“The relationship between the short-term and long-term Phillips curve for the Czech Republic”

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THE RELATIONSHIP BETWEEN THE SHORT-TERM AND LONG-TERM PHILLIPS CURVE FOR THE CZECH REPUBLIC

Abstract

Inflation in Czech Republic in 2021 significantly deviated from the tolerance band. Although the economic results are lagging behind expectations, inflationary pressures, mainly from abroad, are still intensifying. At the same time, the rapid rise in consumer prices affects not only households and consumers, but also business and companies. As is known, a very important tool for understanding inflation is the Phillips curve, which shows the relationship between two variables, the first one is inflation and the second one is unemployment. The aim of this paper is to research the relationship between the short-term Philips curves and long-term Phillips curves for the Czech Republic. For this purpose, data on the inflation rate and unemployment rate between 1993 and 2018 were contrasted based on data published by the Czech Statistical Office. The short-term Phillips curve was assumed under adaptive expectation conditions, whereby a regression analysis was undertaken using SPSS statistical software to determine suitable values for the corresponding parameters. In addition, and in accordance with the trend figure and data description figure for both the unemployment rate variable and inflation rate variable, the basis for the development of the long-term Phillips curve is described. Subsequently, it is concluded that a mutually substitutive relationship exists with regards to the short-term and that the long-term is an irregular circular curve that moves in a clockwise direction.

Keywords short-term Phillips curve, long-term Phillips curve, inflation rate, unemployment rate

JEL Classification E24, E31

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INTRODUCTION

The influence and substitutive relationships that exist between macroeconomic aggregates are not only the external expression of the inherent principles of economics, but also the basis of macroeconomic regulation and economic policy intervention. One such relationship is that between the inflation rate value and the unemployment rate value, which is represented by the so-called Phillips curve. The Phillips curve, which looks at the internal correlation of changes in employment and price levels, has been the focus of attention for quite some time. However, although there was a long history of macroeconomic research into the relationship between changes in price levels and output, it was not until 1958 that Phillips presented his comprehensive theory on the relationship between labor supply and price levels (Nell, 2018). Phillips, who was an economist from New Zealand, calculated a curve representing the dependency between the rate of change of unemployment and monetary wages since mathematical statistics using statistical data for Great Britain for the period 1861 to 1957. The curve later became known as the Phillips curve.

The original Phillips curve revealed that a non-linear negative correlation exists between the rate of change of monetary wages and unem-

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ployment (Oikawa, 2018). Within this context, it is therefore possible to also draw the important economic conclusion that there is a reciprocal relationship between the rate of change of monetary wages and unemployment. It can subsequently be concluded that there is also a substitutive relationship between the rate of change of prices and unemployment. In other words, monetary wage growth rates are high when the unemployment rate is low, and vice versa, monetary wage growth rates are low, or even negative, when unemployment is high.

For this purpose, unemployment and inflation rate data are used for the period 1993 to 2018. The research presented in this paper seeks to determine the correct shape of the Phillips curve for the Czech Republic, to describe what it means and to predict the development of the long-term Phillips curve.

1. LITERATURE REVIEW

1.1. Phillips curve

The Phillips curve is used to describe the relationship between the inflation rate and unemployment rate in social and economic life (Coibion et al., 2018). This curve is a single-equation econometric model which defines the historical inverse relationship between rates of unemployment and corresponding rates of inflation within an economy. The relation between employment and inflation was not easily stated by Phillips himself but was deduced from his statistical findings (Luengo-Prado et al., 2018). The Phillips curve is therefore a type of empirical curve. Figure 1 shows the relationship between the short-term Philips curve and long-term Phillips curve.

For the short-term Phillips curve, there is a substitutive relationship between the variable of unemployment rate and the inflation rate. Since new inflation expectations constantly appear, the inflation rate in relation to the unemployment rate becomes higher and higher, as a result of which the Phillips curve keeps moving to the upper right and eventually evolves into a vertical line, i.e., the long-term Phillips curve (Snower & Tesfaselassie, 2017). The long-term Phillips curve is therefore formed by the constant movement of the short-term Phillips curve.

