Bachelor's thesis

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Relationship between Inflation and Economic Growth

An analysis of the effect of inflation on economic growth

Bachelor's thesis in Economics
Supervisor: Colin Green
May 2022

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Kunnskap for en bedre verden

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Preface

The following research paper is written as a concluding thesis for my bachelor's degree at the department of Economics at the Norwegian University of Science and Technology.

I would like to express my sincere thanks to my academic supervisor, Professor Colin Green, for providing assistance throughout the entire process of writing this thesis. His thorough answers and advice along the way have been valuable to the final product.

May 2022

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Abstract

Countries wish to sustain high economic growth. Inflation is thought to have a major role in determining growth. Worldwide inflation rates are increasing, and central banks are speeding up their contractionary monetary policy (Olsen, 2022). This paper examines the relationship between inflation and economic growth. The study uses time-series data from 1960-2020 for both Norway and Turkey. Two multiple linear regression models are created, one for Norway and one for Turkey. The models add control variables step-by-step to investigate the effect of inflation on economic growth.

The result of the analysis is ambiguous. For Norway the findings were statistically significant, and the conclusion is that inflation affects economic growth negatively. For Turkey inflation and economic growth were also negatively correlated, however the findings were not statistically significant.

Key words: *economic growth, inflation, time-series data, hypothesis testing*

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1 – Introduction

Economic growth is something all countries strive to achieve. Economic growth describes an increase in the quantity and quality of the economic goods and services that a society produces and consumes (Roser, 2013). The intuition is straightforward but measuring economic growth can be difficult. In this paper, economic growth is measured through growth in Gross Domestic Product per capita (GDP p.c.), however the reader should keep in mind that this is a measure, *and* not the definition of economic growth. For many countries it has been problematic to achieve economic growth since there are so many factors that affect economic growth. Inflation, amongst other, is a variable that is thought of as a determinant of economic growth (Barro, 2013). Yet, the relationship between inflation and economic growth is controversial and not clear, both in theory and in empirical findings.

In fact, as is discussed later, some theories state that there is no relationship between inflation and economic growth (Sidrauski, 1967). Tobin (1965) state that there is a positive relationship whilst other argue that the relationship is negative (Fischer, 1993).

In recent decades, central banks have placed increased emphasis on the achievement of low and steady inflation (Barro, 2013). Most policymakers believe that inflation is costly and highlight the importance of low and steady inflation to enhance economic growth. Today, researchers not only examine the relationship between inflation and economic growth, but also certain threshold levels of inflation. Values above certain threshold levels are thought to be extremely harmful for the economy (Barro, 1995). Macroeconomists and central bank authorities need to establish a relationship between inflation and economic growth, to find out whether inflation is beneficial or not with regards to economic growth. The complexity of this relationship speaks for itself, as there are so many ambiguous conclusions out there.

The aim of this study is to explore the relationship between inflation and economic growth, from an economic perspective, by addressing the following research question:

"What is the relationship between inflation and economic growth?"

The research field is broad, and in this research paper the focus is the relationship between inflation and economic growth in Norway and Turkey. Norway has had low and steady inflation for decades, whilst Turkey has experienced both high and low levels of inflation since the 1960s (The World Bank, 2022), making these countries interesting to study.

This research paper is structured as follows: to begin with, some growth theories and econometric tools are presented. The theoretical framework and econometric specification outline the research approach and the theoretical background for further analysis. Section three contains information about the data used in this research paper. This section introduces the variables included in the dataset, and by the end of the section the descriptive statistics are included. Section four contains the regression analysis, where I seek to find the relationship between inflation and economic growth using the statistical tool STATA. By the end of section four, I review the Ordinary Least Squares-assumptions, presented in section two, of the specific sample in question. I do several tests to find out if the assumptions hold for the chosen sample. In section five I discuss some findings and present some implications, both theoretical and practical. The limitations and critics are acknowledged in section six, before the conclusion in the last section yields some final remarks.

2 – Theoretical framework and method

For decades economists have studied inflation and its impact on economic growth and economic issues. This section examines the theoretical framework regarding inflation and economic growth. The first part looks at the different theoretical views of growth, whilst the second part of this section introduces the method used in the analysis. Here the Ordinary Least Squares assumptions and hypothesis testing are introduced.

2.1 Theoretical framework

Classical growth theory

During the industrial revolution, classical growth theory was developed. Amongst many British politicians and economists, Adam Smith is famous for his contribution *The Wealth of Nations*, which is considered the beginning of classical economics (Heilbroner, 2021).

Smith set out a production function consisting of three factors of production: labor, capital, and land, so output was related to labor, capital, and land inputs. Growth in output was driven by population growth, capital investments, and increases in overall productivity. According to Smith the most important factor for economic growth is the economy's savings rate. Through savings, individuals could invest, thus industries will have capital to buy more labor-saving machinery. This would increase returns on invested capital, leading to economic growth. According to classical growth theory there is no direct relationship between inflation and its tax effects on profit level and output. However, classical growth theory assumes that the relationship between inflation and economic growth is implicitly negative, indicated by the reduction in firms' profit levels through higher wage costs (Gokal & Hanif, 2004, p. 5)

Neo-classical growth theory

The most popular neo-classical growth model is the Solow-model. This model exhibit diminishing returns to labor and capital, but constant returns to both factors jointly (Todaro & Smith, 2015, p. 138). The Solow-model depicts that growth arises through innovation or growth of capital, and that this is the primary factor to explain long-term growth. Level of technological change is determined outside the model, and other factors like inflation are also independent.

Several economists gave their own explanations of the relationship between inflation and economic growth. Amongst others, Tobin (1965) developed a model which predicts a positive relationship between inflation and economic growth. The Tobin-effect suggests that when inflation rises, individuals substitute out of money, because of its lower return, and into interest earning assets. This leads to greater capital intensity, thus economic growth. (Gokal & Hanif, 2004, pp. 11-12).

In contrary, Stockman (1981) presents a negative relationship between inflation and economic growth. The model Stockman developed shows that higher inflation leads to a lower steady state level of output and people's welfare declines. Stockman explains money as a compliment to capital, and models cash investments as cash-in-advance restriction on consumption and capital purchases (Stockman, 1981). When inflation rates rise, individuals' purchasing power is reduced. As a result, people reduce their purchase of cash goods and capital, implying that the economy will experience a fall in output, thus a negative relationship between inflation and economic growth (Gokal & Hanif, 2004, p. 13). Finally, some economists, for example Sidrauski (1967) suggest no relationship between the two variables. According to Sidrauski an increase in inflation rate does not affect steady state capital stock, and neither output nor economic growth is affected (Sidrauski, 1967). Neoclassical growth theory present mixed results of the relationship between inflation and economic growth.

Literature

Robert Barro (1995) examines the relationship between inflation and economic growth using data from around 100 countries. The data is gathered from 1960 to 1990. Barro found that the predicted effect of inflation on growth is substantially negative when credible instruments are used in the statistical procedure (Barro, 1995). He also found that the substantial evidence for negative effects of inflation on economic growth comes from countries where there have been experiences of high inflation for a sufficient time horizon.

Fischer (1993) investigated the relationship using cross-sectional data. He found that low rates of inflation and a small budget deficit is conducive to sustained economic growth. He concluded that inflation reduces growth by reducing investment and reducing the rate of productivity growth. Motley (1998) investigated the relationship using the Solow growth model with data from a cross-section of countries over the years 1960 to 1990 and found that inflation and economic growth are negatively related. Motley found a systematic tendency for higher rates of inflation to be associated with slower real growth (Motley, 1998). Yet, Mallik and Chowdhury (2001) find a positive relationship between inflation and economic growth. They collect data from IMF for four countries: Pakistan, Sri Lanka, India, and Bangladesh. Findings for all countries suggests that there is a positive and statistically significant relationship between inflation and economic growth (Mallik & Chowdhury, 2001).

