Bachelor's project

NTNU
Norwegian University of Science and Technology
Faculty of Economics and Management
Department of Economics

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# Estimating the Norwegian Phillips curve

Bachelor's project in Economics
Supervisor: Hildegunn E. Stokke
May 2021

NTNU
Kunnskap for en bedre verden

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# Abstract

This thesis focuses on measuring the basics of macroeconomics represented by the Phillips curve. We investigated if there's empirical evidence regarding if the Phillips curve is applicable to the Norwegian labor market, both prior to 2001 and post 2001, as well as over the whole period which we obtained data. Furthermore, we estimated the long run natural rate of unemployment. This was done by measuring simple linear models using the ordinary least squares with inflation and unemployment rate as dependent and independent variables. Our conclusion was that there is clearly an inverse relationship across the whole period, but we can't confirm that there's a negative relationship after 2001 based on our results. The estimated NAIRU is also uncertain due to lack of significance in our values. Further research is needed to conclude on what may cause the non-existent relationship after 2001.

# Preface

The following thesis is written by four students for the department of Economics for the Norwegian university of science and technology as a concluding thesis for our bachelor's degree.

We would like to thank our supervisor Hildegunn Ekroll Stokke for good help and guidance throughout our working process.

**Trondheim, May 2021**

**Bendik Eidsmo Johansen, Sander Volden Bakkebø, Simen Røseth & Thomas Baugerød**

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# 1. Introduction

## 1.1 Motivation

A.W Phillips developed a new theory in 1958, where he proved empirically that there is a clear negative relationship between inflation and unemployment in the UK for the period of 1861 – 1957 (Phillips, 1958). This finding has gradually gained a lot of consensus among many economists and is an important tool in understanding the mechanisms behind inflation targets (Gruen, et al., 1999) (Iwasaki, et al., 2018). However, it has been proven to be relevant only in short term analysis and some economists have argued that the Phillips curve is gradually losing its relevance as an economical instrument (The Economist, 2017).

In this text we want to estimate whether the Phillips's curve theory is applicable towards the Norwegian labor market. Due to the monetary trilemma, we already know that any central bank must prioritize between free capital movements, stable exchange rate and an independent monetary policy (Krugman, et al., 2017).

This thesis will also seek to measure if there exists any diversion prior to 2001 against post 2001. This is mainly due to a change in the Norwegian Central Bank's monetary policy regime. The change included how the Central Bank wanted to control a stable exchange rate prior to 2001, while they in 2001 changed their target towards having a stable inflation rate (Finansdepartementet, 2001).

## 1.2 Research question

The derivation given above leads us to the following research question:

**"Is it possible to identify the Phillips curve in the short run and long run for the Norwegian labor market, and is there any significant change from 2001?"**

In this thesis we want to investigate if there exists any statistical evidence of a negative relationship between inflation and unemployment rate in the short term in Norway, as well as if the change in the Norwegian Central Bank's monetary policy regime in 2001 has influenced the Norwegian Phillips curve in any significant form. Furthermore, we will try to identify the long run natural rate of unemployment using data on inflation change and the unemployment rate.

# 2. Economic theory, econometric specification, and hypothesis

## 2.1 Introduction

In this part of the thesis, we will explain the mechanisms behind the Phillips Curve, the NAIRU and the econometric method used to answer the research question, the OLS-estimator. Furthermore, we will look at how the OLS is used in regressions. Lastly, we will explain how to use hypothesis testing to substantiate the answers from the analysis.

## 2.2 Phillips Curve

Phillips developed a model in 1958 that states a clear negative relationship between changes in wage rates and unemployment (Phillips, 1958). This article gained increased interest and is today widely accepted and applied as a standard economical tool across economical institutions and national banks (Gruen, et al., 1999). In this thesis, we will base our analysis on a slightly simplified linear relationship between the unemployment rate and inflation. This is based on the argument that a more complex convex model will not add any insights to our main hypothesis.

The framework on which the model is based upon is encapsulated in the following two equations (Holden, 2018, pp. 200-209):

$$\frac{W}{P} = \frac{A}{1+\mu} \qquad \textit{[Eq. 1]}$$

$$\frac{\Delta W}{W} = \frac{\Delta P^e}{P} + \frac{\Delta A^e}{A} - b(u - u^n) \qquad \textit{[Eq. 2]}$$

In equation 1) W is wage, P is nominal price levels, A is a parameter that measures productivity and μ states the price increase on marginal costs. This equation illustrates how real wage is correlated with productivity and the nominal price levels. It states that employees need to consider the nominal inflation when setting wages to maintain the real wage. When this equation is in equilibrium, we acquire the natural rate of unemployment ($u^n$).

In equation 2. Δ is denoting a change in the nominal values. $\frac{\Delta W}{W}$ describes relative change in wages, while $\frac{\Delta P^e}{P}$ describes the expected growth in price levels. $\frac{\Delta A^e}{A}$ denotes the expected growth in productivity. u shows the real unemployment rate, while $u^n$ gives the natural unemployment rate. Thus, the last part of the equation gives the unemployment gap between the natural unemployment rate and real unemployment rate. This part of the equation is the main explanation behind the Phillips curve. A positive unemployment gap, i.e., the unemployment is higher than the natural rate of unemployment, entails in turn a lower inflation through lower wages. This is explained through standard supply and demand theory. In the situation of a positive unemployment gap the supply of labor exceeds the demand. Thus, having a surplus of labor the employers will not have any incentives to bid up the wages to secure competent labor. On the contrary, wages will be pushed up if the gap is negative and we have a demand surplus. In a corresponding situation the employers must bid up the wages to attract employees, which ultimately increases the inflation through higher wages. The parameter b is positive and a constant that illustrates the size of the effect of changes in unemployment gap on wages. Holden derives the model furthermore by rewriting equation 1 with respect to P, so that we can apply a simplified general rule on companies' price setting:

$$P = (1 + \mu)\frac{W}{A} \qquad \textit{[Eq.1*]}$$

Rewriting this as a derivative and holding μ constant, we obtain:

$$\frac{\Delta P}{P} = \frac{\Delta W}{W} - \frac{\Delta A}{A} \qquad \textit{[Eq. 3]}$$

This equation shows how inflation is created, and by inserting equation 2. on $\frac{\Delta W}{W}$, we get that:

$$\frac{\Delta P}{P} = \frac{\Delta P^e}{P} + \frac{\Delta A^e}{A} - b(u - u^n) - \frac{\Delta A}{A} \qquad \textit{[Eq. 3*]}$$

And this equation can be rewritten to the more well-known Phillips-equation that considers expected inflation and unemployment as the key variables:

$$\pi = \pi^e - b(u - u^n) + z^\pi \qquad \textit{[Eq. 4]}$$

Where $\pi$ is denoting all inflation-related variables. That is, $\pi$ gives the real inflation and $\pi^e$ gives the expected inflation. $z^\pi$ includes other factors that may influence the inflation, including productivity and expected productivity. The intuition behind this equation is that when the unemployment is low, the union power will increase for the employees. This will lead to more competition on relevant and good employees, which makes their bargaining power greater, and they may therefore demand higher wages. Higher wages will in turn lead to greater purchasing power, which increases the demand on goods. Various companies can therefore allow themselves to increase the prices on goods and services, and we have increased inflation.

