Theoretical and Applied Economics
Volume XXV (2018), No. 2(615), Summer, pp. 195-204

Inflation unemployment dynamics in Hungary – A structured cointegration and vector error correction model approach

Vijay VICTOR
Szent Istvan University, Godóllö, Hungary
vjvictor7@gmail.com
Maria FEKETE FARKAS
Szent Istvan University, Godóllö, Hungary
Farkasne.Fekete.Maria@gtk.szie.hu
Florence JEESON
St. Michael's College, Cherthala, Alappuzha, India
florencejeeson1212@gmail.com

Abstract. *This paper is an attempt to investigate the existence of long run dynamics between inflation and unemployment in Hungary through a structured cointegration approach and vector error correction model. Using the monthly data of inflation and unemployment in Hungary, this study shows the presence of a long-term relationship between inflation and unemployment. The cointegration test results prove the existence of a long run dynamics between these variables and the vector error correction model depicts that the variables would adjust to long run equilibrium path quickly in case of short run disturbances to the model. The results stand in contrast with the cases of many of the developed countries like USA where recent studies proved that the long run relationships between these two variables are vanishing.*

Keywords: inflation, unemployment, cointegration, vector error correction model, Philips curve.

JEL Classification: C220, C820, E310.

Introduction

Theory of Phillips curve explains the relationship between inflation and unemployment. This implies the possible effect of inflation on unemployment and the relevance of monetary policies formulated to bring desired macro-economic changes in the economy. The detection of Philips Curve has proven a difficult task as the expectations about inflation are very short and it varies among population. (Fritsche et al., 2008). Additionally, there is huge variation in unemployment data due to the usage of different filtering methods (Schreiber and Wolters, 2007). Since 2008, inflation predictions using the conventional Philips curve in the developed economies were remarkably inconsistent. The expected inflation in 2009-2010 period was much lower than the actual level of inflation in the US for the given period and the recent inflation forecasts using traditional Philips Curve were much higher than the actual level of inflation (Ball and Mazumder, 2015).

Over the past few decades, the reliability of Philips curve in predicting the inflationary trend was vehemently questioned by many economists. The argument was empirically confirmed in a recent study conducted by the Federal Reserve of Philadelphia using the post 1985 US inflation and unemployment data. The study concluded that the usefulness of Philips curve is asymmetric in the sense that it helps to improve the accuracy of inflation forecasts when the economy is weak while it hurts the accuracy during expansionary periods. So, it is not desirable to rely on the Philips curve during normal times as an inflation forecasting tool (Dotsey et al., 2017).

In the wake of heated discussions on the validity of the Philip's curve, it is high time to analyse the reliability of this tool in country specific inflation management models. It is the transformation in the dynamics between inflation and unemployment which has weakened the forecasting capacity of the Philips Curve. The very existence of Philips Curve relies on the short run and long run relationship between inflation and unemployment. The purpose of this study is to investigate the existence of inflation - unemployment dynamics in one of the growing European economies, Hungary in the past two decades through a structured cointegration approach and vector error correction model.

1. Hungarian economy in the past decade

The performance of Hungary in terms of GDP growth rate was comparatively better than other countries in the region prior to the crisis of 2008. The reason behind this growth can be partly accounted to the unsustainable external lending. Macro-economic imbalances subsequently started to appear resulting in the steep fall of the GDP growth following the 2008 crisis. However, the GDP growth rate regained its momentum after 2015.The unemployment rates are also declining over the past 5 years. The inflation level has almost reached 3% which is the target set by the central bank implying the signs of economic growth (OECD, 2016).

2. Literature review

A number of studies have been undertaken to figure out the tradeoff between inflation and unemployment. Some of the major empirical and conceptual research works were reviewed. The research papers with similar econometric approach are discussed here.

A.W. Philips identified a strong negative correlation between inflation and unemployment in his major work entitled “The Relationship between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom 1861-1957” which was published in 1958. This tradeoff between inflation and unemployment was named as Philips curve. Numerous studies have been undertaken since then to test the validity of this theory.

The tradeoff between inflation and unemployment was scientifically analyzed for the first time by Paul Samuelson and Solow (1970) based on the inflation-unemployment data of US. They confirmed the existence of the negative relationship between inflation and unemployment. Later, the studies conducted by Solow (1970) and Gordon (1971) reaffirmed the tradeoff between inflation and unemployment. This was later known as “Solow Gordon affirmation”. The proposition of Philips Curve was vehemently criticized by Milton Friedman (1968) and Phelps (1967). They argued that there is no trade off between inflation and unemployment based on their empirical studies. Later in 1976, Robert Lucas criticized the Philips curve by stating the possibilities of the co-existence of inflation and unemployment.

