THE PHILLIPS CURVE: UNEMPLOYMENT DYNAMICS AND NAIRU ESTIMATES OF POLAND'S ECONOMY

ABSTRACT

The purpose of this paper is to investigate the relationship between inflation and unemployment rate, in the case of Poland over the period 1992-2017, within the Phillips curve context. For the long-term equilibrium relationship and the causal relationship of the examined variables, the Autoregressive Distributed Lag (ARDL) technique developed by Pesaran et al. (2001) and the causality approach of Toda and Yamamoto (1995) are applied, as the most appropriate for the sample size and the integration of the variables. The results of the study revealed that there is a long run relation between unemployment rate and the inflation rate for Poland, for the aforementioned period. In addition, the causality results indicated a unidirectional relationship between unemployment rate and inflation rate, with direction from unemployment to inflation. Finally, to forecast the model variables, the impulse response functions and the variance decomposition method are applied. The results for a 10-year forecasting period indicated that shocks in unemployment rate cause a decrease on inflation rate for the first years, followed by a steady increase for the remaining years. Policy implications are then explored in the conclusions.

Keywords: Inflation, Unemployment, NAIRU, Phillips Curve, Poland, Autoregressive Distributed Lag Cointegration Test, Toda-Yamamoto Causality Test, Variance Decomposition, Impulse Response Function

JEL Classification: C22, C32, E31, E50

RIASSUNTO

La curva di Phillips: dinamiche di disoccupazione e stime Nairu dell'economia polacca

Il fine di questo studio è analizzare la relazione tra inflazione e tasso di disoccupazione in Polonia nel periodo 1992-2017, nel contesto della curva di Phillips. Per testare la relazione di lungo periodo e la relazione causale delle variabili esaminate è stata applicata la tecnica ARDL.
(Autoregressive Distributed Lag) di Pesaran et al. (2001) e quella con approccio di causalità di Toda e Yamamoto (1995), considerate le più appropriate per dimensione del campione e integrazione delle variabili. I risultati degli studi evidenziano che c’è una relazione di lungo periodo tra tasso di disoccupazione e inflazione in Polonia, nel periodo considerato. Inoltre, i risultati di causalità indicano una relazione unidirezionale tra tasso di disoccupazione e inflazione, con direzione disoccupazione verso inflazione. Infine per fare previsioni sulle variabili del modello, sono state applicate le funzioni di risposta agli impulsi e il metodo di scomposizione della varianza. I risultati di previsione a 10 anni indicano che gli shock nel tasso di disoccupazione causano un decremento sul tasso di inflazione per i primi anni, seguito da un incremento costante nei successivi. Le implicazioni politiche sono esposte nelle conclusioni.

1. INTRODUCTION

The observed inverse relationship between unemployment and inflation, first discovered by William Phillips (1958) on his article “The Relationship between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861 to 1957”, has come to be known as the Phillips curve. Since then, unemployment and inflation as economic concepts have been a central topic in macroeconomics. These two concepts are considered as key factors in the process of economic development of every country. All government programs are conducted focusing on policies that keep on stable price levels and low unemployment rates.

However, the failure to explain economic phenomena of the crisis of 1970s had created serious doubts about the validity of Phillips curve. The Phillips curve idea was openly criticized by the Monetarist school, among them Milton Friedman. Friedman (1968) argued that there is only short run trade-off between the inflation rate and the unemployment rate, but for the long run he introduced the concept of the NAIRU (Non-Accelerating Inflation Rate of Unemployment). NAIRU is defined as the rate of unemployment when the rate of inflation is stable. Therefore, the long run Phillips curve is vertical and there is no trade-off between unemployment and inflation (see Phelps 2006).

In 2017, unemployment rate in Poland reached the lowest level in the country’s post-communist history, as youth employment picks up. Even during the recent financial crisis of 2007-2008, increasing growth rates helped Polish economy to respond in the difficult conditions of the
global economy. The purpose of this paper is to examine the existence of Phillips curve in Poland using annual time series data for the period 1992-2017.

Most of the previous relevant studies examine the trade-off relationship between inflation and unemployment rate on the developed countries. The focus on the developing countries, regarding the Phillips curve is relatively recent. The structure of the paper is as follows: Section 2 presents the literature. Section 3 analyzes the theoretical framework. Section 4 presents correlations between the two variables. Section 5 describes data and methodology. Empirical results are discussed in section 6. Concluding remarks are given in the final section.

2. LITERATURE REVIEW

An extensive and expanding volume of both theoretical and empirical studies exists on the relationship between inflation and unemployment across developed and developing countries, over varying sample periods and different econometric approaches. However, the issue still remains controversial for the policy makers. The results seem to vary from country to country due to the different structure of their domestic economies and the continuous changes in economic conditions.

Changes in monetary conditions are often believed to have a significant impact on real economic variables, such as output and employment, through the classical Phillips curve relationship (Vermeulen 2017). Among prominent economists who support the existence of the Phillips curve are Samuelson and Solow (1960). Samuelson and Solow (1960) examined the relationship between the rate of inflation and unemployment rate for a twenty-five year period (1934 to 1958) for the case of the United States (US). The results of their study revealed an inverse relationship between inflation and unemployment. It is worth mentioning that these researchers were the first who championed the Phillips curve as a policy tool.


