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Empirical Analysis for Testing the Validity of the Phillips Curve in the Czech Republic

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***Abstract*— Inflation and unemployment are the most important economic indicators for each country. The latest information is always impatiently expected, analyzed and commented not only by economists but also by inhabitants of the country. This article goes back to the original idea of the Phillips curve as a tool for empirical verification of the relationship between inflation and unemployment. The question that arises is whether the unemployment rate can be used to explain the changes in the inflation rate and on the contrary, in the Czech Republic. The verification of this relationship will be carried out on the basis of econometric models (ADL models and cointegration analysis) on the basis of the annual time series from 1995 to 2012.**

***Keywords*—Phillips Curve, inflation, unemployment, time series, model ADL, cointegration.**

I. Introduction

Inflation, together with unemployment, are considered to be the most important economic indicators of a state. Their current information is sensitively perceived not only by economists and economic analysts, but above all by the inhabitants of the given country. From the point of view of stastiticians, inflation manifests itself in the form of price level inflation [IR], which most often is counted as an outgrowth of the average yearly consumer price index. This means that it is perceived as a percentage change in the average price level for the following 12 months, against the average for the previous 12 months. Unemployment is expressed in the form of the Unemployment Rate [UR]. This means the number of unemployed people as a percentage of the total number of inhabitants of active age.

Analysis of the relationship between the level of wage inflation and the unemployment rate was first carried out in 1958 by A.W. Phillips [11]. The author, on the basis of empirical data pointed out the fact that in the period 1861-1957 in England, there was high unemployment accompanied by a growth in nominal wages. As has been said, the purpose of this work „…is to see whether statistical evidence supports the hypothesis that the rate of change of money wage rates in the UK can be explained by the level of employment and the rate of change of employment…". In other words, this explains whether the changes in the inflation rate could be dependent on changes in the unemployment rate. He assumed, therefore, a one sided, non-linear causal relationship coming from the unemployment rate to the rate of inflation.

After some time, [9], [10], [12] and many other authors joined their efforts to Phillips' work. The aim of their analysis was not only to test the one sided relationship leading from the unemployment rate to inflation [wage inflation, moreover, with the passage of time, was replaced in these models by price inflation], but also the opposite relationship; i.e., from inflation to unemployment. Depending on how the calculation technique was developed, there came into existence estimations of the Phillips Curve in the works of his followers which were more complicated and more demanding from the calculation point of view. The original Phillips Curve was constructed on the basis of the yearly time order, and it was, from the point of view of today's statisticians, a relatively simple statistical regression model [it did not contain a delay in both indicators. Even its quality was not tested].Today, thanks to sophisticated time order analysis methods, which started to be applied at the end of the last century [multi-dimensional time order models, and co-integration analysis]. The Phillips Curve became the new challenge for econometric experts and contributions on this theme constantly appear in prestigious professional journals (for all of them, see, for example [7]).

Because this article deals with the relationship between inflation and unemployment in the Czech Republic, it is necessary to mention many of the Czech authors, who have contributed over the past several years to the research into this question. They are, for instance,: [1], [2], [13], [6].

II. Testing the Relationship between Inflation and Unemployment in the Czech Republic

Let us return, in this empirical part, to the original idea of the Phillips Curve; i.e., as an instrument for the empirical testing of the relationship between inflation and unemployment, and this in the conditions peculiar to the Czech Republic. In order to test this relationship we will use the yearly data from the period 1995-2012.