Final remarks on theory and literature

There may be several reasons why there are mixed results throughout history. A few of them are worth mentioning. Certain economic models require specific assumptions to be fulfilled which *may* not always correspond to the real world. In addition, models may require different assumptions to be fulfilled. Thus, different results may be obtained. While some researchers have used panel data, others have used time-series data. Some researchers have selected 100 countries, others have chosen a few. Therefore, it may not be so surprising that the results differ. The different results about the relationship between inflation and economic growth over time keeps the field of study relevant and makes it interesting to look further into.

2.2 Method

This paper examines the relationship between inflation and economic growth using several control variables. The model used for this analysis is a multiple linear regression model, henceforth MLR. The MLR is used to estimate the parameters in question through the Ordinary Least Squares method (OLS). The MLR consists of one dependent variable, y, here changes in GDP p.c., and several independent variables, in this paper: inflation, population growth rate, government consumption spending and investment rate. The OLS is a technique that helps estimate the coefficient of a linear regression. Least squares means that the technique chooses the estimates to minimize the sum of squared residuals (Wooldridge, 2019, p. 71). By using the OLS-method it is possible to estimate the effect of a one unit increase in an independent variable, x_i, on the dependent variable, y. OLS makes it possible to investigate if there is a relationship between inflation and economic growth. In addition, with OLS one can interpret whether this relationship is positive or negative. The relationship between the dependent and independent variables can be formulated as follows:

$$(1)\ y = \beta_0 + \beta_1 x_{1t} + \beta_2 x_{2t} + \cdots + \beta_k x_{kt} + u_t$$

This equation shows the multiple linear regression model assumed to hold for the population in question. The intercept parameter is β_0, also known as the constant. β_k represents the slope of the curve and is therefore known as the slope parameter. The slope indicates an estimated size of the change in the dependent variable when the independent variable, x_k, changes by one unit. Lastly, u represents unobserved variables, which are other factors than x that could possibly explain y. When the error term is larger, this indicates that a greater proportion of variation in the dependent variable can be explained by variables outside the model (Wooldridge, 2019, p. 21). The notation *t* is added to illustrate that I am analyzing time-series data.

Using the OLS, the coefficients are estimated by minimizing the sum of squared residuals (SSR). Squared residuals are the variance in the sample. In general, with k independent variables we seek estimates of the beta-coefficients (Wooldridge, 2019, p. 71). The result is the sample regression function, also known as the OLS regression line:

$$(2)\ \hat{y} = \hat{\beta}_0 + \hat{\beta}_1 x_{1t} + \hat{\beta}_2 x_{2t} + \cdots + \hat{\beta}_k x_{kt}$$

The hats represent that we retrieve estimates of the true population parameters. The population parameters are represented without hats, as shown in equation (1). The model relies on several assumption to be effective and provide an expected estimate of the relationship. In the following section the OLS-assumptions will be presented.

2.2.1 OLS Assumptions

I. MLR.1 – Linearity in parameters, $\boldsymbol{y = \beta_0 + \beta_1 x_i + \beta_2 x_2 + \cdots + \beta_k x_k + u}$

The first assumption that must be met is linearity. All parameters must be linear to be able to use the OLS-method. Variables can be included non-linearly, but the parameters must be included linearly. An error term must also be included, this term intends to depict that our models are based on samples not populations, and the error term captures other things in the model that may affect the dependent variable, which is not included in the model.

II. MLR.2 – Random sampling, $\boldsymbol{\{(x_{i1}, x_{i2}, \ldots, x_{ik}), y);\ i = 1, \ldots, n\}}$.

MLR.2 states that there must be a random sample where each observation, i, has the same probability of being selected. Random sampling is important in order to get a representative sample for the whole population.

III. MLR.3 – No perfect multicollinearity, $\boldsymbol{x_i, i = 1, \dots, n}\}$

MLR.3 states that there must be enough variation between the independent variables, meaning that variance cannot be zero and there cannot be perfect collinearity. If one independent variable is an exact linear combination of other variables, the model suffers from perfect collinearity, hence it cannot be estimated by the OLS (Wooldridge, 2019, p. 80). Some collinearity is allowed, but the stated threshold level is commonly referred to as 0.9 (Wooldridge, 2019, p. 92).

IV. MLR.4 – Zero conditional mean, $\boldsymbol{E(u|x_1, \dots x_k) = 0}$.

This assumption states that the average value of the error term does not change across different x-values of the population. This means that the error term has an expected value of zero, given any values of the independent variable. This assumption can be violated for instance if the functional relationship between the dependent and the independent variable is misspecified or if you omit an important factor that is correlated with any of the independent variables (Wooldridge, 2019, pp. 82-83). MLR.4 is the key assumption for unbiasedness. The model is assumed to be unbiased under the assumptions MLR.1 through MLR.4, this indicates that $E(\widehat{\beta_j}) = \beta_j$.

V. MLR.5 – Homoscedasticity, $\boldsymbol{Var(u|x) = \sigma^2}$

This assumption states that each value of the error term has the same variance given any other explanatory variable. We rely on this assumption to estimate the standard errors. If this assumption is violated, it implies that heteroscedasticity (non-constant variance) is present (Wooldridge, 2019, p. 88).

VI. The normality assumption, $\boldsymbol{u \sim N(0, \sigma^2)}$

The population error u is independent of the explanatory variable and is normally distributed with zero mean and variance, σ^2: $u \sim Normal(0, \sigma^2)$ (Wooldridge, 2019, p. 118).

The assumptions MLR.1-MLR.5 are commonly known as the Gauss Markov Assumptions. When these assumptions are fulfilled, the estimated beta coefficients of the model are the best linear unbiased estimators (BLUEs). This indicates that there is no other linear estimator that has a lower sample variance than the current estimators. MLR.1-MLR.6 are collectively referred to as the Classical Linear Model Assumptions (CLM) (Wooldridge, 2019, p. 118).

This research paper contains time-series data, which means that some of the assumptions slightly change. One important assumption for time-series data is what we call *No serial correlation*. This means that the errors in two different time periods are uncorrelated, so that the serial correlation is equal to zero, meaning $Corr(u_t, u_s|X) = 0$ (Wooldridge, 2019, pp. 342-343). In section six this will be discussed further.

2.2.2 Goodness of fit

R-squared (R^2) measures how much of the sample variance is explained by the independent variables and is usually referred to as the goodness of fit measure (Wooldridge, 2019, p. 37). I present a summary measure to consider the goodness of fit. It consists of the total sum of squares, $SST = \sum_{i=1}^{n}(y_i - \bar{y})^2$. The SST consists of the explained and the non-explained part of the model, meaning the explained sum of squares (SSE) and residual sum of squares (SSR). Based on this we get the equation for R^2, which says something about how well the dependent variables explain the independent variable (Wooldridge, 2019, pp. 76-78).

$$(3)\ R^2 = \frac{SSE}{SST} = 1 - \frac{SSR}{SST} \rightarrow \frac{SST - SSR}{SST}$$

In this research paper the adjusted R-squared is used. Adjusted R-squared takes into consideration that R-squared will increase mechanically every time an additional variable is included, thus adjusted R-squared weights the explained variance up against the number of variables. Adjusted R-squared means that the model will not automatically get higher values of the goodness of fit just because more variables are included (Wooldridge, 2019, pp. 196-197).

2.3 Hypothesis test

Hypothesis testing is used to determine if the sample can say something about the population under given significance levels. This paper investigates whether the effect of one specific independent variable on a dependent variable is statistically significant, and a t-test is used for this. A t-test can be performed using the t-statistic. The t-test is performed using a specific hypothesis, and a specific significance level. Using a t-test one must have a null-hypothesis (H_0) and an alternative hypothesis (H_A), which are mutually exclusive. The null hypothesis is the hypothesis that is examined, and the aim is to test whether the null hypothesis can be rejected or not. If the null hypothesis can be rejected, this provides support for the alternative hypothesis.

