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Analysing the relationship between unemployment rate, inflation rate, and the effect they have on gross domestic product in the United Kingdom (1990-2023)

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# Analysing the Relationship between Unemployment Rate, Inflation Rate, and the Effect they have on Gross Domestic Product in the United Kingdom (1990-2023)

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**Economics and Econometrics Research Institute** Avenue Louise 1050 Brussels Belgium

Tel: +32 2271 9482 Fax: +32 2271 9480 www.eeri.eu

# Analysing the Relationship between Unemployment Rate, Inflation Rate, and the Effect they have on Gross Domestic Product in the United Kingdom (1990-2023)

Lachezar Pavlov, MSc Economics and Finance Students, University of Lincoln, UK. E-mail: 25984338@students.lincoln.ac.uk Aleksandar Vasilev, Senior Lecturer, University of Lincoln, UK. E-mail:

avasilev@lincoln.ac.uk (Corresponding author)

### Abstract

This paper examines the relationship between unemployment rate, inflation rate and economic output in Britain over 34 years. It utilizes a range of different time series techniques, including the ADF and PP unit root test, the autoregressive distributed lag model to cointegration (ARDL model). The modelling provides some useful insights on both the long-run and short-run relationship between the variables. The following results have been produced: The unemployment time series bound test has shown to be inconclusive regarding a long-run relation, while the CPI bounds test showed to have a long-run relation with the other variables, and the bounds test for output showed only a short-run relation. The results in this paper are useful for further development and understanding of the topic and the dynamic interactions on a macroeconomic level.

Keywords: unemployment rate, inflation rate, output, bounds test, ARDL model

JEL Classification: E10, C51

## 1 - Introduction

The scientific field of economics is split in two major categories: macroeconomics and microeconomics. Microeconomics looks at economics on the small scale, analysing firms and individuals, and their behaviour. On the other hand, macroeconomics studies indicators, such as gross domestic product, the growth of the economy, and nationwide economic decision making (Rodrigo, 2022). The main goal for every government is to maximise economic welfare for its population. There are many ways of achieving this, but one key to do it is by making policies which are minimising cyclical unemployment within the country and therefore increasing economic output. This specific type of unemployment is one of the key indicators which shows the state of an economy because it is directly linked to aggregate demand and the business cycles (The Economic Times, 2019). As a result of this, it shows that there is a waste of one of the factors of production in the economy, i.e. labour. Therefore, there is a loss of economic welfare, which decreases the quality of life of the population. The understanding of how to control unemployment level is a key objective for central banks around the world. The idea that monetary and real-life economics can be combined to achieve a degree of control over unemployment is crucial for policy makers. The first theory to suggest that such a feat is possible is the Phillips curve. It describes a non-linear, inverse relationship between inflation rate and the unemployment rate. Therefore, an increase in inflation would lead to a decrease in unemployment and vice-versa, and through appropriate use of monetary policy, i.e. increase or decrease of the money supply in the economy, lower rate of unemployment could be achieved. However, since the first paper demonstrating the relationship between the two was published criticisms regarding the assumptions made have occurred. It is difficult to detect the non-linear, inverse relationship in the United Kingdom. And so, the split between economists whether this theoretical relationship is real has been a topic of discussion for decades. There are some economists who believe that in the short-run the theory is valid, but it fails to hold in the longrun (Gordon, 1997). There are other economists who believe that the relationship between the two macroeconomic indicators is positive (Galí and Monacelli, 2002). Whatever the case may be, the theory has certain caused a split in the conclusions to be drawn from it.

The main purpose of this empirical research is to analyse the relationship between unemployment rate, inflation rate and economic output in a developed country (the United Kingdom was chosen for this paper). The research will use various econometrics tools to tackle the problem with the short-run and long-run problems presented earlier. The goal is to identify how these 3 macroeconomic variables interact with each other over a 34-year period of time (from 1990-2023) in the United Kingdom. With one of the largest economies and population on the European continent, it is important to know whether a change in one would cause a change in the others because if misinformation is presented, the loss of economic welfare would be severe. This is useful information because by controlling one of the variables the others might see a change as well, giving central banks and policy makers more control over the economic well-being of the nation. A more informed central bank means more informed decision making regarding new monetary policy making, leading to less waste of scarce resources and an overall decrease of opportunity cost.

This study has several elements that are included to provide sufficient informational scope available on the topic. Therefore, the first section is the literature review. A section of the study where relevant publications regarding the topic have been published over time. Their relevance is highlighted in the literature review. The part following the literature review is the methodology, where the econometrics side of the research is explained. There the reasoning for using certain statistical tools is provided, with their relevance to the research highlighted. After the explanation of the statistical methods, the results of the research will be provided in an easily readable format. Interpretations regarding the figures will be in that section, along their meanings. Lastly, the paper will conclude with its conclusion, and what can be taken away from it (the relevance of the results), and potentially be applied in the real world.

#### 2 - Literature Review

#### 2.1 – Keynesian Model

The roots of the complex and dynamic relationship between unemployment rate, inflation rate and the gross domestic product can be traced back to 1934 to Cambridge, United Kingdom. This is where John Keynes developed his famous Keynesian model, and the so-called "Keynesian Revolution" began. Up until that point, the field of economics had not been taken over so rapidly by another model. However, it is important to understand why the roots of the relationship between these macroeconomic variables is traced back to this specific year and economist. The 1930s saw many countries experience great unemployment rates, and there was no real explanation presented by classical economists for that phenomenon (Blaug, 2013, pp.641–651). The original purpose for the model was to attempt to understand the Great Depression experienced in 1929. The main idea of the model is that when a deep recession is experienced, government intervention is required to help boost the economy and help stimulate aggregate demand through increase in government spending. This is because the main idea of the theory is that aggregate demand is made out of 3 components, with those 3 components being the sum of the following factors: household, business, and government spending (Jahan, Saber Mahmud and Papageorgiou, 2014). The increase in any of them would lead to an increase in the aggregate demand, which is what Keynes presented as the most important goal. However, during a heavy economic downturn, all of these factors are severely affected, which is where, he argued, that government spending is the best way boost aggregate demand and shift it back to full capacity. This is where the first link between unemployment and actual output was made, however the role of changing prices came later on as more theories were developed as a result of the Keynes argument.