Not long afterwards, Samuelson and Solow discovered a similar result for the Unites States. The relationship was later extended to the more general, overall price level, and other slack variables were employed (Donayre & Panovska, 2016). Then, in the late 1960s, the stable negatively sloping Phillips curve was overturned by the Friedman-Phelps natural rate model. Their Phillips curve was vertical eventually at the natural unemployment rate, and their short-term curve shifted upwards whenever unemployment was pushed below the natural rate (Gordon, 2018). On this basis, Friedman correctly predicted that both inflation and unemployment would increase in the 1973–1975 recession. Lucas believed that rational ex-

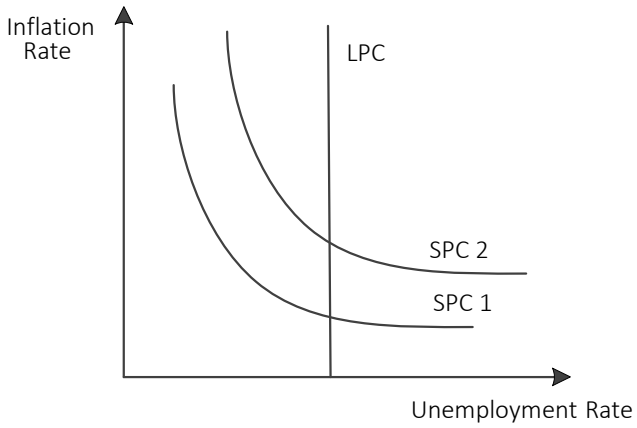

Figure 1. Short-term and long-term Phillips curves

pectations should be applied instead of adaptive expectations because the adaptive expectations adopted under the Phillips curve with additional expectations would easily lead to systematic expectation bias (DeVroey, 2017). Taylor improved the Phillips curve in two ways. Firstly, by introducing rational expectations, believing that enterprises would use existing information to optimally determine their expectations of the current economic state, resulting in no systematic deviation, and secondly, by revising the price rigidity emphasized by the traditional Keynesian Phillips curve by putting forward the theory of sticky prices (Kim, 2018). Calvo further modified the theory of sticky prices by introducing the concept of random duration staggered pricing as an alternative to constant duration staggered pricing (Sauer, 2016). The concept of rational expectations and the theory of sticky prices resulted in the Phillips curve being called the new Keynesian Phillips curve. Gali and Grede, on the basis of Calvo's model, subsequently drew on the assumed sticky prices and rational expectations of manufacturers, assumed the market to be monopolistic and put forward the idea of an improved new Keynesian Phillips curve (Abbas et. al., 2016). This improved new Phillips curve had both a forward and retrospective economic feature. Arruda et al. (2018) adopted this model to research the economic problems in Brazil. Abbas et al. (2016) adjusted the new Keynesian Phillips curve on the basis of research conducted using recent economic data.

1.2. Inflation

In the field of economics, inflation represents a persistent increase in the general price level of goods and services in an economy over a period. When the general price level goes up, each unit of currency purchases fewer goods and services. In other words, inflation represents a reduction in the purchasing power per unit of money (Coulibaly & Kempf, 2019). The inflation rate is one of the most important measures of price inflation. It is usually represented by the consumer price index, an index of the annualized percentage change in general price levels (Balcilar et. al., 2018).

Inflation can influence economies in various positive and negative ways. Many economists and experts have extensively researched the effects of inflation on the economies of various countries. Okimoto (2019) researched the dynamics of trend inflation in Japan over the last three decades based on the Phillips curve smooth transition model and concluded that there is a strong connection between trend inflation and monetary policy regimens. Amiri and Gong (2018) examined the impact of monetary policy and inflation rate on America's economic growth. Fahima and Fethi (2018) investigated the dynamic relationship between inflation rate, interest rate differential, exchange trade and exchange rate parities in Tunisia, and concluded that there was a bidirectional relationship between inflation and the exchange rate and that there was a strong correlation between the terms of trade and inflation. Ignacio and Ruth (2018) analyzed the pass-through effects between exchange rate fluctuations and inflation in the North American Free Trade Agreement (NAFTA) economies. It was shown that both Canada and the United States faced a negligible pass-through coefficient, while Mexico's had declined along with inflation. Aloui et al. (2018) provided a fresh insight into the dynamic relationship of oil prices, inflation the Saudi/US dollar exchange rate, and output growth rate for Saudi Arabia' economy using novel wavelet methods. From these articles, we know that economists generally consider high inflation rates to be caused by the steep growth of money supply.

