

The forecasts for inflation rate and unemployment rate using the Phillips curve

Ondřej Šimpach¹

¹ University of Economics Prague, W. Churchill sq. 4, 130 67 Prague, Czech Republic
ondrej.simpach@vse.cz

Abstract. The aim of this study is to use the classical approach of Phillips curve to find the potential relationship between inflation rate and unemployment rate in the Czech Republic. There are countries in which the assumptions of use of Phillips curve perform very well, but there are also other countries, where the assumptions of Phillips curve do not work. There were found the years in the Czech Republic, when the Phillips curve was possible to use for forecasting the future inflation and future unemployment rate, because there existed a causal relationship. But there were other years, when the causal relationship did not work. So therefore we can say that the assumptions for this curve for the Czech Republic work as far as possible. Using the latest available data it will be analysed this relationship and it will be calculated the forecasts of inflation rate and unemployment rate using the Phillips curve. These forecasts will be subsequently compared with the predictions that result from the ARIMA model approach for stochastic modelling of time series. It will be seen that the forecasts of both models are different.

Keywords: inflation rate, unemployment rate, Phillips curve, ARIMA, forecast.

1 Introduction

From the approach, published by Phillips [7] is clear, that under certain conditions it is possible to find a potential relationship between inflation and unemployment rate and this inflation or unemployment rate is possible to expect and anticipate. The analysis has been used in the past for the United States, United Kingdom, Japan and other major world economies. This has been made because the bigger world economies have existing for a long time and that there is a sufficient amount of data (see e.g. Dittmar and Gavin in [3]). Czech Republic is a young country. There is not enough data, but in the case of using quarterly data published by the Czech Statistical Office (CZSO), it is possible at certain time periods to capture these short or medium-long terms at the moments.

Expecting future inflation or unemployment rate can be either intuitively from the graph, or using linear or polynomial regression. Because of short cycles in the Czech Republic, which took place during its short development, there is unfortunately not enough data for polynomial regression and can be used linear approach only. For the purpose of this study there will be used data with quarterly frequencies published by

CZSO. To express the inflation rate there will be used consumer price indices (CPI), related to the average of basic year 2005. To express the unemployment rate there will be used the common unemployment rate in %. Particular observations start on 1st quarter 2000 and end on 2nd quarter 2012. The 1st and 2nd quarter 2012 are only preliminary estimates, but the analysis will use them.

The work is divided into two parts. Chapter named Development of inflation and unemployment rate aims to present the situation in the Czech Republic from 2000 to present. In this chapter there will be a division of economic development of the Czech Republic into several cycles, in which will be evident the potential relationship between inflation and unemployment rate. The first cycle will be apparent for the situation from 1st quarter 2000 to 4th quarter 2003. The second cycle took place from 1st quarter 2004 to 4th quarter 2008. It was a period of acceleration of the economy until the outbreak of the economic crisis. Period of 2009 is left separately as the year of economic recovery and return to potential rate of unemployment (see e.g. Kiley [5] or Kydland and Prescott [6]). From 1st quarter 2010 to the present, comes the latest separate cycle, which could be called a period of accelerating inflation. For these three mentioned cycles there will be constructed the regression models and will be expressed the relationship between inflation and unemployment rate.