#### 2.2 – The Phillips Curve

As discussed in the previous section, the Keynesian model (1934), was gaining popularity in the economics space, however, an issue Keynesians were facing was the fact that the model could not be fully closed because of the assumption of the of lack of rigidity in wages due to the Keynes and Pigou affects which would occur (Mair and Miller, 1991). This changed in 1958. The first introduction of an empirical study that showed the relationship between unemployment and inflation rate was the paper published by Australian born neo-Keynesian economist William A. Phillips in 1958, titled "The Relation Between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861–1957". The paper investigated how wage rates and unemployment are related in the British economy over nearly the span of century; the conclusion the paper came to was that there was an inverse, non-linear relationship between the two macro-economic variables (Phillips, 1958). Although the paper showed the before mentioned relationship between the two for over a century, William Phillips did not proceed with this particular subject further. His original paper did not provide more than the empirical study, and he never followed up on the research, and instead he focused on other economic problems he was interested in. The original equation which William Phillips used for the curve can be seen in figure 1 below.

# Figure 1: $\pi_t = \sum_{i\geq 1} \gamma_i \pi_{t-i} - \beta u_t$ ,

where  $\pi_t$  is the wage rate, and  $u_t$  is the unemployment level.

However, it did not take long for other economists to notice Phillips' study, and many others would follow up on it with more additions to the original study being added. Shortly after William Phillips' publication in 1958, Richard Lipsey published a follow up of the study. The new extended paper added new context to the original publication. With further analysis on the two variables, Lipsey provided an explanation for the non-linearity of the relation. He did this by introducing by introducing a "dynamic hypothesis that the rate at which w changes is related to the excess demand, and specifically, the greater is the proportionate disequilibrium, the more rapidly will wages be changing" (Lipsey, 1960). And thus, the following equation for the excess demand was shown,  $\dot{w} = \alpha \left(\frac{d-s}{s}, 100\right)$ . Lipsey then followed this up by saying that when s is equal to d, all of the people who want to work can do so at the current wage rate. However, that also meant that even at that rate, there was still frictional unemployment present. Lipsey provided the further explanation based on the Phillips publication. Meanwhile, also in 1960, Paul Samuelson and Robert Solow were working on a paper that focused on the relation between the two as well, but there was a difference on their approach of their paper, it was not a quantitative approach. Their paper called "Analytical Aspects of Anti-Inflation Policy" provided a more theoretical view of the issue between the two indicators and their dynamic relationship. Firstly, nowadays the Phillips curve is not about the wage rates and unemployment levels, but it is about the inflation rate and unemployment levels. As discussed before, the original publication by Phillips focused on wage rate, but the reason why today inflation is used instead is because of the Samuelson and Solow paper published in 1960. They focused on literature related to the topic that was published in the previous 2 decades; they distinguished the difference between the types of inflation (cost-push and demand-pull) and their possible reasons for occurring such as monetary expansion or excess aggregate demand in Keynesian terms. Their focus was not the United Kingdom, and they focused on the United States' economy using the Phillips findings in their paper (Hoover, 2014). While the Samuelson and Solow paper did not use the quantitative research as the previous two publications, their paper solidified the position of the Phillips paper, and popularise the use of it in the next decade by policy makers, as in, policy makers would lean more on inflation manipulating policies to attempt control unemployment levels. It also laid the foundations for later research for the relation between unemployment and inflation in the United States.

To understand the next additions to the Phillips curve and the relevance of them, it is important to consider the economic climate in the late 1950s and the 1960s. It was only 15 years post World War II, the Cold War was heating up, and the British economy was experiencing the political turmoil around the globe. Throughout the entire decade, Britain, and other developed economies, were experiencing rapid growth in GDP, accompanied by flattened period of GDP growth, and policy makers had to change their approach to better suit the new problems their economies were facing (Weston, 2024). The next major additions to this field of study were introduced later on in the decade. This is because when the initial paper came out, economies were experiencing the exact same phenomena as the curve highlighted. Thus, policy makers had a reason to believe in the highlighted relation between the two, and therefore, it was a popular belief that through the manipulation of one of those variables, the other would follow what the theory had suggested. However, as the 1960s progressed, and policy makers were expecting to control one of the variables through influencing the other one, the actual outcome was not the anticipated one. Instead, an occurrence called stagflation was present. Stagflation is seen when an economy is experiencing both high levels of unemployment and inflation, but with little or no economic growth (Jackson, 2022). This caused policy makers to change their views on how to control the economy and consider other ways of promoting economic prosperity; opting out for a long-term neutrality became more popular among economists and policy makers (Gordon, 2008).8 years after the Samuelson and Solow paper, Milton Friedman published his work titled "The Role of Monetary Policy", which suggested that there are other indicators to account for when governments try to reach economic prosperity. He critiqued previous publications for their lack of regard for monetary policy; stating that even though economists agree that an increase in economic welfare is the goal, there is a disagreement whether all of the government objectives are compatible, "There is less agreement that these goals are mutually compatible or, among those who regard them as incompatible, about the terms at which they can and should be substituted for one another" (Friedman, 1968). This is when he introduced the new augmented Phillips' curve, the idea that there was a variable that was not accounted for, which was the speed at which expectation change,  $p = g(U) + bp^{e}$ . The new variable can be seen in the equation, b being the speed of change.

Edmund Phelps arrived at the conclusion that a new Phillips curve was needed to account for the expected inflation, and he added expectations to the original theory. The 70s proved to be the end of the times of an inverse relationship between inflation and unemployment rates, as nations were experiencing stagflation. This led to more papers being published which attempted to explain the existence of high unemployment and inflation. In 1975, it was shown that the Friedman-Lucas model was flawed; the theory was unable to account for a multi-year business cycle, which meant that it was the end for expectational error being a factor in the business cycle. Additionally, there was no empirical studies that followed up the model, and therefore there was no significant evidence of it (Gordon, 2008). By the time of the 1980s, it was a popular belief that there were many issues surrounding the expectations-augmented Phillips curve as it broke down in the 70s. As a result of this, new ways of looking into the Phillips Curve emerged. A key method that was developed was the Calvo Fairy method, developed by Guillermo Calvo in 1983. This method states that a fraction of firms is able to change their price optimally in each time period, whereas the rest of the firms in the market have to stick with their prices (Calvo, 1983). By looking at the firms' behaviour/choices, that can change their price, the New Keynesian Phillips Curve can be obtained. Many economists agree the curve captures the complex dynamics between inflation and unemployment, and all of the other factors that have been added to the original Phillips' curve. In 1999, Gali and Getler proposed the following model which prompts the idea inflation's potential source could be slow the response of marginal costs to output. (Galí and Gertler, 1999). Combining the pricing behaviour from the Calvo method, and the previously discussed backward and forward pricing firms in a competitive market, the NKPC is formed.

