ESTIMATION OF THE PHILLIPS CURVE, THE CASE OF THE CZECH REPUBLIC

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ABSTRACT

The aim of this study is to assess the potential relationship between inflation and unemployment rate in the Czech Republic in light of Phillips curve approach. In some countries the assumptions of use of Phillips curve proved to perform very well, however this is not always the case. Since the Czech Republic is a young economy with lack of data available, causal relationship might not be necessarily valid for all years. This paper aims to analyze whether the assumptions of Phillips curve are limited in their effect or not with latest data set. In addition, forecasts of inflation and unemployment rate will be calculated using the Phillips curve and subsequently compared with the predictions resulting from the ARIMA model approach.

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INTRODUCTION

Followed by Phelps (1967) and Friedman (1968) interpretation of the Phillips curve, which introduced the concept of the natural rate of unemployment, the simple relationship between inflation and unemployment rate introduced originally by Phillips (1958), apparently weakened. In light of this development, the empirical Phillips curve is widely discussed phenomenon, where under certain conditions it is possible to find a potential relationship between inflation and unemployment rate. This inflation or unemployment rate might be expected and anticipated. Recent studies have proved an observable short-term Phillips curve by estimating a time- varying natural rate of unemployment, followed by the examination of deviations of unemployment from its natural rate with regards to inflation. See for instance, King and Watson (1994), in King and Morley (2007), and in Lee and Nelson (2007), where evidence of measurable Phillips curve is provided. In many studies the analysis has been conducted primarily for the United States, United Kingdom, Japan and other major world economies. The reason behind it is that bigger world economies have been existing for a long time and that there is a sufficient amount of data (see e.g. Dittmar and Gavin, (2000). Since the Czech Republic is a young country, there is not enough data, but by using quarterly data published by the Czech Statistical Office (CZSO), it is possible to capture at certain time periods these short or medium-long terms at the moments.

Future inflation and unemployment rate expectations might be formed 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 only linear approach can be applied. For the purpose of this study, data with quarterly frequencies will be used, published by CZSO. To express the inflation rate, consumer price indices (CPI) will be used, 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 quarters of 2012 are only preliminary estimates, but will be also included in the analysis.

The paper is divided into two parts. The first part of study aims to present the situation in the Czech Republic from 2000 to present. In this section, economic development of the

Czech Republic will be divided into several cycles, in which apparent potential relationship between inflation and unemployment rate might be seen. The first cycle will be apparent for the situation from the first quarter 2000 to the fourth quarter 2003. The second cycle took place from the first quarter 2004 to the fourth 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, (1998) or Kydland and Prescott (1977). From the first 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.

In the second part of the analysis suitable ARIMA model for time series of inflation and unemployment rate will be identified, using methodological approach of Box and Jenkins, (1970). Using the estimated models, projections will be constructed for inflation and unemployment rate up to the fourth quarter of 2015. Trough evaluation of results illustrated also in the chart of Phillips curve, we may presume that the assumptions of future accelerating inflation are strong. Based on results obtained, the Czech Republic is expected to maintain a long-range potential rate of unemployment, but there is a danger of continual and uncontrolled accretion of the price level over time.

1 DEVELOPMENT OF INFLATION AND UNEMPLOYMENT RATE AND FUTURE VISION ARISING FROM THE PHILLIPS CURVE

The development of Phillips curve in the Czech Republic from the first quarter 2000 to the second quarter 2012 is shown in Fig. 1. The rate of inflation, expressed by the CPI was in contradiction 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. We can see that at the end of 2003 the inflation rate was approximately at the 95.5 % of level of the average of 2005 and the unemployment rate was approximately 8.1 %. This is the first continuous cycle of the Phillips curve, and as a result linear regression model will be applied. Estimates of unknown parameters are shown in Table 1. The diagnostic tests of the model 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.R²* is 66.1 %, therefore this simple model explains almost two thirds of the variance. The final regression is shown in Fig. 3 (at the top, left).