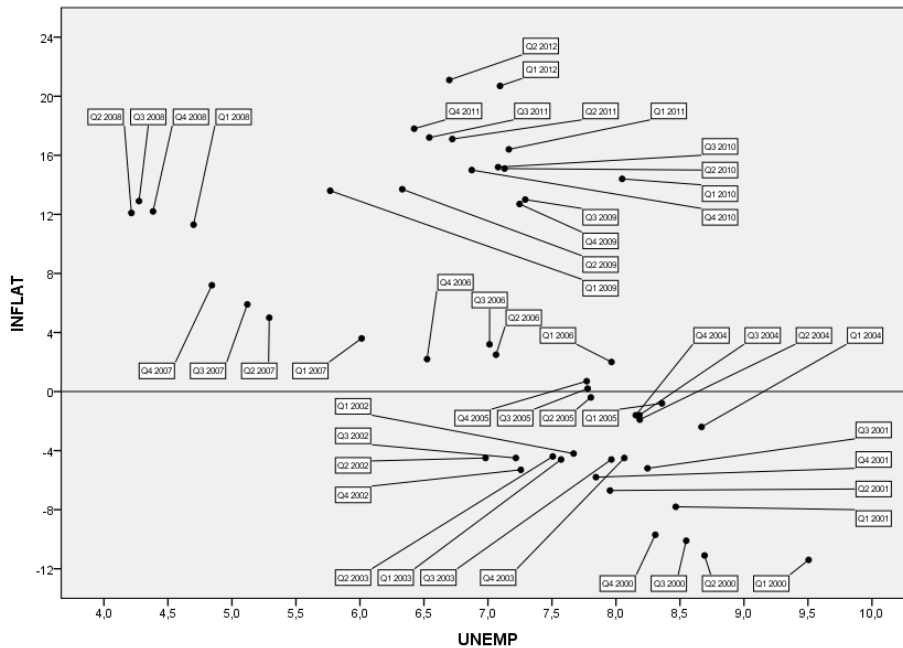


Fig. 1. The development of Phillips curve for the Czech Republic from 1st quarter 2000 to 2nd quarter 2012, where INFLAT is Consumer Price Index (+100 %, the average of 2005 is 100 %) and UNEMP is unemployment rate in %. Source: CZSO, own construction.

In the second part of the analysis called Stochastic modelling of inflation and unemployment rate there will be identified suitable ARIMA model for time series of

inflation and unemployment rate using by methodological approach of Box and Jenkins [2]. Using the estimated models there will be constructed projections for inflation and unemployment rate up to 4th quarter of 2015. These estimates will be published in tables and their values will be recorded in the chart of Phillips curve. It will be clear that the assumptions of future accelerating inflation are strong. The Czech Republic should stay in the long-range potential rate of unemployment, but there is a dangerous of continual and uncontrolled accretion of the price level over time.

2 Development of inflation and unemployment rate

The development of Phillips curve in the Czech Republic from 1st quarter 2000 to 2nd quarter 2012 is shown in Figure 1. The rate of inflation, expressed by the CPI was in confrontation with an average of 2005 at 88,6 % level. The unemployment rate was 9,5 % at that time. As time went on, the unemployment declined with slight fluctuations, the price level gradually grew over time until the end of 2003.

This partial development of the Phillips curve is shown in Figure 2. We can see that at the end of 2003 the inflation rate was approximately at the 95,5 % of level of

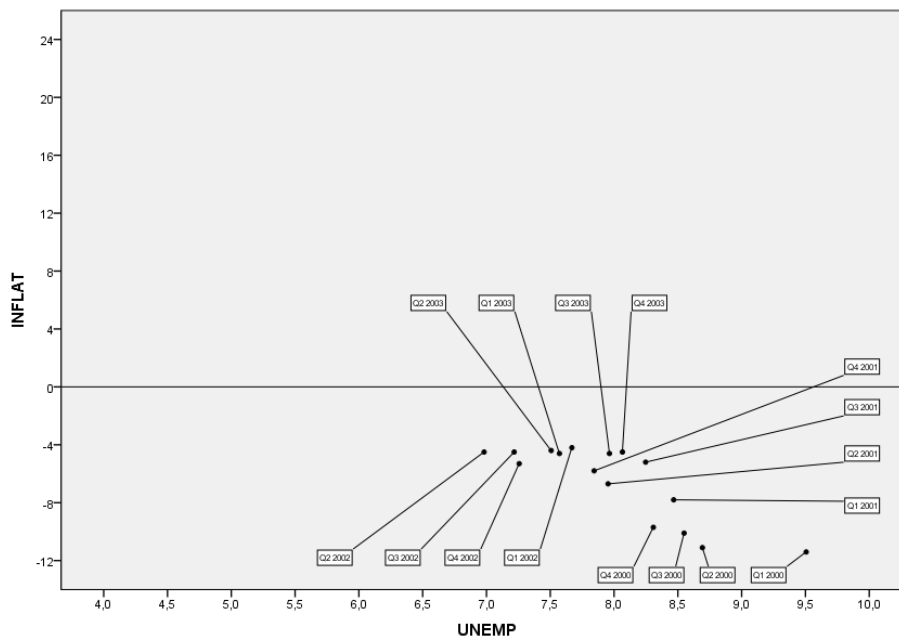


Fig. 2. The partial development of Phillips curve for the Czech Republic from 1st quarter 2000 to 4th quarter 2003, where INFLAT is Consumer Price Index (+100 %, the average of 2005 is 100 %) and UNEMP is unemployment rate in %. Source: CZSO, own construction.

