An empirical analysis of the Phillips Curve - A time series exploration of Germany

Author(s): Patrick Nüß

Tutor: Hyunjoo Kim Karlsson

Examiner: Dominique Anxo

Subject: Economics

Level and semester: Bachelor's Thesis ,
Spring 2013

Linnæus University
School of Business and Economics

Abstract

The purpose of the paper is to explore the relationship between inflation and unemployment in Germany during the period from 1970 to 2012. Through the methods of cointegration, dynamic OLS and an error correction model, this paper highlights that there is no short run negative relationship between inflation and unemployment, and consequently the short run Phillips curve is an unsuitable instrument for making political decisions. Furthermore, there is a long run relationship between inflation and unemployment, which can be explained with asymmetric nominal wage rigidities and resulting frictional growth. Resulting policy implications reflect the advantage of a permanent higher inflation target for Germany. Since the beginning of the European Monetary Union, Germany has been on average 0.5% under the permanent inflation target of the central bank. Therefore, by using fiscal policy, Germany can reduce permanent unemployment without missing the inflation target of the central bank. Finally, despite of variety of intensive changes in the macroeconomic situation and particularly through the establishment of the European Monetary Union, the CUSUM and CUSUMsq test reveal that the estimate holds validity over the entire observation period and has not changed since the beginning of the European Monetary Union.

Key Words: Inflation, Unemployment, Phillips Curve, Cointegration, Error Correction Model

Content

1. Introduction

At the center of macroeconomics lies the exploration of the interaction of the monetary and the real economy, as well as the results of these findings for the political scope for action.

Apart from the Phillips curve, an increasing consensus concerning macroeconomic relationships can be generally determined (Woodford, 2009). As a result, attempts have been made to explain the Phillips curve with various theories and methods for several decades. The theory of the Phillips curve provides a relationship between inflation and unemployment, thus raising the question of a possible influence of inflation on a higher level of employment and the associated relevance of monetary policy on the economy. The detection of the Phillips curve has proven difficult, because data such as inflation expectations are available only for a short period of time and they are also heterogeneous between populations (Fritsche et al., 2008). Furthermore, it is also difficult given that the unemployment data differs due to different filtering methods (Schreiber and Wolters, 2007).

The results of research has prompted the realization that a tradeoff between inflation and unemployment is only true in the short term, and this is also not constant (Gordon, 1997), with other research standing against the theory concerning a positive relation between inflation and unemployment (Gali et al., 2005), while other papers have captured a long run tradeoff (Schreiber and Wolters, 2002). With this work, I would like to help to resolve this dispute by providing information concerning the German Phillips curve through the method of cointegration and vector error correction. The analysis of Germany is interesting for two reasons: firstly, Germany is one of the largest countries in the European Monetary Union, which is why the relationship between inflation and unemployment of Germany holds relevance for the entire monetary union; and secondly, Germany has a variety of events that may have influenced macroeconomic situations over the course of history. Such noteworthy events include the two oil price shocks in the 1970s, the German reunification in 1990, the formation of the European Monetary Union in 1999 and the extensive labor market reforms since 2003. Besides capturing the Phillips curve, these conditions enable a robust test and its stability over time.

The purpose of the paper is to explore the relationship between inflation and unemployment for Germany during the period from 1970 to 2012. This gives rise to the following questions. First, can there be a short run negative relationship between inflation and unemployment in Germany? Second, does Germany have a permanent tradeoff between inflation and unemployment? Finally, if a tradeoff can be observed, is there a stable relationship or does it vary along with the changes in the macroeconomic system? In order to answer these questions, this paper is organized as follows. First, the history of the Phillips curve is presented, before deeper insight is provided into the relevance of the natural rate of unemployment and alternative approaches to the explanation of the Phillips curve in the case of a permanent low level of inflation. An empirical study on the Phillips curve for Germany follows, including a description of the data set and an introduction to the concepts of stationary, the cointegration and vector error correction models. This is followed by a consideration of the estimation results and the final evaluation of the results with a view to its political implications.

2. The Phillips Curve

2.1 History of the Phillips Curve

The Phillips curve is the economic relationship between the change of inflation on the one hand and unemployment on the other. It was observed in 1958 by an English economist by the name of A. W. Phillips, and it provides a connection between the change of nominal wages and unemployment (Phillips, 1958). This model was adopted and extended in subsequent years, with similar patterns also found for the U.S. (Samuelson and Solow, 1960). This relationship was considered permanent and presented policy makers with a choice between high unemployment with low inflation or an alternative a low unemployment with high inflation. However, Friedman and Phelps criticized this because they considered the origin of the negative relationship in a bias of the inflation expectations of workers (Friedman 1968; Phelps 1968). Therefore, the inverse relationship between inflation and unemployment was only found up to an adjustment of inflation expectations, and subsequently moves back to the natural rate of unemployment. By this chain of reasoning, the first version of the Phillips curve had a natural rate of unemployment u_t^n as well as containing inflation expectations $E\pi_t$. The consequence of this model was that inflation only has a short run effect on unemployment. After an adjustment process to the natural rate of unemployment, there will be only an increase in inflation. Therefore, there are no advantages of raising inflation to a higher level, and thus it should rather remain low and constant.

$$\pi_t = E\pi_{t-1} + (u_t - u_t^n) + s_t \qquad (2.01)$$

How the chain of arguments as presented by the Phillips curve was understood as a form of adaptive expectations formation (2.01). However, this changed during the 1970s and the occurrence of the two oil price shocks, owing to the change in the expectation formation of wage setters. Previously inflation was subject to certain fluctuations around a general level of inflation, while in the 1970s inflation rose continuously. The probability that a higher inflation rate followed a high inflation rate in the next year rose, thus voiding the previous tradeoff between inflation and unemployment. In the following years, a large number of countries observed a simultaneous increase in inflation and unemployment, and this stagflation led to a new modification of the Phillips curve with forward-looking inflation expectations $E\pi_{t+1}$ (Lucas, 1972/1973).

$$\pi_t = E\pi_{t+1} + (u_t - u_t^n) + s_t \qquad (2.02)$$

Following a presentation of the history of the Phillips curve, we will adopt a deeper insight into the theoretical framework of the natural rate of unemployment and the implications for monetary and fiscal policy.

2.2 The Natural Rate of Unemployment

As previously mentioned, the experiences of the two oil price shocks and related stagflation caused a change in the theoretical structure of the Phillips curve. The introduction of the natural rate of unemployment and the forward-looking expectations significantly lowered the importance of policy maker's intervention. There was no longer a possibility for policy makers to choose between high inflation with low unemployment and low inflation with high unemployment. Subsequently, the negative relationship between inflation and unemployment was only valid for the short run, prior to an adjustment of inflation expectations. After an adjustment of the expectations, unemployment corresponds to the natural rate of unemployment at a higher level of inflation. One consequence was that the central bank should only focus on the fight against inflation, as in the case of the central bank's low credibility there could be an expected increase in inflation, which is not the case. The wages would increase more than corresponds to the actual inflation, thus providing an increase in unemployment.

A new economic school developed in the subsequent period, attempting to explain the causes of unemployment and the adjustment process to the natural rate of unemployment in the long run by using micro foundation for macroeconomic processes (Gali, 2008). They expanded the reasons for a delay of adjustment in addition to the inflation expectations by nominal and real rigidities. Accordingly, important factors were cited as rigidities in labor (Pfeiffer, 2004) and product markets like imperfect competition (Mikosch, 2012), which were the result of the rational behavior of households and firms. The most common version in presenting the short and long run relevance is the Calvo-price setting model (Calvo, 1983). In the short run, it reflects some agents' incomplete formation of expectations, and a negative relationship between inflation and unemployment. Owing to nominal and real rigidities, an adjustment of the expectations will not directly lead to an adjustment of prices and wages because of the rational behavior of the agents. Given that the rigidities only have a short run effect, they will lose the effect in the long run, which eventually leads to the natural rate of unemployment, which is a vertical Phillips curve. In addition to market imperfections that explain short run fluctuation in unemployment, a number of reasons for structural unemployment in the long run were also found, and most notably the efficiency wage theory, which leads firms to hiring workers above the market clearing wage, leading to a permanent level of unemployment (Summers, 1988).

The result of this theoretical construct was that the central bank, as previously mentioned, has to focus on a low inflation target. However, the stabilization policy of the central bank is only appropriate when they will do not miss the inflation target. Furthermore, the fiscal policy is only granted a short run effect. An increase in government expenditure or cutting of taxes causes short run positive effects on employment, with this exact effect influenced by two factors: first, the fiscal policy is affected by the degree of rigidities; and second, it is influenced by the preferences of the central bank (Sorensen and Whitta-Jacobsen, 2010). A high degree of rigidities provides persistent positive effects of fiscal policy and only a slow increase in inflation. Given that inflation only starts with delay, the central bank will raise its interest rate late and mitigate the effect of fiscal policy. If there is a low degree of rigidities, an increase in inflation occurs after a short time, which will tempt the central bank to increase the interest rate early to achieve the inflation target. Due to this interaction between monetary and fiscal policy, the effect of fiscal policy results in an economic downturn, given that inflation will only increase slightly following an increase in government spending, and the central bank will not raise their interest (Sorensen and Whitta-Jacobsen, 2010). By contrast, there is the possibility of an interest rate cut, because inflation also decreases in a downturn, and the central bank strives to counter this.