1.3. Unemployment

Unemployment means the state of being without any form of work with which to earn a livelihood. Economists distinguish between overlapping types of and theories of unemployment. These include cyclical or Keynesian unemployment, frictional unemployment, structural unemployment, and classical unemployment. There are additional types of unemployment, including seasonal unemployment (Al-Ubaydli & List, 2019), hard-core unemployment (Lu, 2019), and hidden unemployment (Palley, 2018). The unemployment rate is an important measure for evaluating unemployment and is calculated as the percentage of the total number of individuals currently in the labor force that are unemployed (Sommers, 2018). Relatively high unemployment rates are common in societies experiencing an economic recession.

Many economists and experts have conducted in-depth studies into the reasons for unemployment.

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Schaal (2017) studied the impact of time-varying idiosyncratic risk at the establishment level on aggregate unemployment fluctuations. Han and Kim (2019) adopted data from the economically active population surveys for 1986 through to 2014 to comprehensively examine Korean unemployment dynamics, including inflow rates and outflow rates. Altuzarra et al. (2018) examined the relationship between two variables, the first one is the unemployment rate and the second one is the labor force participation rate in Spain. The results revealed that the accuracy of the unemployment invariance hypothesis was decided on a case-by-case basis. Horvath and Zhong (2019) quantified the impact of three key external shocks (interest rates, uncertainty shocks and external demand) on emerging market economies. They found that a decrease in external demand and an increase in external interest rates and uncertainty lead to a higher unemployment rate and a depreciation of the domestic currency. Gil-Alana et al. (2019) examined the development of the unemployment in Turkey by utilizing long-term memory models, with the application of fractionally integrated techniques in particular. The results of their research suggested that unemployment in Turkey is persistently high, with orders of integration in the majority of cases equal to or greater than 1. Another conclusion was that the high unemployment rates were long-term due to the effects of labor and macroeconomic policies.

This paper aims to determine, based on above understanding of the principles that underpin the Phillips curve, whether there is causality between unemployment and inflation in the Czech Republic.

2. DATA AND METHODOLOGY

The original Phillips curve is an experience curve that reflects the relation between the unemployment rate and inflation rate. It is based on the actual economic experience of developed countries after a certain stage of economic development. The basic model was built according to traditional Keynesian macroeconomic theory. However, the Phillips curve is expressed in different models, on the basis of different economic theories and hypotheses.

According to the concept of rational expectation, the general public's expectations of future inflation are determined by current and future information, which can lead to a change in the relationship between the unemployment rate and the inflation rate. For the purposes of this paper, the Phillips curve with rational expectation based on the hypothesis for the Czech Republic, as described in Section 2.4, was adopted.

The data on the inflation rate and unemployment rate between 1993 and 2018 were collated on the basis of data published by the Czech Statistical Office. The trends in the unemployment rate and inflation rate over this period are presented in Figure 2.