Table 1. Linear regression model, situation from 1st quarter 2000 to 4th quarter 2003

Parameter	Estimate	St. Error	T Statistic	P-Value
Intercept	20,6995	4,96376	4,17013	0,0009
Slope	-3,40572	0,619126	-5,50086	0,0001

the average of 2005 and the unemployment rate was approximately 8,1 %. This is the first continuous cycle of Phillips curve, and therefore there will be constructed linear regression model. Estimates of unknown parameters are shown in Table 1.

The diagnostic tests of the model (see e.g. Hušek in [4]) indicate absence of autocorrelation and heteroscedasticity at the 5% significance level. The correlation between inflation and unemployment rate is -0,83, i.e. a strong indirect dependency. Adjusted index of determination $adj.R^2$ is 66,1%, therefore this simple model explains almost two thirds of the variance. The final regression is shown in Figure 3.

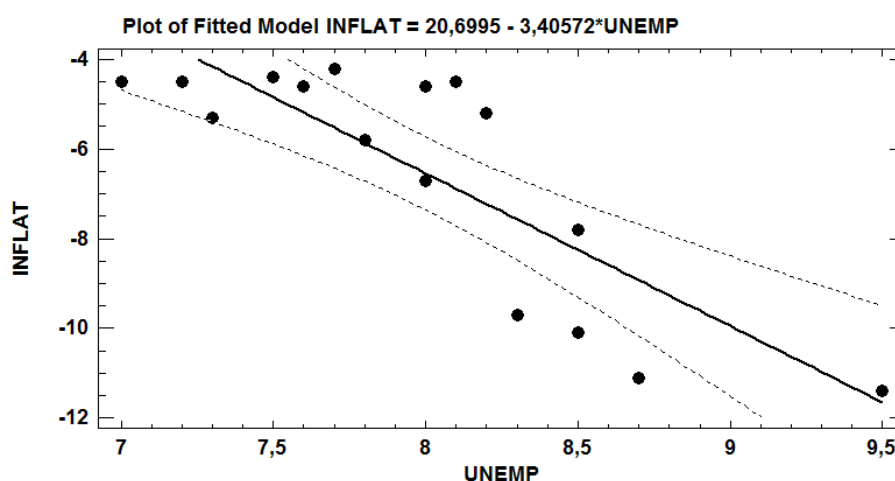


Fig. 3. Regression model for the situation in Czech Republic from 1st quarter 2000 to 4th quarter 2003, where INFLAT is Consumer Price Index (+100 %, the average of 2005 is 100 %) and UNEMP is unemployment rate in %. Source: own construction.

Since 2004, there was a process of acceleration of the Czech economy. The product has grown, the economy prospered and the unemployment rate gradually declined to a very favourable, but long-term unsustainable level. From 8,7 % in 2004 the unemployment rate declined to 4,4 % at the end of 2008. The inflation rate, expressed by the CPI grew slowly from 97,6 % to 112,2 % of level of the average in 2005. Development of this accelerating period is shown in Figure 4.

It is a period of considered second cycle, and therefore there will be estimated another linear regression model. Estimates of unknown parameters are shown in Table 2.

The diagnostic tests of the model indicate the absence of autocorrelation and heteroscedasticity at the 5% significance level. The correlation between inflation and

unemployment rate is -0,95, i.e. a very strong indirect dependency. Adjusted index of determination $adj.R^2$ is 90,2 %, therefore this simple model explains the most of the variance. The final regression is shown in Figure 5.

