Kamila Ulmann

University of Gdańsk, Faculty of Management
2nd year SS2 Informatics and Econometrics, Economic Analysis

University of Gdańsk, Faculty of Economics
2nd year SS2 Economics, Economic Policy and Entrepreneurship Strategy

The relationship between inflation and unemployment: an empirical approach for the European Union countries

Introduction

Due to the complexity of mechanisms of the economy, the most important macroeconomic categories, e.g. inflation and unemployment, are interdependent. The Phillips curve was first published in an article written by New Zealand economist Alban W. Phillips in 1958. A.W. Philips showed that in Great Britain there was observed a strong statistical correlation between the level of inflation and unemployment. Similar relationships were identified also in other countries, and then the term "Phillips curve" was coined in regard to the relationship. Economists have long wondered whether this curve should still be used as a macroeconomic tool, due to the numerous controversies surrounding it. Over the course of history, there have been high levels of inflation and high levels of unemployment at the same time. There is much speculation about the existence of this curve. Some believe that it was only a product of the 1960s, when accidentally the level of inflation was highly dependent on unemployment.

Controversies around this issue concern the shape of the Phillips curve, or even the presence of only an apparent correlation between the described phenomena or the actual causation. Therefore, it was decided to try to answer the question of whether the relationship written off by the Phillips curve is observable in the EU. Therefore, the aim of the study below is to demonstrate the existence of an economic dependence described as the Philips curve on the example of EU countries. For this purpose, data from Eurostat for the period of 2002–2019 for all current EU countries and the United Kingdom (UK) were used (UK was the member of the EU for most of the research period).

1. Theoretical aspects and methodology

In general, the Phillips curve shows an inverse relationship between the unemployment and inflation in economies of different countries[1].

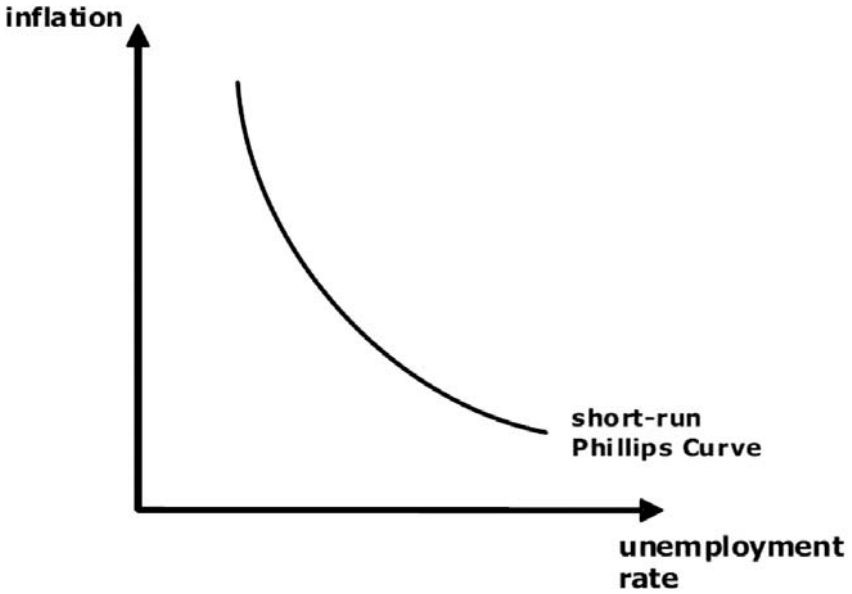

Figure 1. An inverse relationship between the unemployment and inflation

Source: T. Moloi, T. Marwala, *The Phillips Curve, in: Artificial Intelligence in Economics and Finance Theories*. Advanced Information and Knowledge Processing, Springer, Cham 2020.

The inverse relationship means negative relationship which is shown in the figure 1. The aforementioned curve is supposed to indicate the phenomenon of rising prices caused by a decline in unemployment in a particular economy[2]. Justification of the observed negative relationship between the analysed factors may be due to the fact that during period of low unemployment entrepreneurs are more likely to comply with trade union demands and vice versa[3]. The nature of

[1] Ch. Dritsaki, M. Dritsaki, *Phillips curve inflation and unemployment: an empirical research for Greece*, "Int. J. Computational Economics and Econometrics", 2013, vol. 3, no. 1/2, s. 28.