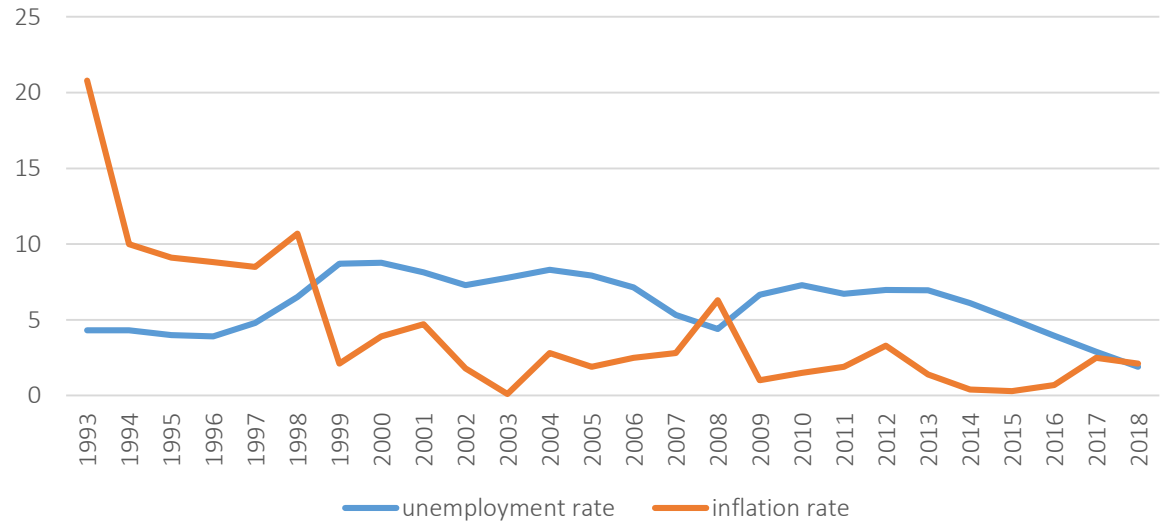

Figure 2. Development of the unemployment rate and inflation rate

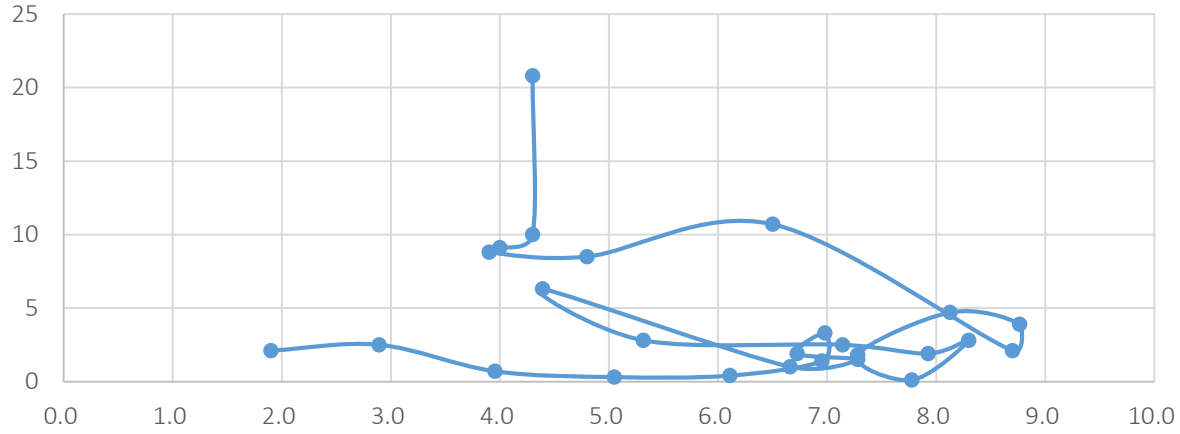

Figure 3. Relationship between the unemployment rate and inflation rat

In Figure 2, the blue line represents the development of the unemployment rate, and the red line represents the evolution of the inflation rate over the given period (1993–2018). The relationship between the unemployment rate and the inflation rate is presented in Figure 3.

In Figure 3, the horizontal axis displays the unemployment rate, and the vertical axis the inflation rate. Each point represents unemployment and inflation in the Czech Republic for each year between 1993 and 2018.

The dataset is presented in Table 1. Microsoft Excel software was used to process the data statistics in this paper.

The data statistics for the value of unemployment rate and the value of inflation rate, based on the dataset, are listed in Table 2.