In the late 1970’s,with the appearance of the new phenomena named stagflation (co-existence of high level of inflation and high level of unemployment), “The Phillips curve fell into a period of neglect in academic circles during the 1980s, however it remained an important tool for policy makers” Debelle and Vickery (1998: 384).However, Philips curve continued to be the general tool for forecasting inflation among the economists in the 1990s.The results of the empirical research works were mixed in nature. The existence of tradeoff between unemployment and inflation was supported by the empirical work of King and Watson (1994) using the US post war macro-economic data. This paper is very similar to the methodological approach followed by Fatima Shad man (1996), who used Johansen’s maximum likelihood Test for cointegration and the major finding of the existence of long run relationship between inflation and unemployment is verified in this study.

The works of Hassler and Neugart (2003), Aguair, Meneul and Martinst (1997) also confirm the linearity of Philips Curve and the negative unemployment inflation correlation. The study based on inflation unemployment data of Latvia by Hansen and Pancs (2001) found out the tradeoff was in existence and significant. In contrast, the study conducted by Islam et.al. (2003) found out that the cointegration relationship between inflation and unemployment was very weak. Atkeson-Ohanion (2001) and Ang et al. (2007) in their studies proved that Philips curve models do not show any significant improvement over the naive predictions for the period 1995-2002.This was reaffirmed by the studies of Stock and Watson (2008). The empirical study based on US data by Saiful Islam and Mustafa (2017) has shown the existence of long run tradeoff between inflation and unemployment. The study by K. Bhattarai (2017) analyzing the relationship between inflation and unemployment in the OECD countries found that there exists a negative long run inflation-unemployment relationship in most of the OECD countries including Hungary. This study has provided an empirical evidence to support the existence of inflation unemployment dynamics in Hungary.

3. Objective of the study

The primary objective of the study is to test whether there exists a long run relationship between inflation and unemployment in Hungary. Ever since the development of Philips Curve, the macroeconomic policies implemented to control inflation by most of the countries are framed by taking into account of the proposition of Philips Curve. So, inflation - unemployment dynamics play a vital role in policy formulation and consequently the well-being of the citizens. The researches carried out in this area have shown contradictory results. Some studies supported the existence of Philips curve or the negative correlation between inflation and unemployment and some did not. Hence it is necessary to do country specific studies to understand the dynamics between these two variables. This study specifically intends to check the existence of a long run relationship between inflation and unemployment through a structured cointegration analysis using the most recent data available.

4. Methodology

4.1 Data source

The monthly data of seasonally adjusted inflation rate and unemployment rate for Hungary from January 1999 to October 2017 were used for data analysis. The data was taken from the OECD website. The inflation data used is the percentage change in the Consumer Price Index (CPI) and unemployment rate is the number of unemployed persons as a percentage of the labour force in the country. The data sources are given in the end of the paper. R programming software (RStudio) was used for conducting all the statistical estimations and tests.

4.2. Econometric methodology

The tests are carried out in four stages:

- In the first stage, unit root test using the Augmented Dicky Fuller (ADF) unit root test is conducted to check the stationarity of the time series data under study. The Augmented Dickey Fuller Test was developed by Dickey and Fuller (1981). The general form of the ADF Test can be given as:

$$\Delta Xt = \delta Xt-1 + \sum \phi jqj=1\ \Delta Xt-j + e1t$$

$$\Delta Xt = \alpha + \delta Xt-1 + \sum \phi jqj=1\ \Delta Xt-j + e2t$$

$$\Delta Xt = \alpha + \beta t + \delta Xt-1 + \sum \phi jqj=1\ \Delta Xt-j + e3\mathrm{t}$$

Xt is a time series for testing unit root problem, t is the time trend and *et* is error term having white noise properties. If j = 0, it represents the simple DF test. The lagged dependent variables in the ADF regression equation are included until the error term becomes white noise. LM test is used as a residual diagnostic test to check serial correlation between the residuals. The null and alternative hypotheses of ADF unit roots are:

H0: $\delta = 0$ non-stationary time series; so it has unit root problem.

Ha: $\delta < 0$ stationary time series.

- The parameters specified in the equation are estimated in the second stage using OLS procedures and the residuals from the estimated model ($\widehat{e_t}$) are again tested for stationarity using Augmented Dicky Fuller (ADF) Test.