Fig. 1: The development of the Phillips curve for the Czech Republic (CR) from the first q. 2000 to the second q. 2012, where INFLAT is CPI (+100 %, the average of 2005 is 100 %) and UNEMP is unemployment rate in %.
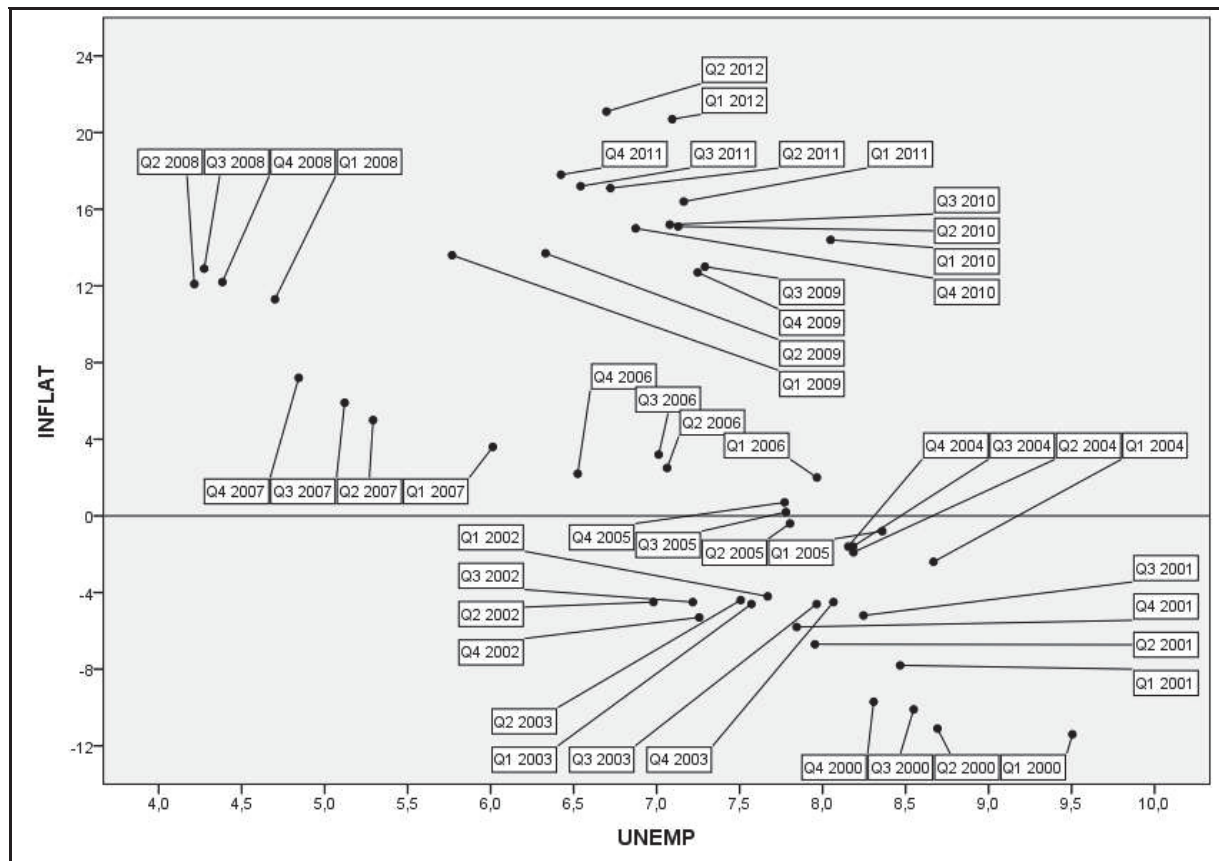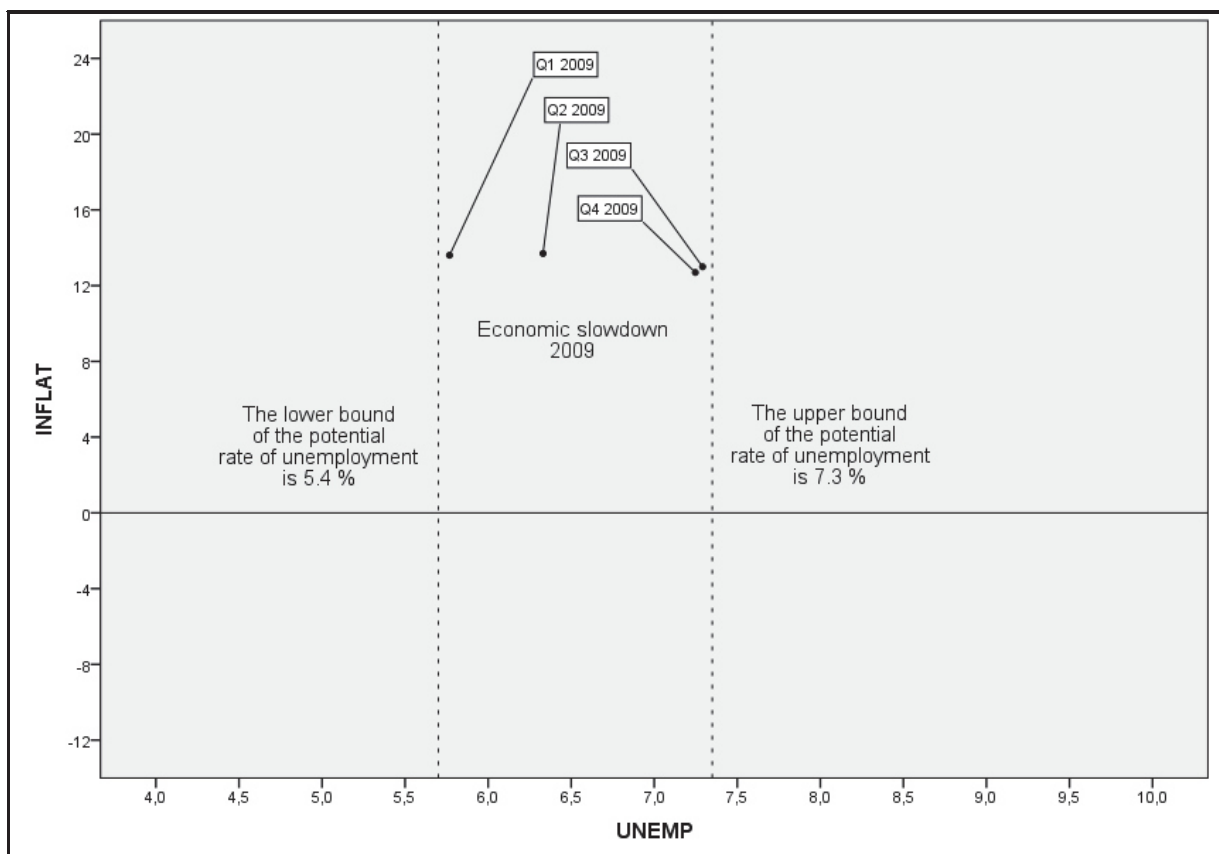

