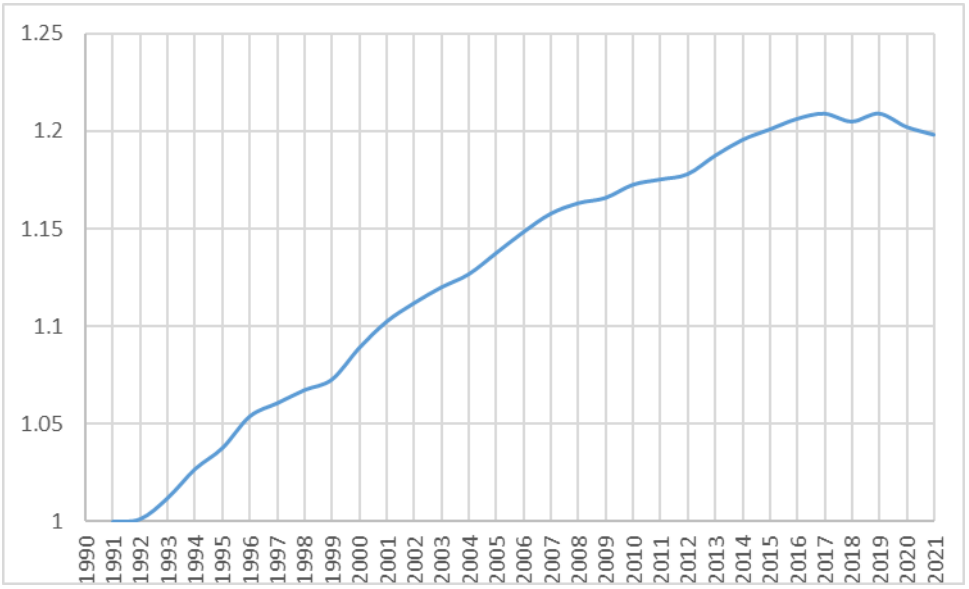
To better illustrate the changes in the HDI over the years, the fluctuations in the chain and base indices are shown in Figures 4 and 5 respectively. The chain index compares the difference between the two following years and shows the annual change. The highest annual change of 0.012 was observed between the years 1996 and 1995 and between 2000 and 1999. The base index is a comparison of the values in each year of the period with the initial observation. In other words, the index represents the development of the HDI value over the whole period. According to Figure 5, the largest increase was observed in 2016 with a value of 1.206 and in 2017 and 2019 with a value of 1.209.

Figure 4 Development of the chain index for the HDI 1990-2021



Source: own calculation based on (United Nation Development Programme, 2024)

Figure 5 Development of the base index for the HDI 1990-2021

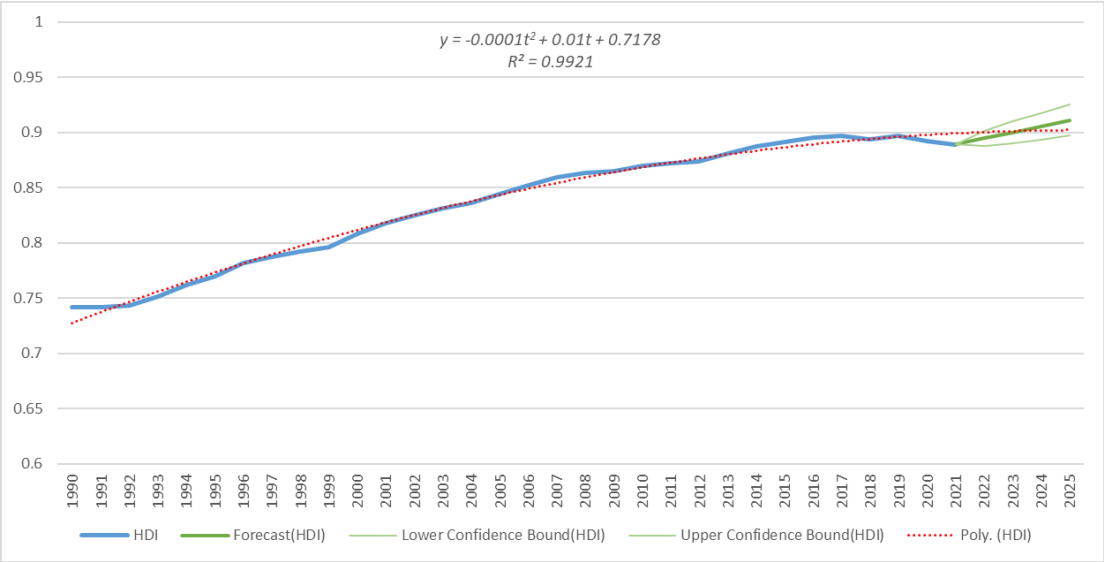


Source: own calculation based on (United Nation Development Programme, 2024)