The test statistics (TS) and the critical value (c) will determine if H_0 can be rejected or not. The t measures how many estimated standard deviations the sample parameter, $\hat{\beta}_j$ is from the hypothesized value of β_j. This can be written as:

$$(4)\ t_{\hat{\beta}_j} = \frac{\hat{\beta}_j - \beta_j}{se(\hat{\beta}_j)}$$

Which indicates that the t-statistic is the value of the estimated value minus the hypothesized value, divided by the standard error (Wooldridge, 2019, p. 128). The t-statistic is distributed as t_{n-k-1}. $n-k-1$ are the degrees of freedom, and is given by the number of observations, n, minus the number of independent variables, k, minus a constant which is equal to one.

As mentioned, the rejection of H_0 is also dependent on the critical value. The critical value defines the threshold level of rejecting the null hypothesis. The precise rejection rule depends on the chosen significance level of the test (Wooldridge, 2019, p. 121). To find the critical value one must also distinguish between a one-tailed and a two-tailed test. In this research paper, I want to investigate whether there is a relationship between inflation and economic growth, meaning that the two-tailed test is the suitable option. Using the two-tailed test, it is possible to investigate whether x_k influences y, without specifying whether this effect is positive or negative. When the critical value is obtained, the critical value is compared with the t-statistic, to determine if the null-hypothesis can be rejected. If we use a significance level at 5%, and the critical value (c) is lower than the t-statistic (TS), meaning that $(TS > c)$, then we can say that the null hypothesis can be rejected with 95% confidence. In a two-tailed test the decision rule is to reject H_0 if the TS is either larger than the upper critical value, or smaller than the lower critical value.

The p-value can also be used to determine whether the null hypothesis can be rejected or not. With the p-value, a chosen significance level determines the critical value. Once critical value is established, the t-statistic is compared to the critical value and the null hypothesis is either rejected or not at a given significance level (Wooldridge, 2019, p. 130). For instance, if the significance level is equal to 0.05, a p-value greater than 0.05 will not be significant, thus the null hypothesis cannot be rejected.

3 – Data

This section contains information about the variables used in the regression model. The section explains why the different variables are included. It also presents descriptive statistics for the models in this research paper.

3.1 Variables

In section four the regression model is presented. It consists of one dependent variable and four independent variables. The model consists of the dependent variable, which is economic growth, inflation which is the variable of interest, and three control variables. Control variables are included so that we can more clearly identify the relationship between the dependent variable and the variable of interest.

Dependent variable

Economic growth

Economic growth is measured by the growth rate of GDP per capita. GDP growth is the annual percentage growth rate of GDP at market prices. From the World Bank Data, the aggregates are based on constant US dollars 2015 prices. The volume of GDP is the sum of value added by households, government and industries operating in the economy. GDP accounts for all domestic production, regardless of whether the income accrues to domestic or foreign institutions (The World Bank, 2022). The data is taken from the World bank's database. The variable is denoted *GDPgrowth* in the following regression models.

Variable of interest

Inflation

Inflation is measured using the annual Consumer Price Index (CPI) and reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods at a certain point of time, for example yearly (The World Bank, 2022). The data has been taken from the World Bank's database. Inflation is denoted *INF* in the following regression models.

Control variables

Population growth rate

The first control variable is population growth rate. Population growth rate is measured in annual percentage and is explained as the growth from year t-1 to t, in percentage (The World

Bank, 2022). This control variable is chosen because the research area between population growth and economic growth is large. The human augmented Solow model predicts that population growth lowers the GDP per capita and slows down economic growth (Canarella & Pollard, 2003). Other investigators argue that in some cases population growth might have positive effects on economic growth (Fengler, 2010). The data is collected from the World Bank's database, and population growth is denoted *POP* in the following regression models.

Government consumption spending as percentage of GDP

The second variable included is total government consumption spending as percentage of GDP. This variable contains all government current expenditures for purchases of goods and services. In addition, it includes expenditures on national defense and security, but excludes government military expenditures that are a part of capital formation (The World Bank, 2022). The variable is included because several researchers like Barro (2003) and Bhaskara-Rao and Hassan (2011) concluded that government consumption spending has a negative and significant effect on economic growth. The data is taken from the World bank's database. Government spending as percentage of GDP is denoted *GSPEND* in the following models.

Investment rate as percentage of GDP

The investment rate is the last control variable. Investment rate is expressed as the ratio of total investment in current local currency and GDP in current local currency. Investment rates are measured in percentage of GDP. Investments are measured as the total value of the gross fixed capital formation and changes in inventories and acquisitions minus disposals of valuables for a sector (The World Bank, 2022). The reason why investment rate is included is because most studies and several economic models indicate that an increase in investments has a positive and statistically significant effect on economic growth. Bleaney et al. (2001) concludes that investments have a positive and significantly effect on economic growth. Freire-Seren (2002) used the Augmented neoclassical growth model and concludes that investments are statistically significant and positively related to growth (Chirwa & Odhiambo, 2016). Data has been taken from The World Bank's database. Investment rate as percentage of GDP is denoted *INV* in the following models.

Based on this the following model is estimated:

$$GDPgrowth_i = \beta_0 + \beta_1 INF_i + \beta_2 POP_i + \beta_3 GSPEND_i + \beta_4 INV_i + u,$$
$$i = Norway, Turkey$$

3.2 Descriptive statistics

Measure of the central tendency is the most basic description of the population. Here, the central tendencies obtained are mean, standard deviation, minimum and maximum values. *Table 1* gives the descriptive statistics for *the Norwegian sample*, whilst *Table 2* gives the descriptive statistics for *the Turkish sample*.

Descriptive statistics for Norway

Variable	Obs	Mean	Std. Dev.	Min	Max
$GDPgrowth_{NOR}$	60	3.016	1.889	-1.727	6.273
INF_{NOR}	60	4.481	3.234	.454	13.643
POP_{NOR}	60	.678	.272	.282	1.313
$GSPEND_{NOR}$	51	20.217	2.17	15.706	26.546
INV_{NOR}	41	25.862	3.205	19.58	32.89

Table 1 – Descriptive statistics: The Norwegian sample

GDPgrowth has a minimum value of -1.727% and a maximum value of 6.273%. The average value of *GDPgrowth*, the mean, is 3.234%. Annual inflation in percentage, *INF*, varies from 0.454% to 13.643%. Norway had *relatively* higher rates of inflation until about 1990, as shown in *Figure 2*. Since around 1990 inflation has been low and steady. Population growth rate, *POP*, varies from 0.282% to 1.313%. The standard deviation is the lowest value obtained, and we have a mean at 0.678%. Government consumption spending and investment rates are both taken as percentage of GDP. For government consumption spending the minimum value is equal to 15.706% and a maximum value equal to 26.546%. Investment rates vary some more from 19.58% to 32.89%. None of the numbers seem subnormal, and they seem intuitive considering that the business cycle varies and that our variables of interest likely change in line with the economy.

Descriptive statistics for Turkey

Variable	Obs	Mean	Std. Dev.	Min	Max
$GDPgrowth_{TUR}$	60	4.658	3.896	-5.75	11.213
INF_{TUR}	60	32.081	28.799	1.12	105.215
POP_{TUR}	60	1.869	.422	1.084	2.426
$GSPEND_{TUR}$	60	11.64	2.067	7.515	15.658
INV_{TUR}	41	25.042	3.465	18.02	31.48

Table 2 – Descriptive statistics: The Turkish sample

For Turkey, *GDPgrowth* varies from -5.75% to 11.213%. In contrast to Norway, the variation in *GDPgrowth* is higher, as shown in *Figure 1*. The red line represents Turkey, and this line has a lot more variation in contrary to Norway, represented with the blue line.