#### 2.3 – Okun's Law

Another theory that is related to two of the investigated variables is Okun's law. The law was developed by economist Arthur Okun in 1962, just 4 years after the paper by William Phillips was published. The article he published highlighted the empirical relation between the level of unemployment and real output. He discovered that a 1% decrease in GDP growth, is accompanied by 0.3% increase in unemployment (Foroni and Furlanetto, 2022). However, since the original article, there have been many studies that have attempted to provide further detail into the relation between the two. The first notable contribution to the theory was made by Robert Gordon. His research titled "Unemployment, Inflation, and the NAIRU", was the first one to highlight the importance of optimising the level of unemployment rate, or at least the point at which low levels of unemployment begin to impact vital economic indicators such as inflation. This is done by introducing the non-accelerating inflation rate of unemployment. This is the point at which the levels of unemployment begin to show the spare capacity in an economy and linking this back to the Keynesian model introduced back in 1934, this is the gap

between maximum output and current output, which in section 2.1 was shown to be the cyclical type of unemployment (Reserve Bank of Australia, 2023). By indicating such a point exists, policy makers have more information available to them to increase the probability of keeping inflation in a stable state, but also reducing the loss of economic welfare by decreasing unemployment.

Another significant addition to the empirical side of the theory is the paper published in 2015 by Regis Barnichon and Andrew Figura titled "Labor Market Heterogeneity and the Aggregate Matching Function". This is significant because it is one of the newer study regarding the United States, and provides updated view of the labor force, in specific, how newer demographics have different views on employment. They found that in the United State, there was a decrease in the motivation to work, with the population being less interested in being fully employed (Barnichon and Figura, 2015). This could change key assumptions economists make to model and make policies regarding the economy. By a decreased rate of participation, the dynamics between gross domestic growth, inflation and unemployment become harder to identify. This also reduces the notion of causality between the three, leading to changes in behavioural economics, and the foundations of policy making.

## 3 - Overview of the British Economy

#### 3.1 – United Kingdom (1990-2000)

The beginning of the 1990s were plagued with political turmoil and instability for the United Kingdom. 1990 marked the beginning of the Gulf War, a conflict which lasted a year, but it resulted in the largest deployment of British troops since World War II (National Army Museum, 2014). As a result of this, the British economy suffered with periods of inconsistent or negative output growth. For example, at the start of the recession in Q1 1990, the economic output growth (as a percentage), was 0.5%, followed by 0.7% in Q2, however, for the next 5 consecutive quarters, output growth declined to its lowest of -1.1% in Q3 in 1990 (ONS, 2022). Unemployment rate was not unaffected either, with it being 6.9% in Q1 of 1990, but it increased to a decade high of 10.6% in the next 3 years (a small example of the lag time needed to be considered when dealing with macroeconomic modelling) (ONS, 2022). The consumer price index indicated an increase in inflation, from 6.1% at the start of Q1 in 1990, to a decade high of 9.2% (ONS, 2022). Even though a recession and a war were occurring, the UK economy began to recover later on in the decade, and key changes to sectors were introduced. The first

big change was the announcement of an independent Bank of England on 6 May 1997. This gave the Bank of England independence from the government regarding monetary policy changes. This meant the government could not interfere with the BoE decision policy making.

Another big change which happened in the 90s was the rapid decline in trade union participation in most developed economies, including the UK. Trade unions saw a decline of 2.1 million members, from 9.9 million at the beginning of the decade in 1990, to 7.8 million in 1998. This can be attributed to many factors, such as the passing of new laws back in the 80s, to a shift from manufacturing economy to a service economy. This is an important change which effects the Phillips' curve. With a decline in trade union members, trade unions begin to lose their bargaining power over employers, which means negotiating new wages and conditions for workers becomes less effective. Instead, potential future employees can begin to negotiate with employers, meaning conclusion to negotiations can be reached quicker, which would reduce the time for people to get into their new positions. Therefore, the speed at which workers change employment reduces, potentially effecting the expectation-augmented Phillips curve.

#### 3.2 – United Kingdom (2000-2010)

The early part of the decade was prosperous, with stable inflation, constant GDP growth and relatively low levels of unemployment. The British economy experienced a period of sustained growth between 1997 to 2008. GDP growth at the start of Q1 in 2000 was 1.2%, and it remained positive until Q1 of 2008, so most of the decade saw the economy grow at a stable rate. The other measures remained stable too, with unemployment being 5.8% in Q1 in 2000, and it remained between 4% to 6% range in the 8-year period to 2008. The consumer price index shows that inflation in the first quarter of 2000 was 1.1%, and it remained below the 2% benchmark until the second quarter of 2005. After that, the index stayed above the 2%, and it reached a peak of 4.5% during the economic crisis in 2008. However, the end of the decade was a catastrophic one for the British economy, which also marked the end of the economic growth experienced over the last 11 years. At the beginning of 2008, the world entered deep economic turmoil, including the UK, as a result of years of decreased financial regulation was present in the banking and financial sectors. The number of risky loans, especially mortgages, were increasing. This all resulted in the 2008 economic meltdown (Reserve Bank of Australia, 2024).

As a result of the crisis, the Financial Stability Board was created to prevent future excessive risk taking by financial institutions in the UK. Another key change in the sector is the passing of new laws which hold bank management more legally accountable, with incentives for senior management to prevent excessive risk-taking (Bank of England.). The economic climate between 2000 and 2010 is two-sided story, with the beginning of the decade being relatively prosperous, and the end of the decade seeing the UK in a deep recession.

#### 3.3 – United Kingdom (2010-2020)

The 2010s started with the recovery from the 2008 economic crisis. GDP growth was slowly recovering, with GDP growth being 0.9% in the first quarter of the decade. Growth throughout the entire 10-year period remained below the 1% mark, fluctuating between 0% and 0.9%, except for the second quarter of 2010. The unemployment rate was increasing for the first 2 years, from 2010 to 2012, however it began to decrease from Q1 of 2012, and it decreased at a steady pace until the end of the decade, when the lowest figure of 3.9% was recorded in Q4 of 2019. Additionally, the consumer price index was at 2.4% in Q1 of 2010; it reached a peak of 4% in Q4 of 2011, but it too, started to decline from that period until it reached its lowest point at 0.2% in Q2 of 2015. Then it started to increase to 1.4% in Q4 in 2019 (ONS).

The 2010s were also eventful times for the British economy, with the biggest example of this being the 2016 Brexit referendum, and the subsequent decision for the UK to leave the European zone. Perhaps the biggest economic decision that occurred in the previous decade is the referendum regarding Britain's decision to leave the free trade European zone (the European Union). The impact of that decision may take decades to be fully observed, but even though the full extent of Brexit will not in the study, it has certainly impacted the latest results that are observed in the study. The end of the 2020s marked another impactful event, the Coronavirus, and the subsequent closures of most physical business activities, effectively changing how business is conducted, reducing economic output, and impacting the business cycle.