2.3 The Phillips Curve by low Inflation

An alternative to the natural rate of unemployment in the long run, which leads to neutrality of fiscal and monetary policy, is an asymmetric effect of nominal rigidities, which intensifies and becomes more meaningful in the presence of permanent low inflation. In particular, nominal wages have a much stronger downward rigidity (Holden, 2004).

These are based on staggered contracts. Since the negotiation of new contracts occurs due to information gathering, meetings and possible strikes to costs, both parties are interested in longer durations. On the employee side, this is particularly the case with risk aversion from a lower income (Fischer, 1977). Therefore, they are willing to forego potential a wage increase for a period, if this also ensures that their wages cannot fall. Consequently, a reduction of wages is only slightly possible above company benefits (Blinder and Choi, 1990). In the case of stronger downward rigidity, it is difficult for firms to adjust their wages in a particular economic downturn. As a result, companies can disappear from the market. In the present of imperfect competition, including barriers to market entry, this can lead to a permanent increase in unemployment. One solution to this problem would be a permanently higher inflation target to mitigate this downward rigidity. The justification for a stronger downward rigidity is currently based upon two concepts: near rationality (Akerlof et al., 2000) and frictional growth (Karanassou et al., 2008).

According to the concept of near rationality, there are permanent downward rigidities that result from the non-rational behavior of some agents (Akerlof et al., 2000). It is mainly based on the concept of efficiency wage (Summers, 1988), according to which workers work harder when they get paid a wage above the market clearing price. Reasons for this include a positive selection of workers, an increase in the opportunity costs of shirking workers, and a possible gift effect (Borjas, 2012). Furthermore, the firm has reduced costs, given that the labor turnover will decrease, which decrease the costs of trainees. Therefore, a decrease of the nominal wage would lead to a decrease in the productivity of firms (Borjas, 2012). Although the economy would need a decrease in wages, it would not be rational for the firms to reduce wages. The non-rationality in the concept begins here. The idea that states behind the concept of near rationality is that not all workers are able to distinguish a nominal wage increase of a real wage increase (Shiller, 1997). When this is true, higher inflation would allow reducing real wages without necessity reducing nominal wages, and would have less negative effects on the productivity of workers. Furthermore, the near rationality of firms leads to general under-weighting of inflation (Akerlof et al., 2000). However, the assumption of near rationality is risky because it ignores possible income and substitution effects of agents and firms (Blinder, 2000).

In addition to the aforementioned approach of near rationality is the concept of frictional growth, which relates to the interaction between inflation and nominal frictions in the economy (Karanassou et al., 2008). This approach is based on the assumptions of rational expectations, the absence of money illusion and the assumption of non-permanent nominal rigidities. One advantage of this approach compared to the near rationality is that we do not have to find a reason for non-rational behavior. Here, the asymmetric nominal wage rigidities is explained through the regulation of the labor market, given that because a decrease in wages is only possible through mutual consent between firms and unions, a decrease in nominal wages is improbable (Holden, 2004). This leads to a strategic advantage for the workers in the wage negotiations, which can prevent a cut in nominal wages (Holden, 2004). The effects will be the same as in the case of near rationality. In the case of a permanent low inflation target, a negative shock can have long run effects on unemployment (Karanassou et al., 2008). This means that in the presence of a low inflation target, inflation has long run effects and we cannot observe a natural rate of unemployment.

This leads to a change in the relevance of monetary and fiscal policy, with the implication for monetary policy that a permanent higher inflation target can be useful to counteract possible long run effects of downward wage rigidities (Karanassou et al., 2008). In addition the central bank should rather focus on employment than on inflation. Moreover, in the presence of a permanent low inflation target, fiscal policy has to respond quickly following a negative economic shock to prevent a permanent increase of unemployment. Automatic stabilizers are particularly useful, due to the absence of an inside and outside lag of policy activities (Sorensen and Whitta-Jacobsen, 2010).

After the presentation of the development of the Phillips curve and an interpretation of newer theoretical approaches, we will adopt a deeper insight into recent empirical findings.

3. Literature Review

Most recent empirical studies on the Phillips curve have focused on the analysis of market imperfections and the formation of expectations, particularly concerning the topic of imperfect information. Therefore, we consider as follows the results of this work. For the research of the relationship between inflation and unemployment, a variety of data records in the form of cross-sectional data, time series as well as panel data were used. Furthermore, the estimation methods were varied with the use of OLS, GLS or GMM estimates as applied to dynamic OLS or error correction estimates, with the results varying accordingly. For example, a panel estimate found a Phillips curve for the bulk of OECD countries (DiNardo and Moore, 1999), whereas another work by the method of cointegration only detected a Phillips curve for Japan and the U.S (Reichel, 2004).

There is consensus amongst most current research that rational expectations only have a small explanation power (Fuhrer, 1997; Rudd and Whelan, 2005; Rudd and Whelan, 2006; Gordon, 2008). One way to prove this is the newer approach of the hybrid Phillips curve, which combines the idea of forward looking expectations $E\pi_{t+1}$ and backward looking expectations $E\pi_{t-1}$, which together with the cyclical component $(u_t - u_t^n)$[1] and a supply shock s_t explain the dynamics of inflation. Therefore, the model is still at the idea of a natural unemployment u_t^n bound and thus also involves the assumption of the various market imperfections. Through the combination of forward and backward looking expectations, part of the agent forms its expectation on the basis of expected future inflation, while part forms its expectation with a rule of thumb.

$$\pi_t = E\pi_{t+1} + E\pi_{t-1} + (u_t - u_t^n) + s_t \qquad (2.03)$$

As a measure of rational expectations, it was previously common to use the realized inflation as a kind of expected inflation. In order to circumvent this venture assumption, research has been increasingly undertaken with data on inflation forecasts or the inflation expectations of households (Chengsi et al., 2009; Paloviita and Mayes, 2005). These provide a clearly decreased importance of forward looking expectations and thus a higher explanatory power for the persistence of inflation.

[1] The cyclical component is often presented as output gap as an alternative to the employment as (Danišková and Fidrmuc, 2011) or as labor share of income (Rudd and Whelan, 2005).

However, a common weakness of these models persists to exist. Due to the high explanatory power of the past and future inflation, the cyclical component is mostly not significant and often a positive sign (Danišková and Fidrmuc, 2011). Although the forward looking expectations generally appear to play a prominent role, they cannot be removed from the model. Forward looking expectations can still be used as an explanation for the occurrence of unstable economies and hyperinflation (Gordon, 2008); however, this cannot explain the remaining components of the model.

Besides the general importance of inflation expectations, as mentioned in section 2.3 another branch is developing that attempts to explain the insignificance and wrong sign of the Phillips curve, including the possibility of a varying natural rate of unemployment. Such research has focused on capturing this natural rate of unemployment, which is varying over time and can be changed via structural policy (Gordon, 1997). Common methods towards this aim include the Hodrick-Prescott filter and the Kalman filter, which are often used for estimating the forward-looking and hybrid Phillips curve. Another way of explaining the insignificance is the concept of near rationality, which could lead to a permanent tradeoff between inflation and unemployment. This concept has been applied in the cases of Sweden (Bryan and Palmqvist, 2005) and other European countries (Millet, 2007), yet there is no empirical evidence using inflation expectations to date. Therefore, near rationality cannot explain a permanent tradeoff between inflation and unemployment.

Regardless of the concepts of near rationality, the theory of the natural rate of unemployment is increasingly recognized as losing acceptance (Franz, 2005). To date, the concept of frictional growth can explain the increase in unemployment in Spain since the beginning of the monetary union (Karanassou et al., 2008). Especially with the concept of cointegration and error correction models, the existence of a long run tradeoff between inflation and unemployment can be shown (Schreiber and Wolters, 2007). If these results are correct, this would reflect an incorrect specification of the data dealing with the use of filtering methods for the detection of the natural rate of unemployment such as the Hodrick-Prescott filter or the Kalman filter, which also explains the non-existent significance as well as the positive sign (Schreiber and Wolters, 2002). If this corresponds to the fact that, in addition to the supply side, the demand side also would have a permanent influence on unemployment and would weaken the advantages of a general low level of inflation, which has become consented during the last decade (Romer and Romer, 2002). At the same time, this would only raise the monetary policy of its relevant in the short term role and encourage the requirement for a higher inflation target (Blanchard et al., 2010).