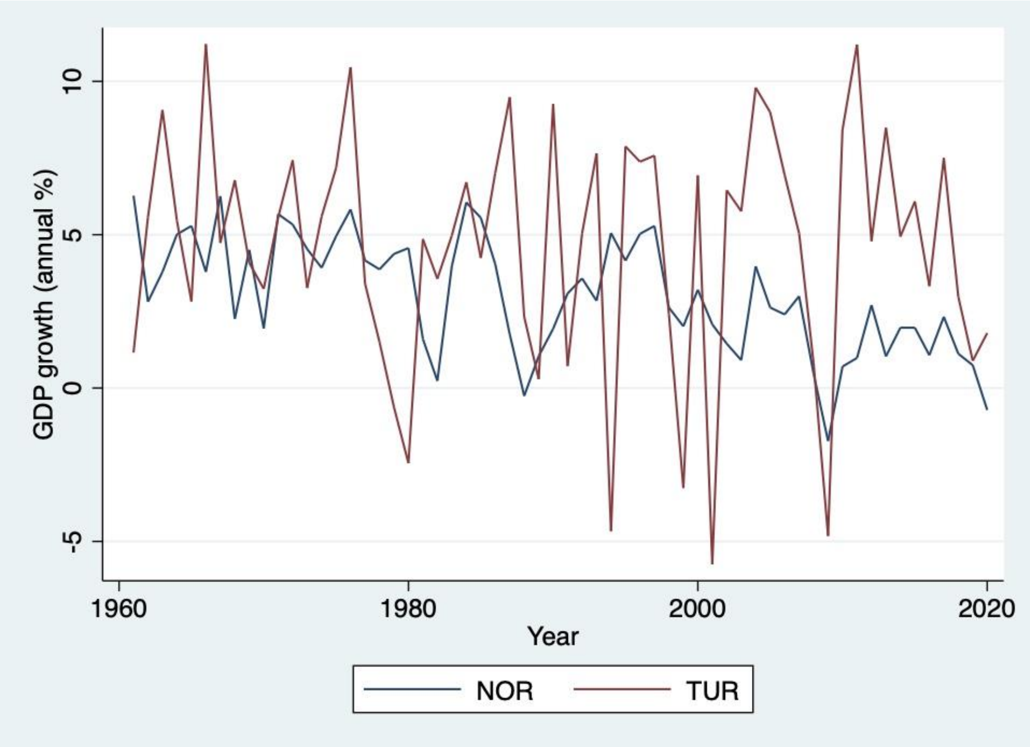


Figure 1 – GDP growth in annual %

Figure 2 depicts the inflation rate from 1960-2020 for both Norway and Turkey. As the graph shows, Turkey has had periods of high inflation, for instance in 1994 when inflation reached 105%. Even though the inflation has met a lower state in recent years, Turkey had annual inflation equal to 12.25% in 2020. In contrary Norway had 1.2%. Therefore, we can state that Turkey has had a lot more variation in inflation rates, and this can be an important factor for the results in the regression analysis later.

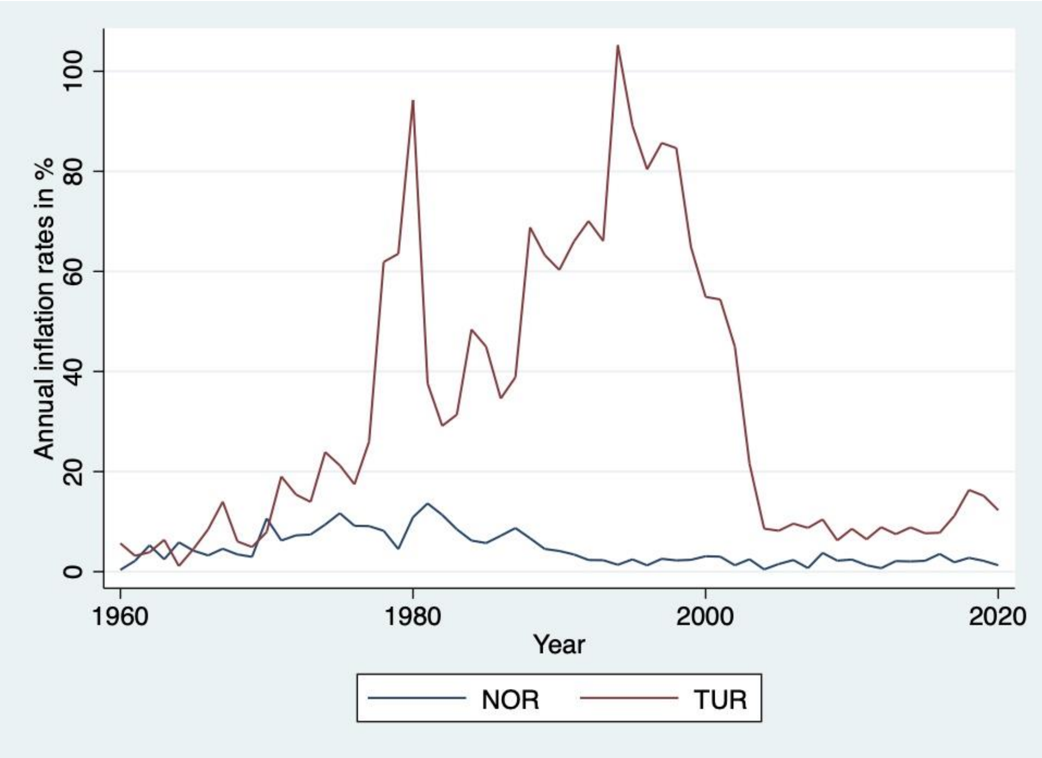


Figure 2 – Annual inflation rates in %

Lastly, we also report descriptive information about the population growth rate, government consumption spending and investment rates. From *Table 2*, population growth rate has a mean of 1.869%. Government consumption spending has a minimum value of 7.515% and a maximum value of 15.658%. Lastly, investments vary with a minimum value equal to 18.02% to a maximum value at about 31.5%.

4 – Regression Analysis

This section reports estimates from a multiple linear regression model based on the Ordinary Least Squares using the statistical tool STATA 17.0. The regression model will make it possible to determine if there exists a relationship between inflation and economic growth, and whether this relationship is positive or negative.

Column (1) through (4) shows how each control variable is added in step-by-step to observe the effect of inflation on economic growth. Column (4) represent the final model where GDP p.c., annual inflation rate, population growth rate, government consumption spending rate and investment rate are all included. Even though there are several control variables included, the main focus is β_{INF} and its relationship with $GDPgrowth$. According to MLR.4, $u = 0$, and this term will be dropped in the further analysis. In section 3.1 the variables were presented, and they are already gathered in percentage from World Bank Data, hence the regression that will be run in STATA and interpreted in this research paper is a level-level regression. This is important with regards to the interpretation of the beta coefficients, which I will look at in the coming section.

Section 4.1 contains two models, Model 1 looks at the relationship between inflation and economic growth in Norway, henceforth *the Norwegian sample*. Model 2 looks at the same relationship but in Turkey, thus *the Turkish sample*. In section 4.3 the OLS-assumptions that were presented in section 2.2.1 will be reviewed, and by running different tests it is possible to determine whether the assumptions hold for the Norwegian and the Turkish sample.

4.1 Models

4.1.1 Model 1: *The Norwegian sample*

The first model estimated is a model for Norway. The model consists of data observations from 1961-2020 on GDP, inflation, population growth rate, government consumption spending and investment rate. Column (3) only shows 51 observations, due to the lack of data available on government consumption spending from 1961-1970, so 9 observations have been removed. For column (4) another 10 observations have been removed due to data issues on investments rates from earlier than 1980.