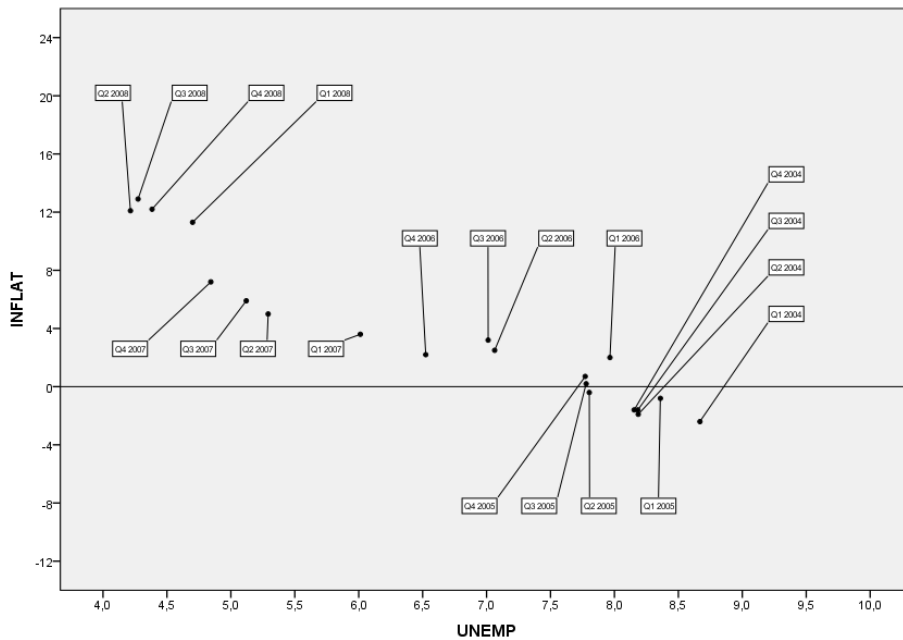


Fig. 4. The partial development of Phillips curve for the Czech Republic from 1st quarter 2004 to 4th quarter 2008, where INFLAT is Consumer Price Index (+100 %, the average of 2005 is 100 %) and UNEMP is unemployment rate in %. Source: CZSO, own construction.

Table 2. Linear regression model, situation from 1st quarter 2004 to 4th quarter 2008

Parameter	Estimate	St. Error	T Statistic	P-Value
Intercept	23,6325	1,55165	15,2305	0,0000
Slope	-3,02151	0,22793	-13,2563	0,0000

At the end of 2008 came the economic crisis. Overheated economy of the Czech Republic slowed and the domestic product began to decline. For this reason, the unemployment began to rise again from the initial low level to 5,8 % in 1st quarter, to 6,3 % in 2nd quarter, to 7,3 % in 3rd quarter and to 7,2 % in the 4th quarter of 2009. During this period slightly decreased the price level. From the 113,6 % in 1st quarter of 2009 successively to 112,7 % in 4th quarter of 2009 in confrontation with an average of 2005. This situation is shown separately in Figure 6.

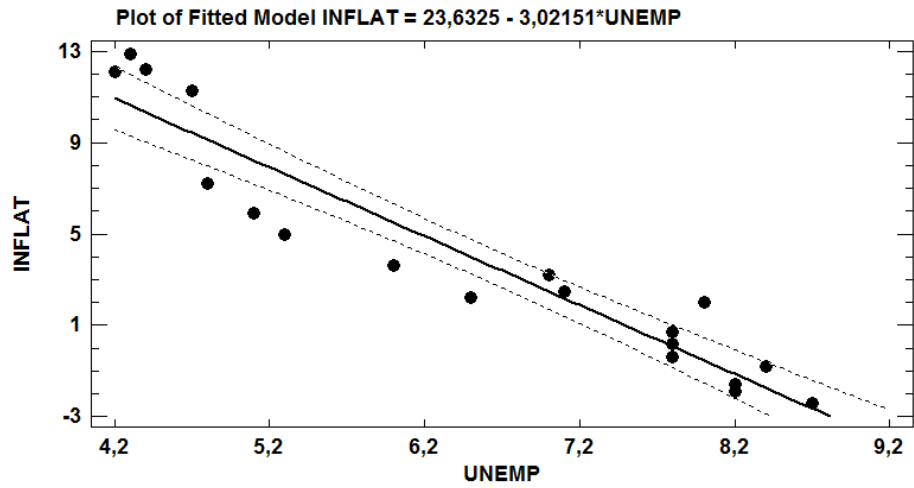


Fig. 5. Regression model for the situation in Czech Republic from 1st quarter 2004 to 4th quarter 2008, where INFLAT is Consumer Price Index (+100 %, the average of 2005 is 100 %) and UNEMP is unemployment rate in %. Source: own construction.