Equation 4 is showing the short run equilibrium and is generally not applicable in the long run due to other slower factors, such as technology and development.

Holding $z^{\pi}$ constant and equal to 0, the Phillips curve is estimated to have the following trajectory given our simplification of the function:

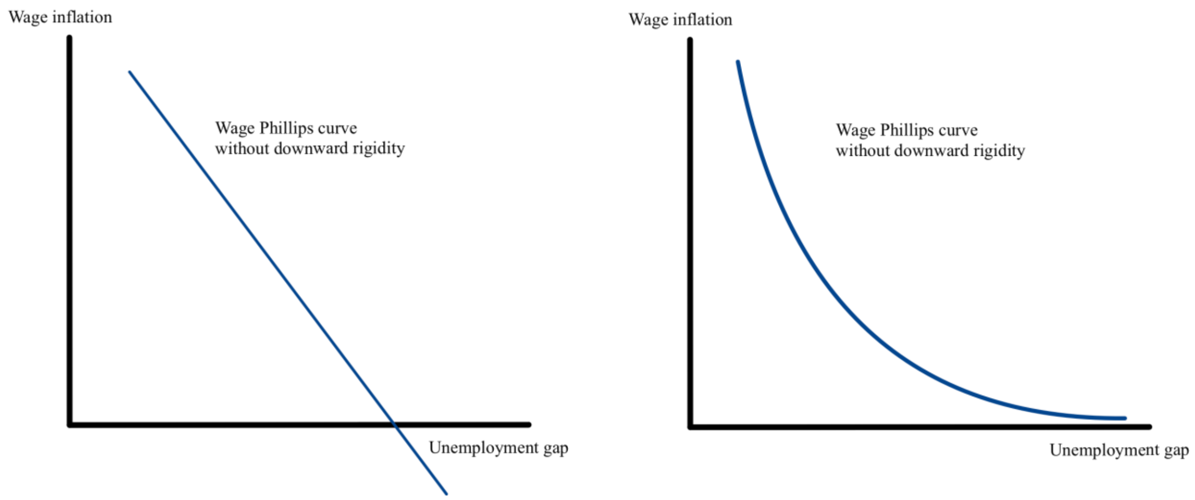


*Figure 1: Phillips Curve*

(Iwasaki, et al., 2018)

We will focus mainly on the left Phillips-curve, as the main idea in the Phillips-curve and our thesis is to investigate whether there exists empirical evidence supporting that this model is applicable to the Norwegian labor market for the last 50 years. The convex Phillips-curve is probably more realistic, because it is reasonable to assume that when unemployment is significantly large, the expected marginal effect on inflation decreases.

The non-accelerating inflation rate of unemployment (hereby abbreviated NAIRU) states the long run natural unemployment rate. Holden states that in the long run, there exists no trade-off between inflation and unemployment, and he also argues that it is impossible to keep a lower real unemployment rate than the natural unemployment rate in the long run (Holden, 2018, pp. 200-209). When deriving the long-run unemployment rate, we must bear in mind the

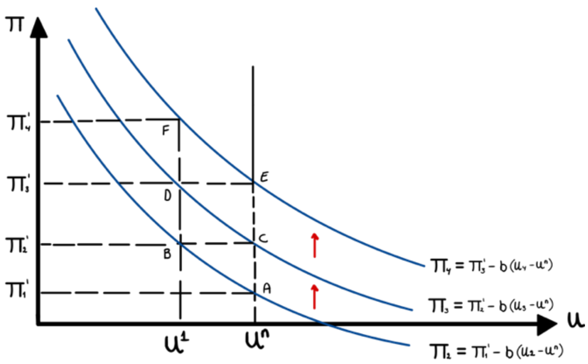


*Figure 2: Non-accelerating inflation rate of unemployment (NAIRU)*

underlying assumption about rational participants in the economics. Because the Phillips-curve is expectations-augmented, the long run effect on the Phillips-curve is mainly connected to the expected inflation.

Since the short-run Phillips-curve states that there is a trade-off between unemployment and inflation, rational participants will realize that short-term sighted politicians will focus primarily on keeping the unemployment rate low, while ignoring the effect on the inflation due to this. This brings us to a situation with adaptive expected inflation, where we are assuming that the employees will expect an inflation equal to the previous year, so that: $\pi^e = \pi_{t-1}$. This gives the following Phillips curve:

$$\pi_t = \pi_{t-1} - b(u_t - u^n) \qquad \textit{[Eq. 5]}$$

This, we can rewrite with emphasis to the change in inflation as:

$$\pi_t - \pi_{t-1} = -b(u_t - u^n) \qquad \textit{[Eq. 6]}$$

Which again can be rewritten as:

$$\Delta\pi_t = -b(u - u^n) \qquad \textit{[Eq. 7]}$$

The long run NAIRU is estimated where $\Delta\pi_t = 0$, so that $u = u^n$. The main intuition behind the long-term NAIRU is that the expectations-augmented Phillips-curve will lead to an expected increase in inflation for every year, so that the Phillips-curve will shift upwards until $\Delta\pi_t = 0$. If we imagine a situation where the unemployment rate is lower than the NAIRU ($u^1 < u^n$), the inflation will rise because of an expectation for the government to keep unemployment rate at the given level. This shift in the expected inflation will cause a shift in the Phillips-curve. In the long run the inflation will rise to unbearable levels, and the CB's must disintegrate the unemployment target in favor of the inflation. Therefore, the central banks must accept that in the long run the unemployment rate is not controllable above their natural level.

As clearly shown above, the long run NAIRU states that there is not a trade-off between inflation and unemployment. The natural level of unemployment is therefore the vertical line shown as $u^n$ in figure 2.

Some economists have pointed out that it is impossible to have a completely steady natural unemployment rate and has also argued that the long-term equilibrium in the Phillips-curve is in fact horizontal, rather than a vertical line as Holden argues (Russel & Banerjee, 2007; The Economist, 2017). In this thesis, we make an assumption that Holden's argument holds up.

## 2.3 Ordinary least squares (OLS)

We will be using simple linear regression (SLR) to estimate the parameters in question through the OLS method. This is a method where one tries to estimate the size of population parameters using a sample from the population in question. This is done under the assumption that the variables in question have a linear relationship. The regression consists of a dependent variable or explained variable $(y)$ and one or more independent variable(s) or explanatory variable(s) $(x_i)$, in this case the inflation rate and the unemployment rate respectively. The relationship between the explained and explanatory variables in a given population can be formulated as follows:

$$y = \beta_0 + \beta_1 x_1 + \varepsilon \qquad \textit{[Eq. 8]}$$

The equation defines the simple linear regression (SLR) line, which is assumed to hold in the population in question (Wooldridge, 2019). $\beta_0$ is the intercept parameter, or the constant, while $\beta_1$ is the slope parameter, indicating the estimated size of the change in y when x changes by one unit. The variable $\varepsilon$ represents the unobserved variables, the factors other than x that affects y (Wooldridge, 2019a, s. 21).