The following models are estimated:

(5) $\widehat{GDPgrowth}_{NOR} = \beta_0 + \beta_1 \mathrm{INF}_{\mathrm{NOR}}$

(6) $\widehat{GDPgrowth}_{NOR} = \beta_0 + \beta_1 INF_{NOR} + \beta_2 POP_{NOR}$

(7) $\widehat{GDPgrowth}_{NOR} = \beta_0 + \beta_1 INF_{NOR} + \beta_2 POP_{NOR} + \beta_3 GSPEND_{NOR}$

(8) $\widehat{GDPgrowth}_{NOR} = \beta_0 + \beta_1 INF_{NOR} + \beta_2 POP_{NOR} + \beta_3 GSPEND_{NOR} + \beta_4 INV_{NOR}$

Variables	(1) $GDPgrowth_{NOR}$	(2) $GDPgrowth_{NOR}$	(3) $GDPgrowth_{NOR}$	(4) $GDPgrowth_{NOR}$
INF_{NOR}	0.115	0.0246	-0.205^{*}	-0.360^{**}
	(0.0752)	(0.0833)	(0.0826)	(0.113)
POP_{NOR}		-2.202^{*}	-3.106^{***}	-3.645^{***}
		(0.991)	(0.795)	(0.858)
$GSPEND_{NOR}$			-0.555^{***}	-0.527^{***}
			(0.118)	(0.137)
INV_{NOR}				0.0619
				(0.0838)
_cons	2.503^{***}	4.400^{***}	16.98^{***}	15.52^{***}
	(0.414)	(0.943)	(2.777)	(2.987)
N	60	60	51	41
adj. R^2	0.022	0.084	0.420	0.425

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3 - Regression analysis: The Norwegian sample

Table 3 shows the estimated models from equation (5) to (8). The stars (*) are intended to show levels of significance for the three most common levels, for example, if the p-value is less than 0.5, the number is flagged with one star. The stars indicate whether the variables are statistically significant in the sample. The models adjusted R-squared, and number of observations are appended at the bottom of the table. We see that our explanatory variables in total explain about 42,5% of the variation in economic growth in Norway. Between the four models, $GSPEND_{NOR}$ increases the adjusted R-Squared by about 33%, indicating a strong effect on the dependent variable. When the control variables are added, *INF* decreases in value. This indicates that the control variables partials out some of the effect on economic growth from the variable of interest. Also here, the most significant effect is from $GSPEND_{NOR}$, which decreases INF from 0.0246 in column (2) to -0.205 in column (3)[1]. Column (4) is considered the complete model, where all variables are included. The information in column (4) gives the following regression line:

$$(8') \; \widehat{GDPgrowth} = 15.52 - 0.36INF - 3.645POP - 0.527GSPEND + 0.0619INV$$

The regression constant of 15.52 explains the effect on economic growth if all our explanatory variables are equal to zero. If inflation rate, population growth rate, government consumption spending rate of GDP and investment rate as percentage of GDP are all equal to zero, Norway will experience a growth equal to 15.52%. This should be interpreted as high, but it is very unlikely – if ever – that we will observe the value zero for all our variables, thus the interpretation of the constant is not so meaningful.

From column (4) we can interpret the relationship between inflation and economic growth as intuitively negative. A one percentage point increase in inflation, will decrease economic growth by -0.36% all else equal. The Norwegian central bank emphasizes low and steady inflation, and the yearly inflation target is set at 2% (Norges Bank, 2020). A two-percentage point increase in inflation would indicate a reduction in economic growth with around 0,7%. The Norwegian Central bank emphasizes some inflation as favorable to the functioning of the economy (Norges Bank, 2019).

Our first control variable, population growth rate, can be interpreted as follows: A whole percentage point increase in population growth reduces economic growth with about 3.645%, all else equal. This is initially interpreted as a relatively large effect, however, from *Table 1*, we see that the mean population growth rate for Norway is 0.678%. This indicates that we more often than not, observe a population growth rate under 1%, meaning that usually, in real life, we observe a lower effect than what we interpret from the regression analysis above. We can also observe that $GSPEND_{NOR}$ has a negative sign. This can be interpreted as follows: a one

[1] An interesting observation is that the relationship between inflation and economic growth is positive, and then turns negative. Estimating model (1) and (2) on the sample from column (4), the relationship between inflation and economic growth is negative. This indicates that it is the change in sample size that changes the effect of inflation on economic growth in column (3) and (4), and not the fact that control variables are included.

percentage point increase in government consumption spending as percentage of GDP is expected to decrease economic growth by -0,527%, all else equal. This negative and statistically significant relationship is in line with what Barro (1995) found in his study. Lastly, investments are included positively however not statistically significant. Many economic models emphasize investments to enhance economic growth (Chirwa & Odhiambo, 2016), but these findings are not statistically significant in *Table 3*, thus we cannot state with certainty that there is a positive relationship between investments and economic growth.

We have established that we expect a negative relationship between inflation and economic growth in Norway. However, it is optimal to run a straightforward hypothesis to confirm if the relationship is reliable or not, due to some measurement- or sampling-errors. I run a hypothesis at a 5% significance level to test whether the intuitive conclusion above is reliable.

The hypothesis is defined as:
H_0: *There is no relationship between inflation and economic growth*
H_A: *There is a relationship between inflation and economic growth*
H_0: $\beta_{inflation} = 0$
H_1: $\beta_{inflation} \neq 0$

The test-statistic, $TS = \frac{\widehat{\beta_{inf}} - \beta_{inf}}{se(\widehat{\beta_{inf}})} = \frac{-0.36-0}{0.113} = -3.17$. Furthermore, a critical value is needed so that the test-statistic can be interpreted. The critical value is obtained through the t-distribution table given the level of significance, and the degrees of freedom. The significance level is 5%. Degrees of freedom is equal to $41 - 4 - 1 = 36$. The critical value is -2.028 thus $TS < c$ $(-3.17 < -2.28)$. We conclude that we can reject H_0, and state that there is a negative and significant relationship between inflation and economic growth for Norway.

4.1.2 Model 2: *The Turkish sample*

The second model estimated is a model for Turkey. The intuition behind this model is the same. Data observations from 1961-2020 on GDP, inflation, population growth rate, government spending and investment rate was collected. For Turkey there was available data on government spending back to 1961, hence there are 60 observations in column (3). For column (4) 20 observations have been removed since there were issues with finding information about investments from further back than 1980.

The following models are estimated:

(9) $\widehat{GDPgrowth}_{TUR} = \beta_0 + \beta_1 INF_{TUR}$

(10) $\widehat{GDPgrowth}_{TUR} = \beta_0 + \beta_1 INF_{TUR} + \beta_2 POP_{TUR}$

(11) $\widehat{GDPgrowth}_{TUR} = \beta_0 + \beta_1 INF_{TUR} + \beta_2 POP_{TUR} + \beta_3 GSPEND_{TUR}$

(12) $\widehat{GDPgrowth}_{TUR} = \beta_0 + \beta_1 \mathrm{INF}_{\mathrm{TUR}} + \beta_2 POP_{TUR} + \beta_3 GSPEND_{TUR} + \beta_4 INV_{TUR}$

Variables	(1) $GDPgrowth_{TUR}$	(2) $GDPgrowth_{TUR}$	(3) $GDPgrowth_{TUR}$	(4) $GDPgrowth_{TUR}$
INF_{TUR}	-0.0418*	-0.0408*	-0.0556**	-0.0372
	(0.0169)	(0.0172)	(0.0180)	(0.0248)
POP_{TUR}		0.539	-1.967	-1.460
		(1.170)	(1.635)	(2.770)
$GSPEND_{TUR}$			-0.719*	-1.018*
			(0.337)	(0.422)
INV_{TUR}				0.507*
				(0.227)
_cons	6.000***	4.960*	18.48**	7.903
	(0.726)	(2.375)	(6.756)	(9.995)
N	60	60	60	41
adj. R^2	0.080	0.067	0.122	0.183

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4 - Regression analysis: The Turkish sample

Table 4 shows the estimated models from equation (9) to (12). The model's adjusted R-squared and number of observations are appended at the bottom of the table. We see that our explanatory variables in total explain about 18.3% of the variation in economic growth in Turkey. What's interesting is that the adjusted R-squared is noticeably much lower for *the Turkish sample* in contrary to *the Norwegian sample*. When *GSPEND* is added to our model, the effect of inflation becomes stronger and more negative, however when *INV* are included the relationship between inflation and economic growth weakens.