### 4 – Methodology

#### 4.1 – Data Summary

There are 3 different measures of inflation in the United Kingdom. They are the following, the Consumer Price Index (CPI), the Consumer Price Index including house costs (CPIH) and the Retail Price Index (RPI). While all 3 of them are published by the ONS, this paper will use the official measurement the Bank of England uses to set goals and to compare the current situation to their benchmark goal for inflation of 2% (Bank of England, 2023), i.e. it will use the Consumer Price Index. While the CPIH would be a more accurate measurement for the research goal, it is not possible to use it for the whole period of the research since the ONS began reporting it from 2013. The RPI is no longer an official measurement of inflation, therefore this paper will not be considering the RPI.

The second variable used in this study is the gross domestic product of the United Kingdom. To understand what this variable is, a definition for it is needed. The GDP stands for Gross Domestic Product, and it is measured the following way: it measures the monetary value of all goods and services that are consumed in the economy in a given period of time (Callen, 2023). This study uses the Gross Domestic Product for the United Kingdom over the period of 34 years, starting in Q1 1990 and ending in Q4 of 2023. The source of the data for this particular variable is the ONS. This variable is normally given in millions, so it does not open itself to being easy to work with, however, this study will use the natural log function to make the study more understandable and accessible for the reader.

The definition of unemployment is key to define in research like this one. An individual is considered unemployed when the following conditions apply: the person is willing and able to work, is actively seeking employment but is unable to find an occupation at any given time and at the current wage rate (Reserve Bank of Australia, 2024). With the definition of unemployment being established, this paper uses the Unemployment rate for people aged between 16 and over. This is reported by the Office of National Statistics, and it is also the indicator the Bank of England uses to measure unemployment within the UK economy. The time period selected for this paper is from the year 1990 to the year 2023. This is because the ONS provides data for the CPI from the year 1989, therefore no further data is available for the research. The data frequency is quarterly, starting from Q1 of 1990 and ending in Q4 of 2023, for all of the monitored variables. Normally the higher the number of the frequency of the data,

the more accurate results will be acquired. However, the Gross Domestic Product is not reported as often as the other variables in this study, therefore, the highest available frequency is quarterly, which means it is the selected frequency.

#### **4.2 – Ensuring Stationarity**

In any given timeseries, stationarity is required. This is when there is a constant mean, constant variance, and constant autocorrelation. It is a requirement for the time series because if constants are not present, then the estimators will not be consistent. Therefore, the t-distribution and hypothesis testing become unusable as they are invalid. This is called a spurious regression (Granger and Newbold, 2014) and it is caused by stochastic trend in the time series, which basically means the trend is driven by random instabilities. This can cause major issues, such as misleading conclusions regarding the strength of the correlation between the variables even though there is no causality (the reported R-squared is higher than it should be because of random factors). This leads to a misinterpretation of the relationship between the variables, and it increases the chance for incorrect policies being implemented by governments. There are several ways to test for stationarity within a model, but this research will use the Augmented-Dickey Fuller and the Phillips-Perron tests. The ADF test sets the null hypothesis to be that there is a unit root present, and vice-versa with the alternative. To do this, the original Dickey-Fuller test is set up the following way: H0:  $\beta_1 = 1$  vs. H1: $\beta_1 < 1$  in  $Y_t = \beta_0 + \beta_0 Y_{t-1} + u_t$ , and the augmented Dickey-Fuller test is an extension of the Dickey-Fuller test, but by removing the autocorrelation from the test. From here, we obtain the augmented version, which expressed by this mathematical expression  $\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \delta_1 \Delta y_{t-1}$ is  $\delta_{p-1}\Delta y_{t-p+1}\varepsilon_t$ . The reported value comes from that expression, and the result of it is determined by the magnitude of negative statistic (Patterson, 2000, pp.p.238-p.241). The reported p-value of test is then compared to the chosen critical value, and if the value is lower than the critical value, then stationarity is assumed. This is a similar way of how the Phillips-Perron test works, with the main difference between the two being autocorrelation in the errors in the PP unit root tests. Additionally, this study has another purpose for these stationarity tests, that purpose being to make sure all of the time series are not integrated to I(2), i.e. only the first difference is taken for the variables and no more. This is a requirement for the next steps of the research, as checking the integration level is a requirement when dealing with Autoregressive Distributed Lag and cointegration.

#### 4.3 – Autoregressive Distributed Lag (ARDL) and Cointegration

The time series model known as the Autoregressive Distributed Lag model to cointegration o has a lot of features that this study will use to explore the complex dynamics of inflation, unemployment, and Gross Domestic Product within the British economy. Firstly, it analyses how the change in one macroeconomic variable might cause a change in another one, over a prolonged time period. This is applicable for this case as change in unemployment might cause a change in the other 2 variables over the short and long run. When dealing with an ARDL model, there are key assumptions that need to be mentioned. They are the following: no autocorrelation between the variables (this is tested later on), the variance and the mean should remain constant throughout the model (no heteroskedasticity present), and the data should be stationary either as it is I(0) or at the first difference I(1), but no higher difference than that should be taken (this was briefly mentioned in 4.2) (Chetty, 2018). The ARDL model to cointegration has another characteristic that suits this type of research well, which is the fact it considers both the short-run and the long-run in the model when dealing with causality among the variables (Stewart, 2019, pp.209–222). The bounds test is needed for this to happen. That is when the upper and lower bounds of the dependent variables are shown with critical values for each region, at the most used critical levels, i.e. 1%, 2.5%, 5%, and 10%. All of the requirements are set and the study can decide whether to accept or reject the null hypothesis. In this case, there are 3 dependent variables in the model, so the hypotheses are the following:

$$H_0: b_{1i} = b_{2i} = b_{3i} = 0$$

$$H_1: b_{1i} \neq b_{2i} \neq b_{3i} \neq 0$$

This is the bounds test for cointegration. To determine whether to accept or reject the null hypothesis, this study will look at the reported F-statistic and T-statistic. After doing this, it will compare the upper and lower bounds for each of the levels. If the F-statistic is higher than the upper bound I(1), then the null hypothesis is rejected, meaning that there is cointegration within the model. If the F-statistic is lower than the lower bound critical value, the null hypothesis is accepted, meaning that there is no cointegration within the model. This process will be repeated for all 3 of the variables as dependent variables.