[2] J.C.W. Ahiakpor, *The Phillips Curve Analysis: An Illustration Of The Classical Forced-Saving Doctrine*, "Journal of the History of Economic Thought", 2009, vol. 31, no. 2, s. 144.

[3] T. Grabia, *The Phillips Curve Controversy*, „Gospodarka Narodowa", 5(273) Rok LXXXIV/XXV, wrzesień–październik 2014, s. 6.

the Phillips curve determines how the interaction of demand and supply will affect the economy[4].

This article focuses on the classic Phillips curve in short run, which means that the dependent variable is the rate of wage growth — first differences of the wage variable. Independent variable is unemployment rate. In this analysis the panel data model is applied, and therefore two dimensions are taken into account: cross-sectional and time series. There are balanced and unbalanced data. The first of these concerns the situation while having data for each object *I* and for each period *T*[5]. The study below uses unbalanced data due to lack of data for individual countries (mainly Cyprus and Malta). Econometrics panel models describe a fixed group of objects in different periods. in this case, the study covers the countries of the European Union including Great Britain in period 2002-2019. The easiest way to model panel data is to use the classic estimation method which means Ordinary Least Squares (OLS). In this case, one can use the following formula[6]:

$$y_{it} = \alpha + x_{it}\beta + v_{it}$$

where: y_{it} – dependent variable, x_{it} – vector of independent (explanatory) variables, α - the intercept, β – vector of structural parameters of the panel model, v_{it} – the total random error, which consists of the individual effect (for the panel model of the estimated OLS, individual effects equal zero).

In the case of using the above method (OLS), the restrictive assumption regarding the homogeneity of the population should be taking into consideration. Further, the fact that in the case of the panel model obtained with the use of the OLS, i.e. pooled model, the differences between the actual values of the variable and the theoretical values are a consequence of the occurrence of only the random component, i.e. such an estimation is permissible only when there is no individual effect[7]. Otherwise, one of the individual effects models should be used. There are fixed or random effects models. In order to be able to correctly determine whether it is appropriate to use the OLS model, a Breusch-Pagan test must be carried out. The Breusch-Pagan LM (Lagrange Multiplier) test can verify the necessity of application a random effects regression and a simple OLS regression.

---

[4] G. Motyovszki, *The Evolution of Phillips Curve Concepts and Their Implications for Economic Policy*, "History of Economic Thought", Term Paper, Central European University, 2013, s. 1.

[5] https://www.reed.edu/economics/parker/s11/312/notes/Notes13.pdf (access: 05.12.2020).

[6] J. Mućk, Econometrics of Panel Data, s. 16, http://web.sgh.waw.pl/~jmuck/EoPD/Meeting1_2018.pdf [access: 06.12.2020].

[7] T. Kufel, *Econometrics. Troubleshooting using GRETL*, Wydawnictwo Naukowe PWN, Warszawa 2007, s. 164.

The null hypothesis in the LM test is that variances across entities is zero which means no significant difference across units (i.e. no panel effect)[8].

RE are models with random component decomposition, which means that each object in the model is assigned a random variable that is directly responsible for the individual effect. The estimator used in the case of the RE model is the GLS – Generalized Least Squares Method[9]. One of the models that takes also into account these effects is the model with fixed effects (FE). In the case of this type of model, it is assumed that the individual effects are estimable, fixed and their occurrence is not accidental. It is assumed that the effects determined for individual units can be captured in differences in the intercept[10]. The individual specific components and the exogeneity of the independent variables are the conditions determining the choice of a particular type of model (RE or FE). The Hausman test is used to verify this selection. The null hypothesis assumes: The appropriate model is Random effects. There is no correlation between the error term and the independent variables in the panel data model. While the alternative hypothesis: the appropriate model is Fixed effects. The correlation between the error term and the independent variables in the panel data model is statistically significant[11].