The fact that there exists an inverse relationship between unemployment and inflation was criticized by Phelps (1967) and Friedman (1968). Phelps (1967) and Friedman (1968) supported that as the Phillips curve shifts over time, the equilibrium rate of unemployment is independent from the rate of inflation. Therefore there is only short run trade-off between inflation and
unemployment rate. For the long run they introduced the concept of NAIRU (Non-Accelerating Inflation Rate of Unemployment). NAIRU refers to a level of unemployment, below which inflation rises. The stability of original Phillips curve was disputed in the early 1970s, where the US economy faced high inflation and unemployment rate simultaneously (stagflation). Later, other researchers argued against the Phillips hypothesis (Lucas, 1976; Okun, 1975).

Contrary to Friedman (1968) and Phelps (1967), Modigliani and Tarantelli (1976) argued that no “natural” unemployment rate exists and that the Phillips curve does not disappear in the long run. Modigliani and Tarantelli (1976) argued that the Phillips curve shifts upward and become steeper every contract renewal.

Lucas (1976) argued that could be a trade-off relationship between unemployment and inflation under the condition that the workers do not expect the policymakers to create an artificial situation of high inflation combined with low unemployment. In a different case, employees would predict high inflation and an increase in wages would be possible. In such a case, high unemployment and high inflation could coexist, which is known as “Lucas Critique” (see also Zaman et al., 2011; Dritsaki and Dritsaki, 2012).

In 1975, Okun commented that “Phillips curve has become an unidentified flying object” (p. 353). However, in the 1990’s, Phillips curve came to the front giving mixed results. Alogoskoufis and Smith (1991) supported empirically the “Lucas Critique”. On the other hand, Fisher and Seater (1993), King and Watson (1994) and Fair (2000) find a long run inflation unemployment trade-off.

Marcelino and Mizon (1999) examined the relationship between wages, prices, productivity, inflation and unemployment in Italy, Poland and the UK between the 1960’s and the early 1990’s. They investigated the labor markets of these countries and found that there are significant changes in the structures of the relationships between wages-prices and unemployment-inflation for the period 1979-80. They concluded that although there are important changes in the labor markets of the examined countries, taking into account a greater degree of flexibility, there are no common characteristics among them.

Recent advances in data analysis methods allow a more in depth examination of the Phillips curve hypothesis. Schreiber and Wolters (2007) investigated the relationship between
unemployment and inflation, using a vector autoregressive model (VAR) and a vector error correction model (VECM), for the case of Germany over the period 1977-2002. Their study revealed a negative relationship between unemployment and inflation, both in the short and in the long run, for the examined period.

Del Boca et al. (2008) examined the existence of Phillips curve in Italy using data covering the period 1978-2000. The results of the study showed that a trade-off relationship exists only during low inflation and stable aggregate supply. Del Boca et al. (2008) captured the effects of structural changes and asymmetries on the estimated parameters of alternative Phillips equations using the Kalman filter.

A similar study, conducted by Russell and Banerjee (2008), examined the Phillips curve hypothesis assuming non-stationarity in the series. They found that there is a positive relation between inflation and unemployment rate in the short run for the case of US during the period 1952-2004.

Islam et al. (2011) used the ARDL bound approach to examine the existence and stability of Phillips curve for North Cyprus using data covering the period 1978-2007. The results of their analysis showed the existence of Phillips curve both in the short and in the long run. In addition, a stable relation is confirmed.

Karahan et al. (2012) investigated the relationship between unemployment and inflation for Turkey over the period 2006-2011. The ARDL bounds tests indicated that, in the short run, unemployment has a negative impact on inflation. However, the results did not reveal any causal relation between the two variables in the long run supporting the views of Friedman (1967) and Phelps (1967), not advocating the “hysteresis effect”.

Dritsaki and Dritsaki (2012) investigated the Phillips curve hypothesis in Greece using data for the period 1980-2010. Their results revealed a long run relationship and a causal relationship between unemployment and inflation. In addition, their results showed that shocks in inflation cause a reduction on unemployment for the first years, following by a slight rise for the remaining years.
<table>
<thead>
<tr>
<th>Authors</th>
<th>Study Period and Area</th>
<th>Main Methods</th>
<th>Main Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schreiber and Wolters (2007)</td>
<td>Germany 1977-2002</td>
<td>VAR and VECM</td>
<td>A negative relationship between unemployment and inflation, both in the short and in the long run</td>
</tr>
<tr>
<td>Del Boca et al. (2008)</td>
<td>Italy 1978-2000</td>
<td>structural changes and asymmetries using Kalman filter</td>
<td>A trade-off relationship exists only during low inflation and stable aggregate supply</td>
</tr>
<tr>
<td>Karahan et al. (2012)</td>
<td>Turkey 2006-2011</td>
<td>ARDL bounds test</td>
<td>No causal relation between inflation and unemployment in the long run</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Shocks in inflation cause a reduction on unemployment</td>
</tr>
<tr>
<td>Nikulin (2015)</td>
<td>Poland and other 5 new EU members 2002-2013</td>
<td>Panel data techniques</td>
<td>An increase of productivity in Poland in comparison to Czech Republic is greater than an increase of wages in Poland in comparison to Czech Republic</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The productivity in Poland in relation to Hungary and Estonia has been growing slower than the wages in Poland in comparison to Hungary and Estonia</td>
</tr>
</tbody>
</table>
Nikulin (2015) examined the relationships between wages, labor productivity and unemployment for Poland and other 5 new EU members (using Poland as benchmark) for the period 2002-2013. The results of the study revealed that the relations among the examined variables in the new EU member countries are diversified. More specific, the results showed that an increase of productivity in Poland in comparison to Czech Republic is greater than an increase of wages in Poland in comparison to Czech Republic. In addition, the productivity in Poland in relation to Hungary and Estonia has been growing slower than the wages in Poland in comparison to Hungary and Estonia. The lower productivity in Poland could be a reason for greater dynamic of productivity growth in the country.