With the help of OLS we can estimate these variables. This is done by minimizing the sum of squared residuals (SSR), i.e., the variance in the sample. The residual $(\hat{\varepsilon}_i)$ is described as the difference between every observation in the sample and the value the regression line predicts – the distance between the blue sample point and the red line as illustrated in figure 3. I.e., by

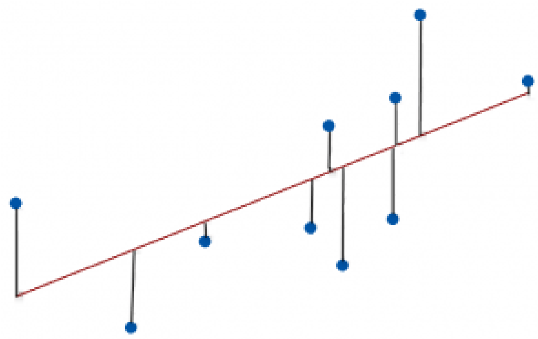

*Figure 3: Residuals and regression line (Frost, 2017)*

looking at the value of each observation in a population sample we can with the help of OLS produce a linear line to estimate the expected effect of a change in some given independent variable, $x_i$, on the dependent variable, $y$. Given this information we can introduce the OLS regression line, or the sample regression function (SRF) (Wooldridge, 2019, p. 28):

$$\hat{y} = \hat{\beta}_0 + \hat{\beta}_1 x \qquad \textit{[Eq. 9]}$$

These variables, with "hats", are estimations of the true population parameters without "hats", that we introduced in equation 8. For these estimators to be unbiased, OLS being unbiased, some assumptions must be fulfilled. The collective term for these assumptions is the *Gauss-Markov assumptions,* for simple regression in this case (Wooldridge, 2019, p. 57):

I. **SLR.1 - Linearity, $\boldsymbol{y = \beta_0 + \beta_1 x_1 + \varepsilon}$**

   Linear in parameters. This assumption is explained through equation 8.

II. **SLR.2 - Random sampling of n, $\{(\boldsymbol{x_i, y_i}): \boldsymbol{i = 1, 2, \dots, n}\}$**

   Random sample of n, pulled from the population model in equation 8.

III. **SLR.3 - Enough variation in x, $\{\boldsymbol{x_i, i = 1, \dots, n}\}$**

   Sample variation in the explanatory variable. The different observations of the independent variable, x, are not all the same value.

IV. **SLR.4 - Zero conditional mean, $\boldsymbol{E(\varepsilon|x) = 0}$, [cov($\boldsymbol{\varepsilon}$,x) = 0]**

   This is a key assumption for the simple regression analysis to have any useful value. It states that the error term, u, has an expected value of zero for any given value of x, the independent variable. I.e., no covariance between the two.

The OLS estimators is unbiased under these assumptions, that is $E(\hat{\beta}_j) = \beta_j$. Although these assumptions guarantee unbiasedness, we'll introduce a fifth assumption to guarantee the most efficient estimator. This assumption states that:

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

   If this assumption is violated, it implies that other estimators are more efficient than this one. This one seeks to explain the variance in the error term, and we want to have a constant error term across all values, denoted $\sigma^2$.

When all of these assumptions are upheld and viable, we are assured that the OLS is the best linear unbiased estimator (BLUEs).

## 2.4 Hypothesis

We will use hypothesis-testing as a method to check whether the results from the OLS gives any information about the real population parameters given some uncertainty-percentage. To examine whether the effect of individual parameters on a dependent variable are significant when the population variance is unknown, we will be using the t-test. This is the relevant test to use in this thesis, because we will be testing single parameters in the population regression function [Eq. 8] (Wooldridge, 2019, p. 120). When performing the hypothesis test, we must state a null hypothesis $H_0$ and an alternative hypothesis $H_A$. The null hypothesis ($H_0$) is the initial hypothesis that is of interest to examine. This is also the basis for whether we reject or fail to reject our hypothesis. The alternative, $H_A$, will be our initial hypothesis, which is contradictory to the null. If the null hypothesis can be rejected, this provides support for the alternative hypothesis. The rejection of $H_0$ is determined by the test statistics (TS) and the critical value. The t statistic, which is used in the t-test, measures the number of standard deviations between the estimator, $\hat{\beta}_j$, and the hypothesized value of $\beta_j$ (Wooldridge, 2019, p. 128). Thus, we get the t statistics as follows:

$$TS = \frac{\hat{\beta}_j - \beta_j}{se(\hat{\beta}_j)} = \frac{(estimate - hypthesized\ value)}{standard\ error}$$

Under the null hypothesis, this t statistic is distributed as $t_{n-k-1}$ (Wooldridge, 2019, p. 128). $n - k - 1$ are the degrees of freedom which is important to know when finding the critical value in the test. $n$ denotes the number of observations, $k$ the number of independent variables, and the 1 represents the constant. Furthermore, a level of significance is required when performing a statistical test. The level of significance affects the critical value, which is the threshold for keeping the null or not, because it expresses the probability of a type 1 error- the probability of rejecting a true null (Wooldridge, 2019, p. 121). Normally, the given symbol for significance level is $\alpha$ and is written in a formula like the following: $\alpha = \Pr(reject\ H_0 | H_0\ is\ true)$ (Thomas, 2005, p. 129).

When performing the hypothesis test, we differ between testing against one-sided and two-sided alternatives. The main difference between the two is how the alternative hypothesis is formulated. In both one-sided and two-sided tests, the null states that the explanatory variable have no effect on the explained variable and is thus formulated as:

$$H_0: \beta_j = 0$$

In the two-sided test the null hypothesis is tested against a two-sided alternative that is formulated as follows:

$$H_A: \beta_j \neq 0$$

When testing for a one-sided alternative, the $H_A$ can be formulated as:

$$H_A: \beta_j < 0$$

We will perform a two-tailed test when testing if there is any significance in our results. This is in line with standard procedures, and it allows us to not only control for negativity in our results, but also testing for positivity.

# 3. Presentation of data

## 3.1 Introduction

To estimate the Norwegian Phillips Curve, we need data on both the Norwegian unemployment rate and inflation. The data on inflation was collected from SSB's Statbank through the consumer price index (CPI), which describes the development in consumer prices for goods and services purchased by private households in Norway (SSB, 2021a). The CPI is based on a defined sample of approximately 650 goods and services and scanner code data as only data source for food, beverages, fuel, and other similar goods (SSB, 2021b). The samples are based on information from the annual household budget survey and branch information. The main method of collecting data are through electronic questionnaires and scanner data. To prevent errors in the questionnaires, the answers are tested with the help of computers. They identify large deviations from previous years and possible duplications. The collected data on consumer price index was used to calculate the inflation. This was done by taking the difference between two subsequent years CPI and then dividing this by the first year's CPI:

$$\pi_t = \frac{CPI_t - CPI_{t-1}}{CPI_{t-1}} \qquad \textit{[Eq. 10]}$$

Thus, we got the percentage increase in the CPI, i.e., the inflation rate ($\pi$). The data provides information about the consumer price index from 1865 to date.