Table 2. Statistics data for the unemployment rate and inflation rate

Variable	Unemployment Rate (%)	Inflation Rate (%)
Minimum	1.90	0.10
Maximum	8.76	20.80
Average	6.00	4.30
Median	6.58	2.50
Variance	3.44	20.74
Standard Deviation	1.89	4.64

Samuelson and Solow introduced the inflation rate into Phillips curve to make it involving the relationship between unemployment rate and inflation rate (Donayre & Panovska, 2016). Okun presented the linear relationship between the unemployment rate and inflation rate (Chen & Desiderio, 2018), and established the function as follows:

$$\alpha\left(Y-\overline{Y}\right)=-\beta\left(u-u^{n}\right), \quad (1)$$

Table 1. Dataset for the unemployment rate and inflation rate

Year	Unemployment rate	Inflation rate	Year	Unemployment rate	Inflation rate
1993	4.3	20.8	2006	7.1	2.5
1994	4.3	10	2007	5.3	2.8
1995	4.0	9.1	2008	4.4	6.3
1996	3.9	8.8	2009	6.7	1
1997	4.8	8.5	2010	7.3	1.5
1998	6.5	10.7	2011	6.7	1.9
1999	8.7	2.1	2012	7.0	3.3
2000	8.8	3.9	2013	7.0	1.4
2001	8.1	4.7	2014	6.1	0.4
2002	7.3	1.8	2015	5.0	0.3
2003	7.8	0.1	2016	4.0	0.7
2004	8.3	2.8	2017	2.9	2.5
2005	7.9	1.9	2018	1.9	2.1

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where Y is the output rate, $\overline{Y}$ is the natural output rate, u is the unemployment rate; and u^n is the natural unemployment rate.

Many economists subsequently made improvements to the Okun function. Lucas put forward the concept of rational expectation $E\pi_t$ (Bandyopadhyay, 2017). The Phillips curve under the condition of rational expectation is therefore expressed as follows:

$$\pi_t = \alpha E\pi_t - \beta\left(u_t - u_n\right) + v_t, \qquad (2)$$

where π_t is the inflation rate in period t, $E\pi_t$ is people's expectations of inflation based on recently observed inflation, whereby $E\pi_t = \pi_{t-1}$, u_t is the unemployment rate in period t, u_n is the natural unemployment rate (equal to sample mean), and v_t is the stochastic disturbance.

On the basis of the methodology described in Section 2.4, Formula 2 was applied to research the Phillips curve, i.e., on the basis of the concept of rational expectation. The relevance of the application of the methodology was then assessed to see if it was suitable for the economy of the Czech Republic. The least squares method was subsequently used to conduct a regression analysis in order to resolve suitable values for the corresponding parameters. SPSS (version 19)[1] statistical software was used to make the calculations.

3. RESULTS

The results of the conducted regression analyses are presented in Table 3 (Anova) and Table 4. The analysis of the calculations illustrates the validity of the final result.

Table 3. Anova

	Model	Quadratic Sum	df	Mean Square	F	Sig.
1	Regression	61.543	2	30.772	27.103	.000
	Residual	24.977	22	1.135		
	Total	86.521	24			

1 https://www.ibm.com/analytics/spss-statistics-software
https://en.wikipedia.org/wiki/SPSS

Analysis for every dataset is presented in Table 4.

Table 4. Case diagnosis

No.	Standard Residual	π	Prediction Value	Residual
1	–.295	4.3000000	4.613994060	–.3139940599
2	–.530	4.0000000	4.565079887	–.5650798866
3	–.337	3.9000000	4.259158322	–.3591583225
4	.613	4.8000000	4.146314651	.6536853485
5	1.281	6.5000000	5.134733150	1.3652668503
6	2.244	8.7000000	6.308493141	2.3915068589
7	.219	8.7640085	8.530178312	.2338301877
8	–.476	8.1280430	8.635450709	–.5074077090
9	–.548	7.2804990	7.863883979	–.5833849786
10	.773	7.7771150	6.953280491	.8238345091
11	.674	8.2976530	7.579450866	.7182021344
12	–.100	7.9269510	8.033058594	–.1061075940
13	–.532	7.1411395	7.707796237	–.5666567372
14	–1.548	5.3158180	6.965486817	–1.6496688175
15	–.939	4.3925400	5.393562455	–1.0010224549
16	2.297	6.6621113	4.214189468	2.4479218318
17	.797	7.2814245	6.432384234	.8490402664
18	–.307	6.7253976	7.052002305	–.3266047054
19	.364	6.9792275	6.591308507	.3879189925
20	.207	6.9532056	6.733089964	.2201156357
21	–.512	6.1079150	6.653619615	–.5457046148
22	–.736	5.0480204	5.832150066	–.7841296659
23	–.823	3.9533188	4.830678617	–.8773598169
24	–.919	2.8925278	3.871693571	–.9791657707
25	–.869	1.9000000	2.825877481	–.9258774815

The final formula for the Phillips curve for the Czech Republic can therefore be expressed as:

$$\pi_t = 0.965 \cdot E\pi_t - 0.054 \cdot \left(u_t - u_n\right) + 0.153. \qquad (3)$$

The shape of the corresponding curve is presented in Figure 4.