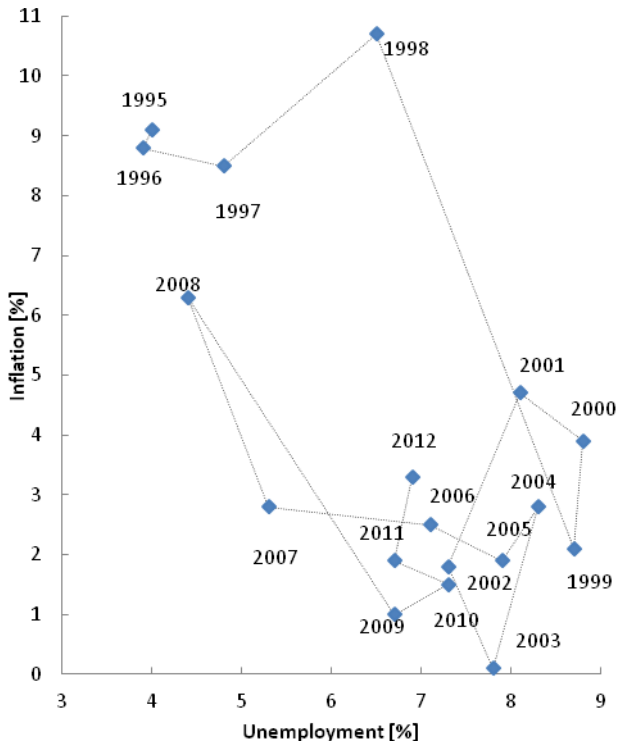

Fig. 1. Phillips Curve in the Czech Republic in the period 1995-2012
Source: data Czech Statistical Office

Fig. 1. shows on the point diagram the relationship between the inflation rate and the unemployment rate during the period 1995-2012. It is apparent that in the short term [e.g., 1996-1999, 2005-2008 and 2008-2009] the relationship between both indicators can be identified fairly easily. However, can the assumed relationship over the entire period under examination be tested?

Fig. 2. The inflation rate and the unemployment rate in the Czech Republic in the period 1995-2012
Source: data Czech Statistical Office

For testing this hypothesis, we use the standard methods which are used for the analysis of the time order. The basic assumption of a possible, mutual, relationship between the time orders is, that they result from similar developments. Therefore, it is necessary to test whether the time orders under examination [Figure 2] are stationary [I[0]], or non-stationary [I[1]], because analysis of the relationships between the time orders make sense only if these time orders are integrated into the same order. From the ADF test [3], individual roots [Table I] are the result of both time orders being non-stationary, type I [1].

TABLE I. UNIT ROOT TESTS

1995-2012	y_t		Δy_t	
	t_{ADF}	Prob.	t_{ADF}	Prob.
IR	-1.85192	0.0623	-6.71773	0.0000
UR	-2.61244	0.1088	-3.68034	0.0011

Source: Own calculations

The Engle-Granger test of co-integration [4], which arises from analysis of the residue of the static regressive models of both time orders, from which we have eliminated the possibility of spurious regression [Table II]. The time orders are, therefore, co-integrated, and we can identify a long term relationship between them.

TABLE II. UNIT ROOT TEST OF

$\hat{a}_t$	t_{ADF}	Prob.
	-2.632112	0.0119

Source: Own calculations

A. *From unemployment to inflation*

If we assume that there is a one sided direction causing the time order of the unemployment rate on the time order of the inflation rate, and if we know that $\hat{a}_t$ from Table II is auto-correlated, it is sufficient to estimate the relationship between both time orders in the ADL (*Autoregressive Distributed Lag model*, [8]) [Table III] in the form:

$$Y_t = c + \alpha_1 Y_{t-1} + \beta_1 X_t + a_t. \quad (1)$$

TABLE III. ESTIMATE OF THE ADL MODEL

Dependent variable: IR				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	8.785245	2.956477	2.971525	0.0095
IR(-1)	0.388793	0.170633	2.278531	0.0378
UR	-0.960111	0.374551	-2.563364	0.0216
R-squared	0.573678		Durbin-Watson stat	2.3678
F-statistic	10.09233		Prob(F-statistic)	0.0016
Diagnostics tests			**Statistics**	**Prob.**
Breusch-Godfrey Serial Correl. LM Test:			0.558695	0.5851
Jarque-Bera Test			0.529154	0.7675
ARCH Test			0.009699	0.9229