In order to estimate the NAIRU, we must add a variable that denotes the annual change in inflation. The NAIRU is, as explained above, the level of unemployment that gives a constant level of inflation, i.e., the level of unemployment that is compatible with stable inflation. The change in inflation is calculated by finding the difference in inflation between two subsequent years:

$$\Delta\pi_t = \pi_t - \pi_{t-1} \qquad \textit{[Eq. 11]}$$

The data regarding unemployment rate was collected from both SSB and NAV, which are the two main sources of data on unemployment in Norway. We chose both to investigate whether they deviate from each other given the data we use. The unemployment data from SSB is gathered through the Labor Force Survey, which purpose is to provide information on the development in employment and unemployment (SSB, 2021b). The data is collected through surveys such as interview by telephone and provides data on unemployment from 1972 to date. The number of participants each year is approximately 100 000 in total, where 25 000 is reported quarterly with an average dropout rate between 10 and15 percentage points (SSB, 2021b). In cases where it is not possible to contact the observation unit, proxy interviews (asking near family members) are done, which represents 14 to15 percentage points of the interviews (SSB, 2021b). The unemployment data from NAV is registered by the case officer at the NAV office and through self-service on nav.no and covers the period of 1948 to date (NAV, 2021).

## 3.2 Presentation of the dataset

The set consists of different variants of the two variables inflation and unemployment rate, which are used to formulate the Phillips curve, and the change in inflation, which is used to estimate the NAIRU. When estimating the Phillips curve the inflation rate is the explained variable, while unemployment rate is the explanatory variable. In the case of NAIRU, the change in inflation is the explained variable, while unemployment rate is the explanatory variable. The inflation and unemployment variables differ in how and where the data is collected. As well as distinguishing between SSB and NAV data, we have been looking at differences in the coefficient between different time periods. Thus, we made two variables distinguishing between before and after 2001. The distinction is set in 2001 because Norway changed the monetary policy regime from exchange rate targeting to inflation targeting this year. Exchange rate targeting is a way of using monetary policies to stabilize the exchange rate up against another stable exchange rate such as euro or dollars. Inflation targeting, on the other hand, is a management goal where the country or monetary union tries to realize a given yearly inflation rate through the monetary policies (Holden, 2018, p. 282). Norway's monetary policy regime is flexible inflation targeting, which implies that the central bank wants both low and stable inflation and stabile production (Holden, 2018, p. 282).

All the variables on inflation are from SSB through the CPI but differ from each other by the time period they present. *infl* shows the inflation rate for the same time period as we have data on unemployment rate from SSB, 1972 – 2020. *infl_pre* is data on inflation for the period before Norway changed its monetary policy regime from exchange rate targeting to inflation targeting, 1972 – 2000. The variable *infl_post* is the inflation rate in the period after Norway changed its monetary policy regime to inflation targeting, 2001 – 2020. And the variable *infl_change* represents the annual change in the inflation rate. This variable provides data in the period of 1972-2020 to complement the same period of time as the unemployment variables. We want the same number of observations on the different variables when performing the simple linear regression.

The variables on unemployment rate differ both by where it is collected and which time period they display. *unem_ssb* is the unemployment rate from SSB, which gives data in the period 1972 – 2020. *unem_nav* is the data on unemployment from NAV in the same period of 1972 – 2020. The data on unemployment from NAV covers the period of 1948 to date, as mentioned, but the variable will cover the same period as SSB numbers to maximize the basis for comparison between the two. *unem_pre* is the unemployment rate in the period before Norway changed its monetary policy regime to inflation targeting, in SSB numbers, 1972 – 2020. Lastly, *unem_post* is the unemployment rate in the period after Norway changed its monetary policy regime to inflation targeting, in SSB numbers, 2001 – 2020.

SSB has created a Venn diagram (Figure 4) to illustrate how their data compared to the data from NAV is correlated. The model does not consider people who receives unemployment benefits.  We are able to identify that only one third of the people who are registered at NAV is registered in the AKU survey.

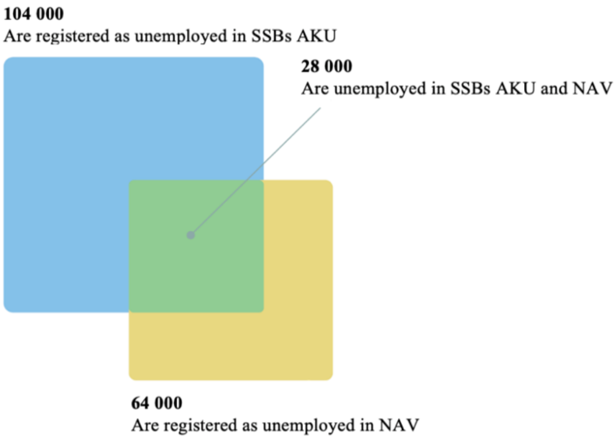

*Figure 4: Unemployment overlap, (SSB, 2021b)*

*Table 1: Overview of variables*

| | |
|---|---|
| ***infl*** | Inflation in the period 1972-2020 |
| ***infl_pre*** | Inflation in the period 1972-2000 |
| ***infl_post*** | Inflation in the period 2001-2020 |
| ***infl_change*** | Annual change in inflation in the period 1972-2020 |
| ***unem_ssb*** | Unemployment rate from SSB in the period 1972-2020 |
| ***unem_nav*** | Unemployment rate from NAV in the period 1972-2020 |
| ***unem_pre*** | Unemployment rate in the period 1972-2000, SSB numbers |
| ***unem_post*** | Unemployment rate in the period 2001-2020, SSB numbers |

## 3.2 Descriptive statistics

*Table 2: Descriptive statistic on inflation, pre and post 2001*

| | Inflation before 2001 | Inflation after 2001 |
|---|---|---|
| **Mean** | 6.117 | 2.004 |
| **Min** | 1.337 | 0.372 |
| **Max** | 13.589 | 3.774 |
| **Standard deviation** | 3.490 | 0.908 |
| **Observations** | 29 | 20 |
| **Median** | 6.345 | 2.138 |

The descriptive statistic shows that there is a difference between the inflation rate in the two time periods. The average inflation rate was approximately 4.1 percentage points higher before 2001, where the recessions of 1970s and 1980s might be one of the explanations (Bergo, 2004). There is also a larger gap between the lowest and largest value in the time period prior to 2001, which was one of the reasons why the inflation targeting policy was introduced (Bergo, 2004). The standard deviation is noticeable lower in the period after 2001, which could be a result of the central bank implementing their strategy of 2.5% inflation over time.

It is also reasonable to have a look at the median when we are analyzing differences in the two periods. The median could give a more accurate representation of the distribution than the mean, because the mean could be exposed to extreme values and therefore give error in the distribution. We see that the median and the mean for both periods are different, but the difference is higher for the period before 2001.