$\Delta\widehat{e_t} = a_1\widehat{e_t} + \eta_t$

If the residuals ($\widehat{e_t}$) are stationary then the variables are said to be cointegrated and vice versa. This residual based method to test cointegration was developed by Engle Granger (1987). The Johansen cointegration procedure which is based on maximum likelihood developed by Johansen (1991/1992) and Johansen-Juselius (1990) was further used to confirm the results.

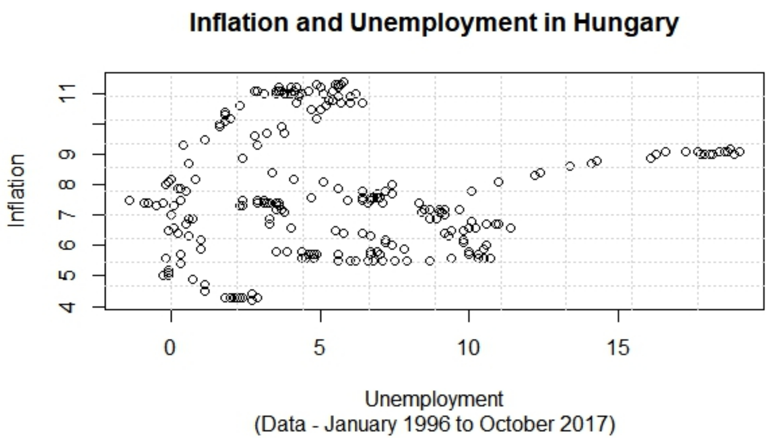
- In the third stage, a Vector Error Correction Model (VECM) is fit to the cointegrated variables to analyse the dynamic interrelationship between the variables. Stationarity of the dataset is a pre-condition for the Vector Error Correction Models.

The general form of a simple vector error correction model can be given as follows;

$\Delta Y_t = \propto + \lambda Z_{t-n} + \beta\Delta X_{t-n} + \mu_t$

Z_{t-n} shows the Error correction term and λ is the coefficient of the error correction term. $\propto$ is the constant term for the specified model. β denotes the coefficient for the independent term. The error correction term must be negative and significant. It shows the rate of adjustment to equilibrium in case of a shock to the system.

- Finally, residual diagnostics are conducted to test the stability of the model. The Breusch-Pagan Test for Heteroscedasticity and the Durbin Watson Test for autocorrelation are carried out.



5. Empirical findings

5.1 . Unit root tests

A prior requirement before using the Johansen and Engle Granger Cointegration test is to ensure that the time series data under consideration are stationary in nature, in other words it should not contain unit root. The presence of non-stationary data will lead to spurious relationship between variables. The Augmented Dickey Fuller Unit Root Test is used to test stationarity of the data series and the results are given in the Table1.

Table 1. *Results of ADF unit root test*

Test regression drift

Variables	Test statistic	P Value	Test Critical Values		
			1% level	5% level	10% level
Inflation	-2.8173	3.19e-05	-3.46	-2.88	-2.57
Unemployment	-0.4278	2.2e-16	-3.46	-2.88	-2.57

The Augmented Dickey Fuller test results show that both the data series under consideration are stationary after second order differencing. The data series being stationary, we can proceed with the test for cointegration between the variables.

5.2. Residual unit root test

The variables unemployment and inflation are regressed and the residuals of the regressed variables are tested for stationarity. The stationary of residuals implies that the variables under study are cointegrated. This two-step method of cointegration is based on the Engle Granger test for cointegration. Our null hypothesis H0 = Residuals are non-stationary.

Table 2. *Residual unit root test results*

ADF Test for Unit Root

```
Augmented Dickey-Fuller Test Unit Root Test

Test regression none
Call:
lm(formula = z.diff ~ z.lag.1 - 1 + z.diff.lag)
Residuals:
    Min        1Q         Median     3Q         Max
-0.54859   -0.06261    0.00456    0.07701    0.49034

Coefficients:
         Estimate Std. Error t value Pr(>|t|)
z.lag.1     -1.4602    0.1028    -14.208    <2e-16 ***
z.diff.lag  0.1241     0.0636    1.952      0.0521.
---
Signif. codes:   0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1305 on 242 degrees of freedom
Multiple R-squared:  0.6546,    Adjusted R-squared:  0.6518
F-statistic: 229.4 on 2 and 242 DF,  p-value: < 2.2e-16

Value of test-statistic is: -14.2077
Critical values for test statistics:
      1pct  5pct  10pct
tau1 -2.58 -1.95  -1.62
```

The test results of the ADF test of residuals in Table 2 indicate a p value which is less than 0.05% implying that the residuals are stationary. Hence, we conclude that there exists cointegration between inflation and unemployment. So, we can confirm the presence of a long run relationship between the variables under consideration.