4. Empirical analysis

4.1 Data

This paper uses annual data on inflation and unemployment, with the data for inflation taken from on the OECD[2] database, relating to the change in the general price level logarithmic since the previous period. The unemployment data is taken from AMECO[3], a data provider of the European Commission. By definition, the unemployment rate is the total number of unemployed as a percentage of the corresponding total labor force. This definition only includes the total number of employed and unemployed people in the economy. Following the ILO[4] definition, people who did not search for a job in the past period are not included in the unemployed people. The time series covers from 1970 to 2012 and comprises 43 observations per variable. Data on the unemployment rate before 1991 only refers to West Germany because no such data was available for East Germany prior to the reunification.

Table 4.1 Descriptive statistics from 1970 to 2012

Variables	Obs	Mean	Max	Min	St.Dev	INF	UNP
INF	43	2.89	7.03	-0.13	1.89	1.00	-0.72
UNP	43	6.18	11.30	0.50	2.92	-0.72	1.00

Source: OECD, AMECO

Considering the descriptive data during the sample period, inflation has a mean of 2.89% and decreases over time to a lower stable level. It is noticeable here that, with a value of -0.0013%, negative values are thus also present for inflation, which means there was deflation.

In 1970, the unemployment was at a level of 0.5%, reflecting the German economic wonder from the 1950s and 1960s, commonly explained with the catch up hypothesis (Persson, 2010). However, this effect ends in 1973 and increased permanent unemployment over time. The unemployment rate has risen to a level of around 8% since 2000. A correlation for the entire series also shows a value of -0.72 with a

[2] Organisation for Economic Cooperation and Development.
[3] Annual Macroeconomic Database is a database of the European Commission. http://ec.europa.eu/economy_finance/ameco/user/serie/SelectSerie.cfm
[4] International Labour Organization

strong negative relationship between inflation and unemployment, which already corresponds to the expected result of the Phillips curve. When we only refer to the time of the European Monetary Union, it becomes striking that Germany is permanently below the inflation target of the European Monetary Union. Furthermore, we can observe from table 4.2 that the negative relationship detected with the simple correlation between inflation and unemployment seems to have decreased.

Table 4.2 Descriptive statistics from 1999 to 2012

Variables	Obs	Mean	Max	Min	St.Dev	INF	UNP
INF	14	1.55	2.63	0.31	0.64	1.00	-0.21
UNP	14	8.40	11.30	5.50	1.68	-0.21	1.00

Source: OECD, AMECO

This suggests a possible change in the relationship over time towards a possible structural break, as the review should consider using an appropriate econometric method.

The presence of deflation in the time series necessitates a first change in the time series. In order to facilitate the interpretation of the results, it is a common means using the logarithm to reproduce the data as elasticity. Owing to negative values in the time series, we have to take the logarithm by transforming the percentage values in decimal numbers, add it up by one and subsequently taking the logarithm.

$$ln(1 + x) \approx x \qquad (4.01)$$

Finally, the transformation of the data set led to no effect on the negative relationship between inflation and unemployment, as the new correlation of both variables with -0.72 is the same.

4.2 Methodology

A prerequisite for the use of time series analysis is the knowledge concerning potential problems of the estimation process. If some rules are disregarded, the time series analysis leads to spurious regressions, first an introduction to the concepts of stationary time series and cointegration with their relevance for the Phillips curve. After this, we will look at the idea of the method of the error correction model in order to understand its advantages in terms of an analysis of the Phillips curve.

One condition for a useful result is the observance of three assumptions of the Gauss-Makrov conditions, namely a constant expected value over time (4.02), a constant variance over time (4.03) and a covariance of the sole length of the lag k, which is not dependent on the time (4.04).

If these assumptions of the time series are met, it is referred to as stationary, and an ordinary least squares estimation provides correct results.

Mean: $E(Y_t) = \mu$, for all $t = 1,2,\dots,T$ (4.02)

Variance: $Var(Y_t) = E(Y_t - \mu)^2 = \sigma^2$ (4.03)

Covariance: $\gamma_k = E[(Y_t - \mu)(Y_{t+k} - \mu)]$, for all $t = 1,2,\dots,T-k$ (4.04)

$k = 1,2,\dots,T-1$

However, when one or more of these assumptions are broken, we have the problem of spurious regression, which means that our estimation renders a relationship that is not given. Processes that contradict the assumptions of stationary are generally referred to as non-stationary processes.

As a useful example, here is a first-order autoregressive process: when a time series is such as the equation (4.05) the actual value is a result of the previous period and an error term, meaning it has no constant variance over time $Var(Y_t) = t\sigma^2$, and thus contradicts one of the basic assumptions of a stationary process.

$$Y_t = \beta_1 Y_{t-1} + u_t, \qquad \beta = 1 \qquad (4.05)$$

These are called a random walk process time series, which would not lead to information about the actual effect of the change in the time series, because the relevant information would only be found in the error term, but our estimate of Y_t

would use the value of Y_{t-1} to estimate a relationship. An example of such a random walk process is the price level of an economy, which is the price level of the last period plus its actual change. Another form of non-stationary time series is the random walk with drift (4.06), which is as before a result of the previous period Y_{t-1} and the addition of a constant δ value.

$$Y_t = \delta + \beta_1 Y_{t-1} + u_t,\ \ \beta_1 = 1, \delta \neq 0 \tag{4.06}$$

If so, in addition to the violation of a constant variance, there is also the absence of a constant expectation value. The encountered during a random walk with drift expectation value is subsequently about $E(Y_t) = Y_0 + t\delta$.

An alternative to the basic stationary process is the trend stationary process (4.07).

$$Y_t = \beta_1 + \beta_2 t + \beta_3 Y_{t-1} + u_t \tag{4.07}$$

When such a process exists, the time series is stationary around a time trend, with individual values are moving away from the expected mean, rising with a constant amount over time. In order to detect the presence of or absence of stationary, a variety of methods are possible, including the autocorrelation function and the correlogram, although they are only a first assessment because they are not appropriate test methods (Gujarati and Porter, 2009). An accurate method is represented by the Dickey-Fuller test, which uses an OLS estimate with the null hypothesis of non-stationary or alternative called unit root. Therefore, the opposite hypothesis is stationary.

$$H_0: \delta = 0\ \rightarrow non - stationary$$

$$H_1: \delta < 0\ \rightarrow stationary$$

The idea behind this test procedure is that in the case of non-stationary, namely that $\beta_1 = 1$, the first difference of the series (4.05) leads to equation (4.08) where Y_{t-1} has the coefficient $(\beta_1 - 1)$.

$$Y_t - Y_{t-1} = \beta_1 Y_{t-1} - Y_{t-1} + u_t \tag{4.08}$$

$$Y_t - Y_{t-1} = (\beta_1 - 1) Y_{t-1} + u_t \tag{4.09}$$

$$\Delta Y_t = \delta Y_{t-1} + u_t, \qquad \delta = (\beta_1 - 1) \tag{4.10}$$

An estimate of this equation in the case of a non-stationary process is when δ corresponds to the value zero, which would consequently lead to the problem of spurious regression, which means that the use of this data is not permitted.

If so, the Dickey-Fuller test rate δ would be smaller than one, thus the time series in its simple form would be stationary, and there would be no correction needed. However, since the simple Dickey-Fuller test in the case of a drift and a deterministic trend is faulty, it is also the Dickey-Fuller test with a constant and trend to expand (4.11), (4.12).

$$\Delta Y_t = \beta_0 + \delta Y_{t-1} + u_t \tag{4.11}$$

$$\Delta Y_t = \beta_0 + \beta_1 t + \delta Y_{t-1} + u_t \tag{4.12}$$

However, the simple use of these tests can lead to errors resulting from the widespread problem of the serial correlation of time series. In the presence of such problems, this can lead to an erroneous significance, which in turn can prompt an incorrect judgment of the time series process. This problem was corrected with the augmented Dickey-Fuller test (4.13) by including the difference of Y_t. With the proper use of the test with all major variables, the error term corresponds to a white noise[5] process $\varepsilon_t \sim (0, \sigma^2)$ (Gujarati and Porter, 2009).

$$\Delta Y_t = \beta_0 + \beta_1 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t \tag{4.13}$$

Given that we are now in a position to make a non-stationary process identify, the next step relates to the possibility of correcting this problem to render a dataset usable. The easiest way to make a time series stationary involves using the first difference of the variable. If the simple time series has a unit root process, there is the possibility that the first difference (4.15) corresponds to a stationary process that reflects the characteristics referred to at the beginning. The time series subsequently only consists of the random process u_t. If an ADF test on this first difference is also not stationary, a further difference is formed and tested again until we achieve the desired stationary process.

$$Y_t = \beta_1 Y_{t-1} + u_t \tag{4.14}$$

$$\Delta Y_t = (Y_{t-1} - Y_{t-1}) = u_t \tag{4.15}$$

[5] White Noise is a stochastic process with zero mean, constant variance and no autocorrelation.