*Table 3: Descriptive statistics*

| Variables | Observations | Mean | Std. Dev. |
|---|---|---|---|
| *Infl* | 49 | 4.438 | 3.406 |
| *infl_pre* | 29 | 6.117 | 3.490 |
| *infl_post* | 20 | 2.004 | .908 |
| *infl_change* | 49 | -0.118 | 1.735 |
| *unem_ssb* | 49 | 3.461 | 1.244 |
| *unem_nav* | 49 | 2.781 | 1.243 |
| *unem_pre* | 29 | 3.217 | 1.494 |
| *unem_post* | 20 | 3.815 | 0.632 |

From the unemployment sample from before 2001 we see that the average unemployment rate is approximately 3,2 percentage points, in contrast to the sample from after 2001 where the average unemployment rate is 3,8 percentage points. From the standard deviation we see that the spread is lower for the mean in the last 20 years, than before, which can be interpreted as a more predictable period for unemployment, but a period with a higher unemployment rate.

*Table 4: Descriptive statistic - NAV and SSB unemployment*

| Variable | unem_ssb (1972-2020) | unem_nav (1972-2020) |
|---|---|---|
| **Mean** | 3.461 | 2.781 |
| **Min** | 1.5 | 0.7 |
| **Max** | 6 | 5.5 |
| **Standard deviation** | 1.244 | 1.243 |
| **Observations** | 49 | 49 |
| **Median** | 3.4 | 2.7 |

As explained earlier we have collected data on unemployment from two sources, NAV and SSB. The SSB data have a mean unemployment rate which is approximately 0,7 percentage points higher than NAV. The data from SSB is obtained by a Labor Force Survey which is measuring the total unemployment in Norway. The NAV data is collected by the number of people who are registered as unemployed or in the need of unemployment benefits from NAV. From SSBs website we could conclude that their data would always give an unemployment rate which is higher than NAV (Sandvik, 2020). The above-mentioned table illustrated that there are differences in the mean between the two samples, which confirm the information from SSBs website. Based on this information we could assume that SSBs data gives us the most accurate data on the total unemployment level.

## 3.3 Critique of Datasets

In the dataset the two samples from SSB and NAV have different types of data on unemployment because of the collection method. This could potentially give an error in the estimate and violate the random sampling assumption, which makes the estimate difficult to generalize an estimation for the whole population. We have therefore chosen to primarily focus our regression model on SSBs data on unemployment, but we are also going to use the NAV data to substantiate our analysis.

Even though our focus will be on SSB, the data may consist of some errors. These errors may be due to discrepancies in the response rate and the use of proxy interviews, which may increase the problems of measurement (SSB, 2021b). As mentioned, the average dropout rate was between 10 and15 percentage points. Jacobsen explains in his book "*Hvordan gjennomføre undersøkelse*" (How to conduct surveys) that as a rule of thumb, a response rate of over 70% can be considered very good (Jacobsen, 2015). This is the case in SSBs unemployment data, which supports the use of this set.

It could be interesting to include more variables on different macroeconomic factors that generate inflation. This could for instance be GDP, import/export, recessions in the world economy and other relevant events or variables. Since we are going to empirically test the Phillips curve, we have chosen to simplify the model and test the basic relationship between inflation and unemployment which is the main variables in the Phillips curve equation.

## 3.4 Summary

Our dataset consists of 147 observed values from 3 different variables in a time series data based on the mean value of unemployment and inflation over a 49-year period in Norway. Therefore, the dataset includes 49 observation units, where one observed unit equals data on the different variables from one year. This gives us a basic, but useful amount of data to test if the data matches the theory of the Phillips curve and if there are any significant differences from the years before and after 2001. We have used two variables, one dependent and one independent to analyze the effects. More variables could be included, but in this thesis, we concluded that two variables are sufficient to test the theory.

# 4. Regression Analysis

## 4.1 Introduction

In this section we are going to perform simple linear regressions based on the ordinary least squares using Stata. We are going to use various measurements in determining both unemployment and inflation, as well as perform a test regarding whether the measured Phillips-curve differ in terms of being prior to 2001 against post 2001. Lastly, we will perform simple linear regressions in order to estimate the Norwegian NAIRU.

We want to examine if there is a clear negative relationship between inflation and unemployment, thus making it a simple linear regression with one dependent variable and one independent variable. This leads to the following equation, introduced in section 2.3:

$$y = \beta_0 + \beta_1 x_1 + \varepsilon \qquad \textit{[Eq. 8]}$$

Throughout all our models our focus will be at the $\beta_1$- parameter because this is the parameter that efficiently describes the relationship between the two variables. It is generally this sign that is of utter interest in our analysis. Furthermore, we will drop the ε parameter in our estimates accordingly with SLR 4.

## 4.2 Models

### 4.2.1 Model 1: Phillips-curve, 1972 – 2020 (unemployment data SSB)

The first model we want to estimate is through our data obtained by SSB. This consists of observations from 1972 – 2020 on both the unemployment rate and inflation. To efficiently measure if there exists a negative relationship between those variables, we are running a simple linear regression and controlling for the measures using hypothesis testing. We are holding inflation as our explained variable and the unemployment rate as our explanatory variable. Thus, the estimated values are as following:

*Table 5: SLR - Phillips-curve, 1972 – 2020 (unemployment data SSB)*

| | (1) |
|---|---|
| VARIABLES | infl |
| | |
| unem_ssb | -1.856*** |
| | (0.294) |
| Constant | 10.86*** |
| | (1.079) |
| | |
| Observations | 49 |
| R-squared | 0.460 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This information gives us the following OLS regression line, relating inflation and unemployment:

$$\widehat{infl} = 10.86 - 1.856unem\_ssb$$

From our regression the sign is evidently of negative character which can be intuitively interpreted as a negative relationship between inflation and unemployment. Although to confirm whether this is due to random values obtained through sampling variability or not, we want to run a straight-forward hypothesis test at a 5% significance level to test whether our intuitive conclusion is viable or not.

Our null and alternative hypothesis are defined as:

$H_0: \beta_{unem\_ssb} = 0$

$H_A: \beta_{unem\_ssb} \neq 0$

Furthermore, we are determining our test statistics as $TS = \frac{\hat{\beta}_j - \beta_j}{se(\hat{\beta}_j)} = \frac{-1.856-0}{0.294} = -6.32$. This value alone is useless without a rejection region, which is given as: |TS| > 2.021 when having a 5% level of significance. The critical value of 2.021 is obtained through the t distribution table given the level of significance, 5%, and degree of freedom, 47 (49-1-1). This implies that we reject our null hypothesis, and we can assume that there is a negative relationship between inflation and unemployment rate. This rejection is further confirmed by the p-value, which states the lowest level of significance at which the null hypothesis is rejected (Wooldridge, 2019, p. 130). In this case the p-value is equal to .000, i.e., the probability of observing a TS as extreme as we did if the null hypothesis was true is approximately 0%. Thus, we have evidence that there is a negative relationship through the simple linear regression, which states that when unemployment is increased by 1 percentage point, the expected decrease in inflation is measured to be 1.856 percentage point, ceteris paribus.