3. **Correlation between inflation and unemployment**

In this section, we present correlations between the two variables. The correlation matrix and the graphs of inflation rate and unemployment rate for the period 1992-2017 are following.

The inverse relationship between inflation and unemployment is most obvious during the period 1998-2008. This correlation is the evidence which is traditionally associated with Phillips curve hypothesis and significantly different from zero (see Table 2).

<table>
<thead>
<tr>
<th></th>
<th>INF</th>
<th>UN</th>
</tr>
</thead>
<tbody>
<tr>
<td>INF</td>
<td>1.000</td>
<td>-0.195 (0.072)*</td>
</tr>
<tr>
<td>UN</td>
<td>-0.195 (0.072)*</td>
<td>1.000</td>
</tr>
</tbody>
</table>

*Note: * indicates significance at 10% level of significance, p-values in parentheses.
Figure 1 - Inflation Rate for Poland (period 1992-2017)

Figure 2 - Unemployment Rate for Poland (period 1992-2017)

4. Materials and Methods

4.1 Data

The variables that are used in this study are inflation (INF) expressed as percentage change of average consumer prices, and unemployment (UN) expressed as a percentage of civilian labor force. The sample data of this study is 1992-2017. Data are gathered from economic databases of
International Monetary Fund (IMF) and Annual Macro-Economic Database (AMECO). Figure 3 plots the actual and forecast values of inflation and unemployment rates.

**Figure 3 - Actual and Forecast Values of the Inflation and Unemployment (INFF and UNF Denote Forecast Values of Inflation and Unemployment Rate Respectively)**

The descriptive statistics for all variables are shown in Table 3.

**Table 3 - Descriptive Statistics**

<table>
<thead>
<tr>
<th></th>
<th>INF</th>
<th>UN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>9.201962</td>
<td>12.27308</td>
</tr>
<tr>
<td>Median</td>
<td>3.596000</td>
<td>11.50000</td>
</tr>
<tr>
<td>Maximum</td>
<td>43.00000</td>
<td>20.00000</td>
</tr>
<tr>
<td>Minimum</td>
<td>-0.933000</td>
<td>5.000000</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>12.25142</td>
<td>4.299633</td>
</tr>
<tr>
<td>Skewness</td>
<td>1.540673</td>
<td>0.326658</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>4.139750</td>
<td>2.134451</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>11.69320</td>
<td>1.273996</td>
</tr>
<tr>
<td>Observations</td>
<td>26</td>
<td>26</td>
</tr>
</tbody>
</table>
4.2 Econometric Methodology

After presenting the descriptive statistics for the variables, the paper involves into the following objectives:

- The first is to examine the stationarity of the variables using the Augmented Dickey Fuller test (ADF) (1979), the Phillips Perron test (PP) (1988) as well as the test proposed by Kwiatkowski et al. (KPSS) (1992).

- If the variables are integrated of order one then Johansen’s (1998) cointegration test is the most appropriate to be used. In the case that the variables do not have the same integration order, Pesaran et al. (2001) cointegration test is the most appropriate. The Johansen’s cointegration method, except the integration I(1) of the variables, requires a large number of observations in order to give robust results. In this study we apply the ARDL approach.

- The third is to estimate the long run and short run relationship between the variables of the examined model.

- The fourth step is to check the causal relationship between the variables using a dynamic vector error correction model (VECM). In this paper, the Toda-Yamamoto (1995) causality technique is applied.

- The fifth aim is to estimate the variance decomposition analysis and impulse response functions using Choleski technique.

4.2.1 Unit Root Tests

We begin our analysis by checking the stationary properties of the variables included in the study. We apply the tests suggested by Dickey-Fuller (ADF) (1979), Phillips-Perron (PP) (1988) and Kwiatkowski et al. (KPSS) (1992). In all these tests, the null hypothesis is that the variable contains a unit root (i.e., it is not stationary).