If the time series is integrated in order d I(d), the series must be differenced d times in order to be stationary (Harris and Sollis, 2003). In time series econometrics, we predominantly make use of data that corresponds to a stationary process after the formation of the first difference, which represents an integration of the first order I (1). However, the use of a difference in estimates leads to two problems: first, it is not considered that the variables in levels can be away from one another at all; and second, we remove differences in the educational information from the data. The variables can also be in a long run relationship where the differences by form can no longer be recognized. Here, the concept of cointegration can help us: when two time series are cointegrated, we are able to estimate with non-stationary time series data to perform without succumbing to form relationships. The resulting estimate is thereby the long run context of the variables that we can connect in an error correction model with the short period later. The concept of Engle and Granger helps to detect the cointegration (Engle and Granger, 1987).

When Y_t and X_t are integrated in the order I(d,b), the residuals in the equation (4.16) should be integrated in order Zero I(0), given that when d is equal to b, I(d - b) = 0 (Harris and Sollis, 2003).

$$Y_t = \beta_0 + \beta_1 X_t + u_t \tag{4.16}$$

This means that when both variables are I(1) and the residuals are $u_t \sim I(0)$, the two series should be cointegrated in order CI(1,1) and have a long run relationship (Harris and Sollis, 2003). Only in such a case it is allowed to use non-stationary series for estimation without incurring the trouble of spurious regression. In order to ensure the co-integration of the variables using a statistical method, we use the ADF test previously used on the residuals u_t (Gujarati and Porter, 2009). Moreover, in the case of time series consisting of the same degree of integration, there is the possibility of non-stationary residuals. In this case, the time series are not cointegrated and we cannot identify a long run relationship between them.

The components of the long run equation play an important role for the further proceedings. The coefficients β_0 and β_1 provide us with the long run relationship of the variables Y_t and X_t. A special role falls upon the residuals u_t, which represent an imbalance and thus contain more useful information. Therefore, when the model is in equilibrium, the residuals of this model are equal to zero. One explanation for the deviations from the long run can be found in the different approaches of market imperfections, as partially shown in Section 2. Furthermore, they also reflect why it is important to differentiate between the short and long run effects of macroeconomic models.

Prior to dealing with the estimation of the vector error correction method, the question of the importance of providing the aforementioned properties of stationary as the cointegration for an analysis of the Phillips curve should be addressed. However, where inflation as well as unemployment are order one stationary processes, they move to a sustained level and only affect each other in the short run (Schreiber and Wolters, 2002). Therefore, we should be able to locate a Phillips curve. However, during stationary inflation and unemployment as non-stationary yet integrated in the first order, there is the possibility that a change in the inflation has long run effects on employment and thus a permanent tradeoff (Haldane and Quah, 1999). If inflation is non-stationary yet after first differentiating and the unemployment rate is stationary, it is possible to estimate a short run Phillips curve, although it represents the long run unemployment as a natural one that is equivalent to a vertical Phillips curve (Schreiber and Wolters, 2002). If both variables are stationary after first differentiating, this can set two results. In the case of cointegration, we can find a long run tradeoff and thus an absence of a natural rate of unemployment. When both variables are not cointegrated, there a short run relationship can no longer be captured, because as already explained a long run estimate in the case of cointegration is only possible if we want to avoid spurious regression.

Given that we now have the long run model and a basic knowledge of the data properties, in the following we will develop the short run model to catch the short run dynamic. For the estimation of a model with short run dynamics, a version of the long run model with time delayed variables is considered appropriate. Hereby the possibility of serial correlation must be prevented, because this type of models is very sensitive to it. A disregard of serial correlation provides a high coefficient of determination in the simultaneous presence of bad t-values (Harris and Sollis, 2003). To determine the optimal number of lags, the information criteria AIC and BIC were used.

$$Y_t = \alpha_0 + \gamma_0 X_t + \gamma_1 X_{t-1} + \alpha_1 Y_{t-1} + u_t \quad (4.17)$$

Here, we can interpret γ_0 as short run effect from X_t to Y_t. When this specification is correct, the residuals will be white noise $u_t \sim (0, \sigma^2)$. We can transform this short run model to the long run (4.18) with setting $Y_t = Y_{t-1}$ and $X_t = X_{t-1}$.[6]

$$Y_t = \beta_0 + \beta_1 X_t + \varepsilon_t, \quad \beta_0 = \frac{\alpha_0}{(1-\alpha_1)}, \quad \beta_1 = \frac{(\gamma_0+\gamma_1)}{(1-\alpha_1)}, \quad \varepsilon_t = \frac{u_t}{(1-\alpha_1)}, \tag{4.18}$$

Remember that equation (4.17) can be non-stationary and leads to spurious regression. To fix this problem and observe the effect of a change in X_t we can build the first difference of the series and transform the equation to get equation (4.19) (Harris and Sollis, 2003).

$$\Delta Y_t = \gamma_0 \Delta X_t - (1-\alpha_1)[Y_{t-1} - \beta_0 - \beta_1 X_{t-1}] + u_t \tag{4.19}$$

Where $Y_{t-1} - \beta_0 - \beta_1 X_{t-1}$ is the residual ε_{t-1} from the long run equation (4.18) (Harris and Sollis, 2003). When estimation (4.18) is the long run relationship between Y_t and X_t, the residuals of this equation have to be the adjustment process from the short run to the long run relationship. This resulting equation produces an Error Correction Model (4.20), which allows us to interpret the short run dynamic and adjustment process to the long run after a change in X_t.

$$\Delta Y_t = \gamma_0 \Delta X_t - (1-\alpha_1)[\varepsilon_{t-1}] + u_t \tag{4.20}$$

The short run effect of X_t to Y_t corresponds to the coefficient γ_0. The coefficient $-(1-\alpha_1)$ provides us information concerning the speed of adjustment. For example, the coefficient value -0.5 after one period means that 50% of the short run deviations are corrected by long run equilibrium. With the correct specification of the model, it also is a white noise error term $u_t \sim (0, \sigma^2)$. Should the test results not lead to a great fit, the model (4.20) can further be extended with lags and other short run components.

Advantages of this method include that all the time series are stationary and thus enable us to proceed with a simple OLS estimation (Harris and Sollis, 2003); moreover, we can observe both the short run and the long run dynamics of the cointegrated variables. Furthermore, this allows us to use the Phillips curve to analyze their dynamic effects. The initial prerequisite for this is that the time series

[6] The detailed procedure can be found in Appendix X.

dataset for Germany is cointegrated. Therefore, we will use the methods described here for the German case in the following.

4.3 Empirical findings

A first detailed analysis of the time series shows that inflation as well as unemployment are non-stationary processes in both cases, which leads with high probability to the problem of spurious regression.

After the form of the first difference of both these variables comprise at least stationary at the 5% significance level when using the ADF test. Thus, both time series are integrated in the first order I (1), giving us the possibility of a short-term analysis. For detection of the optimal lag length, the AIC and the BIC were used.[7] Moreover, a further analysis using the Engle-Granger method also reveals that both variables cointegrated CI (1,1) at the one percent level of significance and thus have a long run relationship. As mentioned in Section 4.2, this is already a first indication of an absence of the natural rate of unemployment. Although both variables are cointegrated, this relationship can subsequently change over time (Islam et al., 2011).

The result of the estimation of the long run relationship indicated by an adjusted coefficient of determination of 0.51 and an F-test indicates the 1% significance level for a good quality of the estimate. Furthermore, the analysis of the individual variables is promising given that the constant and unemployment at the 1% significance level are different from zero.

$$LINF_t = \gamma_0 - \gamma_1 LUNP_t + \varepsilon_t \tag{4.21}$$

$$\widehat{LINF}_t = 0.0569 - 0.4791\, LUNP_t$$

$$(0.01)^{*} \qquad (0.07)^{*}$$

$$R^2 = 0.5247 \quad \bar{R}^2 = 0.5131 \quad \mathrm{F-Stat.} = 45.26 \quad \mathrm{F-Prob.} = 0.0000$$

The Notation *, **, *** refers to significance at 1%, 5% and 10% level respectively.

[7] To avoid the probability of unrecognized lags the AIC attributed a greater importance.

As expected according to theory, there is a negative relationship between inflation and unemployment. Contrary to the theory of the natural rate unemployment, this results a long run relationship between both variables. Because it is a logarithm of the variables in the estimation, a direct interpretation of the constants is not possible. By transforming it back, it is generally assumed that inflation is constant by 5.86% when there is no unemployment. Such a transformation in the case of unemployment is not necessary given that we can directly interpret this as elasticity. When unemployment LUNP falls by one percent, inflation rises by 0.48 percent. However, this only reflects the inflation dynamics, without informing us about the impact of inflation to the level of unemployment, as is the case in the theoretical Phillips curve. In order to exclude the possibility of autocorrelation and ensure the robustness of the estimate, a dynamic estimation of the model will also be tested (Stock and Watson, 1993), which includes the lag of the differenced inflation $\Delta LINF_{t-1}$ and the lag difference of the unemployment rate $\Delta LUNP_{t-1}$, as well as including a time trend variable named $Time$.