A more detailed picture of the change of the HDI in the Czech Republic can be obtained by studying the descriptive statistics of the index. To help with this and other statistical tasks, the SAS Software was used. The mean of the HDI value is around 0.835. This suggests that, on average, the Czech Republic has a relatively high level of well-being in the dimensions of health, education, and income over the whole observation period. The standard deviation of 0.053 indicates a moderate degree of variability around the mean. The values are somewhat scattered, suggesting a diversity of the HDI levels between years. The minimum value is 0.742 and occurred in 1990 and 1991. The maximum value is 0.897 and was recorded in the years 2017 and 2019. The median is 0.848. As the median is close to the mean, this suggests a relatively symmetric distribution of HDI values without significant skewness. With a variance of 0.00283, the dataset shows a certain degree of spread or dispersion around the mean. It expresses the average squared differences of the individual HDI values from the mean. The mode is 0.742 and represents the most frequent HDI value. The range between the minimum and maximum index values in the dataset is 0.155.

In order to examine the HDI trend in more detail, a new time series graph was created and shown in Figure 6.

Figure 6 Trend line and forecast for the HDI



Source: own calculation

A trend line was applied to the graph, as it is the most important characteristic of a time series. This linear model aims to capture the primary direction of the HDI changes over time, and as Figure 6 shows, the trend was upward until 2019, but the last two years have been slowly declining. To assess the suitability of the model, the coefficient of determination (R-square) and the equation for the trend line were calculated. The equation $y = -0.0001t^2 + 0.01t + 0.7178$ appears to be a quadratic function where y or the HDI value is predicted based on a relationship with t or years. The resulting R-square value is 0.9921. This indicates a strong relationship between the quadratic trend function and the observed HDI values, meaning that the trend model explains about 99.21% of the HDI variability. From a practical point of view, the quadratic trend model effectively captures most of the observed fluctuations in the HDI, demonstrating its reliability as a forecasting tool. In summary, this time series analysis, with a well-fitted linear trend model and a high R-square value, provides insights into the evolving dynamics of the Human Development Index. Using Microsoft Excel to make a forecast from 2022 to 2025, the expected trend will not continue to fall, but will start to rise slowly. The expected value of the HDI is 0.895 in 2022, 0.9 and 0.906 in 2023 and 2024 respectively, and 0.911 in 2025.

4.2 Correlation and Regression analysis

After analysing the development of the HDI over the years, the second question of this paper is whether macroeconomic indicators such as inflation, GDP and unemployment have

a significant relationship with the HDI. These factors are chosen because of their central role in shaping human well-being and societal development. Given the multifaceted nature of human well-being, economists focus on quantifying different components, with macroeconomic factors such as GDP, inflation and unemployment rates serving as key indicators (Mankiw, 2010, 2007, 2003). These measures reflect the overall health and vitality of an economy, which has a direct impact on living conditions and therefore human development. The analysis is based on data for the period 1992-2021.

Multicollinearity is a serious problem for regression models, potentially leading to incorrect signs for regression coefficients. It is essential to test for multicollinearity first, as it tends to inflate the variances, increasing the chance of observing incorrect signs for one or more of the regression coefficients (Montgomery, et al., 2021). To get started, multicollinearity is performed using SAS software and the results are given in Table 2.