#### **4.4** – Testing for Serial Correlation

The Durbin-Watson and the test will be used in this study to see whether serial correlation is present in the error terms. The test is based on the following statistic:

Equation 1: 
$$d = \frac{\sum_{t=2}^{T} (\hat{e}_t - \hat{e}_{t-1})^{/2}}{\sum_{t=1}^{T} \hat{e}_t^2}$$

And the following test is set up. The null hypothesis states that there is no autocorrelation in the first order. The alternative is that there is autocorrelation in the first order. To specifically utilise this test, the research will use the reported Durbin-Watson d-statistic. Afterwards, the d-statistic will be compared to the critical values to determine if serial correlation is a cause for concern. However, there are some factors that the Durbin-Watson test does not consider when dealing with the data (Judge, 1988).

Another test that will be carried out is the Breusch-Pagan test. This test will be used because it is necessary to test if the data is heteroskedastic. The test assumes the following: H0: there is homoskedasticity in the regression. H1: there is heteroskedasticity in the model. The next step after this is to obtain the p-value of the regression. By doing this, the p-value can then be compared to the selected significance level. If the reported p-value is greater than the seleted significance level, then the null hypothesis is accepted, meaning there is homoskedasticity present in the regression (Zach, 2020).

### 5 – Results

#### 5.1 – The Descriptive Statistics of the Variables

#### Table 1

	MEAN	STANDARD	MIN	MAX
		DEVIATION		
GROSS DOMESTIC PRODUCT	446828.6	81060.22	311418	569076
(IN MILLIONS OF £)				
CONSUMER PRICE INDEX (AS	2.75	2.18	0	10.7
A %)				
UNEMPLOYMENT RATE (AS A	6.29	1.85	3.8	10.6
%)				

Table 1 shows the summary statistics for the variables used in this research. The gross domestic product has a mean of £446828.6 (in millions), which means that the average gross domestic product between 1990 and 2023 in the United Kingdom is £446828.6 million. The standard deviation of the gross domestic product is £81060.22 (in millions). The consumer price index has an average of 2.75% for the period between 1990 and 2023. This means that the average inflation for the period is close to the target inflation of the Bank of England (the target is 2%). The standard deviation of the consumer price index is 2.18%. Lastly, the average unemployment rate for the United Kingdom for the period is 6.29%, and the standard deviation of unemployment is 1.85%.

# 5.2 – Graphical Representation of Gross Domestic Product, Consumer Price Index and Unemployment Rate

5.2.1 – The Unemployment Rate and Inflation Rate between 1990-2000, Graphical Representation





Figure 1 shows the unemployment and CPI in percentage and plotted for the first 40 quarters of the chosen period of time (the first 40 quarters being the start of Q1 in 1990 to Q4 in 1999). As seen from the figure, the first 10 quarters, or 2 and half years to 1992, the consumer price index has an overall decreasing trend. However, for that same amount of quarters, the unemployment rate is seen to have an overall increasing trend.

# 5.2.2 – The Unemployment Rate and Inflation Rate between 2000-2010, Graphical Representation

#### FIGURE 2



Figure 2 shows the same dynamic as figure 1, but in the following decade, 2000-2010. The pattern described in the previous decade for these two indicators is applicable here to some extent. First, the CPI begins to increase but it is not a significant change since it is still below the 2%, while the opposite can be observed from the unemployment rate. It gradually begins to decrease but one again it stays within the 4 to 6% mark. The major changes are observed when the financial crisis of 2008 occurs. That is when CPI shoots up to nearly 5%, while unemployment increases to nearly 8%. CPI experiences a decrease after reaching the all-time high in the decade, to below the 2% mark.

# 5.2.3 - Unemployment Rate and Inflation Rate between 2000-2010, Graphical Representation

#### FIGURE 3



Figure 3 shows the CPI and unemployment rate follow a positive relationship for most of the decade. Both begin the decade with a decrease, unemployment from 8.2% and CPI from 4.7% to 5.8% and 1.5% respectively, in 2015. That is when the expected relationship deduced from the Phillips curve can be observed for 2 and a half years, and then the relationship between the two stays positive until the end of the decade.

#### 5.3.1 – Graphical Representation of the National Gross Domestic Product (1990-2000)

#### **FIGURE 4**



#### 5.3.2 – Graphical Representation of the National Gross Domestic Product (2000-2010)



#### FIGURE 5

#### 5.3.3 – Graphical Representation of the National Gross Domestic Product (2010-2020)





#### FIGURE 7



Figure 7 shows the values of both unemployment and inflations (as a percentage) plotted on the Y-axis, and the number of observed quarters on the X-axis. From an eyeball observation, it seems that inflation and unemployment rates have a positive relation, as when the consumer price index increases or decreases, unemployment seems to correspond in a similar pattern, but with changes being a lesser scale. This observation is highlighted further when table 1 is considered. The reported standard deviation for the unemployment rate is 1.85, but the standard deviation for the consumer price index is higher at 2.18. However, there are also small periods of time within the chosen 134 quarters where they seem to have a negative relationship.



FIGURE 8

Figure 8 shows the gross domestic product for the period, and the changes in the GDP. From nearly the start of the period in Q1 1990 to Q4 2007 there was a stable increase of the British gross domestic product. However, as highlighted in the previous section (section 3.2), the financial crisis of 2008 happened. This is visible from the plot of the graph, as there is a visible decrease in the total value of goods and services in the economy on the graph. Post 2008 financial crisis, there was another period of relative stable growth within the country, up until the year 2020, where there is another decrease in the total gross domestic product. This is as a result of the COVID-19 restrictions and the subsequent closure of day-to-day business operations. The decline of gross domestic product is highlighted near the end of the period.

#### 5.4 – Augmented Dickey Fuller and Phillips Perron Stationarity Tests

5.4.1 – stationarity test results for first difference of unemployment time series

 TABLE 2 (augmented Dickey-Fuller test results)

	TEST STAT	1%	5%	10%
Z(T)	-4.474	-3.4030	-3.446	-3.146

H0: Unit root is present.

MacKinnon approximate p-value for Z(t) = 0.0017

Table 2 shows the first stationarity test carried out for the first difference for the time series of unemployment (Dickey-Fuller). The reason this was carried out was to check if the time series is stationary at either I(0) or I(1). In order to carry to use an autoregressive distributed lag model, the time series must not be differenced more than once. This is because models that use I(2) time series might not be consistent, and therefore unwanted in the ARDL model. This makes the understanding the long-run relationship between the variables harder to interpret. For the differenced unemployment rate, Table 2 shows the Z(t) statistic of -4.474 is greater, in absolute terms, compared to the 5% critical value of Z(t) of -2.983. Therefore, since the test statistic is greater in absolute terms, then the null hypothesis can be rejected, and stationarity can be assumed.