Table 3. *Johansen cointegration test result*

Unrestricted Cointegration Test (Maximum eigenvalue)

```
Johansen-Procedure
Test type: maximal eigenvalue statistic (lambda max), without linear trend and constant in cointegration

Eigenvalues (lambda):
[1] 2.687388e-01  2.335070e-01  2.775558e-17

Values of test statistic and critical values of test:

          test   10pct   5pct   1pct
r <= 1 | 63.29   7.52    9.24   12.97
r = 0  | 74.49  13.75   15.67   20.20
```

The result in the Table 3 further confirms the existence of cointegration between the variables under study. The test statistics and eigen values indicate that the hypothesis of no cointegration can be rejected at 1% significance level. The rank of the cointegration is greater than 1 as we can reject $r \leq 1$ at 1% significance level.

5.3. Vector error correction model

Cointegration being confirmed, vector error correction model can be employed now. The dataset used in this study have been transformed to their first difference to ensure stationarity. But, the first differences would not give a clear picture of the long run relationship between the variables. This means that the variables should be used in levels as well. Using an Error Correction Model will help to solve this problem as it incorporates variables both in their levels and first differences. If the value of error correction term is negative and between "0 to 1" we can assume the convergence of the model towards long run equilibrium. The value also implies the rate of adjustment which takes place every year. The estimated long run relationship among inflation and unemployment can be identified by analysing the coefficients in the cointegrating equation. The vector error correction model shows how deviations from the long run relationship affect the changes in the variable in the consecutive periods. The model also adjusts to both short run changes in variables and equations.

The empirical models of the VECM for this study can be shown as below.

$$\Delta Inflation_t = \propto + \lambda Z_t - n + \Sigma\beta 1 \Delta Unemployment_{t-n} + \mu_t \quad (1)$$

Where, $\propto$ is the constant intercept, λ is the coefficient of the error correction term zt-nand $\beta 1$ is the coefficient of the independent variable, μt is the error term and. The coefficient of cointegrated equation specifies how quick the adjustment towards long-run equilibrium would occur. The result from the optimal lag length criteria according to Akaike information criteria (AIC), Hannan-Quinn (HQ) is 8 lags for this model.

Table 4. *Vector Error Correction (VECM) of inflation rate*

Dependent variable: Unemployment

```
Coefficients:
        x.d      y.d
ect1*  -0.10852  -0.19272

x.dl1  -1.30862   0.18889  x.dl2  -1.42501   0.19093  x.dl3  -1.29668   0.16604
y.dl1   1.98484   1.99482  y.dl2   1.73495   1.62431  y.dl3   1.03567   1.12000

x.dl4  -1.03984   0.12982  x.dl5  -0.61958   0.10179 x.dl6  -0.27085   0.06633
y.dl4   0.81318   0.78471  y.dl5   0.79880   0.53245 y.dl6   0.34522   0.23510

x.dl7  -0.10970   0.03049
y.dl7  -0.12389   0.08409

$beta
             ect1
x.l1     1.000000e+00
y.l1     1.807533e+01
constant 4.143933e-04
```

x = Inflation, y = Unemployment, number of lags = 8.
ect1* = error correction term1.

The short run dynamics between inflation and unemployment is explained by the VECM. The results of the Vector Error Correction Model are given in the Table 4. The negative signs of the error correction term show that the results are significant and the coefficient of the Error Correction Term (ECT) is not too small (-0.10852) implying that the speed of convergence to the long run equilibrium will not be too slow once the system is exposed to an exogenous shock.

5.4. Residual diagnostic tests

Table 5. *Breusch-Pagan test*

Residual Test for Heteroscedasticity

```
Studentized Breusch-Pagan test

data:  y ~ x
BP = 0.33285, df = 1, p-value = 0.564
```

y = Unemployment, df = degree of freedom, H_0 = Error terms are constant.
x = Inflation.

The result of the Breusch Pagan Test for Heteroscedasticity given in Table 5.1 indicates that the residuals in the model are constant or in other words we can confirm homoscedasticity.

Table 6. *Durbin Watson test*

Residual Test for Autocorrelation

```
Durbin-Watson test

data:  x ~ y
DW = 2.8702, p-value = 0.91
alternative hypothesis: true autocorrelation is greater than 0
```

y = Unemployment, DW = Durbin Watson Test Statistic, H_0 = No serial correlation.
x = Inflation.

The results of the Durbin Watson Test for autocorrelation as shown in the Table 5.2 reveal that the residuals are not correlated and hence we reject the presence of autocorrelation in the model.