### 4.2.2 Model 2: Phillips-curve, 1972 – 2020 (unemployment data NAV)

In this second model we want to estimate the curve by using our data obtained by NAV. This data consists of observations on unemployment and inflation data from 1972 – 2020. We will run the same simple linear regression as previously, controlling the measures using hypothesis testing to efficiently conclude if there exist a negative relationship between the variables. The main point with this model is to obtain information about how the numbers compare to the one from model 1. This estimated beta-coefficients will be:

*Table 6: SLR – Phillips-curve, 1972 – 2020 (unemployment data NAV)*

| VARIABLES | (1)<br>infl |
|---|---|
| unem_nav | -1.581*** |
| | (0.326) |
| Constant | 8.836*** |
| | (0.993) |
| Observations | 49 |
| R-squared | 0.333 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This information gives us the following OLS regression line:

$$\widehat{infl} = 8.836 - 1.581 unem\_nav$$

A quick overview of the $\beta_1$- parameter again confirms our hypothesis about there being an inverse relationship between the two variables. To check if the results are valid, we are going to use the same method as in the first model, with a 5% significance level. Again, we get the following two-tailed test hypothesis:

$H_0: \beta_{unem\_nav} = 0$

$H_A: \beta_{unem\_nav} \neq 0$

The test statistics is determined the same way as earlier: $TS = \frac{\hat{\beta}_j - \beta_j}{se(\hat{\beta}_j)} = \frac{-0.963}{0.297} = -3.24$. Given a 5% significance level, the rejection region is formulated as: $|TS| > 2.021$. This is the same critical value as previously with a degree of freedom of 47. The p-value in this regression is also given as .000, so that we are going to reject our null hypothesis for any significance level. We reject the null hypothesis and get the same conclusion as the first model. However, the results indicates that the expected decrease in inflation following an increase in unemployment is lower given the NAV numbers. I.e., the curve is steeper given SSB numbers, compared to NAV. This is also illustrated in the appendix.

### 4.2.3 Model 3: Phillips-curve, 1972 – 2000 (unemployment data SSB)

Following from our previous deviations about NAV and SSB data, it is evidently a clear inverse relationship regarding inflation and unemployment. We also want to test whether there is any significant difference between the various monetary policies on the Phillips curve, and we are going to test on both before 2001 when there was an exchange rate focused central bank, and after 2001 when they changed towards an inflation targeted monetary policy.

This time around, we are going to utilize the data obtained by SSB prior to 2001 and compare them to post 2001, accordingly with the derivation about our data. This is done by the same method as when we were regressing the first two models. This time around, we are using the data by limiting the observations from 1972 – 2000. This is to show how the beta coefficient was in the time of stable exchange rate. When running a new regression with inflation from 1972 – 2000 as an explained variable and data of unemployment from 1972 – 2000 as an explanatory variable, we are obtaining the following values for the beta coefficients:

*Table 7: SLR - Phillips-curve, 1972 – 2000 (unemployment data SSB)*

| VARIABLES | (1)<br>infl_pre |
|---|---|
| unem_pre | -1.740*** |
| | (0.300) |
| Constant | 11.71*** |
| | (1.061) |
| Observations | 29 |
| R-squared | 0.554 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This gives the following estimates on a simple linear model:

$$\widehat{infl\_pre} = 11.71 - 1.74unem\_pre$$

Again, we want to confirm if this result is feasible by performing a hypothesis test with the same null and alternative hypothesis, as well as the same formula as in our other derivations in obtaining test statistics. This gives the following null and alternative hypothesis:

$H_0: \beta_{unem\_pre} = 0$

$H_A: \beta_{unem\_pre} \neq 0$

And for test statistics:

$$TS = \frac{\hat{\beta}_j - \beta_j}{se(\hat{\beta}_j)} = \frac{-1.74 - 0}{0.3} = -5.8$$

We are defining our rejection region based on the degrees of freedom and significance level, so that our rejection region is given as: $|TS| > 2.052$. This is given a 5% significance level and 27 degrees of freedom. The reported p-value in this case is also .000, meaning we can be close to certain that there is a relationship between the two variables. This again leads us to reject the null hypothesis as before, and we may again assume that there exists a negative relationship between inflation and unemployment in the period of 1972 – 2000, ceteris paribus.

#### 4.2.4 Model 4: Phillips-curve, 2001 – 2020 (unemployment data SSB)

Model 4 is probably the most relevant model today, as it accounts for the latest 20 years. This is aiming to measure if there was any significant change in the relationship between inflation and unemployment due to the change of the Norwegian central bank's monetary policy. This time around, we are measuring the data from 2001 – 2020 on both inflation and on our obtained values of unemployment rate from SSB. Again, we are using inflation as our dependent variable while we want to have unemployment rate as our independent variable. This gives us the following values on the beta coefficients:

*Table 8: SLR - Phillips-curve, 2001 – 2020 (unemployment data SSB)*

| VARIABLES | (1)<br>infl_post |
|---|---|
| unem_post | -0.0131 |
| | (0.339) |
| Constant | 2.054 |
| | (1.309) |
| Observations | 20 |
| R-squared | 0.000 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Our immediate interpretation of this estimate is that there is a significant change in terms of the relationship between unemployment and inflation. The estimated values on $\beta_1$ and the intercept $\beta_0$:

$$\widehat{infl\_post} = 2.054 - 0.0131 unem\_post$$

Once more, we want to test our results by using hypothesis test as done earlier with a 5% significance level and the same defined null and alternative hypothesis. This gives the following rejection region with 20 observations: |TS| > 2.101. Our test statistics is then computed and valued as -0.04. This time our test statistics fall within our rejection region, so that we fail to reject our null hypothesis, and we cannot conclude that there is a clear negative relationship between inflation and unemployment anymore. This time around, a p-value of 0.97 does not confirm a clear negative relationship but is still accordingly with our conclusions through hypothesis testing. It states that we are 97% confident that there is a non-existent relationship ($\beta = 0$) in this case.

### 4.2.5 Model 5: Estimating the NAIRU, 1972 – 2020 (unemployment data SSB)

Through this model we will estimate the Norwegian NAIRU, by estimating the expected change in the variable $\Delta\pi_t$ following a given change in the unemployment rate. We will perform the regression in both SSB and NAV numbers. This model will consist of unemployment data collected from SSB. Thus, the variables *infl_change* and *unem_ssb* is the explained and explanatory variables. This gives us the following estimated values:

*Table 9: SLR - NAIRU, 1972 – 2020 (unemployment data SSB)*

| | (1) |
|---|---|
| VARIABLES | infl_change |
| | |
| unem_ssb | -0.289 |
| | (0.199) |
| Constant | 0.881 |
| | (0.731) |
| | |
| Observations | 49 |
| R-squared | 0.043 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This gives the following estimates of a simple linear model:

$$\widehat{infl\_change} = 0.881 - 0.289 unem\_ssb$$

The model implies that the expected change in the explained variable ($\Delta\pi_t$) due to one percentage point increase in the unemployment rate is equal to -0.289, ceteris paribus. Using the information obtained from the SLR we can calculate the NAIRU by solving the SLR equation above with respect to the variable *unem_ssb*, setting $\widehat{infl\_change}$ equal to 0. This way we get the unemployment rate that corresponds to a stable or constant level of inflation, i.e., the NAIRU. Hence, we will use the following equation:

$$\Delta\pi_t = a_0 + a_1 u_t \qquad \textit{[Eq. 12]}$$

Setting the change in inflation ($\Delta\pi_t$) equal to 0 and implementing the values estimated from model 5 we thus get:

(1) $$0 = 0.881 - 0.289 u_n$$

Solving with respect to the unemployment variable, we get the NAIRU ($u_n$):

(2) $$0.289 u_n = 0.881$$

(3) $$u_n = \frac{0.881}{0.289}$$

(4) $$u_n = 3.048\ \%$$

Following this information, we can say that the Norwegian NAIRU equals approximately 3.05 percentage points. I.e., the unemployment rate at which the inflation is constant, equals 3.05%. However, to decide whether these results are significant or not we have to perform a hypothesis test on the results provided in table 9.