#### **TABLE 3 (Phillips Perron test results)**

	TEST STAT	1%	5%	10%
Z(RHO)	-55.398	-19.913	-13.768	-11.045
Z(T)	-5.778	-3.499	-2.888	-2.578

H0: no unit root is present in the series.

MacKinnon approximate p-value for Z(t) = 0.0000

As seen from table 3, the reported Z(t) for the test statistic is |-5.778| > |-2.980| and thus, the null hypothesis is also rejected in the Phillips perron test. No non-stationarity is present in the time series.

#### 5.5 - stationarity test results for the consumer price index time series

5.5.1 - stationarity test results for first difference of CPI time series

#### TABLE 4 (augmented Dickey Fuller test results)

	TEST STAT	1%	5%	10%
Z(T)	-5.400	-4.030	-3.446	-3.146

H0: Unit root is present.

Table 4 shows the augmented Dickey-Fuller test for the first difference of the consumer price index. As seen from table 3, the Z(t) for I(1) for the consumer price index is -5.400, which is greater than all of the reported critical regions Z(t), and thus, the null hypothesis is rejected, and stationarity is present in the time series at I(1).

#### TABLE 5 (Phillips Perron test results)

	TEST STAT	1%	5%	10%
Z(RHO)	-73.253	-19.913	-13.768	-11.045
Z(T)	-6.590	-3.499	-2.888	-2.578

MacKinnon approximate p-value for Z(t) = 0.0000.

Table 5 shows the Phillips perron test static to be |-6.590| and that is higher than the absolute value of the 5% critical reported value, and therefore the null hypothesis is rejected, confirming the initial augmented Dickey-Fuller test results.

#### 5.6 - stationarity test results for the natural log of gross domestic product

5.6.1 - stationarity test results for first difference of LNGDP time series

#### TABLE 6 (augmented Dickey Fuller test)

	TEST STAT	1%	5%	10%
Z(T)	-6.216	-4.030	-3.446	-3.146

H0: Unit root is present.

Table 6 shows the augmented Dickey-Fuller test for the first difference of the natural log of the gross domestic product. As seen from table 4, the Z(t) for I(1) for the natural log of gross domestic product is -6.216, and therefore it is greater than all of the reported critical values (in absolute terms). Therefore, the null hypothesis is rejected, thus the time series is stationary and can be used in autoregressive lag model to cointegration.

#### TABLE 7 (Phillips Perron)

	TEST STAT	1%	5%	10%
Z(RHO)	-161.178	-19.913	-13.768	-11.045
Z(T)	-15.496	-3.499	-2.888	-2.578

H0: Unit root is present.

Table 7 shows the Z(t) statistic to be |-15.496| > |-2.980|, therefore the null hypothesis is rejected for the Phillips perron test. This means stationarity is present at I(1), and the autoregressive distributed lag model to cointegration can be commenced.

#### 5.7 – Autoregressive Distributed Lag and Bounds Test Results

Below are the ARDL model equations for the 3 variables. The hypothesis is stated in the methodology.

Equation 1:  $\Delta Unem = a_1 + b_1 Unem_{t-i} + b_2 CPI_{t-i} + b_3 lngdp + \sum_{i=1}^{P} a_{1i} \Delta Unem_{t-i} + \sum_{i=1}^{q} a_{12i} \Delta CPI_{t-i} + \sum_{i=1}^{q} a_{3i} \Delta lngdp_{t-i} + e_{1t}$ , this is set out with unemployment rate being the dependent variable.

Equation 2:  $\Delta CPI = a_1 + b_1 CPI_{t-i} + b_2 Unem_{t-i} + b_3 lngdp + \sum_{i=1}^{p} a_{1i} \Delta CPI_{t-i} + \sum_{i=1}^{q} a_{12i} \Delta Unem_{t-i} + \sum_{i=1}^{q} a_{3i} \Delta lngdp_{t-i} + e_{1t}$ , and in this part of the model the consumer price index is the dependent variable.

Equation3:  $\Delta lngdp = a_1 + b_1 lngdp_{t-i} + b_2 Unem_{t-i} + b_3 + CPI + \sum_{i=1}^{P} a_{1i} \Delta lngdp_{t-i} + \sum_{i=1}^{q} a_{12i} \Delta Unem_{t-i} + \sum_{i=1}^{q} a_{3i} \Delta CPI_{t-i} + e_{1t}$ , and the final set up for the autoregressive distributed lag model is the equation where the natural log of gross domestic product, and the main area the study is interested in.

#### 5.7.1 – Optimal Lag Selection

Lag	LL	LR	df	р	FPE	AIC	HQIC	SBIC
0	-457.33				0.21460	6.97463	7.00125	7.04014
1	173.003	1260.7	9	0.000	.000018	-2.43944	-2.33294	-2.17736
2	236.345	126.68	9	0.000	7.7e-06	-3.2628	-3.07644	-2.8041*
3	254.46	36.231*	9	0.000	6.7e06*	-3.4009*	-3.1347*	-2.74573
4	260.988	13.056	9	0.160	7.0e-06	-3.36346	-3.01735	-2.51172

#### TABLE 8 (Lag-order selection criteria)

Table 8 shows the results of the lag-order selection criteria. To continue with the autoregressive distributed lag, the study needs to select the optimal lag it will be using to do so. This research paper will utilise the Akaike Information Criterion. This is because the AIC account for both the goodness of fit and the complexity of the time series. Thus, as seen from table 8, and using the AIC, the optimal lag is 3.

**5.7.2** – the Autoregressive Distributed lag model and bounds test (Unemployment rate as the dependent variable)

#### TABLE 9

				Num	ber of obs		132	
				F(10,	121)		1637.82	
				Prob	> F		0.0000	
				R-sq	uared		0.9927	
				Adj I	R-squared		0.9921	
				Root	MSE		0.1665	
Unemployment	Coefficient	Std. err.	t	L	P>t	[9:	5%	interval]
						co	nf.	
Unemployment								
LAG 1	1.271488	.0904004	14.0	07	0.000	1.0	)92517	1.45046
LAG 2	1641664	.1441112	-1.1	4	0.257	4	494725	.1211397
LAG 3	1397852	.0785022	-1.7	78	0.077	2	952011	.0156307
СРІ								
	.0703227	.0228794	3.0	7	0.003	.02	250269	.1156185
LAG 1	0483844	.0228034	-2.1	2	0.036	0	935297	0032391
LNGDP								
	-1.165302	.639559	-1.8	32	0.071	-2.	431478	.1008738
LAG 1	-3.189668	.744632	-4.2	28	0.000	-4	.663864	-1.715473
LAG 2	.6658368	.7752568	0.80	6	0.392	8	689886	2.200662
LAG 3	2.055117	.7602497	2.70	C	0.008	.55	500017	3.560231
LAG 4	1.313175	.6968692	1.88	8	0.062	0	664616	2.692811
_cons	4.343934	1.652398	2.63	3	0.010	1.0	)72576	7.615292

Table 9 shows the results of the autoregressive distributed lag model with the change in unemployment being the dependent variable. As seen from the results of the model, the change in unemployment has the following characteristics. At the consumer price index has a significant t-value (0.003 < 0.01), and therefore the coefficient for the consumer price index is 0.0703227, which makes shows a positive relation. This indicates that as unemployment rate increases by 1%, so does the consumer price index by 0.07%, assuming ceteris paribus and at

the 1% significance level. Secondly, the natural log of gross domestic product has a very significant value in the first lag, 0.66583.