Table 2 Multicollinearity test

Parameter Estimates								
Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|	Tolerance	Variance Inflation
Intercept	Intercept	1	0.78525	0.01611	48.75	<.0001	.	0
Inflation	Inflation	1	-0.00349	0.00078599	-4.44	0.0001	0.39376	2.53959
GDP	GDP	1	0.00046119	0.00004453	10.36	<.0001	0.39420	2.53681
Unemployment	Unemployment	1	0.00030623	0.00142	0.22	0.8308	0.54648	1.82990

Source: own calculations

The variance inflation factor (VIF) and the tolerance for each independent variable are shown. The VIF values above 10 or the tolerance values below 0.1 are an indication of significant multicollinearity concerns. Inflation has the VIF equals to 2.53959 with the tolerance of 0.39376, GDP is 2.53681 with the tolerance equals to 0.3942 and Unemployment is 1.82990 with 0.54648 of the tolerance. All of the observations have the VIF less than 10 and the tolerance greater than 0.1, meaning that multicollinearity is not an issue, and the results of the regression analysis can be discussed.

However, the correlation analysis for inflation, GDP and unemployment must be processed before the regression. The degree of their association will be quantified by the correlation coefficient, usually denoted by *r*. It ranges from -1, which indicates a perfect negative correlation, to 1, demonstrating a perfect positive correlation (Hindls, et al., 2006).
Hypotheses to be tested:
H_0: there is no relationship between the independent variables.

H_1: at least one of the independent variables has a relationship with another.

Significance level = 0.05

Table 3 Results of the correlation analysis of the independent variables

Pearson Correlation Coefficients, N = 30 Prob > |r| under H0: Rho=0			
	Inflation	**GDP**	**Unemployment**
Inflation **Inflation**	1.00000	-0.58850 0.0006	-0.30628 0.0997
GDP **GDP**	-0.58850 0.0006	1.00000	-0.30466 0.1016
Unemployment **Unemployment**	-0.30628 0.0997	-0.30466 0.1016	1.00000

Source: own calculations

The r of Inflation and GDP is -0.5885, which is shown a moderate negative correlation, and p-value is 0.0006, which is below the significance level, so the correlation is significant. The r of Inflation and Unemployment equals to -0.30628, representing a low negative correlation, and p-value is 0.0997, which is above the significance level, so there is no correlation between Inflation and Unemployment. Finally, the r of GDP and Unemployment has a value of -0.30466, indicating a low negative correlation as well, and p-value of 0.1016, which is also above the significance level, so there is no correlation. As the independent variables are not highly correlated, there is no need for the addition of the dependent variable. Then the study will be continued in the next stage.

The significance test for regression assesses whether there's a linear relationship between the response variable (the HDI) and each of the regressor variables (Inflation, GDP, Unemployment). It serves as a global test of model fit, with analysis of variance (ANOVA) helping to identify the independent variable in relation to the dependent variable by examining differences in means (Montgomery, et al., 2021).

Hypotheses to be tested:

H_0: there is no relationship between the HDI and the independent variables.

H_1: at least one of the independent variables contributes significantly to the model.

Significance level = 0.05

Table 4 Results of the ANOVA test

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	0.06560	0.02187	152.57	<.0001
Error	26	0.00373	0.00014332		
Corrected Total	29	0.06933			

Root MSE	0.01197	R-Square	0.9463
Dependent Mean	0.84077	Adj R-Sq	0.9400
Coeff Var	1.42392		

Source: own calculations

Table 4 presents the results of the ANOVA test, according to which the p-value is less than 0.0001. As the p-value is below the significance level, it can be concluded that the HDI is related to at least one independent variable and therefore, the null hypothesis can be rejected. The R-Square value of 0.9463 indicates that 94.63% of the variance in the dependent variable can be explained by the independent variables.

Since the result of the regression analysis has already been shown in Table 3, it is only necessary to state the hypotheses and the interpretation of the results.

Hypotheses to be tested:

H_0: there is no significant relationship between the HDI and the independent variables.

H_1: there is significant relationship between the HDI and the independent variables.

Significance level=0.05

The p-value for intercept, Inflation and GDP are below the significance level, but for unemployment is 0.8308. It indicates that the variable is insignificant and should be excluded from further analysis. On this basis, a new Table 5 was created to reflect the final results of the regression analysis:

Table 5 Final results of the regression analysis

Root MSE	0.01176	**R-Square**	0.9462
Dependent Mean	0.84077	**Adj R-Sq**	0.9422
Coeff Var	1.39855		

Parameter Estimates						
Variable	**Label**	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	Intercept	1	0.78833	0.00732	107.66	<.0001
Inflation	Inflation	1	-0.00359	0.00059917	-6.00	<.0001
GDP	GDP	1	0.00045513	0.00003397	13.40	<.0001

Source: own calculations

All p-values are less than 0.0001, indicating that the null hypothesis can be rejected. There is a significant relationship between the HDI, Inflation and GDP. The R-square value decreased by only 0.001 and now stands at 0.9462. The intercept is equal to 0.78833, with Inflation's coefficient being -0.00359 and GDP's coefficient being 0.00045513, but that does not mean that it is the final model. Further tests of model adequacy are required.