The null and alternative hypothesis are in this case defined as the following:

$H_0: \beta_{unem\_ssb} = 0$

$H_A: \beta_{unem\_ssb} \neq 0$

Given a 5% level of significance and 47 degrees of freedom we obtain the critical value, 2.012, and thus the rejection region |TS| > 2.012. The test statistical equals -1.45, so that we are failing to reject the null hypothesis. That is, we don't have enough evidence to conclude with the calculated NAIRU at a 5% level of significance. From the SLR done in Stata we get that the p-value is equal to 0.154 for the beta ($\beta_{unem\_ssb}$). Thus, we have that the probability of observing a TS as extreme as we did if null is true equals 15.4%. Meaning there is a 15.4% probability that the null hypothesis, which states no relationship between the explained and explanatory variable, is correct.

### 4.2.6 Model 6: Estimating the NAIRU, 1972 – 2020 (unemployment data NAV)

Lastly, we will again try to estimate the Norwegian NAIRU using unemployment data from NAV. The main reasons to perform the same regression with two different data sets on unemployment, is to compare the result and possibly strengthening the conclusion, and of course to see if this regression provides any significant results. Using *infl_change* as the explained variable and *unem_nav* as the explanatory variable we get the following values through the SLR:

*Table 10: SLR - NAIRU, 1972 – 2020 (unemployment data NAV)*

| VARIABLES | (1)<br>infl_change |
|---|---|
| unem_nav | -0.386* |
| | (0.196) |
| Constant | 0.955 |
| | (0.595) |
| Observations | 49 |
| R-squared | 0.076 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This information gives us the following OLS regression line:

$$\widehat{infl\_change} = 0.955 - 0.386unem\_nav$$

This estimate states that as the unemployment rate is increased by 1 percentage point, the average expected change in the dependent variable ($\Delta\pi_t$) is $-0.386$. Furthermore, in line with the same derivation as introduced in model 5 to compute the NAIRU, we're obtaining the following values:

(1) $$0 = 0.955 - 0.386u_n$$

Solving this equation with respect to the unemployment variable, we're getting the following natural rate of unemployment ($u_n$):

(2) $$0.386u_n = 0.955$$

(3) $$u_n = \frac{0.955}{0.386}$$

(4) $$u_n = 2.47\%$$

We also want to control for a 5% significance level in accordance with our other models, which states the following null and alternative hypothesis:

$H_0$: $\beta_{unem\_nav} = 0$

$H_A$: $\beta_{unem\_nav} \neq 0$

Given that our degrees of freedom are still 47, as well as keeping our significance level at 5%, our rejection region is still determined as |TS| > 2.012. The test statistics is equal to $-1.97$, which states that we're failing to reject our null hypothesis. Although there's not a lot of clearance in our test statistics, it's marginally enough to fail to reject our null hypothesis. This is also in line with the stated p-value from our regression, as it is valued at 0.055. This states that with a 10% significance level, we're actually getting a significant result.

## 4.3 Results

Firstly, we are observing a clear negative relationship between inflation and unemployment. This is measured by using data regarding the period between 1972 and 2020. We are also observing some variation on our beta parameters of our two datasets, although they do not change in comprehension with our research question. This is in line with our expectations as there are also differences in the data between the two, as mentioned in the section regarding data. To avoid running a false conclusion because of sampling variability, we ran a straightforward hypothesis test. This further confirmed our intuitive conclusion about the estimated beta coefficient, and they also presented quite some clearances following our given

5% significance level. Given our data sets and statistical methods, we can make a unilateral conclusion that there exists an inverse relationship between inflation and unemployment in the Norwegian labor market.

In terms of the second part of our research question, we are observing two various effects on the Phillips curve. Prior to 2001, i.e., 1972 – 2000, gave us the expected results following the results obtained in model 1 and 2, as well as the generally accepted theory about the Phillips curve, which depicts a clear inverse relationship between inflation and unemployment.

The second and most recent period on the other hand gave us an unexpected result, where we discovered that there is no clear empirical evidence regarding an inverse relationship between inflation and unemployment. Our regression analysis gives a relationship at approximately 0, and the deviation from 0 was specified as not significant to conclude a negative relationship following our hypothesis testing.

We have illustrated our measurements graphically in the appendix. The two first models are presented combined in figure 6 to show how they both state a clear negative relationship. We want to clarify that there is also some deviation in the two models, but nothing alarming that changes our conclusion. The last two models are shown in the same graph in figure 5 to clearly show the differences in our two measurements. This augmented insight shows how the Phillips curve has been flattening after 2001.

Lastly, we estimated the Norwegian NAIRU to equal approximately 3.05% given SSB numbers on unemployment. However, we did not have enough evidence to reject the null hypothesis at a 5% level of significance. The data could not estimate a clear significance relationship between the variable change in inflation and unemployment, thus preventing us from rejecting the null and estimating the size of the NAIRU. Furthermore, the regression using NAV numbers on unemployment estimated the NAIRU to equal 2.47%. These results could also not provide enough evidence to reject the null at a 5% level of significance. However, the p-value of the beta ($\beta_{unem\_nav}$) presented in model 6 was equal to 0.055. This indicates that we can reject the null given a 10% level of significance. In addition, the fact that the two results provide a NAIRU somewhat close to each other, strengthens the conclusion of the Norwegian NAIRU being close to these results (2.5 – 3%).

# 5. Discussion and conclusion

## 5.1 Discussion

The most critical weakness of these estimated models is the assumptions on which these models is based upon. Especially the SLR 4, which states that our independent variable can't have any correlation with the error term is highly unreasonable. This is primarily based on other factors that may influence the unemployment rate, such as economy, corona or mismatch between available labor and demanded labor, to mention some. We also know that random sampling is not possible with times series data, as we must fix them in a chronological order. Enlightened by the weaknesses of the assumptions which has been made, the results should be interpreted with a hint of skepsis.

Because our results were generally accordingly with our expectations, we want to focus mainly on the flattening of the Phillips curve that is derived from the results obtained in model 4: Post 2001.

The reason for this may be a nexus of various forces, but economists have contrasting opinions regarding this change in the Phillips curve. We will present some various theories on why the Phillips curve has been flattening out in recent years to present some further options on further reading regarding this subject.