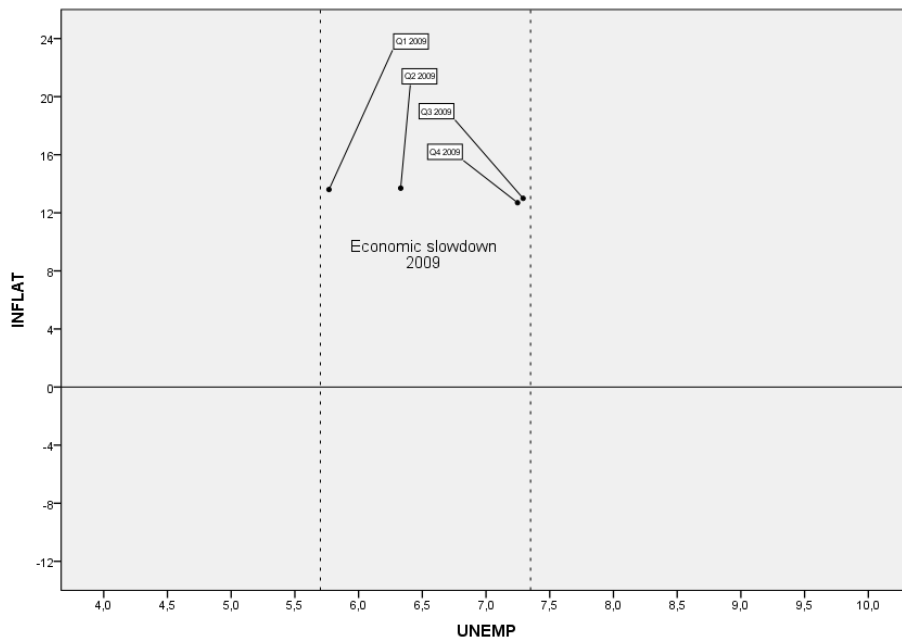


Fig. 6. The situation of the Czech Republic during economic slowdown from 1st quarter 2009 to 4th quarter 2009 (return to potential unemployment rate), where INFLAT is Consumer Price Index (+100 %, the average of 2005 is 100 %) and UNEMP is unemployment rate in %. Source: CZSO, own construction.

The last cycle, the recovery from the crisis is shown in Figure 7. It is a development from 1st quarter of 2010 to the present. Last published values from CZSO are 1st and 2nd quarter of 2012 and these are preliminary estimates. The situation, which is shown in the Figure 7, has the character of the accelerating inflation (see Dittmar and Gavin [3]). Given that the observations are currently not enough (only 10) and they have a great variance, the slope in the final regression in Table 3 is statistically insignificant. There is shown a square in Figure 7, in which would be intuitively find the estimates of inflation and unemployment rate for 3rd and 4th quarter of the 2012.

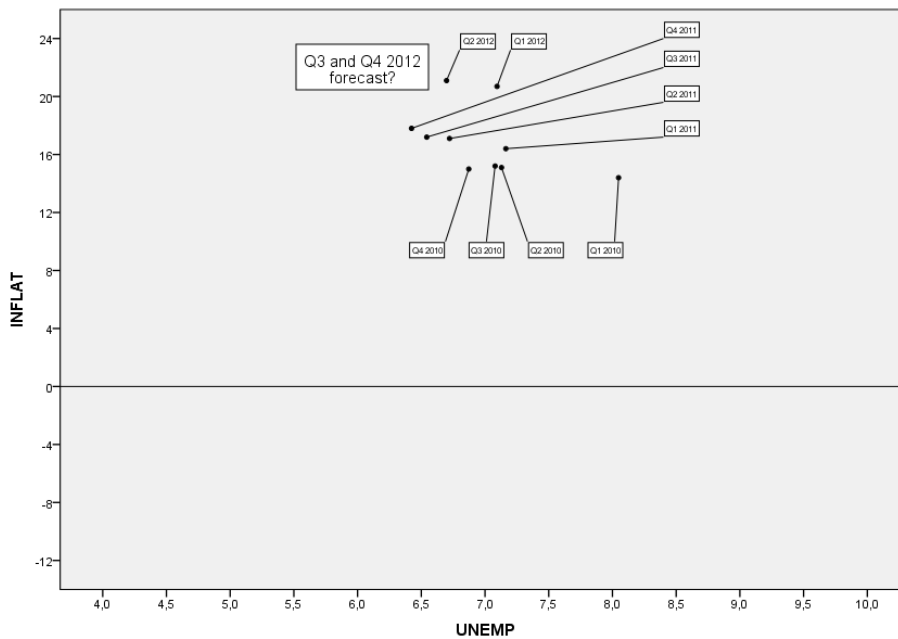


Fig. 7. The situation of the Czech Republic from 1st quarter 2010 to 2nd quarter 2012 and the potential coordinates of forecast for 3rd and 4th quarter 2012, where INFLAT is Consumer Price Index (+100 %, the average of 2005 is 100 %) and UNEMP is unemployment rate in %. Source: CZSO, own construction.

Table 3. Linear regression model, situation from 1st quarter 2010 to 2nd quarter 2012 and the statistical insignificance of slope.