#### 5.7.3 – Bounds Tests from ARDL Results

#### TABLE 10

								F	4.625
								t	-2.640
	[ <b>I</b> _0]	[I_1]	[ <b>I_</b> 0]	[ <b>I</b> _1]	[ <b>I_</b> 0]	[I_1]	[ <b>I</b> _	_0]	[I_1]
	L_1	L_1	L_05	L_05	L_025	L_025	L_	01	L_01
k_2	3.17	4.14	3.79	4.85	4.41	5.52	5.1	5	6.36

The next part of the research is the bounds test from the ARDL model. Table 10 shows the results of the bounds test. As seen from the table, there are various significance levels the relation between unemployment and the other 2 variables was tests. To decide whether a long-run relation is present, the study will compare the reported F value to the other values at different significance levels. The reported F value is 4.624, which means that it is in between the different values. When the value is between the selected bounds, that means that the test is inconclusive. It is not possible to conclude whether a long-run relationship is present.

Lastly, the study uses the Durbin-Watson and Breusch-Godfrey tests to check if there is any serial correlation present within the model. The results and interpretations are reported below.

The Durbin-Watson d-statistic (11, 132) = 1.985055

(TABLE 11) Breusch–Godfrey LM test for autocorrelation

lags(p)	chi2	df	Prob > chi2
3	1.166	3	0.7611

H0: no serial correlation

The following tests for autocorrelation show that there is no autocorrelation in the model. This is because the Durbin-Watson statistic is near 2, which means that the null hypothesis is accepted. Additionally, the chi<sup>2</sup> probability from the Breusch-Godfrey test is way greater than any of the significance levels, thus, it shows no auto correlation within the model.

#### 5.6.4 – White's Test Result

H0: Homoskedasticity

Ha: Unrestricted heteroskedasticity

TABLE 12

Chi2(65)	60.85				
Prob > chi2	0.6229				
Source		chi2		df	р
Heteroskedas	ticity	60.8	35	65	0.6229
Skewness		5.53	i	10	0.8529
Kurtosis		0.05		1	0.8308
Total		66.4	-3	76	0.7754

Reported Prob > chi2 = 0.6229. The reported  $\text{chi}^2 > 0.05$  (the significance level), therefore the null hypothesis cannot be rejected, and thus the model is not suffering from homoscedasticity.

#### 5.7.1 – The Consumer Price Index

#### TABLE 13

Number of obs	132
F(10, 121)	173.88
Prob > F	0.0000
R-squared	0.9349
Adj R-squared	0.9269
Root MSE	0.5531

СРІ	Coefficient	Std. err.	t	P>t	[95%	interval]
					conf.	
СРІ						
LAG 1	1.25007	.0871009	14.35	0.000	1.077631	1.422509
LAG 2	1337488	.1425045	-0.94	0.350	415874	.1483764
LAG 3	2500828	.0901716	-2.77	0.006	4286013	0715642
Unemployment						
	.7696327	.2644286	2.91	0.004	.2461265	1.293139
LAG 1	7152149	.259343	-2.76	0.007	-1.228653	201777
LNGDP						
	6.319192	2.062192	3.06	0.003	2.23654	10.40184
LAG 1	.4884314	2.703091	0.18	0.857	-4.863051	5.839914
LAG 2	.848371	2.480881	0.34	0.733	-4.063186	5.759929
LAG 3	-1.981645	2.506984	-0.79	0.431	-6.94488	2.981591
LAG 4	-5.049359	2.157126	-2.34	0.021	-9.319959	7787584
_cons	-8.226827	5.580191	-1.47	0.143	-19.27429	2.820632

Table 13 shows the results from the ARDL model in the short-run with the consumer price index as the dependent variable. The following can be deduced from the table. One percent change in the first lag of the consumer price index is associated with a 1.25% change in the consumer price index (the result is statistically significant because the p-value is below the 1% significance level). Additionally, a -0.72% change in the second lag of unemployment is

associated with a 1% change in the CPI. The last statistically significant coefficient at the 1% level is the first lag of the natural log of the gross domestic product.

#### 5.7.2 – Bounds Test Results

#### TABLE 14

								F	8.856
								t	-5.009
	[ <b>I_0</b> ]	[I_1]	[ <b>I_</b> 0]	[I_1]	[ <b>I_0</b> ]	[I_1]	[I_	0]	[I_1]
	L_1	L_1	L_05	L_05	L_025	L_025	L_	01	L_01
k_2	3.17	4.14	3.79	4.85	4.41	5.52	5.1	5	6.36

Table 14 shows the results of the bounds test, and the reported F-statistic. Comparing the Fstatistic to the upper bounds of the bounds test shows that it is greater than the 1% significance level, and therefore the null hypothesis is rejected. This means that there is cointegration present in the model, and therefore a long-run relation. The long-run table is presented below.

#### TABLE 15

D.CPI						
LONG RUN	Coefficient	Std .err.	t	$\mathbf{P} > \mathbf{t}$	95% conf.	Interval
Unemployment	.4068275	.3039981	1.34	0.183	1950169	1.008672
LNGDP	4.672435	3.079972	1.52	0.132	-1.425182	10.77005

However, in the long run, the issue of statistical insignificance is present, as the p > 0.01, but that does not mean there is no long-run relation. The Durbin-Watson and Breusch-Godfrey results for autocorrelation are reported below.

Durbin–Watson d-statistic (11, 132) = 2.007963

#### TABLE 16

lags(p)	chi2	df	Prob > chi2
3	0.686	3	0.8764

H0: no serial correlation

Once again, the Durbin-Watson statistic is close to 2, and therefore there is no autocorrelation. This is further showed by the Breusch-Godfrey chi^2, which is greater than 0.1, and thus the null is rejected, showing no autocorrelation.