Conclusion

Results of this empirical study support the existence of long run dynamics between inflation and unemployment in Hungary. The results of the Engle Granger and Johansen Tests for cointegration give strong evidence to believe that there exists a long run relationship between these variables. Furthermore, the vector error correction model confirms that the short run dynamics between inflation and unemployment is very strong and the variables adjust to the equilibrium path quickly in case of an external shock. The residual diagnostic tests conducted provide satisfactory results to reject the presence of autocorrelation and heteroscedasticity in the model hence verifying the stability of the overall model. This study ends with the conclusion that despite the current controversies on the relevance of Philips curve in many countries, there exist a long run relationship between inflation and unemployment in Hungary.

References

Ang, A., Bekaert, G. and Wei, M., 2007. Do Macro Variables, Asset Markets, or Surveys Forecast Inflation Better? *Journal of Monetary Economics,* 54, pp. 1163-212.

Atkeson, A. and Ohanian, L.E., 2001. Are Phillips Curves Useful for Forecasting Inflation. *Federal Reserve Bank of Minneapolis Quarterly Review, 25*(1), pp. 2-11.

Ball, L. and Mazumder, S., 2015. A Phillips Curve with Anchored Expectations and Short-Term Unemployment, *IMF Working Papers*, Vol. 15(39).

Bhattarai, K., 2016. Unemployment–inflation trade-offs in OECD countries, *Economic Modelling,* Vol. 58, November, pp. 93-103

Debelle, G. and Vickery J., 1998. Is the Phillips Curve: Some Evidence and Implications for Australia. *The Economic Record,* 74, pp. 384-398.

Dickey, D. and Fuller, W., 1979. Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association,* Vol. 74, No. 366, pp. 427-431.

Dickey, D. and Fuller, W., 1981. Likelihood Ratio Tests for Autoregressive Time Series with a Unit Root. *Econometrica,* Vol. 49, No. 4, pp. 1057-1072.

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

Dotsey, M. and Stark, T., 2005. The relationship between capacity utilization and inflation. *Federal Reserve Bank of Philadelphia Business Review,* Q2, pp. 8-17

Dotsey, M., Fujita, S. and Stark, T., 2017. Do Phillips Curves Conditionally Help to Forecast Inflation?, *Working Paper*, No. 17-26, Federal Reserve Bank of Philadelphia, August 2017.

Friedman, M., 1968. The Role of Monetary Policy. *American Economic Review,* 58, pp. 1-17.

Friedman, M., 1970. *Monetary Statistics of the United States: Estimates, Sources, Methods.* New York, Columbia University for the NBBR.

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

Gordon, R.J., 1971. Price in 1970: The Horizontal Phillips Curve. Brookings Papers on Economic Activities, 3, pp. 449-458.

Granger, C.W.J., 1981. Some Properties of Time Series Data and Their Use in Econometric Model Specification, *Journal of Econometrica,* 16, pp. 121-130.

Hansen, M. and Pancs, R., 2001. The Latvian Labour Market Transition: the Beveridge and Phillips Curve as Indicators of Normalization, Riga: Euro Faculty.

Islam, F., Hassan, K., Mustafa, M. and Rahman, M., 2003. The Empirics of U.S. Phillips Curve: A Revisit, *American Business Review,* 20(1), pp. 107-112.

King, R.G. and Watson, M.W., 1994. The Post-War U.S. Phillips Curve: A Revisionist Econometric History, Carnegie-Rochester Conference Series on Public Policy, 41, pp. 157-219.

Neugart, U. and Hassler, M., 2003. Inflation-unemployment tradeoff and regional labor market data. *Empirical Economics,* 28, pp. 312-324.

Saiful Islam, M. and Mustafa, R., 2017. Quest for a Valid Phillips Curve in the Long Run: An Empirical Approach, *International Business Research,* Vol. 10, No. 4.

Schreiber, S., Wolters, J., 2007. The long-run Phillips curve revisited: Is the NAIRU framework data-consistent? *Journal of Macroeconomics,* 29, pp. 355-367.

Shadman, F.M., 1996. Does Modern Econometrics Replicate The Phillips Curve? IRES, Université Catholique de Louvain.

Solow, R.M. and Samuelson, P.A., 1960. Analytical Aspects of Anti-inflation Policy. *American Economic Review,* pp. 177-194.

<http://www.oecd.org/economy/economic-survey-hungary.htm>

<https://data.oecd.org/price/inflation-cpi.htm>

<https://data.oecd.org/unemp/harmonised-unemployment-rate-hur.htm>