In Figure 4, the x axis represents $E\pi_t$ – people's expectations of inflation based on recently observed inflation, the y axis u_t – the corresponding unemployment rate, and the *z* axis π_t – the corresponding inflation rate.

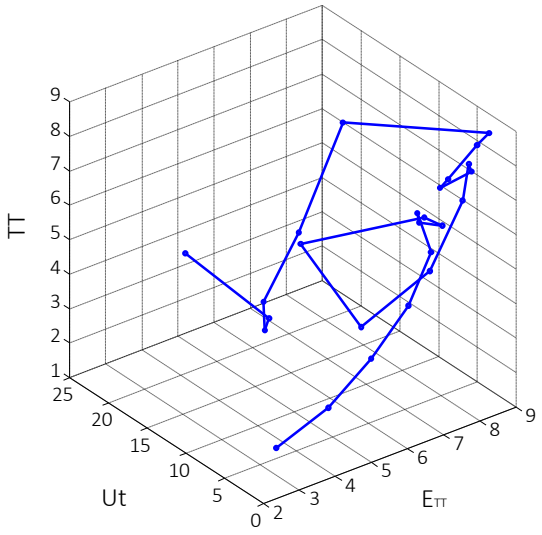

Figure 4. Shape of the Phillips curve for the Czech Republic

4. DISCUSSION

Short-term Phillips curve: The analyzed results of variance are presented in Table 3. The mean square of the regression is 30.772, and the mean square of the residual is 1.135. The significance level is 0.000 < 0.05, which indicates that the linear regression equation is significant. Table 4 displays the results of the regression analysis for the entire given period. It was possible to obtain original dependent variables, prediction values, standardized residuals, and residuals for each sample. The calculations using SPSS statistical software produced the following results: coefficient $\alpha = 0.965$; coefficient $\beta = 0.054$; constant = 0.153. On the basis of the final formula (3), it is truly clear that the prediction values tend to develop in line with the original dependent variables. It is therefore possible to conclude that the Phillips curve with rational expectation is suitable for application to the economy of the Czech Republic.

Long-term Phillips curve: When analyzing the trends in and the relationship between the value of unemployment rate and the value of inflation rate to obtain the long-term Phillips curve for the Czech Republic, it is clear from Figure 2 that the relationship differs at different times. For example, from 1993 to 1998, both the unemployment rate and inflation rate almost followed the exact trend, whereas both showed a downward trend in 2017 and 2018, and at all other times an almost reverse relationship. Generally speaking, the volatility of the inflation rate is greater than that of the unemployment rate. The development of the inflation rate is U-shaped and that of the unemployment rate the reverse.

In addition, when analyzing Figures 3 and 4, it is possible to state that the long-term Phillips curve is an irregular one that moves in a clockwise direction, and which both rises and falls. On this basis, it is possible to divide the long-term Phillips curve into four stages as presented in Figure 5.

Stage 1: the unemployment rate rises, and the inflation rate falls. Stage 2: both the variables fall. Stage 3: the unemployment rate falls, and the inflation rate rises. Stage 4: both the variables rates rise.