#### 5.7.3 – White's Test Result

H0: Homoskedasticity

#### H1: Unrestricted heteroskedasticity

#### TABLE 17

Chi2(65)	113.90				
Prob > chi2	0.0002				
Source ch		chi2		df	р
Heteroskedasticity		113.	90	65	0.0002
Skewness 13.		13.6	2	10	0.1910
Kurtosis 3.0		3.02		1	0.0823
<b>Total</b> 130.		53	76	0.0001	

Reported Prob > chi2 = 0002. The reported  $\text{chi}^2 < 0.05$  (the significance level), therefore the null hypothesis can be rejected, and thus the model is homoscedastic.

#### 5.8.1 – The natural log of the gross domestic product

#### TABLE 18

Number of obs	132
F(10, 121)	1006.57
Prob > F	0.0000
R-squared	0.9850
Adj R-squared	0.9840
Root MSE	0.0233

LNGDP	Coefficient	Std. err.	t	P>t	[95%	interval]
					conf.	
LNGDP						
LAG 1	.5520633	.0957393	5.77	0.000	.3625533	.7415734
LAG 2	.1418592	.1007276	1.41	0.162	0575248	.3412432
LAG 3	.278709	.0923444	3.02	0.003	.0959189	.4614991
Unemployment						
	0278935	.0104072	-2.68	0.008	0484938	0072931
LAG 1	.0267509	.0102382	2.61	0.010	.006485	.0470167
СРІ						
	.0115465	.0034797	3.32	0.001	.0046587	.0184344
LAG 1	0166527	.0058269	-2.86	0.005	0281867	0051186
LAG 2	.005507	.0037012	1.49	0.139	0018193	.0128332
_cons	.3689305	.2320835	1.59	0.114	0904646	.8283255

Table 18 shows the results of the ARDL model, with the natural log of gross domestic product as the dependent variable. The following can be interpreted from the table. At the 1% significance level, the coefficients for the first and third lag for of lngdp indicate that a 1% change in the natural log of gross domestic product, there is an association of 0.55% change in the first lag and 0.28% change in the third lag. Additionally, another statistically significant association is the first lag of unemployment rate (at 1%), is as there is 1% change in the LNGDP there is a change of 0.027% in the first lag of unemployment. Lastly, the association between

LNGDP and the consumer price index means that as there is a 1% change in the LNGDP, there is a -0.02% change in the first lag of CPI.

#### 5.8.2 – Bounds Test Results

#### TABLE 19

								F	1.003
								t	-1.516
	[ <b>I_0</b> ]	[I_1]	[ <b>I_</b> 0]	[I_1]	[ <b>I_0</b> ]	[ <b>I</b> _1]	[ <b>I</b> _	0]	[I_1]
	L_1	L_1	L_05	L_05	L_025	L_025	L_	01	L_01
k_2	3.17	4.14	3.79	4.85	4.41	5.52	5.1	5	6.36

Table 19 shows the results of the bounds test, and the reported F-statistic. The same process as before is repeated, where the F-statistic is compared to the different bounds.  $1.003 < L_1$ , which means that the null hypothesis is accepted. This means that there is no cointegration in the long run.

Durbin–Watson d-statistic (9, 133) = 2.057516

#### TABLE 20

lags(p) chi2		df	Prob > chi2		
3	2.005	3	0.5715		

H0: no serial correlation

Once again, the Durbin-Watson statistic is close to 2, and therefore there is no autocorrelation. This is further showed by the Breusch-Godfrey chi^2, which is greater than 0.1, and thus the null is rejected, showing no autocorrelation.

#### 5.8.3 – White's Test Result

H0: Homoskedasticity

H1: Unrestricted heteroskedasticity

#### TABLE 21

Chi2(65)	114.85				
Prob > chi2	0.0000				
Source		chi2		df	р
Heteroskedas	Heteroskedasticity 1		85	44	0.0000
Skewness	Skewness 10.		1	8	0.2251
Kurtosis		1.06		1	0.3034
Total 120		126.:	51	53	0.0000

Reported Prob > chi2 = 0002. The reported  $\text{chi}^2 < 0.05$  (the significance level), therefore the null hypothesis can be rejected, and thus the model is homoscedastic.

### 6 - Conclusions

In conclusion, understanding the complex dynamics through various econometric models is key for any central bank and policy maker. By doing this, a better understanding of economic behaviour can be obtained, and therefore better policy implementations can be introduced. This study uses a time series approach to try to further provide understanding regarding how unemployment, inflation and gross domestic product interact with each other. The use of autoregressive distributed lag model allows the data to be analysed for various different purposes, with the main one being to establish whether cointegration is within the data variables, and to highlight both a long and short-run relation between the variables. The main point of interest is how the unemployment rate and inflation rate might affect the gross domestic product of Britain. Through the use of the ARDL model, and the bounds test, it was shown that the relation between the three variable is only in the short-run; establishing that through the F statistic and showing that a long-run relation is not present.

Furthermore, the ARDL model was also used to showed that a long-run relation and cointegration was present in the model where the dependent variable was the consumer price

index (CPI). This means shows that the way these variables affect each other is different, which further indicates the complex dynamic between them. This also means that policy makers can use this knowledge when considering how to control the consumer price index, due to the fact there is a long-run relation, meaning they can try to impact one of the other two variables to maintain a stable inflation rate. This also connects the Phillips curve with Okun's law, as mentioned in section 2 of the paper. It is important to establish these connections to know if previous research is still relevant.

Lastly, the only inconclusive determination from the bounds test was on unemployment rate. This is because the bounds test when compared to the F-statistic indicated that a long-run relation could not be confirmed, therefore, the test is deemed inconclusive. The problem with having this as a result is the lack of full information on how unemployment changes when the other two variables change over time. This means that policymakers cannot use that information with a guarantee for their relationship, meaning that a new bounds test should be carried out. One way of fixing such a problem is by adding other variables to the autoregressive distributed lag model, which should change the F-statistic to a more decisive end. By doing this, a clearer notion of how other variables impact the change in the unemployment rate will be present.

Overall, this study shows the level of complexity in how the economy and its indicators react to each other, and whether they have a way to be partially controlled. However, one big problem with the study is that more variables could have been selected to further demonstrate the dynamics of the economy in a more detailed model. The study can be used to assess further how variables interact, and it can provide policy makers more informed policy making. And as the study mentions at the start, optimising economic welfare for the population is a key part of its targets. Lastly, by understanding how they interact and potentially including optimal policy making, governments can reduce the waste of factors of production, which means less resources are wasted (decrease in unemployment means a decrease in the waste of labor) and therefore productivity is increased on a national scale.

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