Source: Own calculations

The following ADL model of the dependence of inflation on unemployment in the Czech Republic can be written like this:

$$\hat{IR}_t = 8.785245 + 0.388793IR_{t-1} - 0.960111UR_t, \quad (2)$$

from which it arises that the inflation rate in time t directly depends on its value in time $t-1$ and indirectly points to the unemployment rate in time t. Diagnostic control of the model indicates, the unsystematic make up of the model has the same properties of the processes of white noise [Table III]. The re-written equation of the ADL model into the form of the ECM (*Error Correction Model*; [5]) model, like so:

$$\Delta Y_t = c + \beta_1 \Delta X_t + (\alpha_1 - 1)[Y_{t-1} - \frac{\beta_1}{\alpha_1 - 1} X_{t-1}] + a_t, \quad (3)$$

we get:

$$\Delta \hat{IR}_t = 8.7852 - 0.9601\Delta UR_t - 0.6112(IR_{t-1} + 1.5708UR_{t-1}), \quad (4)$$

where we gain through the parameters $(\alpha_1 - 1) = -0.61121$ information about the speed with which the system reacts to deviations from equilibrium. The value of the long term multiplier $\beta_1/(1 - \alpha_1) = -1.57084$ indicates that in the period 1995-2012 in the Czech Republic was confirmed the long term indirect orientation of the dependence of the inflation rate on the unemployment rate, because the increase of the unemployment rate by one percentage point caused a drop in the inflation rate by an average of 1.57 percentage points.

B. From inflation to unemployment

If we consider the opposite directional flow, i.e., the dependence of unemployment on inflation, we get the ADL model from Table IV.

TABLE IV. ESTIMATE OF THE ADL MODEL

Dependent variable: UR				
Variable	***Coefficient***	***Std. Error***	***t-Statistic***	***Prob.***
C	4.116266	1.421115	2.896505	0.0117
UR(-1)	0.522758	0.171439	3.049242	0.0087
IR	-0.239689	0.101610	-2.358907	0.0334
D1	2.439173	1.090637	2.236467	0.0421
R-squared	0.732137		Durbin-Watson stat	1.267881
F-statistic	12.75518		Prob(F-statistic)	0.000272
Diagnostics tests			***Statistics***	***Prob.***
Breusch-Godfrey Serial Correl. LM Test:			2.025284	0.1746
Jarque-Bera Test			0.099651	0.9514
ARCH Test			0.027736	0.8700

Source: Own calculations

This model is in the form:

$$\hat{UR}_t = 4.1163 + 0.5228UR_{t-1} - 0.2397IR_t + 2.4392D_t \quad (5)$$

from which it arises that the unemployment rate in time t directly and proportionately depends on its value in time $t-1$ and indirectly proportionately on the inflation rate in time t. The model contains the artificially changed D_t (in which 1998 = 1, other periods = 0), for correcting deviations in the time order of the inflation rate, which emerged as a consequence of the financial crisis in the Czech Republic in the final years of the 20th century. Diagnostic control of the model indicates that the unsystematic make up of the model has the properties of the process of white noise [Table IV]. Upon rewriting the ADL model equation in the ECM form, we get:

$$\Delta \hat{UR}_t = 4.1163 - 0.2397\Delta IR_t - 0.4772(UR_{t-1} + 0.5022IR_{t-1}). \quad (6)$$

The reaction speed of the system to deviations from equilibrium is given by the parameters $(\alpha_1 - 1) = -0.47724$ and the value of the long term multiplier $\beta_1/(1 - \alpha_1) = -0.50224$ shows that increasing the inflation rate by one percentage point caused a drop in the unemployment rate by an average of 0.5 a percentage point. The long term indirect proportionate dependence of the unemployment rate on the inflation rate was confirmed, and overturned, in the Czech Republic in the period 1995-2012.

C. Testing exogenity

From the point of view of the above mentioned results, when in the Czech Republic during the period under examination, it was proven not only the dependence of the inflation rate on the unemployment rate, but also that of the unemployment rate on the inflation rate; it would be useful to test the exogenity of both time orders, in order to confirm or overturn the above discovered results.

In the classic regressive model it is assumed that the explanatory change is not correlated with the unsystematic make up of the model. In the case of the relationship between two stochastic time orders, this does not apply, however. If, for instance, the time order of the unemployment rate is not correlated with the unsystematic make up of the model, then the development of the inflation rate is contingent on the development of the time order of the unemployment rate and not the other way around.

The unemployment rate is then changed exogenuously and the inflation rate is changed endogenuously. If this condition does not apply, a one directional relationship between the time orders is not guaranteed. Also, it is necessary, for modelling the relationship, to use the double equation model; VAR, in which the alternative relationship is also dealt with. Therefore, we will carry out the exogenity test [4] for both time orders.