When comparing the relationship between the short-term and long-term Phillips curves, the following observations can be made. Firstly, under the short-term Phillips curve, and for the period 1993 to 2000, the unemployment rate rises as the inflation rate falls, which is indicative of the mutually substitutive relationship. This situation is reflected in the shape of the first stage of the long-term Phillips curve. Secondly, under the short-term Phillips curve, and for the period 2001 to 2012, although the inflation rate fell less than the unemployment rate, both the variables which are the unemployment rate and the inflation rate show a downward trend. This situation approximately reflects the shape of the second stage of the

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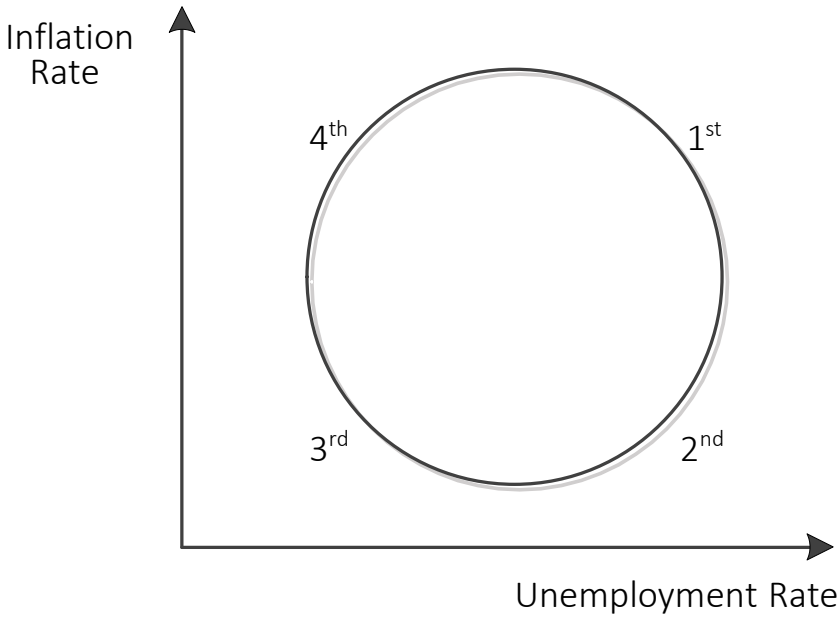

Figure 5. Long-term Phillips curve for the Czech Republic

long-term Phillips curve. Thirdly, under the short-term Phillips curve, and for the period 2013 to 2018, the inflation rate rises as the unemployment rate falls, which is also indicative of the mutually substitutive relationship, but this time in reverse to that in stage one. This situation approximately reflects the third stage of the long-term Phillips curve. On this basis it is therefore possible to predict that under the long-term Phillips curve, both of the variables will rise at the same time.

CONCLUSION

This paper focuses on the use of unemployment and inflation rate data for the period 1993 to 2018 to analyze the Phillips curve for the chosen country, which is the Czech Republic.

To construct the Phillips curve, including the concept of rational expectation, the formula put forward by Lucas was adopted. A regression analysis was conducted to calculate the parameters in the formula, which revealed that the obtained linear regression equation was significant. The relationship between the short-term Philips curve and long-term Phillips curve for the Czech Republic were subsequently analyzed.

According to the analysis, there is a mutually substitutive relationship between the two variables, which are the unemployment rate and the inflation rate. In this case, the substitutive relationship concerning policies, which is to reduce the unemployment rate or the inflation rate, remains valid. However, there are also other situations where both the unemployment rate and the inflation rate simultaneously rise or fall. It is therefore important to select appropriate economic policies according to the changes in the Phillips curve at that time. With regards to the long-term Phillips curve, it was shown that it is an irregular circular curve that runs in a clockwise direction. This indicates that it is not sensible to implement simple economic policies, but that the simultaneous implementation of a mixture of comprehensive, coordinated, flexible and forward-looking policies is the order of the day for reducing both variables the unemployment rate and the inflation rate and for promoting stable economic growth.

Future research should focus on validating the Phillips curve in this paper and obtaining more accurate form.

AUTHOR CONTRIBUTIONS

Conceptualization: Lu Wang, Pavel Rousek.
Data curation: Lu Wang.
Formal analysis: Pavel Rousek.
Investigation: Lu Wang.
Methodology: Lu Wang, Marek Vochozka.
Project administration: Pavel Rousek.
Resources: Pavel Rousek.
Software: Lu Wang, Marek Vochozka.
Supervision: Marek Vochozka.
Validation: Lu Wang, Marek Vochozka.
Visualization: Lu Wang, Marek Vochozka.
Writing – original draft: Lu Wang, Pavel Rousek.
Writing – review & editing: Marek Vochozka.

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