4.2.2 Autoregressive Distributed Lag (ARDL) Cointegration Analysis

The purpose of this paper is to investigate the relationship between unemployment and inflation in the case of Poland, within the Phillips Curve context. For this reason, this study employs the Auto-Regressive Distributed Lag (ARDL) analysis of cointegration, developed by Pesaran and Shin (1999) and extended by Pesaran et al. (2001) (see also Dritsaki and Stamatiou 2018).
The ARDL approach has a number of advantages over traditional cointegration methods, such as Engle and Granger (1987), Johansen (1988), and Johansen and Juselius (1990), as noted below: i) it provides consistent estimates regardless of whether the variables are integrated I(0) or I(1), ii) all variables of the models assumed to be endogenous, iii) it is more efficient for small sample data, iv) it allows that the variables may have different lag lengths, v) in addition, the bounds of ARDL approach can distinguish and eliminate autocorrelation and endogeneity problems between dependents and independents variables, vi) finally, a dynamic error correction model can be derived from the ARDL method through a simple linear transformation (Harris and Sollis, 2005; Jalil and Ma, 2008) (see also Dritsakis and Stamatiou, 2016; Stamatiou and Dritsakis, 2014).

The autoregressive distributed lag (ARDL) cointegration technique as a general vector autoregressive (VAR) model of order $p$ is shown below:

$$L_t = (INF_t, UNGAP_t)$$  \hspace{1cm} (1)$$

where $L_t$ is a column vector composed of the two variables.

The ARDL models that are used in this study are the following:

$$\Delta UNGAP_t = \beta_{01} + \delta_{11} UNGAP_{t-1} + \delta_{21} INF_{t-1} + \sum_{i=1}^{p} \alpha_{1i} \Delta UNGAP_{t-i} + \sum_{i=0}^{q} \alpha_{2i} \Delta INF_{t-i} + \epsilon_{1t} + \epsilon_{1t} + \epsilon_{2t}$$  \hspace{1cm} (2)$$

where $\Delta$ denotes the first difference operator, $\beta$ is constant and $\epsilon_{1t}$, $\epsilon_{2t}$ are the “well behaved” random disturbance terms. The error terms assumed to be independently and identically distributed.

The optimal values for the maximum lags, $p$ and $q$, will be determined by the minimum values of criteria Akaike (AIC), Schwarz (SIC) and Hannan-Quinn (HQC) in accordance with the following models:
where $\text{UNGAP}_t$ and $\text{INF}_t$ are the dependent variables, $\beta$ is constant, $\alpha_{1i}$ and $\alpha_{2i}$ are the long terms and $(p, q)$ are the optimal lag lengths of the ARDL model. Under the equations (2) and (3), the null and alternative hypotheses are as follow:

\[
H_0 : \delta_{11} = \delta_{21} = 0
\]

i.e., there is no cointegration among the variables

\[
H_1 : \delta_{11} \neq \delta_{21} \neq 0
\]

i.e., there is cointegration among the variables

and

\[
H_0 : \delta_{12} = \delta_{22} = 0
\]

i.e., there is no cointegration among the variables

\[
H_1 : \delta_{12} \neq \delta_{22} \neq 0
\]

i.e., there is cointegration among the variables.

According to Pesaran et al. (2001) the null hypothesis is tested by conducting an $F$-test for the joint significance of the coefficients of the lagged levels of the variables.

Two sets of critical values, for a given level significance, have been calculated by Narayan (2005). Narayan (2005) critical bounds are more appropriate for small samples. The lower bound is based on the assumption that all variables including in the model are $I(0)$, and the upper bound is based on the assumption that all of the variables are $I(1)$.

The null hypothesis of no cointegration is rejected when the $F$-statistic exceeds the upper critical bound value. If the calculated $F$-statistic is lower than the critical value of lower limit, we accept the null hypothesis. The cointegration test is inconclusive when the $F$-value is between the lower and the upper limit of critical bounds (Pesaran et al., 2001).

Once cointegration is confirmed, the next step is to proceed with the estimation of the long run
coefficient of the ARDL model using equations (6) and (7):

\[
\text{UNGAP}_t = \beta_{01} + \sum_{i=1}^{p} \delta_{1i} \text{UNGAP}_{t-i} + \sum_{i=0}^{q} \delta_{21} \text{INF}_{t-i} + e_{1t},
\]

(6)

\[
\text{INF}_t = \beta_{02} + \sum_{i=1}^{p} \delta_{11} \text{INF}_{t-i} + \sum_{i=0}^{q} \delta_{22} \text{UNGAP}_{t-i} + e_{2t},
\]

(7)

This study also estimates a dynamic error correction model (ECM) to investigate the short run dynamics of the respective variables towards the long run equilibrium. The ECM integrates the short run coefficient with the long run coefficient without losing long run information.

The dynamic unrestricted ECM is depicted in equations (8) and (9), as shown below:

\[
\Delta \text{UNGAP}_t = \beta_{03} + \sum_{i=4}^{p} \alpha_{0i} \Delta \text{UNGAP}_{t-i} + \sum_{i=0}^{q} \alpha_{1i} \Delta \text{INF}_{t-i} + \lambda_1 \text{ECM}_{t-1} + \epsilon_t,
\]

(8)

\[
\Delta \text{INF}_t = \beta_{04} + \sum_{i=4}^{p} \alpha_{0i} \Delta \text{INF}_{t-i} + \sum_{i=0}^{q} \alpha_{2i} \Delta \text{UNGAP}_{t-i} + \lambda_2 \text{ECM}_{t-1} + \epsilon_t,
\]

(9)

where ECM_{t-1} is the error correction term.