The outcome of the dynamic OLS estimation is an increase in the adjusted coefficient of determination, and the F-test remains different from zero at the 1% significance level. Indeed, apart from the coefficients for the time trend, all the coefficients are different from zero at the 1% significance level. The lack of significance for the time trends is again reflected in the form of a very small coefficient.

$$LINF_t = \gamma_0 - \gamma_1 LUNP_t + \gamma_2 \Delta LUNP_{t-1} + \gamma_3 \Delta LINF_{t-1} + \gamma_4 Time + u_t \quad (4.22)$$

$$\widehat{LINF}_t = \underset{(0.01)^*}{0.0579} - \underset{(0.11)^*}{0.4818}\, LUNP_t + \underset{(0.24)^*}{0.8960}\, \Delta LUNP_{t-1} + \underset{(0.14)^*}{0.6484}\, \Delta LINF_{t-1} - \underset{(0.00)}{0.0001}\, Time$$

$$R^2 = 0.7545 \quad \bar{R}^2 = 0.7272 \quad \mathrm{F-Stat.} = 27.66 \quad \mathrm{F-Prob.} = 0.0000$$

The Notation *, **, *** refers to significance at the 1%, 5% and 10% level respectively.

The two added variables in lag have a significant positive value, yet do not change the coefficients of our original estimate. Furthermore, the use of Durbin's alternative test for autocorrelation leaves no doubts, given that it confirms the absence of serial correlation, with the essential coefficients unchanged. As an interim conclusion, it can be initially noted that inflation has a long run impact on unemployment, thus suggesting evidence against the natural rate of unemployment for Germany.

As explained in Section 3.2, through the concept of vector error correction models we have the possibility to create a connection between the short and long term if we have a cointegrated time series. The previous estimates show us both a cointegration of the variables inflation and unemployment, and the existence of a long run Phillips curve. Therefore, in the next step we can use the residuals of the long run Phillips curve, and as previously explained earlier, short run deviation from the long run equilibrium to capture the short run dynamics of the Phillips curve on these routes. The model is presented in section 3.2 as the basic model in the first difference of the dependent variable inflation $\Delta LINF_t$, the first difference of the independent variable in the unemployment $\Delta LUNP_t$ and the adjustment process to the long run equilibrium ECM_{t-1}. Moreover, it is also a departure from the basic model, which includes a lag of the first difference of the unemployment rate $\Delta LUNP_{t-1}$, given that this improves a statement of the information criteria the quality of the estimate. As before, this estimation is conducted using an OLS estimation. A first look at the quality of the estimate with a corrected coefficient of determination 0.25 as well as an F-value of 0.00 indicates the relevance of the estimate. Even if the F-value of the estimate has significance at the 1% level, in the consideration of the single variables, only the residuals of the long run adjustment ECM_{t-1} are different from zero at the 1% significance level. Such significance cannot be determined with all other components, with the absence of significance in the constants attributable to their irrelevance.

$$\Delta LINF_t = \delta_0 + \delta_1 \Delta LUNP_t + \delta_2 \Delta LUNP_{t-1} + \delta_3 ECM_{t-1} + u_t \qquad (4.23)$$

$$\Delta L\widehat{IN}F_t = -0.0003 + 0.1297\Delta LUNP_t - 0.3163\Delta LUNP_{t-1} - 0.3809 ECM_{t-1}$$

$$(0.00) \qquad (0.23) \qquad (0.23) \qquad (0.14)^{*}$$

$$R^2 = 0.3017 \quad \bar{R}^2 = 0.2451 \quad \mathrm{F-Stat.} = 5.33 \quad \mathrm{F-Prob.} = 0.0037$$

The Notation *, **, *** refers to significance at 1%, 5% and 10% level respectively.

It is initially noticeable that the coefficient of variation of unemployment is positive and opposite of the theory, thus confirming no inverse relationship between inflation and unemployment. Indeed, only the first lag of a change in unemployment is negative. However, there is no significance for both coefficients, and consequently we cannot interpret them. Furthermore, the coefficient of the error correction provides the expected negative relationship and tells us that the process of the short run dynamic deviation from the long run equilibrium after a year is corrected by 38.01%, which indicates a high degree of rigidities.[8] Therefore, it can be concluded that we cannot find a short run effect on employment due to a change in inflation. On the contrary, there is the possibility of an increase in unemployment due to higher inflation. Together with the first lag of the change in inflation, it seems that this model can only provide an explanation of the short run inflation dynamic. However, before we can use the present findings, it is necessary to explain the ensured accuracy of the estimation using the conventional test method.

An analysis of the residuals draws attention to a few problems.[9] Initially, it can be seen that the residuals cannot be interpreted as a normal distribution at the 10% significance level. However, this result arises by the time the financial and economic crisis caused the shock, which cannot be explained with this model. By disregarding these outliers, the test results for normal distribution of the residuals with a chi-value of 0.22, led to the conclusion of normal distributed residuals. Thus, the single outlier test is the Breusch-Godfrey LM test for the detection of serial correlation. Since the Ramsey RESET test indicates no misspecification of the model, we can exclude this source of error as the cause of the serial correlation using a Newey-West estimate (Gujarati and Porter, 2009). For the Newey-West estimate, we shall use the number of three lags specified by the Breusch-Godfrey LM test. In this case, the model is identical in its construction to that previously used, and also provides identical coefficients. The only difference is a possible change in the statistical significance caused by the presence of serial correlation (Hill et al., 2011).

$$\Delta LINF_t = \delta_0 + \delta_1 \Delta LUNP_t + \delta_2 \Delta LUNP_{t-1} + \delta_3 ECM_{t-1} + u_t \qquad (4.24)$$

$$\Delta L\widehat{IN}F_t = -0.0003 + 0.1297 \Delta LUNP_t - 0.3163 \Delta LUNP_{t-1} - 0.3809 ECM_{t-1}$$

$$(0.00) \qquad (0.28) \qquad (0.29) \qquad (0.12)^*$$

$$R^2 = 0.3017 \quad \mathrm{F-Stat.} = 8.86 \quad \mathrm{F-Prob.} = 0.0001$$

The Notation *, **, *** refers to significance at the 1%, 5% and 10% level respectively.

As the estimate shows, there is a change in the individual t-values, although this did not alter the significance of the individual coefficients. However, with an F-value of 0.00, the estimate as a whole indicates a further improvement of significance. Since

[8] For comparison, an estimate for North Cyprus that used an identical method to correct the short run dynamics after one year by 69.04% (Islam et al., 2011).
[9] The detailed test results can be found in Appendix V.

the estimate was already different at the 1% significance level of zero, this takes no crucial role for further evaluation of the estimate.

Following the tests of the residuals, any further problems are now resolved and the specification of the model is therefore likely to be correct. Finally, the stability of the Phillips curve over the observation period should be proved. Since macroeconomic relationships may change in time, and in particular Germany could be characterized by multiple structural breaks throughout its history,[10] it proves difficult here to capture these potential breaking points. Given that the Chow structural break test is not suitable for analysis at unknown time points of structural breaks, the CUSUM[11] test and CUSUMsq[12] test represent better alternatives. If the plots of the Statistics between the critical values suggest there are no structural breaks, the estimate is correctly specified and can be applied to the entire time series (Islam et al., 2011). The result of this test tells us there is no structural break found at the 5% level of significance, and thus indicates a suitable representation of the inflation dynamic.[13]

[10] The two oil price shocks, the German reunification 1990, formation of the Eurozone 1999 and extensive labor market reforms since 2003, called "Agenda 2010".

[11] *Cumulative sum* is a sequential analytical method for the detection of changes in a sequential data set or time series by using recursive residuals.

[12] Cumulative sum squared is fundamentally the same approach as the CUSUM test, but uses the squared recursive residuals (Islam et al., 2011).

[13] The test figures can be found in the statistical appendix.

5. Conclusion

This study aimed to investigate the existence of the Phillips curve for Germany. Using the ADF Tests, inflation and unemployment were recorded as integrated in the first order and reported upon further examination of cointegration. The paper subsequently estimated a Phillips curve by using the concept of cointegration and an error correction model.

One of the main results emerging from this work is that no negative relationship between inflation and unemployment can be detected in the short run. Furthermore, contrary to expectations, this relationship is positive, which is consistent with the general results using a hybrid Phillips curve (Gali and Gertler, 2000) or an error correction model (Schreiber and Wolters, 2007). Therefore, the model used is only useful in understanding short run dynamics of inflation, and also confirms the relatively high degree of rigidities in Germany.