Parameter	Estimate	St. Error	T Statistic	P-Value
Intercept	33,3295	11,2946	2,95091	0,0184
Slope	-2,34283	1,61737	-1,44854	0,1855

In the case that the estimates of the 3rd and 4th quarter of 2012 were actually marked in the square, and in the case, that the model would be recalculated, the slope probably would become statistically significant. Meanwhile is a correlation between inflation

and unemployment rate only -0,46, i.e. a quite poor indirect dependency. Regression is shown in Figure 8.

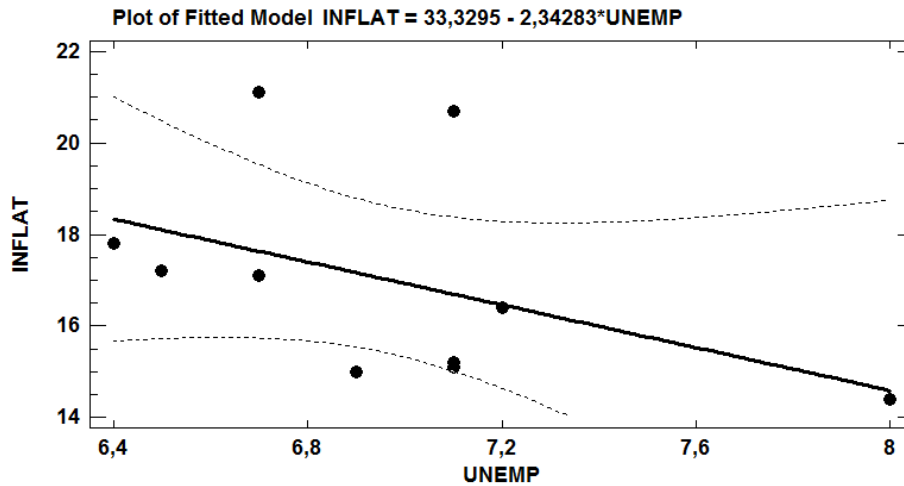


Fig. 8. Regression model for the situation in Czech Republic from 1st quarter 2010 to 2nd quarter 2012, where INFLAT is Consumer Price Index (+100 %, the average of 2005 is 100 %) and UNEMP is unemployment rate in %. Source: own construction.

3 Stochastic modelling of inflation and unemployment rate

For the purpose of estimate of the future development of inflation and unemployment rate by sophisticated method, there was used Box and Jenkins approach for stochastic modelling of time series. For a time series consumer price indices there was identified ARIMA model (1, 0, 0) and final estimate is shown in Table 4.

Table 4. ARIMA (1, 0, 0) model for Consumer Price Index (inflation rate).

Parameter	Estimate	St. Error	T Statistic	P-Value
AR(1)	1,00566	0,0012469	806,501	0,0000

The diagnostic tests (see e.g. Arlt, Arltová in [1]) indicate absence of autocorrelation and heteroscedasticity at the 5% significance level. From the model showed above there were constructed the predictions of indices of consumer prices up to 4th quarter of 2015. This development with 95 % confidence intervals is shown in Figure 9 and in Table 5 is shown the numerical output.

Subsequently, there was identified ARIMA model (2, 1, 1) for the time series of unemployment rate and final estimate is shown in Table 6. The diagnostic tests again indicate the absence of autocorrelation and heteroscedasticity at the 5% significance level, and therefore could be constructed the forecast of unemployment rate up to 4th