The coefficient of ECM_{t-1} should be negative and statistically significant. This coefficient indicates the speed of adjustment to the long run equilibrium after a short run shocks.

4.2.3 Diagnostics Tests of the Model

One of the most important and crucial assumptions in the bounds testing (ARDL) approach is that the error terms of equations (2) and (3) have to be serially independent and normally distributed. So, in order to check the validity and reliability of the estimation results, several diagnostics are performed. The diagnostic tests include Jarque-Bera normality test, ARCH test for heteroscedasticity, Breusch-Godfrey Serial Correlation (LM) test and Ramsey RESET specification test.

4.2.4 Stability Tests of the Model

The existence of cointegration does not necessarily imply that the estimated coefficients of the model are stable. Therefore, in order to check that all parameters used in each of the models are sufficiently stable, the cumulative sum (CUSUM) and the cumulative sum of squares
(CUSUMSQ) proposed by Brown et al. (1975) are applied. These tests are also suggested by Pesaran et al. (2001) for measuring the parameter stability.

4.2.5 Toda-Yamamoto Causality Analysis

The objective of our study is to identify the causality relations between inflation and unemployment rates for the case of Poland, using data covering the period 1992-2017. In this paper, we employ the Toda-Yamamoto (1995) and the Modified Wald (MWALD) causality techniques in order to find out the direction of causality between the two variables.

Toda-Yamamoto (1995) test:

- Ignores the condition of stationary or cointegration of the series to test the causality.
- Uses a standard vector autoregressive (VAR) model in the levels of the variables (rather than in the first differences as in Granger's test) minimizing, in this way, the risks associated with the possibility of the wrong specification of the integration order of the variables, or the presence of cointegrated vector among them.
- Minimizes the distortion of the test's sizes as a result of pretesting (Giles 1997, Mavrotas and Kelly 2001).

Toda and Yamamoto (1995) procedure can improve the power of Granger causality test. The procedure makes valid estimation of the parameters even the VAR system is not cointegrated.

Toda and Yamamoto (1995) develop a different approach based on a level VAR model. The steps of the procedure are shown below:

- We begin with the specification of integration order of the series. If the order is different we get the maximum (dmax).
- We create a level VAR model.
- We define the appropriate lag order (k) of the VAR model using the Likehood Ratio (LR), Akaike Information Criterion (AIC), Schwarz Information Criterion (SC), Final Prediction Error (FPE) and Hannan-Quinn (HQ) Information Criterion.
- If series have the same integration order then we continue with the Johansen cointegration approach. Otherwise, we employ ARDL bounds test proposed by Pesaran et al. (2001).
- Regardless the presence of a cointegrated vector among the series, we continue with
the investigation of the causality relations between them.

- We apply Granger causality and Modified Wald (MWALD) techniques for the significance of parameters on the following equations:

\[ IN_{t} = \mu_{0} + \sum_{i=1}^{k} a_{i} IN_{t-i} + \sum_{j=k+1}^{d_{max}} a_{j} IN_{t-j} + \sum_{j=1}^{d_{max}} \beta_{j} UNGAP_{t-j} + \varepsilon_{0} \]  
\[ UNGAP_{t} = \varphi_{0} + \sum_{i=1}^{k} \gamma_{i} UNGAP_{t-i} + \sum_{j=k+1}^{d_{max}} \gamma_{j} UNGAP_{t-j} + \sum_{i=1}^{k} \delta_{i} IN_{t-i} + \sum_{j=k+1}^{d_{max}} \delta_{j} IN_{t-j} + \varepsilon_{2} \]  

where \( k \) is the optimal lag length on the initial VAR model and \( d_{max} \) is the maximum integration order in VAR model.

In equation (10), \( UNGAP_{t} \) causes \( IN_{t} \) if \( \beta_{ij} \neq 0 \), for all \( i \). Similarly, in equation (11), \( IN_{t} \) causes \( UNGAP_{t} \) if \( \delta_{ij} \neq 0 \) for all \( i \).

4.2.6 Impulse Response Function (IRF) and Variance Decomposition Method (VDM)

The vector error correction tests provide little evidence on the dynamic properties of the model, since they show only the causality relations of the endogenous variables during the examined period. So, we continue with the forecast error variance decomposition (FEVD) in order to test the strength of causal relationship between inflation and unemployment.

The variance decomposition method (VDM) shows the percentage of variability of a variable of the VAR model over the variable itself, as well as the system variables. The VDM indicates the impulse, the innovation or the shock of each variable of the system to the others (including itself), providing an indication of these relationships which can be described as “out of sample” causality tests (Kling and Bessler, 1985).