The information in column (4) set out the following estimating regression line:

$$(12') \ \widehat{GDPgrowth} = 7.903 - 0.0372INF - 1.460POP - 1.018GSPEND + 0.507INV$$

The regression constant of 7.9 explains the effect on economic growth if all our explanatory variables are equal to zero. If this is the case, Turkey will experience a growth equal to 7.9 percent. This is somewhat high, but again; a situation where all variables are zero is very uncommon, and rarely observed.

We interpret the relationship between inflation and economic growth from column (4) as negative. A one percentage point increase in inflation is expected to decrease economic growth by –0.03% all else equal. The effect is negative, but small. From *Table 2* we can see that Turkey has had a mean yearly inflation of about 32%, which is relatively high. In February of 2022 Turkey reached the highest inflation of 20 years, due to a currency-crisis. The president of Turkey, Recep Erdogan, cut the interest rate drastically, because he – in contrary to general economic theory – believes that an increase in the interest rate will cause higher inflation (Finansavisen, 2022). Read right from the table the result from the analysis does not seem to be statistically significant. However, high inflation rates may cause dissatisfied citizens, which in return potentially could cause political imbalances, therefore worth mentioning.

The effect of population growth can be interpreted as follows: A one percentage point increase in population growth rate is expected to decrease economic growth with -1.460%, all else equal. From the descriptive statistics, the yearly mean population growth rate in Turkey is just below 2%. Turkey has made noticeably progress in the quality of life of its citizens the last decades. There have been lower unemployment rates, lower infant mortality rates, more people completing upper secondary education, and life expectancy at birth is around 79 years (OECD, 2020). These are all indicators that there has been improvement in living standards, which can possibly cause higher population growth. Since around the 21st century the population growth has been positive but decreasing (World Population Review, 2022). This indicate that we in reality will observe that population growth will cause a larger decrease in economic growth than what we expect in the regression in *Table 4.*

A one percentage point increase in government consumption spending is expected to decrease economic growth by around 1%, all else equal. We can interpret this relationship as statistically significant at a 5% significance level. Lastly, a one percentage point increase in the investment rate as percentage of GDP is expected to increase economic growth by 0.5%, all else equal. This relationship is also expected to be statistically significant at a 5% significance level.

I run a hypothesis at a 5% significance level, to confirm that the intuitive relationship between inflation and economic growth is reliable.

The hypothesis is stated as follows:
H_0: $There\ is\ no\ relationship\ between\ inflation\ and\ economic\ growth$
H_A: $There\ is\ a\ relationship\ between\ inflation\ and\ economic\ growth$
H_0: $\beta_{inflation} = 0$
H_1: $\beta_{inflation} \neq 0$

The test-statistic: $TS = \frac{\widehat{\beta_{inf}} - \beta_{inf}}{se(\widehat{\beta_{inf}})} = \frac{-0.037-0}{0.0248} = -1.5$. The rejection region is based on the degrees of freedom and the significance level. Degrees of freedom are equal to 36. The critical value is -2.028. Since $-1.5 > -2.028$, this indicate that $TS > c$, thus H_0 cannot be rejected. For Turkey, it is not possible to conclude that inflation has a negative and significant impact on economic growth.

4.2 Review of the OLS-assumptions

The assumptions of the OLS-regression model are thoroughly presented in section 2.2.1. This section contains several tests and calculations to see if the OLS-assumptions are likely to hold for the two different models.

MLR.1 – Linearity

The first assumption that must be met is linearity. As stated earlier, all parameters must be linear to be able to use the OLS-method. Misspecification of the functional form can lead to wrong estimates of the population. One way to check for linearity is to add the quadratic term of the independent variables. Adding the quadratic term makes it is possible to investigate if the effect of x_k changes when x_k increases, meaning that there is a non-linear relationship between the dependent and the independent variable (Ringdal & Wiborg, 2017). In *Table 5* and *Table 6* the squared terms for all independent variables are included, and denoted INF^2, INV^2 et cetera. We can test the null hypothesis that the variable is linear against the alternative hypothesis that it is non-linear.

The hypothesis is formulated as follows:

$H_0: Variable\ is\ linear$

$H_A: Variable\ is\ non-linear$

$H_0: \beta_1 = 0, \beta_2 = 0, \beta_3 = 0, \beta_4 = 0$

$H_A: \beta_1 \neq 0, \beta_2 \neq 0, \beta_3 \neq 0, \beta_4 \neq 0$

The hypothesis for *the Norwegian* and *the Turkish sample* is tested at a 5% significance level.

The Norwegian sample

	(1)
	$GDPgrowth_{NOR}$
INF_{NOR}	-0.679
	(0.338)
POP_{NOR}	-8.988
	(5.821)
$GSPEND_{NOR}$	0.633
	(2.163)
INV_{NOR}	1.562
	(1.067)
INF^2_{NOR}	0.0198
	(0.0220)
POP^2_{NOR}	2.652
	(3.369)
$GSPEND^2_{NOR}$	-0.0257
	(0.0499)
INV^2_{NOR}	-0.0284
	(0.0206)
_cons	-14.07
	(28.76)
N	41
adj. R^2	0.423

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5 - Test for linearity: The Norwegian sample

Directly from the table we see that none of the p-values are statistically significant because they are not flagged with stars, thus H_0 cannot be rejected. This suggests that the variables in *the Norwegian sample* are linear in parameters, thus MLR.1 is assumed to hold.

The Turkish sample

Including the squared terms in *the Turkish sample* we get the following:

	(1) $GDPgrowth_{TUR}$
INF_{TUR}	0.000790 (0.101)
POP_{TUR}	38.66* (18.20)
$GSPEND_{TUR}$	5.011 (2.586)
INV_{TUR}	1.868 (2.175)
INF^2_{TUR}	-0.000828 (0.000929)
POP^2_{TUR}	-11.49* (5.180)
$GSPEND^2_{TUR}$	-0.267* (0.114)
INV^2_{TUR}	-0.0265 (0.0439)
_cons	-75.08* (32.22)
N	41
adj. R^2	0.338

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6 - Test for linearity: The Turkish sample

From *Table 6* we observe that inflation and investments are expected to be linear in parameters, whilst the squared term of population growth rate and government spending indicate that these variables are not linear in parameters. Usually, when the squared terms are statistically significant, we keep the squared term in the model, because then the sample becomes closer to the true population. However, since the focus of this paper is inflation, and it seems like there is a linear effect of inflation on economic growth, the squared terms are not included in the further analysis. In conclusion, the MLR.1 holds for *the Norwegian sample*, and partly for *the Turkish sample*. The squared term for government spending and investment could have possibly been included in *the Turkish sample* since the relationship between these two variables and *GDPgrowth* seems to be non-linear. Future research could include the squared term of government spending and investment to create a sample closer to the true population.

MLR.2 – Random Sampling

Random sampling implies that each observation, i, has the same probability of being selected. This assumption holds true if the sample size is sufficiently large. According to the central limit theorem this is $n \geq 30$ (Anderson, et al., 2017). There are over 30 observations in the data set, so this holds true. However, time-series data have many observations of the same object over a certain time period. This means that the sample cannot be treated as randomly drawn as there is a natural temporal order of the findings. The observations cannot be independent of each other, as they usually depend on earlier observations of the same variable (Wooldridge, 2019, p. 343). For example: This year's inflation depends on the inflation last year, which was dependent on the inflation the year before and so on.

This indicates that MLR.2 does not hold, however doing small corrections makes it possible to use time-series data whilst MLR.2 still holds. For instance, it is, amongst other, important to achieve stationarity. A stationary time-series process is one in which the probability distributions are stable over time (Wooldridge, 2019, p. 367). In conclusion, time-series data is problematic with regards to MLR.2 and thus conclusions from the models in this research paper should be carefully interpreted. The assumption has been considered as best as possible and is devoted some time in section six.