Furthermore, this study found significant evidence of a long run relationship between inflation and unemployment in Germany, thus contradicting the theory of a natural rate of unemployment. My results are consistent with previous research for Germany (Schreiber and Wolters, 2002; Franz, 2005). Germany has been affected by a variety of intensive changes in macroeconomic situations throughout its history, and particularly the establishment of the European Monetary Union. Due to the longer observation period of 13 years for the European Monetary Union, this paper can also provide information concerning this time. While it was expected to influence a change in the effect of the Phillips curve (Paloviita, 2008), this result is not confirmed with this work when using the CUSUM tests. Therefore, the estimate is valid over the entire observation period and does not change following the beginning of the European Monetary Union.

Moreover, this study provides important implications for the German inflation levels and also for the European Monetary Union. In the case of a permanent low inflation target, as in the European Monetary Union, shocks can influence the unemployment in the long run, which can be explained by asymmetric nominal rigidities (Akerlof et al., 2000; Holden, 2004). As the estimations show, we can observe this long run relationship between inflation and unemployment for Germany. Accordingly, a permanent increase in the inflation target can lead to a permanent lower level of unemployment for Germany. Besides this, the implication for monetary policy is a stronger shift to the unemployment gap by choosing the interest rate in a recession, to ensure that the increase in unemployment will not be permanent (Karanassou et al., 2008).

The most important point relates to the implication of a permanent higher inflation target, which can lead to two different points. The first such effect would be a permanent increase in the inflation target of the European Monetary Union. In order to make a judgment on this, we first have to find evidence for a long run tradeoff between inflation and unemployment for the whole European Monetary Union, and also have to include the costs of inflation. However, since this is not considered within this work, it cannot be stated as a conclusive result.

Second, since the being of the European Monetary Union, Germany finds itself for the first time in an ideal position to reduce permanent unemployment through an increase in inflation. An observation of German inflation since the beginning of the European Monetary Union shows that Germany was permanently with an average inflation of 1.5% below the European central banks inflation target of 2%, yet unable to correct this for two reasons: first, because the European Monetary Union has one common central bank and therefore monetary policy cannot used to aim only at Germany; and second, an increase in fiscal policy in the past had negative effects for other countries in the monetary union. In addition to Germany being permanently under the inflation target, other countries were permanently above the inflation target, with the European Central Bank on average reaching the inflation target. Therefore, an increase in government spending would lead to an increase in inflation, which would increase the inflation level of the monetary union above the inflation target. In turn, this would lead to an increase of the interest rate, prompting negative effects for other countries inside the monetary union. Within the current euro crisis, the average inflation of the European Monetary Union is under the inflation target of 2%. Accordingly, this fiscal policy can be used to replace the infrastructure and increase the German inflation to 2% without an increase of the interest rate of the European central bank.

In this respect, Germany is able to counteract the decline of infrastructure, can reduce unemployment by increasing the inflation permanently to a higher level without missing the inflation target of the central bank, and also has positive spillover effects for other countries of the European Monetary Union.

References

Akerlof, G. A., W. T. Dickens, and G. L. Perry (2000), ‘Near–rational wage and price setting and the long-run Phillips curve‘, *Brookings Papers on Economic Activity*, 31 (1), 1–60.

Blanchard, O., G. Dell´Ariccia, and P. Mauro (2010), ‘Rethinking Macroeconomic Policy‘, *IMF Staff Position Note*, International Monetary Funds.

Blinder, A. S. (2000), ‘Comment on Akerlof, Dickens and Perry, Near–rational wage and price setting and the long-run Phillips curve‘, Brookings Papers on Economic Activity, 31 (1), 1–60.

Borjas, G. J. (2012), *Labor Economics*, 6th edition, New York, US: Mcgraw-Hill.

Bryan, M. F. and S. Palmqvist (2005), ‘Testing Near-Rationality Using Detailed Survey Data‘, *Federal Reserve Bank of Cleveland Working Papers*, 05 (02), Cleveland.

Calvo, G. A. (1983), ‘Staggered Prices in a Utility-Maximizing Framework‘, *Journal of Monetary Economics*, 12, 383–398.

Chengsi, Z., D. R. Osborn and D. H. Kim (2009), ‘Observed Inflation Forecasts and the New Keynesian Phillips Curve‘, *Oxford Bulletin of Economics and Statistics*, 71 (3), 375–398.

Danišková, K. & J. Fidrmuc (2011) ‘Inflation Convergence and the New Keynesian Phillips Curve in the Czech Republic‘," *Czech Economic Review*, 5 (2), 99-115.

DiNardo, J. and M. Moore (1999), ‘The Phillips Curve is Back? Using Panel Data to Analyze the Relationship between Unemployment and Inflation in an Open Economy‘, *NBER Working Papers*, 7328.

Doepke, J., J. Dovern, U. Fritsche, and J. Slacalek (2008), ‘The Dynamics of European Inflation Expectations‘, *The B.E. Journal of Macroeconomics*, 8 (1).

Engle, R. F. and C. W. J. Granger (1987), ‘Cointegration and Error Correction: Representation, Estimation and Testing‘, *Econometrica*, 55 (2), 251-271.

Franz, W. (2005), ‘Will the German Nairu Please stand up? *German Economic Review*, 2, 131-153.

Friedman, M. (1968), ‘The Role of Monetary Policy‘, American Economic Review, 58 (1) 1-17.

Fuhrer, J. C. (1997), ‘The (Un)Importance of Forward-Looking Behavior in Price Specifications‘, *Journal of Money, Credit, and Banking*, 29 (3), 338–350.

Gali, J. (2008), *Monetary Policy, Inflation and the Business Cycle: An Introduction to the New Keynesian Framework*, Princeton, NJ: Princeton University Press.

Gali, J. and M Gertler, (1999) ‘Inflation Dynamics: A Structural Econometric Analysis‘, *Journal of Monetary Economics*, 44 (2), 195-222.

Gali, J., M. Gertler and D. Lopez-Salido, (2005), ‘Robustness of the estimates of the hybrid New Keynesian Phillips curve‘, *Journal of Monetary Economics*, 52 (6), 1107-1118.

Gordon R. J. (1997), ‘The Time-Varying NAIRU and its implication for Economic Policy‘, *Journal of Economic Perspectives*, 11 (1) 11-32.

Gordon R. J. (2008), ‘The History of the Phillips Curve: An American Perspective‘, Paper presented at NU Macro Workshop Revised version of paper given at Australasian Meetings of Econometric Society Evanston, IL September 29th.

Gujarati D. and D. Porter (Eds.) (2009), *Basic Econometrics, 5th edition*, New York, US: McGraw-Hill.

Haldane, A. and D. Quah (1999), ‘UK Phillips Curves and Monetary Policy‘, *Journal of Monetary Economics*, 44, 259-278

Harris, R. and R. Sollis (Eds.) (2003) *Applied Time Series Modelling and Forecasting*, 1st edition, New York, US: Wiley & Sons.

Hill, R. C., W. E. Griffiths and C. L. Guay (Eds.) (2011), *Principles of Econometrics*, 4th edition, New York, US: Wiley & Sons.

Holden, S. (2004), ‘The costs of price stability: Downward nominal wage rigidity in Europe‘, Econometrica, 71 (281), 183-208.

Islam, F. and M. Shahbaz and M. Shabbir (2011), ‘Phillips curve in a small open economy: A time series exploration of North Cyprus‘ Munich Personal Research Papers of Economists, 28397.

Karanassou, M., H. Sala and D. J. Snower (2008), ‘Long-Run Inflation-Unemployment Dynamic: The Spanish Phillips Curve and Economic Policy‘, Kiel Working Papers 1326

Lucas, R. E. (1972), ‘Expectations and the neutrality of money‘, *Journal of Economic Theory*, vol. 4 (2), 103-124.

Lucas, R. E. (1973) ‘Some International Evidence on Output-Inflation Trade-offs‘, *American Economic Review*, 63, 326–334

Mikosch, H. (2012), ‘Sticky Prices, Competition and the Phillips Curve‘, in: KOF Working Papers 294.

Millet, F. C. (2007), ‘Inflation Expectations, the Phillips Curve and Monetary Policy‘, Kiel Working Papers 1339,

Paloviita M. (2008), ‘Comparing alternative Phillips curve specifications: European results with survey-based expectations‘, *Applied Economics*, 40, 2259-2270.

Paloviita, M. and D. G. Mayes (2005) ‘The use of real time information in Phillips Curve relationships for the euro area‘, *The North American Journal of Economics and Finance*, 16, 415-434.

Persson, K. G. (2010), ‘*An Economic History of Europe*‘, 1st edition, Camebridge, UK: Cambridge University Press

Pfeiffer, F. (2004), ‘Ausmaß und Konsequenzen von Lohnrigiditäten‘, ZEW Discussion Papers, 0413.

Phelps, E. S. (1968), ‘Money-wage Dynamics and Labor-market Equilibrium‘, Journal of Political Economy, 76 (4), 678-711.

Phillips, A.W. (1958), ‘The Relation between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom‘, *Economica*, 25 (100), 283-299.