In addition, the impulse response functions (IRF) is an alternative way of variance decomposition method (VDM) and describes the reaction of the system due to shocks in variables that parameterizes the dynamic behavior of it (Stamatiou and Dritsakis, 2019). These shocks are expressed using the standard deviations of the disturbance terms (Dritsaki and Dritsaki, 2013). The IRF allows us to understand the possible effects of a random disorder of an equation of the system on the endogenous variable of the equation itself, as well as on the other endogenous variables of the system.
5. Empirical Results

5.1 Unit Roots Tests

The preliminary stage of the study is to define the integration order for each time series. We apply ADF by Dickey and Fuller (1979), PP by Phillips and Perron (1988) as well as KPSS by Kwiatkowski et al. (1992) test. The results of these tests are presented in Table 4.

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF</th>
<th>PP</th>
<th>KPSS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>C,T</td>
<td></td>
</tr>
</tbody>
</table>

Notes: *** and ** show significant at 1% and 5% levels respectively, the numbers within parentheses followed by ADF statistics represent the lag length of the dependent variable used to obtain white noise residuals, the lag lengths for ADF equation were selected using Schwarz Information Criterion (SIC), Mackinnon (1996) critical value for rejection of hypothesis of unit root applied, the numbers within brackets followed by PP and KPSS statistics represent the bandwidth selected based on Newey West (1994) method using Bartlett Kernel, C Constant, T Trend, Δ First Differences.

The unit root analysis results (see Table 4) revealed that INF is stationary in levels in all the test that were applied which means that INF is integrated I(0), while UNGAP is stationary in first differences which means that UNGAP is integrated I(1). So, we examine the long run relationship of the variables using the ARDL bounds test.
5.2 ARDL Cointegration Analysis

In order to estimate the parameters of equations (2) and (3), we select the optimal values of $p$ and $q$ lags by the minimum value of Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC), Hannan-Quinn Criterion (HQC), and Likelihood Ratio (LR). The results of these criteria are presented in Table 5.

<table>
<thead>
<tr>
<th>Lag</th>
<th>LogL</th>
<th>LR</th>
<th>FPE</th>
<th>AIC</th>
<th>SIC</th>
<th>HQC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-120.994</td>
<td>NA</td>
<td>246.091</td>
<td>11.181</td>
<td>11.280</td>
<td>11.204</td>
</tr>
<tr>
<td>1</td>
<td>-84.501</td>
<td>63.034</td>
<td>12.871</td>
<td>8.227</td>
<td>8.524</td>
<td>8.297</td>
</tr>
<tr>
<td>2</td>
<td>-70.298</td>
<td>21.948*</td>
<td>5.156</td>
<td>7.299</td>
<td>7.795*</td>
<td>7.416</td>
</tr>
<tr>
<td>3</td>
<td>-67.024</td>
<td>4.465</td>
<td>5.673</td>
<td>7.365</td>
<td>8.060</td>
<td>7.529</td>
</tr>
<tr>
<td>4</td>
<td>-60.019</td>
<td>8.279</td>
<td>4.565*</td>
<td>7.092*</td>
<td>7.985</td>
<td>7.302*</td>
</tr>
</tbody>
</table>

Notes: * indicates lag order selected by the criterion.

The ARDL bound test is sensitive to lag length, so we use the Akaike Information Criterion to determine the optimal lag length in equations (4) and (5). AIC showed that optimal lag length in these equations is (2, 4) and (1, 0) respectively. Table 6 shows the cointegration results using ARDL bounds test.

![Figure 4 - Optimal Lag Length in Eq. (4) and Eq. (5) Respectively](image-url)
The results of Table 6 indicate that, in equation (3), the calculated F statistic (15.41) exceeds the upper bound critical value (5.58) at 1% level of significance. Findings confirm that there is a long run relationship between inflation rate and unemployment in Poland.

Within the cointegration test results, a number of standard diagnostic tests were applied in order to check the robustness of the model. The ARDL model fulfills the assumptions of normality, autoregressive conditional heteroskedasticity (ARCH), functional forms and serial correlation.

5.3 Long Run and Short Run Estimates

Table 7 presents the results of long and short run relationship between the variables in our model.
From the above table we see that, in the long run equation of INF, a decrease 1% of unemployment will cause an increase 0.30% of inflation. The ECM_{t-1} is negative and statistically significant which implies a long run relationship between the examined variables. This means that in the short term the deviations from the long run equilibrium are adjusted by 86% every year.

The DW statistic is 2.04 which confirms that the model is not spurious. The R squared is 0.96 implying that 96% variations in the dependent variable are explained by the model and the rest by the error term. In addition, the computed F-statistic (296.3) clearly rejects the null hypothesis that the regressors have zero coefficients.
5.4 Diagnostics Tests

As illustrated in the tables below, the model passes the tests regarding normality (Jarque-Bera), serial correlation (LM) heteroscedasticity (ARCH) and specification (Ramsey RESET). The results of all the diagnostics tests for the long run and short run equations are displayed in Table 8 and 9 respectively.

<table>
<thead>
<tr>
<th>Diagnostics Tests</th>
<th>$X^2$ Normal</th>
<th>$X^2$ Serial</th>
<th>$X^2$ ARCH</th>
<th>$X^2$ Reset</th>
</tr>
</thead>
</table>

*Notes:* Numbers in brackets are lags for ARCH and Serial tests and fitted terms for Reset test.