The regression equation confirming the existence of a relationship does not fully indicate causation. Correlation does not necessarily imply causation. Specific tests are carried out to indicate the actual causation between certain economic categories. Among them the Granger causality test can be used[12].

2. An empirical approach for the European Union

The following research can be used to verify the thesis about the negative relationship between unemployment and inflation in the European Union, including Great Britain, during period 2002–2019. For this purpose, data from Eurostat were used. Data relate to average wages and unemployment in the discussed economies. Then the first differences of the variable average wages were created in order to show the growth rate of this variable.

The second figure shows the changes of the average wage in the discussed economies. In 2019 Luxemburg had the highest average salary. At the beginning

---

[8] O. Torres-Reyna, *Getting Started in Fixed/Random Effects Models using R*, s. 19, https://www.princeton.edu/~otorres/Panel101R.pdf [access: 06.12.2020].

[9] T. Kufel, *Econometrics. Troubleshooting using GRETL…*, s. 169.

[10] Ibidem, s. 166.

[11] T. Sheytanova, *The Accuracy of the Hausman Test in Panel Data: a Monte Carlo Study*, Örebro University School of Business Master's program "Applied Statistics", 2014, s. 11.

[12] http://www.eviews.com/help/helpintro.html#page/content/groups-Granger_Causality.html (access: 17.12.2020).

of the analysed period (2002), the highest average salary was in Great Britain, Luxemburg and Ireland. In the case of Cyprus, there are many gaps in the database for this variable.

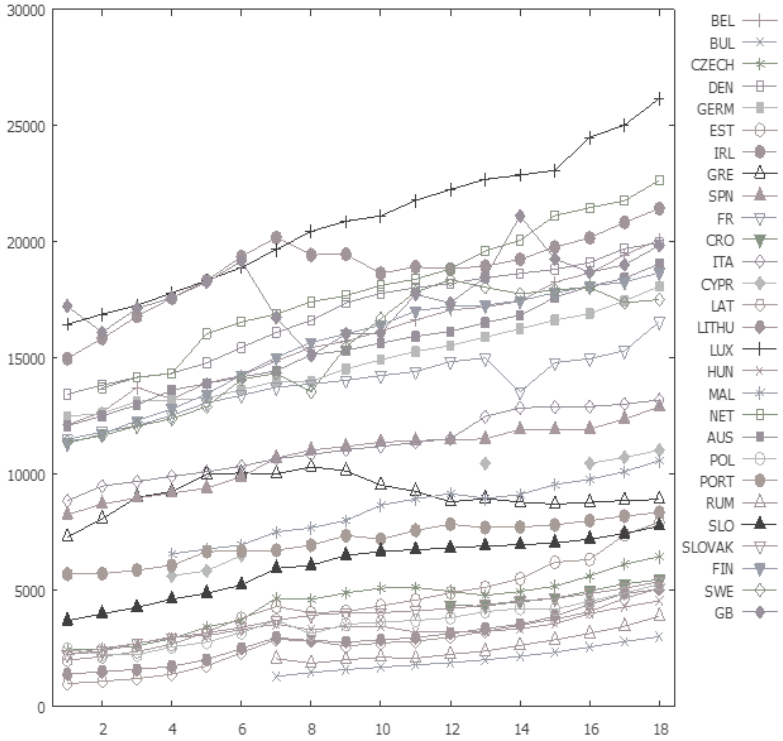

Figure 2. Average wages during 2002–2019 in the EU

Source: own figure based on the data from Eurostat using Gretl.

In the case of unemployment (fig. 3), the highest values were currently observed in Greece and Spain, the lowest, in turn, in the Czech Republic. At the beginning of the analysed period, one of the highest unemployment rates were for Poland, while in 2019 it was one of the lowest rates.

It is also worth mentioning how the average, minimum and maximum values changed for individual variables, especially in the case of average salary — these statistics are shown in table 1. The average value of remuneration between the analysed years increased by EUR 3882, while the minimum value by 2024 EUR. The standard deviation changed by more than EUR 1500 — which may indicate an increase in income differences in the analysed economies.