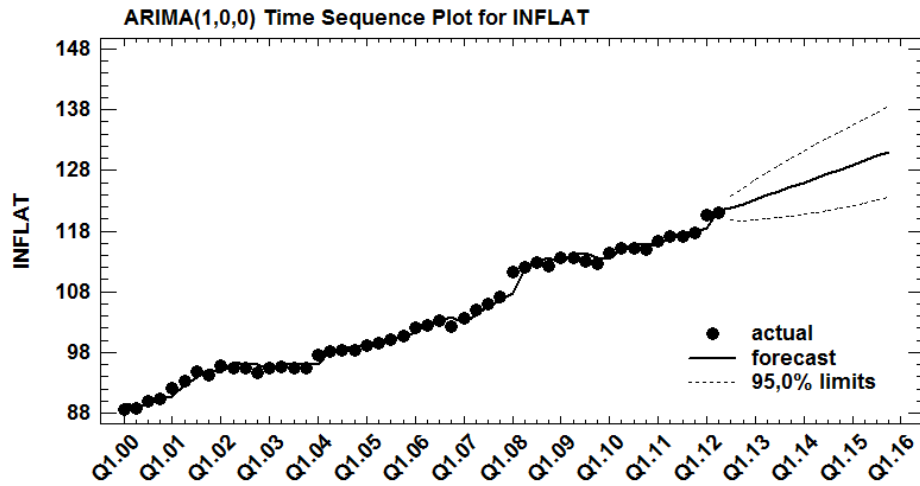


Fig. 9. The forecast of the development of Consumer Price Index (inflation rate) in the Czech Republic from 3rd quarter 2012 to 4th quarter 2015 (+100 %, the average of 2005 is 100 %). Source: own construction.

Table 5. The forecast of the development of Consumer Price Index (inflation rate) in the Czech Republic. Source: own construction.

Period	Forecast	Lower 95,0% limit	Upper 95,0% limit
Q3 2012	121,785	119,854	123,717
Q4 2012	122,475	119,735	125,214
Q1 2013	123,168	119,803	126,532
Q2 2013	123,865	119,969	127,761
Q3 2013	124,566	120,197	128,934
Q4 2013	125,271	120,472	130,07
Q1 2014	125,98	120,781	131,178
Q2 2014	126,693	121,119	132,266
Q3 2014	127,41	121,481	133,338
Q4 2014	128,131	121,864	134,398
Q1 2015	128,856	122,264	135,448
Q2 2015	129,585	122,68	136,49
Q3 2015	130,319	123,111	137,526
Q4 2015	131,056	123,555	138,558

quarter of 2015. This forecast is shown in figure 10 with calculated confidence intervals. For the purposes of possible further analyses there is the prediction of unemployment rate listed in Table 7. It is important to note that both forecast of the consumer price indices and forecast of the unemployment rates is based on the assumption of *ceteris paribus*.

Table 6. ARIMA (2, 1, 1) model for unemployment rate.

Parameter	Estimate	St. Error	T Statistic	P-Value
AR(1)	-0,466502	0,131251	-3,55426	0,00089
AR(2)	0,548865	0,127731	4,29705	0,000089
MA(1)	-0,882458	0,092296	-9,56117	0,00000

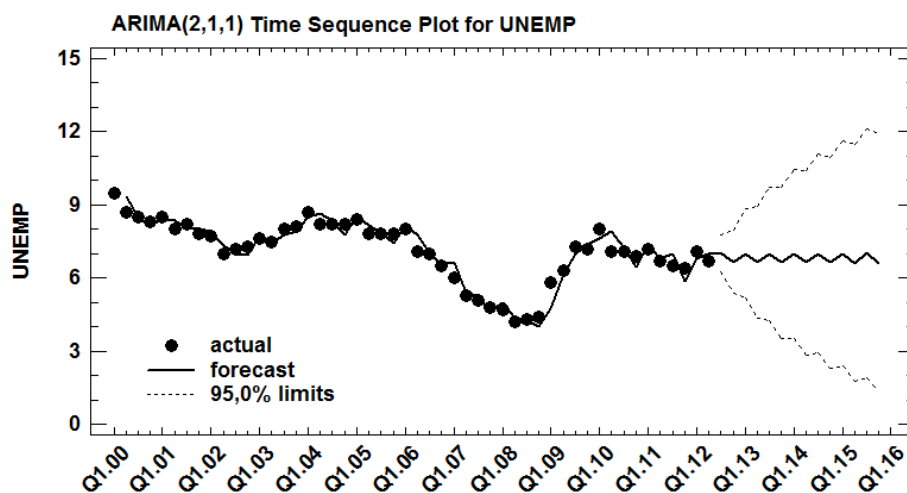


Fig. 10. The forecast of the development of unemployment rate in the Czech Republic from 3rd quarter 2012 to 4th quarter 2015. Source: own construction.

Table 7. The forecast of the development of unemployment rate in the Czech Republic. Source: own construction.