Firstly, some economists are arguing that the increasing degree of globalization is the main pulling force for the flattening of the Phillips curve. Iakova (2007) argues that the flattening of the Phillips curve may be the result of three different forces following the increased globalization. She states that it may be partly because local industries have less availability to increase their prices due to an increased competition within the same market from foreign industries. She also argues that it may be due to the availability to goods and prices, so that their elasticity is less sensitive to demand shocks, resulting in lower price increase due to demand. The last reason, she argues, is due to labor mobility across borders, so that a lack of labor force is decreasing as a factor for wage growth (Iakova, 2007).

According to the Economist, there is generally three other theories about why the Phillips curve has been flattening in recent years (The Economist, 2019). All three of the theories should be viewed as having limited reliability as they all possess certain flaws and in terms of acceptance by economists. The first one is derived from Goodhart's law, which states that when statistical relationships are exploited and used as an active tool, they seize to exist. This is further substantiated by McLeay and Tenreyro in their working paper on behalf of the Bank of England (McLeay & Tenreyro, 2019).

Another reasonable explanation presented is based upon a change in expectations regarding the inflation. It is argued that as the Central Banks with inflation target have gradually earned more credibility in their ability to control the inflation through good monetary policy (Iakova, 2007). This again leads to a more constant expectation towards inflation, and wage negotiation and price settings are less vulnerable to short-term fluctuations in the inflation.

The last explanation according to the Economist is that the Phillips curve still exists, but it is non-linear (The Economist, 2019). The main argument is that there exists a threshold where inflation will skyrocket should the unemployment rate reach a certain point. This may have various shapes, but either an asymptotic or a negative exponential function is most likely to be close to the true shape of the Phillips curve according to this theory, alike the one illustrated in figure 1.

## 5.2 Conclusion

In accordance with our findings, there was a clear difference in the results depending on whether the Central Bank targeted inflation or not. This suggests that it’s reasonable to assume that a stable inflation rate is part of the explanation of why the Phillips curve has been flattening out. This is further supported by the assumption that the inflation target has gradually gained realistic expectations towards the inflation target. Nevertheless, further testing with more variables is needed to determine the significance of this implication. Regarding the estimation of the NAIRU, the data could not provide any significant results. However, both the regressions using SSB, and NAV data presented a NAIRU in the same order of magnitude which strengthens the theory of the Norwegian NAIRU being somewhat close to the interval of 2.5 – 3 %.

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# Appendix

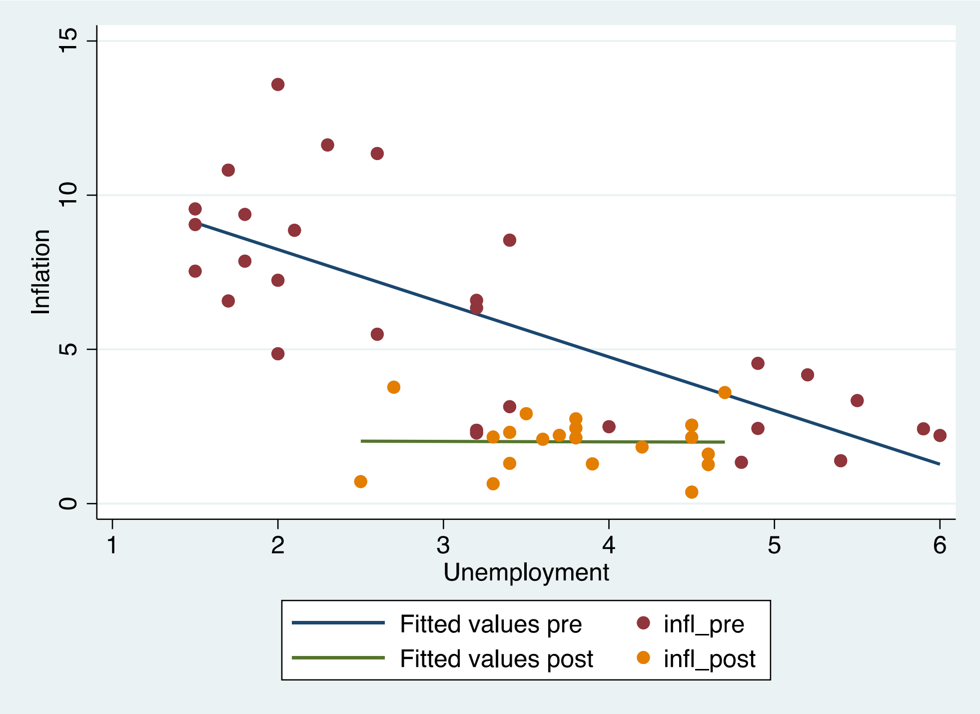


*Figure 5: Comparison SLR pre and post 2001*

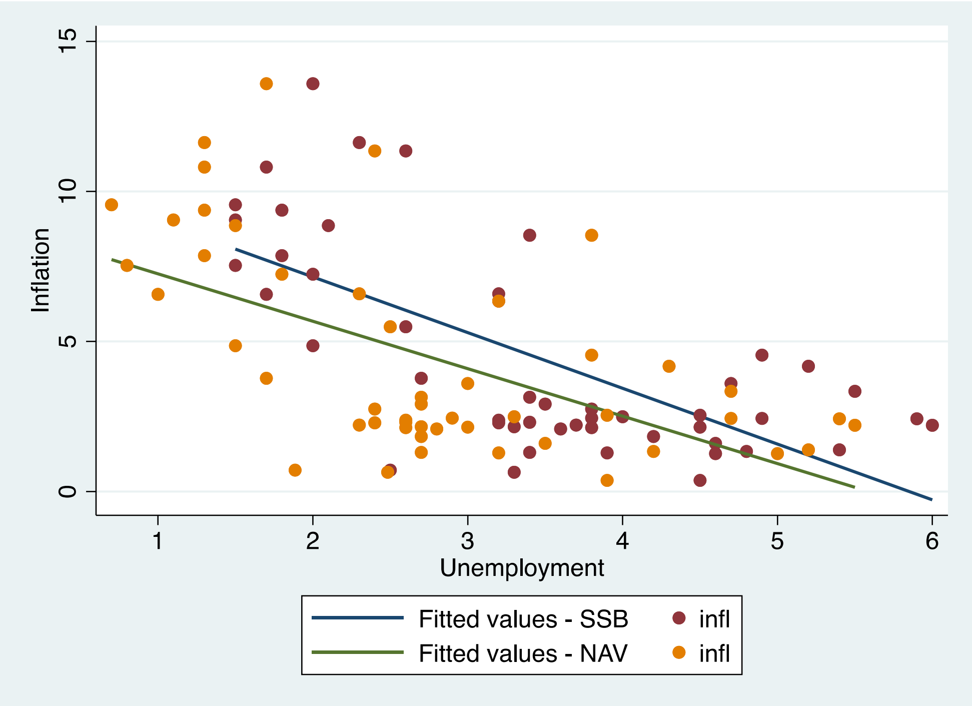


*Figure 6: Comparison SLR NAV and SSB*

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