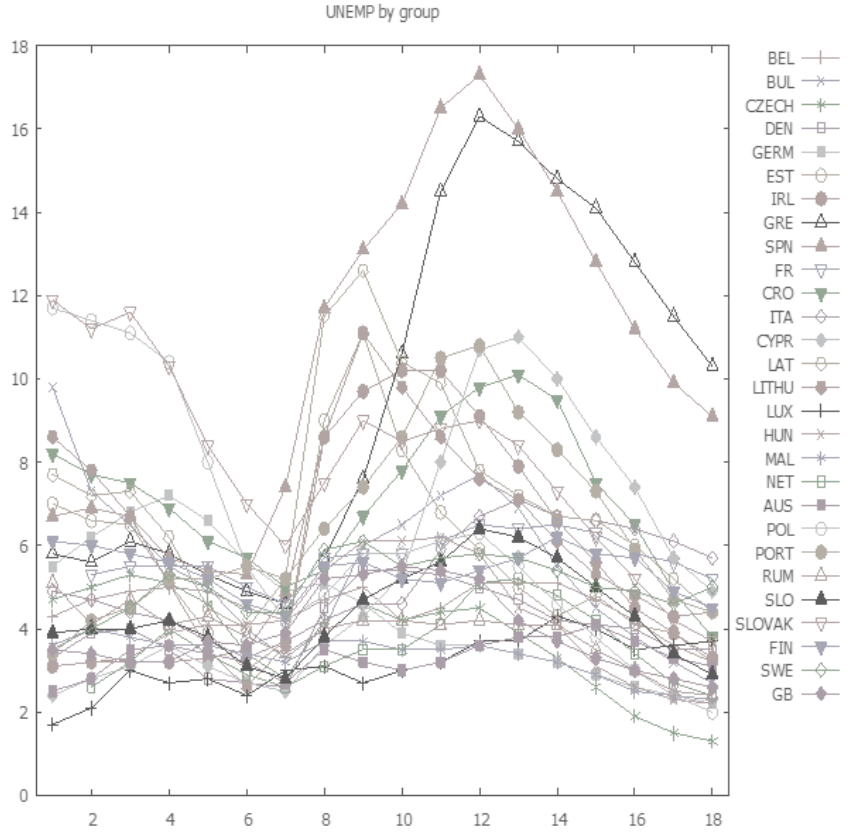

Figure 3. Unemployment rate during 2002-2019 in the EU

Source: own figure based on the data from Eurostat using Gretl.

Table 1. Summary of main statistics for wages and unemployment variables in 2002 and 2019

2002					
Variable	Mean	Median	S.D.	Min	Max
WAGE	8435	8859	5351	991,	17231
UNEMP	5,33	4,70	2,82	1,70	11,9
2019					
Variable	Mean	Median	S.D.	Min	Max
WAGE	12317	10807	6925	3015	26163
UNEMP	3,87	3,40	1,98	1,30	10,3

Source: own elaboration using data from Eurostat.

Estimation results presented in table 2 show simple OLS panel model which was then subjected to diagnostic testing in order to determinate the appropriate model.

Table 2. Estimation results of Pooled Model using OLS

Dependent variable: d_WAGE					
	coefficient	std. error	t-ratio	p-value	
const	518.065	42.9844	12.05	4.61e-029	***
UNEMP	**−42.1570**	**7.14848**	**−5.897**	**7.43e-09**	***
Mean dependent var	290.5812	S.D. dependent var		411.5438	
Sum squared resid	68377732	S.E. of regression		396.4722	
R-squared	0.074032	Adjusted R-squared		0.071903	
F(1, 435)	34.77864	P-value(F)		7.43e-09	
Log-likelihood	−3233.473	Akaike criterion		6470.945	
Schwarz criterion	6479.105	Hannan-Quinn		6474.165	
rho	0.062841	Durbin-Watson		1.784361	

Source: own elaboration using Gretl.