After estimating the parameters in the model, the most important issue becomes "What is the overall adequacy of the model?". There are several hypothesis testing procedures that are useful in answering this question. The formal tests require that random errors are independent and follow a normal distribution, and that the variance of the residuals is homoscedastic. Assessing homoscedasticity is critical to ensuring the reliability of model assumptions in multiple regression analysis. There should be no pattern in the residuals plotted against the fitted values if the model is well fitted. If the variance of the residuals is not constant, then the residual variance is said to be "heteroscedastic". A common method for this examination is the White test (Montgomery, et al., 2021).

Hypotheses to be tested:

H_0: The variance of the residuals is homoscedastic.

H_1: The variance of the residuals varies is heteroscedastic.

Significance level=0.05

The degrees of freedom are 5 and the p-value is 0.470, which is greater than the significance level, so the null hypothesis cannot be rejected. This implies that there is homoscedasticity, which means that the variance of the residuals remains constant across the different levels of the independent variables.

Testing for Normality of Residuals guarantees that p-values for t-tests are valid. The Shapiro-Wilk test is a check of the null hypothesis that the data is normally distributed. The results of this test indicate whether our dataset meets the normality assumption necessary for reliable regression analysis (Montgomery, et al., 2021).

Hypotheses to be tested:

H_0: The data follows a normal distribution.

H_1: The data does not follow a normal distribution.

Significance level=0.05

Table 6 Result of the normal distribution test

Tests for Normality				
Test	Statistic		p Value	
Shapiro-Wilk	W	0.949843	Pr < W	0.1674
Kolmogorov-Smirnov	D	0.095978	Pr > D	>0.1500
Cramer-von Mises	W-Sq	0.070107	Pr > W-Sq	>0.2500
Anderson-Darling	A-Sq	0.509761	Pr > A-Sq	0.1909

Source: own calculations

The result of the normality test as follow: the "W" statistic is 0.949843, indicating that the data are more consistent with a normal distribution. The p-value is 0.1674, which is higher than the significance level, so the null hypothesis cannot be rejected. This means that the residuals follow a normal distribution.

Autocorrelation is a critical issue in multiple regression analysis because its presence can violate the assumption of independent errors, which can lead to inefficient parameter estimates and can affect the validity of statistical inferences. To assess the presence of autocorrelation in the residuals of a regression model, the Dublin-Watson (DW) test is used. The test statistic ranges from 0 to 4, with values around 2 indicating no significant autocorrelation (Montgomery, et al., 2021).

Hypotheses to be tested:

H_0: There is no first-order autocorrelation in the residuals.

H_1: There is first-order autocorrelation in the residuals.

Significance level=0.05

Table 7 Result of the autocorrelation test

Durbin-Watson Statistics			
Order	DW	Pr < DW	Pr > DW
1	1.4614	0.1317	0.8683

The DW is equal to 1.4614 and is close to 2, suggesting a possible lack of autocorrelation. The p-value is 0.1317 and is above the significance level, meaning that the null hypothesis cannot be rejected. Therefore, there is no autocorrelation of the first order in the residuals, which indicates that the errors are independent.

The final multiple regression model after successful completion of all necessary tests is as follows:

$$Y = 0.78833 - 0.00359X_1 + 0.00045513X_2 + \varepsilon$$

Where Y = HDI,

0.78833 – intercept,

-0.00359 – coefficient of X_1,

X_1 – Inflation,

0.00045513 – coefficient of X_2,

X_2 – GDP,

ε – error term.