Period	Forecast	Lower 95,0% limit	Upper 95,0% limit
Q3 2012	7,02504	6,27926	7,77082
Q4 2012	6,65386	5,36107	7,94665
Q1 2013	7,00542	5,15737	8,85348
Q2 2013	6,63769	4,33874	8,93664
Q3 2013	7,0022	4,26217	9,74222
Q4 2013	6,63032	3,52608	9,73456
Q1 2014	7,00387	3,53794	10,4698
Q2 2014	6,6255	2,85462	10,3964
Q3 2014	7,00703	2,92736	11,0867
Q4 2014	6,62137	2,27712	10,9656
Q1 2015	7,0107	2,39415	11,6272
Q2 2015	6,6174	1,76494	11,4699
Q3 2015	7,01456	1,91628	12,1128
Q4 2015	6,61342	1,30057	11,9263

5 Conclusion

Estimates of the consumer price indices and unemployment rate from the previous chapter were recorded in the chart of Phillips curve, which is shown in Figure 11. It is clear that the estimates reflect the zone of potential unemployment rate and rather prefer an acceleration of inflation over time. Partly, this is also confirmed by assumption of long-term Phillips curve, which takes the form of vertical.

The forecasts in this study are based on the assumption of *ceteris paribus*. Unexpected interference in the economy may threaten their stability. It is important to note that the study showed that the Phillips curve for the Czech Republic can be used as a tool to show the relationship between inflation and unemployment rate at least for a period of several economic cycles. There are countries where assumptions of Phillips curve has never worked or worked poorly.

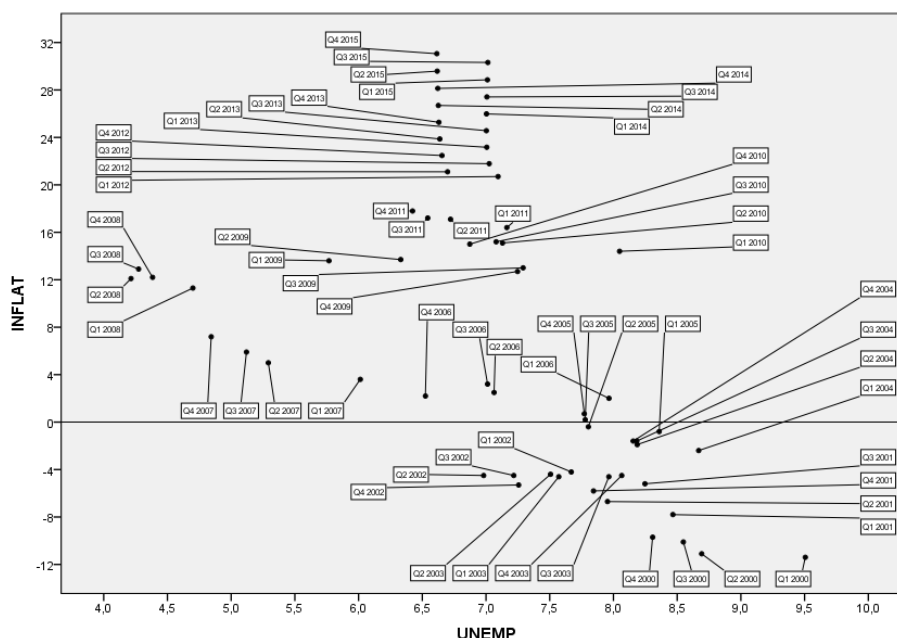


Fig. 11. The development of Phillips curve for the Czech Republic from 1st quarter 2000 to 4th quarter 2015, (3rd quarter 2012 – 4th quarter 2015 is forecast – future long term equilibrium), where INFLAT is Consumer Price Index (+100 %, the average of 2005 is 100 %) and UNEMP is unemployment rate in %. Source: CZSO, own construction.

References

1. Arlt, J., Arltová, M.: „*Ekonomické časové řady*“, Grada Publishing, 2007.
2. Box, G.E.P., Jenkins, G.: „*Time series analysis: Forecasting and control*“, San Francisco, Holden-Day, 1970.

3. Dittmar, R., Gavin, W.T.: What Do New-Keynesian Phillips Curves Imply for Price-Level Targeting? *Federal Reserve Bank of St. Louis Review*, March/April 2000, p. 21-30.
4. Hušek, R.: „*Ekonomická analýza*“, Oeconomica VŠE, Praha, 2007.
5. Kiley, M.T.: Monetary Policy under Neoclassical and New-Keynesian Phillips Curves, with an Application to Price Level and Inflation Targeting. *Board of Governors of the Federal Reserve System, Working Paper*, 1998, p. 1-20.
6. Kydland, F.E., Prescott, E.C.: Rules Rather than Discretion: The Inconsistency of Optimal Plans. *Journal of Political Economy*, 1977, no. 3, p. 473-491.
7. Phillips, A.W.: The Relation Between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861-1957. *Economica*, 1958, no. 5, p. 283-293.