The results of diagnostics tests of panel model are shown in table 3. Joint significance of differing group means shows no grounds for rejection of null hypothesis – that the pooled OLS model is adequate, in favour of the fixed effects alternative. Also, the critical value is 1.51322. P-value of Breusch-Pagan test indicates that also there are no grounds for rejecting of the null hypothesis. A low p-value counts against the null hypothesis that the pooled OLS model is adequate, in favour of the random effects alternative. The statistics of the Hausman's test and the p-value indicate the null hypothesis that both estimators are consistent and unbiased, but the GLS for the RE model is more effective. Critical value for Breusch-Pagan and Hausman tests is 3.84146. On the basis of diagnostic tests was found that OLS turned out to be the most appropriate model. To be sure, the Chow test was also carried out, indicating whether the structural parameters in the two samples are the same for all periods of time and units. The results are shown in table 3. P-value indicates that there are no grounds for rejecting the null hypothesis. Therefore, the OLS model (table 2) turns out to be appropriate and live up to the strict test requirements.

The results of the assessment confirm the existence of a an inversive correlation between unemployment and the rate of wage growth. The goodness of fit of a statistical model for example adjusted R-squared describes how well it fits a set of observations. In this case they turned out to be low. These results indicate that unemployment is not the only factor influencing the rate of wage growth, which in the light of economic theory and logic is justified.

Table 3. Diagnostics of panel model using n = 28 cross-sectional units

Joint significance of differing group means:
F(27, 408) = 1.50996 with p-value 0.0508777
Breusch-Pagan test statistic:
LM = 2.34951 with p-value = prob(chi-square(1) > 2.34951) = 0.125323
Hausman test statistic:
H = 3.50293 with p-value = prob(chi-square(1) > 3.50293) = 0.0612604
Chow test for structural break at observation 14:18
F(2, 433) = 0.992922 with p-value 0.3713

Source: own elaboration using Gretl.

As it was mentioned correlation does not necessarily imply causation. Therefore, it was decided to perform a Granger session causality test. Stacked test (common coefficients) with including 2 lag were used. The results are shown in table 4.

Table 4. The results of Granger Causality Test

Pairwise Granger Causality Tests			
Lags: 2			
Null Hypothesis:	Obs	F-Statistic	Prob.
UNEMPLOY does not Granger Cause DWAGE	379	8.92199	0.0002
DWAGE does not Granger Cause UNEMPLOY		2.20145	0.1121

Source: own elaboration using EView 11.

The null hypothesis of Granger Causality test include: unemployment rate does not Granger Cause the rate of growth of wages and the rate of growth of wages does not Granger Cause unemployment. The estimates of the test statistic and the p-values indicate an alternative hypothesis for either of the two assumptions – the unemployment rate does Granger Cause the rate of growth of wages with p-value at 0.0002. In the above case, the causality is as indicated by the test results, i.e. one-way.

Conclusions

The herein results clearly indicate the existence of an inversive relationship between unemployment and the rate of wage growth among the European Union countries, including the United Kingdom. The results of the estimated model clearly show a relationship through the sign of the unemployment variable. In addition, the Granger causality test indicates one-sided causality between the analysed variables — causality from unemployment to wage growth. Therefore, this test additionally confirms the existence of such a relationship – unemployment has a significant impact and contributes to shaping

the growth of wages in the discussed economies. Therefore, the results prove the existence of a relationship described by the Phillips Curve for the indicated sample and period (2002-2019). It should be taken into consideration that the indicated dependence is only in short run (due to the fact that the wage growth variable was used as a dependent one). Therefore, the results should not be regarded as proving a long-term relationship generally. The theory of lack of the long run correlation between unemployment and inflation was proven by M. Friedman. It was indicated that the factors taken into account in the analysis of the impact on inflation in the long term could be also for example NAIRU (lowest permanent unemployment rate) and inflation expectations. Nevertheless, the approach for the UE is an interesting case and could be repeated in the future in order to observe whether the described dependence occurs in in these or other economies, especially in economies related to each other such as the EU or other economic and political unions like APEC or Mercosur.

References

Ahiakpor J.C.W., *The Phillips Curve Analysis: An Illustration of the Classical Forced-Saving Doctrine*, "Journal of the History of Economic Thought", 2009, vol. 31, no. 2.