5 Results and Discussion

5.1 The result of Time Series analysis of HDI

The time series of the Human Development Index (HDI) in the period 1990-2021 was analysed. In this analysis it was found that its trend is best described by trend line in the form of quadratic function equation $y = -0.0001t^2 + 0.01t + 0.7178$. Where *y* is the value of the Human Development Index (HDI) at a given time (*t*), *t* is the time variable, measured in years. $-0.0001t^2$ indicates the quadratic component of the trend. This term suggests that the HDI does not change linearly over time, but rather follows a curved trajectory with a decreasing rate of change over time. $0.01t$ represents the linear component of the trend. This term is a measure of the rate of change of the HDI over time. A positive coefficient indicates that the HDI is generally increasing over time, although the rate of increase may slow down over time. The constant term 0.7178 represents the intercept point, which is the estimated value of the HDI when the time (*t*) is equal to zero. In other words, it represents the initial value of the HDI at the beginning of the period. The R-squared value is 0.9921, which suggests that the linear trend model explains about 99.21% of the variability of the HDI. The forecast suggests a slow rise in HDI from 2022 to 2025, with values projected to reach 0.895 in 2022, 0.9 in 2023, 0.906 in 2024, and 0.911 in 2025. To gain a better understanding, descriptive statistics and the chain and base index analysis were also performed. The relatively high mean of 0.835, coupled with a moderate standard deviation of 0.053, suggests a dataset with a generally positive but moderately dispersed well-being profile. The mode of 0.742 and median of 0.848 provide insight into the concentration and central position of the HDI values, while the range of 0.155 and variance of 0.00283 highlight the overall spread and variability of the dataset. In time series analysis, the most important aspect of a chain index is its ability to reflect evolving patterns and to remain relevant despite fluctuations in the underlying data, as it can take into account changes in the composition of the series over time. Between 1996 and 1995 and between 2000 and 1999, the highest annual changes of 0.012 were observed. As for the base index, it serves as a reference point, allowing meaningful comparisons to be made and relative changes over time to be interpreted. The largest increase was observed in 2016, reaching 1.206, followed by 2017 and 2019, reaching 1.209.

5.2 The result of the correlation and regression analysis

Both analysis covering the period from 1992 to 2021 examined the collected data on the HDI, Inflation, GDP and Unemployment in the Czech Republic. Based on the results of the multicollinearity test, all observations have a VIF less than 10 and a tolerance greater than 0.1, which means that the relationship between the variables does not contain multicollinearity. Correlation analysis was then applied to only the independent variables to see if there was a relationship between them. As a result, there is a significant moderate negative correlation between Inflation and GDP, and no correlation between Inflation and Unemployment, nor between GDP and Unemployment. In addition, all the independent variables are not highly correlated between each other, so there was no need to add the dependent variable.

Finally, a regression analysis was run and according to the results, the macroeconomic indicator of Unemployment was found to be insignificant. The finding of its insignificance led to its exclusion, allowing us to focus on other relationships. The results of the final regression analysis indicate a significant relationship between the HDI, Inflation and GDP. The R-squared value decreased by only 0.001 and now stands at 0.9462, meaning that 94.62% of the variability in the HDI is explained by Inflation and GDP. However, before presenting the final regression model, the further tests of model adequacy require that the random errors are independent and follow a normal distribution, and that the variance of the residuals is homoscedastic. The results of homoscedasticity imply that the variance of the residuals remains constant across the different levels of the independent variables, i.e. they are homoscedastic. The normality test concluded that the data are normally distributed. As for the autocorrelation test to obtain the result, there is no first order autocorrelation in the residuals, which indicates that the errors are independent. The final multiple regression model after successful completion of all necessary tests is as follows: $Y = 0.78833 - 0.00359X_1 + 0.00045513X_2 + \varepsilon$. The intercept of 0.78833 stands for the estimated value of the HDI when Inflation and GDP are equal to zero. The coefficient of -0.00359 for X_1 means a one-unit increase in Inflation is associated with a 0.00359 unit decrease in the HDI, holding other variables constant. Similarly, the coefficient of 0.00045513 for X_2 implies that a one-unit increase in GDP is associated with a 0.00045513 unit increase in the HDI, holding Inflation unchanged.