<table>
<thead>
<tr>
<th>Diagnostics Tests</th>
<th>$X^2$ Normal</th>
<th>$X^2$ Serial</th>
<th>$X^2$ ARCH</th>
<th>$X^2$ Reset</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.45</td>
<td>3.24[2]</td>
<td>0.03[1]</td>
<td>0.08[1]</td>
</tr>
</tbody>
</table>

*Notes:* Numbers in brackets are lags for ARCH and Serial tests and fitted terms for Reset test.

The diagnostics tests further strengthen and confirm the reliability and validity of our estimation results.

5.5 Instability Tests

It is obligatory to ensure the dynamic stability of any model having autoregressive structure. A graphical representation of Recursive Residuals, CUSUM and CUSUMSQ statistics are provided in Figures 5, 6, 7, 8. If the plots of the Recursive Residuals and CUSUM tests lie inside the critical bounds at 5% level of significance it would signify the parameter constancy and the model stability.
**FIGURE 5 - Plots of CUSUM and CUSUMSQ (Long Run)**

**FIGURE 6 - Plots of Recursive Residuals (Long Run)**

**FIGURE 7 - Plots of CUSUM and CUSUMSQ (Short Run)**
From the above figures we can see that the straight lines are crossed by CUSUMSQ and Recursive Residuals in the long run model and by CUSUMQ in the short run model. According to the test results for the given regression, we conclude that all the coefficients are not stable over the sample period.

5.6 Toda-Yamamoto Causality Test

The objective of our study aims to identify the causal relationships between unemployment rate and inflation. Table 10 presents the results on Toda and Yamamoto (1995) causality testing according to equations (10) and (11). In Table 4 the unit root tests confirm that the maximum integration order (dmax) for the selected variables is 1. In addition, Table 5 suggests that the optimal lag length (k) is 4.

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>MWALD Test</th>
<th>Causality Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>INF&lt;sub&gt;t&lt;/sub&gt;</td>
<td>8.63* (0.07)</td>
<td>UNGAP&lt;sub&gt;t&lt;/sub&gt; → INF&lt;sub&gt;t&lt;/sub&gt;</td>
</tr>
<tr>
<td>UNGAP&lt;sub&gt;t&lt;/sub&gt;</td>
<td>2.44 (0.65)</td>
<td></td>
</tr>
</tbody>
</table>

Notes: * show significant at 10% level, p-values in parentheses.
As reported in Table 10, the results provide evidence of a unidirectional causal relationship between inflation (INF) and unemployment rate (UNGAP) at 10% level of significance, with direction from unemployment rate to inflation (see Figure 9). The knowledge about the direction of causality will help policy makers to trace out policies for sustainable economic growth in Poland.

**Figure 9 – Causality Relation for Poland**

5.7 Impulse Response and Variance Decomposition Analysis

Figure 10 plots the impulse responses of unemployment rate (UNGAP) and inflation rate (INF) over a horizon of 10 years. Standard errors are calculated by the Monte Carlo method, with 100 repetitions (of ± 2 standard deviations).

Impulse responses suggest that shocks in inflation rate (INF) have a negative impact on the variable itself in the first and in the last 3 years (under investigation), whereas there is a stabilization of inflation rate over the middle 4 years. Regarding unemployment rate (UNGAP), Figure 10 suggests that shocks in UNGAP have a positive impact on the variable itself in the first and in the last 2 years (under investigation), whereas there is a negative impact over the middle 6 years.

In addition, shocks in unemployment rate (UNGAP) cause a decrease on inflation rate (INF) over the first 4 years followed by an increase of the following 5 years.

Finally, shocks in inflation rate (INF) cause a slight increase on unemployment rate (UNGAP) over the first 2 years followed by a slight decrease for the next 2 years and a steady increase for the next 4 years.
The results from variance decompositions analysis are shown in Figure 11 and in Tables 11 and 12.

**Figure 10 – Impulse Response Function**

Response to Cholesky One S.D. Innovations ± 2 S.E.

- Response of INF to INF
- Response of INF to UNGAP
- Response of UNGAP to INF
- Response of UNGAP to UNGAP

**Figure 11 – Variance Decomposition**

Variance Decomposition ± 2 S.E.