Dritsaki Ch., Dritsaki M., *Phillips curve inflation and unemployment: an empirical research for Greece*, „Int. J. Computational Economics and Econometrics", 2013, vol. 3, no. 1/2.

Grabia T., The Phillips Curve Controversy, „Gospodarka Narodowa", 2014, no. 5 (273), Rok LXXXIV/XXV, http://www.eviews.com/help/helpintro.html#page/content/groups-Granger_Causality.html.

Kufel T., *Econometrics. Solving problems using GRETL*, Wydawnictwo Naukowe PWN, Warszawa 2007.

Moloi T., Marwala T., *The Phillips Curve, in: Artificial Intelligence in Economics and Finance Theories. Advanced Information and Knowledge Processing*, Springer, Cham 2020.

Motyovszki G., *The Evolution of Phillips Curve Concepts and Their Implications for Economic Policy*, "History of Economic Thought", Term Paper, Central European University, 2013.

Mućk J., *Econometrics of Panel Data*, http://web.sgh.waw.pl/~jmuck/EoPD/Meeting1_2018.pdf.

Reed College, Models for Pooled and Panel Data, https://www.reed.edu/economics/parker/s11/312/notes/Notes13.pdf.

Sheytanova T., *The Accuracy of the Hausman Test in Panel Data: a Monte Carlo Study*, Örebro University School of Business Master's program "Applied Statistics", 2014.

Torres-Reyna O., *Getting Started in Fixed/Random Effects Models using R*, https://www.princeton.edu/~otorres/Panel101R.pdf.

Summary

The aim of the article was to prove the existence of an inverse relationship between the variables: unemployment and rate of wage growth. For this purpose, the Eurostat database and the Gretl and EViews 11 econometric programs were used. Then basic model

was subjected to diagnostic tests to verify the appropriate estimator. The final model on the basis of which the relationship was described and conclusions were drawn is a model created using the Ordinary Least Squares. Estimation results indicated a negative relationship between the above-mentioned variables. This relationship turns out to be significant. The results also showed a low fit with empirical data, which is justified due to the existence of other factors influencing the increase in wages over the years. Additionally, due to the fact that the relationship indicated by the model could not define causality, the Granger causality tests for panel data was also used. The results showed the existence of causality run one-way from unemployment to the growth rate of wages variable. In the last part of the research, conclusions were drawn from the entire analysis including estimation of OLS and other tests.

Keywords: inflation, unemployment, Phillips curve, panel data

ZWIĄZEK MIĘDZY INFLACJĄ A BEZROBOCIEM: PODEJŚCIE EMPIRYCZNE. ANALIZA KRAJÓW UNII EUROPEJSKIEJ

Streszczenie

Celem artykułu było wykazanie odwrotnej zależności między zmiennymi: bezrobociem i tempem wzrostu wynagrodzeń. W tym celu wykorzystano bazę danych Eurostatu oraz oprogramowania Gretl i EViews 11. Następnie podstawowy model poddano testom diagnostycznym w celu zweryfikowania odpowiedniego estymatora. Ostatnim modelem, na podstawie którego opisano zależność i wyciągnięto wnioski, jest model utworzony za pomocą metody MNK. Wyniki oszacowań wskazały na ujemną zależność między wymienionymi zmiennymi. Ta zależność okazuje się istotna. Wyniki wykazały również niskie dopasowanie do danych empirycznych co jest uzasadnione ze względu na istnienie innych czynników wpływających na wzrost wynagrodzeń na przestrzeni lat. Dodatkowo, ze względu na to, że wskazana przez model zależność nie mogła zdefiniować przyczynowości, zastosowano również testy przyczynowości Grangera dla danych panelowych Wyniki wykazały istnienie związku przyczynowego przebiegającego jednostronnie – od bezrobocia do zmiennej odnoszącej się do dynamiki wynagrodzeń. W ostatniej części badań wyciągnięto wnioski z całej analizy, w tym modelu panelowego i wymienionych testów.

Słowa kluczowe: inflacja, bezrobocie, krzywa Phillipsa, dane panelowe