Reichel R. (2004), ‘On the Death of the Phillips Curve: Further Evidence‘, *Cato Journal*, 24, 341-348.

Romer, C. D. & D. H. Romer (2002), ‘The evolution of economic understanding and postwar stabilization policy‘, *Proceedings, Federal Reserve Bank of Kansas City*, 11-78.

Rudd, J. & Whelan K. (2005), ‘Does Labor's Share Drive Inflation?‘, *Journal of Money, Credit and Banking*, 37 (2), 297-312.

Rudd, J. and K. Whelan (2006) ‘Can Rational Expectations Sticky-Price Models Explain Inflation Dynamics?‘, *American Economic Review*, 96 (1), 303-320.

Rudd, J. and Whelan K. (2005), ‘New tests of the New-Keynesian Phillips curve‘, *Journal of Monetary Economics*, 52 (6), 1167-1181.

Samuelson, P. A. and R. M. Solow (1960), ‘Analytical Aspects of Anti-Inflation Policy‘, *American Economic Review*, 50 (2), 177-94.

Schreiber, S. and J. Wolters (2002), ‘What's Wrong with the (German) NAIRU?‘, *Diskussionsbeitrage des Fachbereichs Wirtschaftswissenschaft der Freien Universität Berlin*, 2002/08.

Schreiber, S. and J. Wolters (2007), The long-Run Phillips Curve Revisted: Is the NAIRU Framework Data-consistent? *Journal of Macroeconomics*, 29, 355-367.

Shiller, R. J. (1997), ‘Why do people dislike inflation?‘, in Romer C. D. and D. H. Romer (Eds.), *Reducing Inflation: Motivation and Strategy*, Chicago, US: University of Chicago Press.

Stock J. H. and M. W. Watson (1991), ‘A simple estimator of cointegrating vectors in higher order integrated systems‘, Econometrica, 61 (4), 783-820.

Summers, L. H. (1988), ‘Relative Wages, Efficiency Wages, and Keynesian Unemployment‘, *The American Economic Review*, 78 (2), 383-388.

Woodford, M. (2009), ‘Convergence in Macroeconomics: Elements of the New Synthesis‘, *American Economic Journal: Macroeconomics*, 1 (1), 267-279.

Appendix A

Descriptive statistics Germany 1970-2012

Variables	Obs	Mean	Max	Min	St.Dev	INF	UNP
INF	43	2.8947	7.0320	-0.1299	1.8947	1.0000	-0.7237
UNP	43	6.1767	11.3000	0.5000	2.9227	-0.7237	1.0000

Source: OECD, AMECO

Descriptive statistics Germany 1970-2012

Variables	Obs	Mean	Max	Min	St.Dev	LINF	LUNP
LINF	43	0.0284	0.0679	-0.0013	0.0183	1.0000	-0.7243
LUNP	43	0.0595	0.1071	0.0049	0.0277	-0.7243	1.0000

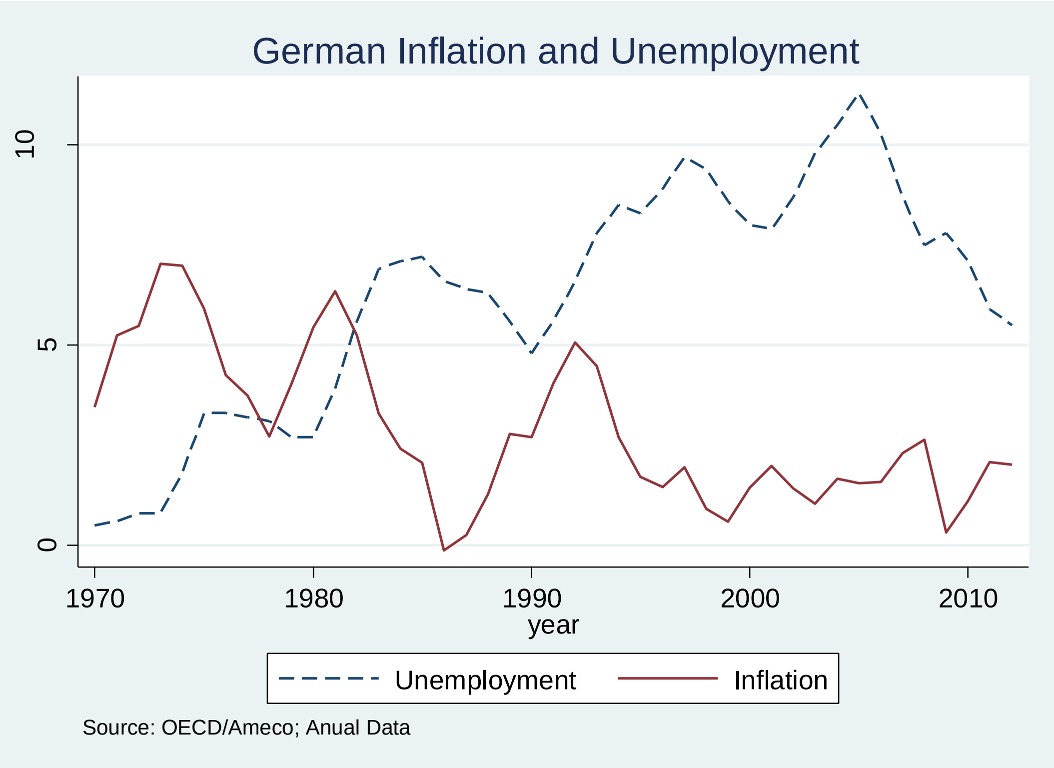
Source: OECD, AMECO

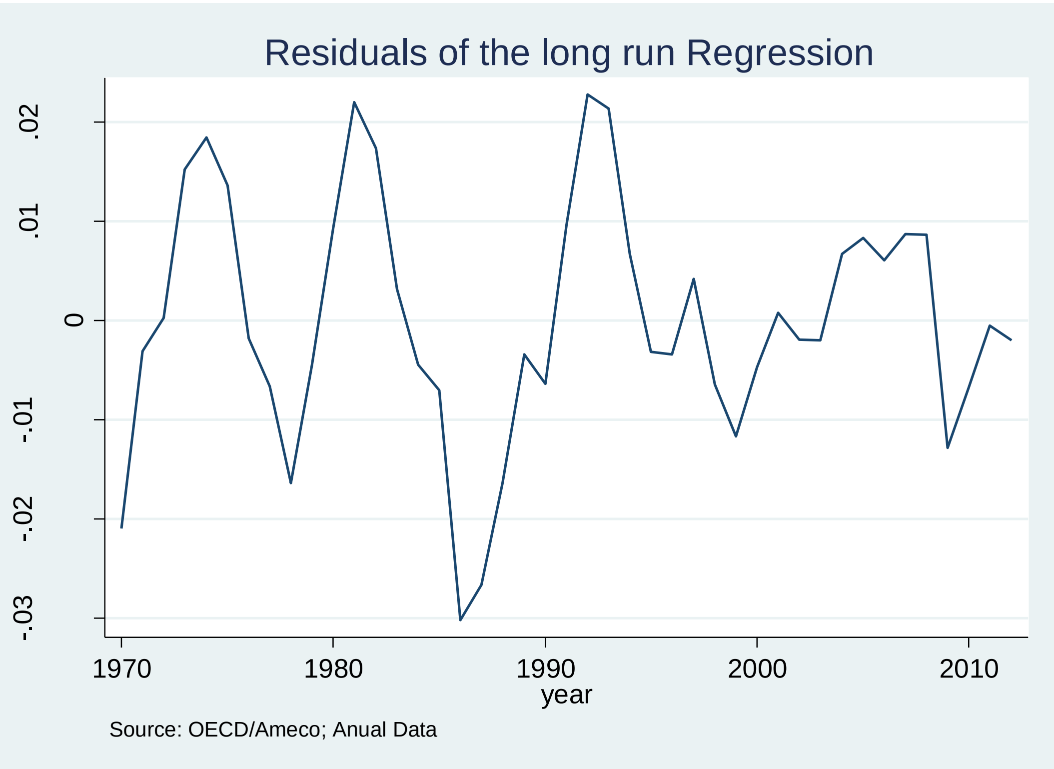
Descriptive statistics Germany 1999-2012

Variables	Obs	Mean	Max	Min	St.Dev	INF	UNP
INF	14	1.5487	2.6284	0.3127	0.6425	1.0000	-0.2076
UNP	14	8.4000	11.3000	5.5000	1.6765	-0.2076	1.0000

Source: OECD, AMECO

Appendix B


German Inflation and Unemployment
0
5
10
1970
1980
1990
2000
2010
year
Unemployment
Inflation
Source: OECD/Ameco; Anual Data


Residuals of the long run Regression
-.03
-.02
-.01
0
.01
.02
1970
1980
1990
2000
2010
year
Source: OECD/Ameco; Anual Data

Appendix C

Augmented Dickey-Fuller Test Results

Variable	T. calculated	Prob. Value	Lags*
LINF	-2.365	0.1519	2
LUNP	-2.432	0.1328	3
	With Drift		
LINF	-2.365	0.0118	2
LUNP	-2.432	0.0102	3
	With Trend		
LINF	-3.518	0.0375	2
LUNP	-1.421	0.8548	3
	ADF at 1st Difference		
ΔLINF	-4.396	0.0003	2
ΔLUNP	-3.201	0.0199	2
	With Drift		
ΔLINF	-4.396	0.0000	2
ΔLUNP	-3.201	0.0015	2
	With Trend		
ΔLINF	-4.373	0.0024	2
ΔLUNP	-3.846	0.0144	2

*Number of lags chosen by the Akaike information criterion.