- Percent INF variance due to INF
- Percent INF variance due to UNGAP
- Percent UNGAP variance due to INF
- Percent UNGAP variance due to UNGAP
From Table 11 we observe that a significant percentage of the variance of inflation rate (99.57%) is explained by inflation innovations in the short run (in a horizon of two years). On the other hand, the percentage of variance of unemployment rate (UNGAP) is, in the short run, 0.42%. In a longer horizon of 10 years the percentage of variance of INF is falling at 90.70, while the percentage of variance of UNGAP is increased at 9.29%.
<table>
<thead>
<tr>
<th>Period</th>
<th>S.E.</th>
<th>INF</th>
<th>UNGAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.906835</td>
<td>18.39250</td>
<td>81.60750</td>
</tr>
<tr>
<td></td>
<td>(13.8542)</td>
<td>(13.8542)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1.599316</td>
<td>14.67072</td>
<td>85.32928</td>
</tr>
<tr>
<td></td>
<td>(14.9858)</td>
<td>(14.9858)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1.979140</td>
<td>18.18667</td>
<td>81.81333</td>
</tr>
<tr>
<td></td>
<td>(16.9247)</td>
<td>(16.9247)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2.251889</td>
<td>32.09485</td>
<td>67.90515</td>
</tr>
<tr>
<td>5</td>
<td>2.352473</td>
<td>37.45516</td>
<td>62.54484</td>
</tr>
<tr>
<td></td>
<td>(18.1715)</td>
<td>(18.1715)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2.420825</td>
<td>35.37986</td>
<td>64.62014</td>
</tr>
<tr>
<td></td>
<td>(18.4028)</td>
<td>(18.4028)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>2.549667</td>
<td>34.44883</td>
<td>65.55117</td>
</tr>
<tr>
<td></td>
<td>(18.6819)</td>
<td>(18.6819)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>2.702437</td>
<td>36.06916</td>
<td>63.93084</td>
</tr>
<tr>
<td></td>
<td>(18.8363)</td>
<td>(18.8363)</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>2.820433</td>
<td>38.18643</td>
<td>61.81357</td>
</tr>
<tr>
<td></td>
<td>(18.9872)</td>
<td>(18.9872)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>2.867711</td>
<td>39.41225</td>
<td>60.58775</td>
</tr>
<tr>
<td></td>
<td>(18.9546)</td>
<td>(18.9546)</td>
<td></td>
</tr>
</tbody>
</table>

In addition, Table 12 indicates that a steady percentage of the variance of unemployment rate (UNGAP) (85.32%) is explained by unemployment innovations in a horizon of two years (short run). On the contrary, the percentage of variance of INF is, in the short run, 14.67%. In a longer horizon of 10 years the percentage of variance of UNGAP is falling at 60.58%, while the percentage of variance of INF is increased at 39.41%.

6. CONCLUSIONS AND POLICY IMPLICATIONS

This study represents an attempt to investigate the hypothesis referred by Phillips curve in the
case of Poland, using data covering the period 1992-2017. In 2017 unemployment rate in Poland hit a 25 year low, as youth employment picks up. The labor market of the country remains resilient in relation to the impact of the global financial crisis of 2007-2008. It is important to be mentioned that low unemployment rates are due to the intense business activity of international companies (such as “Gillette International”, “Dell Computers”, “Fujitsu”, “P & G”, etc.) through the investment incentives provided by the Polish government (Special Economic Zones (SEZs)).

On the other hand, low unemployment rates can have important implications for monetary policy (Altig et al., 1997). Although the numbers may be impressive, behind them is the labor supply which is under pressure from immigration, the low workforce participation rate and government policies such as raising the retirement age. Poland's central bank estimates that the unemployment rate is already lower that the rate which puts upward pressure on wages.

The results of this paper, based on the bounds testing for cointegration, confirm that the inflation-unemployment hypothesis exists in Poland. More specifically, the long run estimates show that a decrease 1% of unemployment will cause an increase 0.30% of inflation. In addition, the causality results based on Toda-Yamamato analysis (1995) reveal that there is a unidirectional causality relationship between unemployment rate and inflation, with direction from unemployment rate to inflation. Finally, the impulse response functions revealed that, in the short run, a decrease in inflation rate has a positive effect on unemployment rate. On the other hand, an increase in unemployment rate has a negative effect on inflation rate.

The finding, that a stable Phillips curve exists for Poland, opens opportunities for the central bank to adopt monetary policies that would keep inflation and unemployment at political and social acceptable rates. Polish government, as a matter of necessity and concern, should continue or improve the macroeconomic policies for a sustainable economic framework that will enhance the domestic output, while continuing controlling inflation.

This study provides strong empirical existence of Phillips curve in Poland, both in the short and long run. Based on the findings of this study, one could forecast the future trend for the next ten years. The study recommends that the Polish government should pay attention to its findings in order to tackle unemployment issue, and encourages it to conduct active labor market programs to reduce unemployment level through the creation of productive and labor intensive projects (the replace of foreign labor with local labor could be the starting point).
Policy makers should continue improving the agricultural sector in order to increase the supply in farm products and other essential of life. This fact will reduce price level, generate employment and reduce the level of inflation in the economy. In 2017, employment in agriculture accounted almost 11% of total employment in Poland, ranking as the fourth country in EU after Romania (25.8%), Bulgaria (18.2%) and Greece (11.1%) (AMECO, 2018). It’s worth mentioning that Poland’s volume of exports of agricultural products has quadrupled since 2004 (accession time in the EU) till today.

The results of the paper agree with these of Islam et al., 2011, who found that a stable Phillips curve exists for the case of North Cyprus for the period 1978-2007. Policy makers could make use of this paper for their future policy-making decisions which would stabilize the price level by controlling inflation and at the same time, living within an unemployment rate consistent with inflation (Islam et al., 2011).

REFERENCES


IMF (2018), International Monetary Fund, USA.