From the results of the regression model, the following hypotheses can be discussed:

1. Inflation has a significant relationship with HDI in the Czech Republic. Moreover, the relationship is negative, which can be compared with the research of Koyuncu and Yalcinkaya (Koyuncu & Yalcinkaya, 2022). The results of their tests showed a negative, statistically significant relationship between inflation and human development, more specifically, a 1% increase in inflation was associated with a 0.1088% and 0.1101% decrease in human development in two different models. When in the model above, a 1% increase in inflation leads to a 0.359% decrease in the HDI.
2. GDP has a significant relationship with the HDI in the Czech Republic. This relationship is positive and can be compared with the work of Shome and Tondon (Shome & Tondon, 2010). According to them the increase in each of the parameters in HDI will lead to increase in GDP in Malaysia. My regression model showed a similar result, a 1% increase in GDP is associated with 0,004551% increase in the HDI in the Czech Republic.
3. Unemployment does not have a significant relationship with HDI in the Czech Republic. Since Unemployment was considered insignificant and was excluded from the final regression table, there is no relationship between it and the HDI. This result can be compared with the work of Wahyuningrum and Soesilowati (Wahyuningrum & Soesilowati, 2021). Based on the results of testing the influence of the open unemployment rate on HDI in 38 districts or cities in East Java, they concluded that there is no significant relationship between unemployment.

6 Conclusion

The first goal of this thesis was to follow the progress of the Human Development Index (HDI) in the Czech Republic from 1990 to 2021 using time series analysis. The second aim was investigating the effect of Inflation, Gross Domestic Product (GDP) and Unemployment on the Index in the Czech Republic for the period from 1992 to 2021 using correlation and regression analysis. This thesis successfully achieved its primary objectives. The established quadratic trend function for the HDI showed that only 0.79% of the variability cannot be explained by the trend line, confirming its reliability for forecasting. The multiple regression model showed that 94.62% of the variability of the HDI is explained by Inflation and GDP. Unemployment was found to be insignificant and was removed.

This study is important because it explores the intricate links between macroeconomic indicators and the well-being of the population, with implications for both politicians and the wider academic field. The identified influences of inflation and gross domestic product (GDP) on the Human Development Index (HDI) highlight the critical role of economic stability and growth in shaping the course of human development. These findings, which have a direct and substantial impact on the overall well-being of populations, underscore the need for politicians to optimise economic conditions.

It is crucial to note the limitations of this study, as it only looked at the influence of the main macroeconomic indicators, whereas people's lives can be affected by many other areas, such as the environment, government policies, housing conditions, etc. In order to better capture the nuanced dynamics at play, future research could explore additional variables or refine the analysis. This study serves as a foundation that paves the way for more in-depth investigations into the complex interplay between macroeconomic indicators and the Human Development Index.

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8 List of figures, tables and appendices

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Appendix

Appendix 1 HDI data for time series

year	HDI	Life expactancy at birth (years)	Expected years of schooling (years)	Mean years of schooling (years)	Gross national Income per capita (constant 2017 PPP$)
1990	0.742	71.4	11.8	9.1	22,487
1991	0.742	72	11.8	9.3	19,864
1992	0.743	72.3	11.6	9.5	19,751
1993	0.751	72.9	11.9	9.7	19,892
1994	0.762	73.1	12.4	9.9	20,467
1995	0.77	73.2	12.7	10	21,614
1996	0.782	73.8	13.1	10.2	22,835
1997	0.787	73.9	13.3	10.4	22,811
1998	0.792	74.6	13.1	10.6	23,308
1999	0.796	74.7	13.2	10.8	23,527
2000	0.808	75	13.9	11	24,150
2001	0.818	75.3	14.3	11.2	25,151
2002	0.825	75.4	14.6	11.4	25,883
2003	0.831	75.4	14.8	11.6	26,927
2004	0.836	75.9	14.6	11.7	27,987
2005	0.844	76.2	14.8	11.9	29,410
2006	0.852	76.7	15	12.1	30,367
2007	0.859	76.9	15.3	12.1	32,009
2008	0.863	77.2	15.5	12.2	32,404
2009	0.865	77.3	15.8	12.3	30,788
2010	0.87	77.6	16	12.4	30,855
2011	0.872	77.8	16.1	12.5	30,812
2012	0.874	78	16.1	12.5	30,967
2013	0.881	78.2	16.6	12.6	31,223
2014	0.887	78.8	16.7	12.6	32,12
2015	0.891	78.6	16.9	12.7	33,842
2016	0.895	79	16.8	12.7	34,856
2017	0.897	79	16.8	12.8	36,627
2018	0.894	79	16.2	12.8	37,668
2019	0.897	79.2	16.2	12.9	38,506
2020	0.892	78.6	16.2	12.9	37,551
2021	0.889	77.7	16.2	12.9	38,745