Engle-Granger Test for Cointegration

Variable	T. calculated	Prob. Value	Lags*
Residuals	-4.159	0.0008	2
	With Drift		
Residuals	-4.159	0.0001	2
	With Trend		
Residuals	-4.112	0.0061	2

*Number of lags chosen by the Akaike information criterion.

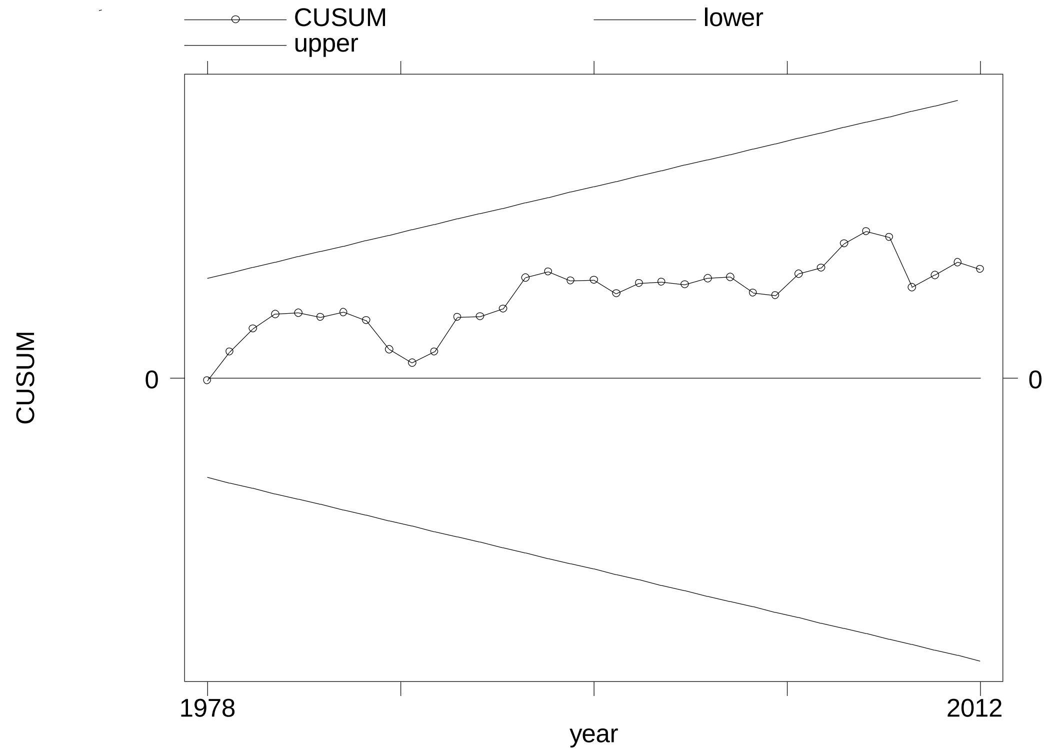
Tests of the Residuals

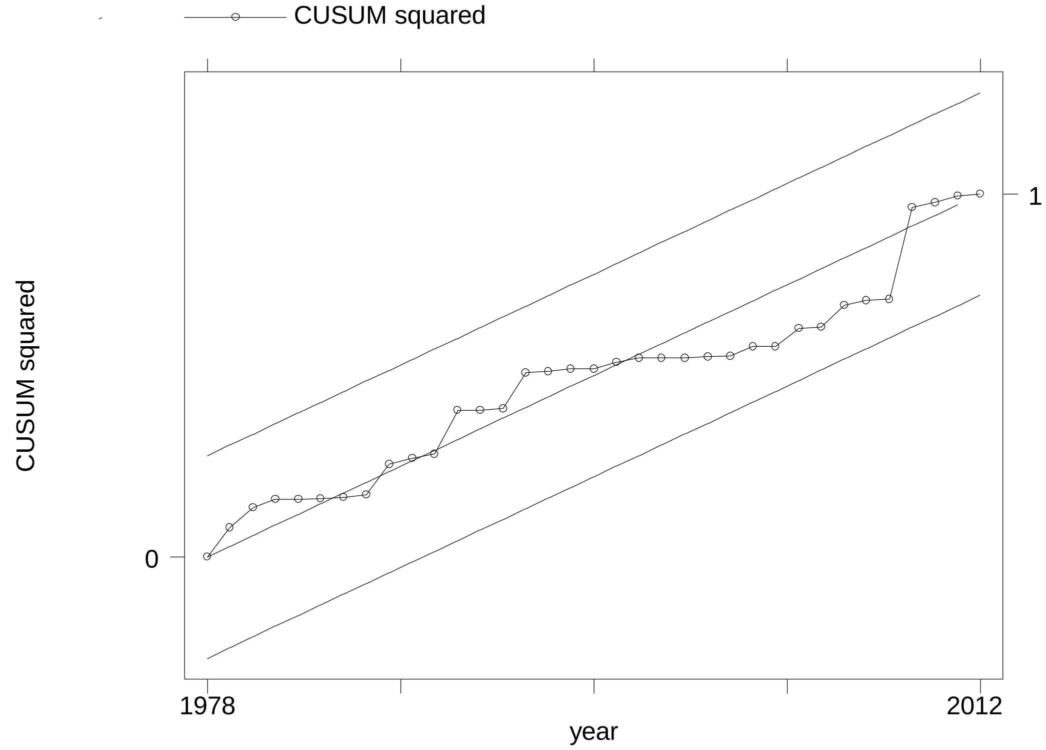
Serial Correlation LM Test = 7.770(0.0510)
ARCH Test = 0.597 (0.4396)
Heteroscedasticity Test = 0.29 (0.5925)
Normality Test = 4.98 (0.0830)
Normality Test* = 3.04 (0.2185)
Ramsey Test = 1.69 (0.1868)

Test = Value (Prob)

*Normality Test by excluding the error term from 2009 because of the financial crisis shock.

Results of the for breaking points tests





Appendix D

Transform the equation from the short to the long run

$$Y_t = \alpha_0 + \gamma_0 X_t + \gamma_1 X_{t-1} + \alpha_1 Y_{t-1} + u_t, \quad Y_t = Y_{t-1}, \quad X_t = X_{t-1} \tag{D.01}$$

$$Y_t = \alpha_0 + \gamma_0 X_t + \gamma_1 X_t + \alpha_1 Y_t + u_t \tag{D.02}$$

$$Y_t - \alpha_1 Y_t = \alpha_0 + \gamma_0 X_t + \gamma_1 X_t + u_t \tag{D.03}$$

$$Y_t - \alpha_1 Y_t = \alpha_0 + (\gamma_0 + \gamma_1) X_t + u_t \tag{D.04}$$

$$(1 - \alpha_1) Y_t = \alpha_0 + (\gamma_0 + \gamma_1) X_t + u_t \tag{D.05}$$

$$Y_t = \frac{\alpha_0}{(1-\alpha_1)} + \frac{(\gamma_0+\gamma_1)}{(1-\alpha_1)} X_t + \frac{u_t}{(1-\alpha_1)}, \quad \alpha_1 < 1 \tag{D.06}$$

$$Y_t = \beta_0 + \beta_1 X_t + \varepsilon_t, \ \beta_0 = \frac{\alpha_0}{(1-\alpha_1)}, \quad \beta_1 = \frac{(\gamma_0+\gamma_1)}{(1-\alpha_1)}, \quad \varepsilon_t = \frac{u_t}{(1-\alpha_1)}, \tag{D.07}$$

Linnaeus University – a firm focus on quality and competence

On 1 January 2010 Växjö University and the University of Kalmar merged to form Linnaeus University. This new university is the product of a will to improve the quality, enhance the appeal and boost the development potential of teaching and research, at the same time as it plays a prominent role in working closely together with local society. Linnaeus University offers an attractive knowledge environment characterised by high quality and a competitive portfolio of skills.

Linnaeus University is a modern, international university with the emphasis on the desire for knowledge, creative thinking and practical innovations. For us, the focus is on proximity to our students, but also on the world around us and the future ahead.

Lnu.se

Linnæus University
SE-391 82 Kalmar/SE-351 95 Växjö
Telephone +46 772-28 80 00