MLR.3 – No perfect collinearity

MLR.3 states that there needs to be enough variation and no perfect collinearity. Collinearity measures the correlation between the variables that are used in an analysis. In the case with perfect collinearity between variables it will be impossible to get unique estimates of the coefficients because all combinations will work the same way (Wooldridge, 2019, p. 81). Too high correlation may cause problems regarding the estimates and can also limit the R-squared. As stated earlier, if correlation > 0.9 then severe correlation may be present (Wooldridge, 2019,

p. 92). One alternative to check for correlation is to investigate the correlation matrix and see if any variables correlate highly. *Table 7* show the correlation matrix for *the Norwegian sample*.

Correlation matrix for Norway

Variables	(1)	(2)	(3)	(4)	(5)
(1) $GDPgrowth_{NOR}$	1.000				
(2) INF_{NOR}	0.196	1.000			
(3) POP_{NOR}	-0.337	-0.486	1.000		
(4) $GSPEND_{NOR}$	-0.520	-0.618	0.224	1.000	
(5) INV_{NOR}	-0.195	0.446	-0.001	0.048	1.000

Table 7 - Correlation matrix: The Norwegian sample

From the table above we observe that none of the variables are close to the threshold level. This is a very good indicator that MLR.3 is not violated, and that multicollinearity is not present in our model. The correlation matrix gives a good indicator, and to see if there is absence of perfect correlation it is possible to check the Variance Inflation Factor, henceforth VIF. VIF measures how much the variance of an independent variable is influenced by other independent variables. In STATA the VIF test allows us to quickly measure how much of a variable is contributing to the standard error in the regression. This is illustrated in *Table 8*.

Variables	VIF	1/VIF
INF_{NOR}	2.726	.367
INV_{NOR}	1.592	.628
POP_{NOR}	1.576	.635
$GSPEND_{NOR}$	1.513	.661
Mean VIF	1.852	

Table 8 - VIF: The Norwegian sample

Threshold levels for VIF is stated to be 10 (Wooldridge, 2019, pp. 92-93) and none of the VIF tests show such numbers. Thus, the conclusion is that there are no reasonable problems with multicollinearity in *the Norwegian sample*.

Correlation Matrix for Turkey

We must also check for multicollinearity in the Turkish model. The procedure is the same – STATA is used to enable a correlation matrix and examine if there are any values above the threshold level. *Table 9* shows the correlation matrix for *the Turkish sample*

Variables	(1)	(2)	(3)	(4)	(5)
(1) $GDPgrowth_{TUR}$	1.000				
(2) INF_{TUR}	-0.309	1.000			
(3) POP_{TUR}	0.098	-0.133	1.000		
(4) $GSPEND_{TUR}$	-0.158	-0.192	-0.674	1.000	
(5) INV_{TUR}	0.310	-0.558	-0.378	0.538	1.000

Table 9 - Correlation matrix: The Turkish sample

From *Table 9* there are no indications of perfect correlation, however it should be observed that government consumption spending correlate relatively high with population growth, thus it is valuable to check the VIF is anywhere near the threshold level of 10. This is illustrated in *Table 10*.

Variables	VIF	1/VIF
$GSPEND_{TUR}$	2.541	.394
POP_{TUR}	2.023	.494
INV_{TUR}	1.686	.593
INF_{TUR}	1.55	.645
Mean VIF	1.95	

Table 10 - VIF: The Turkish sample

The VIF is far away from the threshold level, thus the conclusion is that there are no problems with perfect correlation, and MLR.3 is assumed to hold.

MLR.4 – Zero conditional mean

MLR.4 is the key assumption for unbiasedness. The assumption states that there should be nothing in the error term, u, that is correlated with both the dependent variable, y, and the independent variable, x. It can be difficult to satisfy this assumption, and it is also difficult to directly test. When MLR.4 is violated, it is often the cause of omitted variable bias. If there is a factor in the error term that correlates with both the dependent and the independent variable, the zero conditional mean assumption will not be satisfied, and our estimator will be biased.

Realistically, it is reasonable to believe that this assumption may be violated in the models. The models try to predict a certain relationship between inflation and economic growth, but this relationship is likely to be affected by many factors, and some of these factors are not included. For instance, variables that was hard to find data about was human capital or trade openness, which potentially could cause omitted variable bias. The assumption has been considered as best as possible, and the assumption for zero conditional mean is assumed to hold for both regression models.

MLR.5 – Homoscedasticity

MLR.5 is the assumption of homoscedasticity, which is an assumption about the variance of the error term. To find out whether the MLR.5 holds or not, it is possible to perform a Breusch-Pagan test to test for homoscedasticity (Wooldridge, 2019, p.270). Breusch-Pagan-test is run in STATA, and tests whether the variance in the error term is dependent of the values of the independent variables. The test is run for *the Norwegian sample* and *the Turkish sample*.

The hypothesis test is stated as follows:

H_0: $Homoscedasticity\ is\ present\ (the\ residuals\ are\ distributed\ with\ equal\ variance)$

H_A: $Heteroscedasticity\ (the\ residuals\ are\ \textbf{not}\ distributed\ with\ equal\ variance)$

For **The Norwegian sample** the values are:

$chi2(1) = 0.11$

$Prob > chi2 = 0.7373$

For **The Turkish sample** the following values are obtained:

$chi2(1) = 3.77$

$Prob > chi2 = 0.0523$

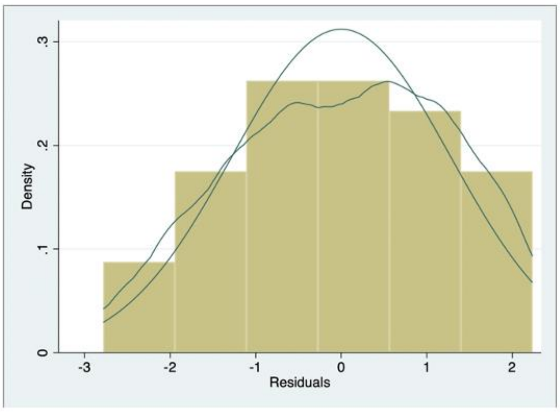
The chi-squared test statistics for Norway and Turkey is 0.73 and 0.0523 respectively. At a 5% significance level H_0 cannot be rejected since the p-value is greater than 0,05. The conclusion is that there is constant variance and therefore homoscedasticity is present, and MLR.5 is assumed to hold

MLR.6 – The Normality Assumption

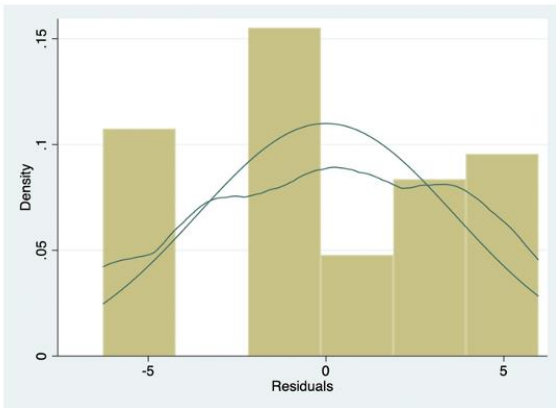
MLR.6 states that the population error, u, is independent of the explanatory variables and is normally distributed with zero mean and variance, $u \sim N(0, \sigma^2)$. The assumption is known to be much stronger than the other assumptions, and rarely holds, since it states that the error term is independent of all variables, both expected value and variance (Wooldridge, 2019, p. 118).

The argument that justifies the normal distribution for the error term is; since the error term is the sum of many unobserved factors affecting the independent variable, the central limit theorem can be invoked to conclude that *u* has an approximately normal distribution (Wooldridge, 2019, p. 119). In the analysis for both Norway and Turkey there are factors that are not included. These factors could, of course, influence the dependent variables. Even though they are not included, it is assumed that they would – in line with the Central limit theorem – affect the independent variable separately and additive (Wooldridge, 2019, pp. 119-120).