Appendix 2 Descriptive statistics for the HDI

Analysis Variable : HDI HDI								
Mean	Std Dev	Minimum	Maximum	Median	N	Variance	Mode	Range
0.8345937	0.0531643	0.7420000	0.8970000	0.8480000	32	0.0028264	0.7420000	0.1550000

Appendix 3 Chain and base indices for the HDI

years	HDI	Chain index	Base index
1990	0.742		
1991	0.742	0	1.000
1992	0.743	0.001	1.001
1993	0.751	0.008	1.012
1994	0.762	0.011	1.027
1995	0.77	0.008	1.038
1996	0.782	0.012	1.054
1997	0.787	0.005	1.061
1998	0.792	0.005	1.067
1999	0.796	0.004	1.073
2000	0.808	0.012	1.089
2001	0.818	0.01	1.102
2002	0.825	0.007	1.112
2003	0.831	0.006	1.120
2004	0.836	0.005	1.127
2005	0.844	0.008	1.137
2006	0.852	0.008	1.148
2007	0.859	0.007	1.158
2008	0.863	0.004	1.163
2009	0.865	0.002	1.166
2010	0.87	0.005	1.173
2011	0.872	0.002	1.175
2012	0.874	0.002	1.178
2013	0.881	0.007	1.187
2014	0.887	0.006	1.195
2015	0.891	0.004	1.201
2016	0.895	0.004	1.206
2017	0.897	0.002	1.209
2018	0.894	-0.003	1.205
2019	0.897	0.003	1.209
2020	0.892	-0.005	1.202
2021	0.889	-0.003	1.198

Appendix 4 Forecast results for the HDI

years	HDI	Forecast(HDI)	Lower Confidence Bound(HDI)	Upper Confidence Bound(HDI)
1990	0.742			
1991	0.742			
1992	0.743			
1993	0.751			
1994	0.762			
1995	0.77			
1996	0.782			
1997	0.787			
1998	0.792			
1999	0.796			
2000	0.808			
2001	0.818			
2002	0.825			
2003	0.831			
2004	0.836			
2005	0.844			
2006	0.852			
2007	0.859			
2008	0.863			
2009	0.865			
2010	0.87			
2011	0.872			
2012	0.874			
2013	0.881			
2014	0.887			
2015	0.891			
2016	0.895			
2017	0.897			
2018	0.894			
2019	0.897			
2020	0.892			
2021	0.889	0.889	0.89	0.89
2022		0.895	0.89	0.90
2023		0.900	0.89	0.91
2024		0.906	0.89	0.92
2025		0.911	0.90	0.92

Appendix 5 HDI, Inflation, GDP and Unemployment data

year	HDI	Inflation	GDP	Unemployment
1992	0.743	11.1	34.81	2.6
1993	0.751	20.8	40.87	4.3
1994	0.762	10	47.85	4.3
1995	0.77	9	60.15	4.1
1996	0.782	8.8	67.39	3.9
1997	0.787	8.6	62.18	4.7
1998	0.792	10.7	66.81	6.5
1999	0.796	2.1	65.17	8.7
2000	0.808	3.8	61.83	8.8
2001	0.818	4.7	67.81	8.1
2002	0.825	1.9	82.2	7.3
2003	0.831	0.1	100.09	7.8
2004	0.836	2.8	119.81	8.3
2005	0.844	1.9	137.14	7.9
2006	0.852	2.5	156.26	7.1
2007	0.859	2.9	190.18	5.3
2008	0.863	6.4	236.82	4.4
2009	0.865	1	207.43	6.7
2010	0.87	1.5	209.07	7.3
2011	0.872	1.9	229.56	6.7
2012	0.874	3.3	208.86	7
2013	0.881	1.4	211.69	7
2014	0.887	0.3	209.36	6.1
2015	0.891	0.3	188.03	5
2016	0.895	0.7	196.27	4
2017	0.897	2.5	218.63	2.9
2018	0.894	2.1	249	2.2
2019	0.897	2.8	252.55	2
2020	0.892	3.2	245.97	2.6
2021	0.889	3.8	281.79	2.8

Appendix 6 Homoscedasticity test

Test of First and Second Moment Specification		
DF	Chi-Square	Pr > ChiSq
5	4.55	0.4730