We shall, first of all, reveal the marginal model for both time orders [Table V], and the residue of this model will be used for testing the exogenity in the conditional models [from Table III and Table IV].

TABLE V. MARGINAL MODEL (STANDARD ERRORS IN ( ) & T-STATISTICS IN [ ])

	UR	IR
UR(-1)	0.933693	0.138178
	(0.04741)	(0.12550)
	[19.6947]	[1.10103]
IR(-1)	0.127511	0.679280
	(0.05716)	(0.15133)
	[2.23059]	[4.48885]

Correl. LM Tests		Heteroskedasticity Tests		Jarque-Bera Tests		
Lags	*LM-Stat*	*Prob*	*Chi-sq*	*Prob*	*Ser.*	*JB*	*Prob*
1	4.9737	0.2900	15.0258	0.2400	UR	0.8440	0.6557
2	4.7733	0.3114			IR	0.0302	0.9850

Source: Own calculations

TABLE VI. TEST OF THE EXOGENITY OF THE UNEMPLOYMENT RATE IN THE CONDITIONAL MODEL

Dependent variable: IR				
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	8.286318	3.839299	2.158289	0.0488
IR(-1)	0.400931	0.185182	2.165064	0.0481
UR	-0.893465	0.496260	-1.800396	0.0934
RESID_UR	-0.157018	0.731719	-0.214588	0.8332
R-squared	0.575075	Durbin-Watson stat		2.402854
F-statistic	6.315674	Prob(F-statistic)		0.006225
Diagnostics tests			*Statistics*	*Prob.*
Breusch-Godfrey Serial Correl. LM Test:			1.755196	0.2145
Jarque-Bera Test			0.787919	0.6744
ARCH Test			0.003953	0.9537

[a.] Source: Own calculations

From the values of the test criteria *t* for the parameters of the residual explanatory changes *RESID_URt* [Table VI], it appears that the unemployment rate is exogenuous to the other parameters of the conditional model [parameters do not change], and the model from Table III can be used to model estimates of the inflation rate.

TABLE VII. TEST OF THE EXOGENITY OF THE INFLATION RATE IN THE CONDITIONAL MODEL

Dependent variable: UR				
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	2.498754	1.560836	1.600908	0.1334
UR(-1)	0.659190	0.173257	3.804706	0.0022
IR	-0.053672	0.135589	-0.395844	0.6986
D1	2.422238	1.002242	2.416819	0.0311
RESID_IR	-0.237121	0.125327	-1.892019	0.0810
R-squared	0.789971	Durbin-Watson stat		1.651335
F-statistic	12.22408	Prob(F-statistic)		0.000241
Diagnostics tests			*Statistics*	*Prob.*
Breusch-Godfrey Serial Correl. LM Test:			1.490106	0.2675
Jarque-Bera Test			0.562210	0.7549
ARCH Test			1.462591	0.2542

Source: Own calculations

In the case of the second model, from the values of the test criteria *t RESID_IR*$_t$ (Table VII), it emerges ($\alpha = 0{,}1$), that the inflation rate (*IR*) is not exogenuous from the point of view of the other parameters of the conditional model [the parameters changed] and the model from Table IV cannot be used for the model for estimating the inflation rate, because the inflation rate is endogenuously changed.

III. CONCLUSION

The aim of this article was to model the relationship between inflation and unemployment in the Czech Republic in the period 1995-2012 in the context of the Phillips Curve. On the basis of theoretical assumptions we, first of all, constructed a model of the dependence of the inflation rate on the unemployment rate, and in the second phase we turned this relation around and analysed the model of the dependence of the unemployment rate on the inflation rate.

From the results it appears that during the period under analysis, the long term one directional indirect proportionate dependence of the inflation rate on the unemployment rate is as was assumed by [11] in his original work. However, if we wanted to analyse the dependence of the unemployment rate on the inflation rate, it is not possible to construct this model in a one directional way [i.e., in the form of the ADL model].So, from the point of view of the endogenity of the inflation rate, only the two equation VAR model can be used. This model contains the two sided relationship between the time orders.

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