The distribution of the error term is shown below. *Figure 3* shows the distribution for *the Norwegian sample* on the left-hand side, whilst the distribution for *the Turkish sample* is shown on the right-hand side. The figures each have two lines – one representing the normal density plot and the other representing the kernel density plot. The kernel density plot represents the distribution of the residuals whilst the normal distribution shows the normal density plot. Adding the normal density plot shows whether the kernel density plot is close to normally distributed or not, therefore it is helpful to include both lines.



Norway



Turkey

Figure 3 – Test for normality

The figure shows that the distribution of the error term for both Norway and Turkey are close to normally distributed. Intuitively this can be interpreted as follows: MLR.6 holds. However, it may be useful to test the intuitive results to see if MLR.6 holds. This can be done by using a Jarque-Bera test, which is one of the most popular goodness-of-fit tests utilized in economics (Gel & Gastwirth, 2008). This test can be done using STATA 17.0.

The following hypothesis is stated:

H_0: $The\ data\ follows\ a\ normal\ distribution$

H_A: $The\ data\ does\ not\ follow\ a\ normal\ distribution$

The Norwegian sample:

$chi(2) = 1.488$

$Prob > chi = 0.4753$

The Turkish sample:

$chi(2) = 2.345$

$Prob > chi = 0.3096$

With a 5% significance level and p-values being 0.4753 and 0.3 for the Norwegian and Turkish samples respectively. Since $0.4753 > 0.05\ and\ 0.3 > 0.05$, H_0 cannot be rejected, indicating that the initial interpretation that MLR.6 is not violated was correct. As a result, MLR.6 is assumed to hold for both samples in question. One should be aware that some have pointed critics towards the Jarque-Bera test, especially with regards to samples of small size, since the test might be biased (Thadewald & Büning, 2004).

5 – Results and discussion

The results from the regression analysis across the two countries are ambiguous. *The Norwegian sample* predicts a negative and statistically significant relationship between inflation and economic growth. This is in line with for instance what Stockman (1981) and Fischer (1993) found in their research. The relationship for *the Turkish sample* is also negative, however not statistically significant. This means that it is not possible to state that the relationship is negative. None of the models show a positive relationship, like Tobin (1965) predicted, or what Mallik and Chowdhury (2001) found. One reason why the relationship may differ from Mallik and Chowdhury's findings is because Turkey and Norway are European countries, and the study by Mallik and Chowdhury only look at Asian countries. The use of different countries could potentially have a substantial effect on the results.

What is interesting is that earlier research and theory almost always conclude that investments enhance economic growth, these findings hold for Turkey, however for Norway this relationship is not statistically significant. For both models, government consumption spending as percentage of GDP affects economic growth negative and statistically significant, in line with what Barro (1995) found.

A major finding in the analysis is that the effects of inflation on economic growth are not large. For example, a 1% increase in inflation in Norway is expected to decrease economic growth by 0.36%. However, over sufficient time periods these changes in growth rates may have dramatic effects on standard of living, which can justify an interest from the policy makers and central bank to emphasize low and steady inflation. In addition, the relationship was not significant for Turkey, however this does not mean that inflation is not important. Many economists state that low and steady inflation will cause a predictable future for households and that political imbalance will be avoided (Oner, 2020).

The models contain several limitations, which should be considered when interpreting the results. This is further discussed in section six. Future research on the area should include several countries, not only European countries but high-, middle- and low-income countries from all around the world. Furthermore, additional control variables could be included to predict a more accurate relationship.

6 – Robustness and critics

There are some critics and limitations to this research paper that must be acknowledged. Throughout the regression analysis there were several assumptions that had to be fulfilled to make the analysis valid. In this chapter the econometric limitations and weaknesses, as well as some empirical limitations are reviewed.

Omitted variables

What is obvious is that this research area is huge. There are a lot of factors that affect economic growth and inflation that are not captured in this model. Several control variables could have been included, such as human capital or trade openness. Human capital could have been measured using school attainment or as the ratio between skilled and total adults in the national economy (Romer, 1990). A measure for trade openness could have been the ratio of exports plus imports over GDP (The World Bank, 2022). These, amongst other possibly important variables, were not included in the model. One reason is the struggle of finding reliable data on each single variable online over a sufficient time horizon. In section 4.2 the MLR.4 was stated to hold, however there is a possibility that the model could be biased due to omitted variables (Wooldridge, 2019, pp. 84-85).

Random sampling

When the assumptions were reviewed in section 4.2. a problem arose: The data is time-series, and not cross-sectional. Time-series data consists of a set of observations with temporal ordering. As a result, the random sampling assumption will not hold for the population in question. This is a weakness in this model – and time-series data in general, thus one should adjust the assumptions when we take on time-series data. The reader should keep this in mind when reading this research paper.

No serial correlation

Using time-series data it is important to recognize that the past can affect the future (Wooldridge, 2019, p. 334). For time-series data there is one important assumption that must hold that I have not looked very deep into, but only mentioned in section 2.2.1. This assumption is called *No serial correlation*, and states that conditional on x, the errors in two different time periods are uncorrelated (Wooldridge, 2019, p. 342). A consequence of the error terms being serially correlated is that the estimation of the regression coefficients is inefficient, and this gives inaccurate confidence intervals (Wooldridge, 2019, p. 342). This was not investigated further; however future research should investigate *No serial correlation*.

Lagged variables

No serial correlation assumes nothing about the temporal correlation in the independent variables in the model (Wooldridge, 2019, p. 343). This means that there could be some correlation across time for the independent variables, but this will not cause the *No serial correlation*-assumption to not hold. However, I would like to emphasize the importance and limitations of lagged variables. A lagged variable means that its value is coming from an earlier point in time. This could for instance be the case for inflation. Today's inflation rates are likely to have been affected by earlier inflation rates, and future inflation is likely to be a result of earlier inflation rates. In conclusion, next year's economic growth is likely forecasted by past and current values of growth and lagged independent variables. Neither lagged independent nor lagged dependent variables are included in this paper, which is a limit in the study.

Goodness of fit

As explained in 2.3.2 the R-squared explains the goodness of fit. High levels of R-squared is usually desirable. High levels of R-squared indicate a value as close to 1 as possible. In *the Norwegian sample* the adjusted R-squared is 0.425, which is *relatively* satisfactory. In contrary, *the Turkish sample* has an adjusted R-squared corresponding to 0.18, which is not very high. As a result, another limitation of this research paper may be that the independent variables do not explain so much of the variability of the dependent variable, this is mainly an issue for *the Turkish sample*. However, one should be aware that low values of R-squared is not necessarily problematic, but worth mentioning.

Degrees of freedom

The last thing that should be addressed is the degrees of freedom. In column (4) in *Table 3* and *Table 4*, where all variables are included, there are 41 observations, and doing the hypothesis test the model has 36 degrees of freedom. Higher number of degrees of freedom means more power and certainty to reject a false null-hypothesis. Since 36 degrees of freedom is relatively low, this can weaken the conclusions found in this research paper.

Section six wraps up some of the limitations in this research paper. To sum up, there are some important factors that are missing in the model, for instance due to data collection issues. These limitations should be considered when interpreting results in this research paper.

7 – Conclusion

This research paper has investigated the relationship between inflation and economic growth. The aim of the paper was to find out whether or not inflation enhances economic growth. The paper began with presenting some earlier research and economic theory was presented. The findings from earlier research differed, as some studies claim that inflation is harmful, while others concluded that inflation has a positive impact on economic growth.

In this research paper, a multiple linear regression model was used to determine the relationship. Using a Norwegian sample and a Turkish sample, two models were created. *The Norwegian sample* found a negative and statistically significant relationship between inflation and economic growth, whilst *the Turkish sample* also found a negative relationship, however the findings were not statistically significant. The results were discussed in light of theory and earlier research. One of the most important findings was that the relationship between inflation and economic growth is not strong, however increasing levels of inflation over time may have sufficient effects on living standards in a country, thus it should be of policy makers interest to keep inflation low and steady. This research paper also devoted some time to discuss limitations and problems with the regression model and recommended some possible improvements for further research.

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