Source: CZSO, own construction

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. It is a period of considered second cycle, and therefore another linear regression model will be estimated. Estimates of unknown parameters are shown as well in Table 1. 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.R²* is 90.2 %, therefore this simple model explains the most of the variance. The final regression is shown in Fig. 3 (on the bottom, left).

At the end of 2008 came the economic crisis. Overheated economy of the Czech Republic slowed down 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 the first quarter, to 6.3 % in the second quarter, to 7.3 % in the third quarter and to 7.2 % in the fourth quarter of 2009. During this period the price level slightly decreased. It decreased from 113.6 % in the first quarter of 2009 successively to 112.7 % in the fourth quarter of 2009 in confrontation with an average of 2005. This situation is shown separately in Fig. 2.

Fig. 2: The situation of the Czech Rep. during economic slowdown from the first q. 2009 to the fourth q. 2009 (return to potential unemployment rate), where INFLAT is CPI (+100 %, the average of 2005 is 100 %) and UNEMP is unemployment rate in %
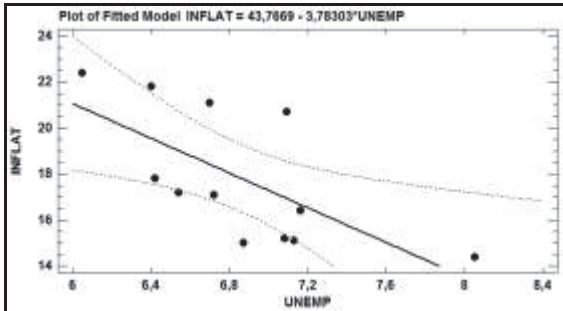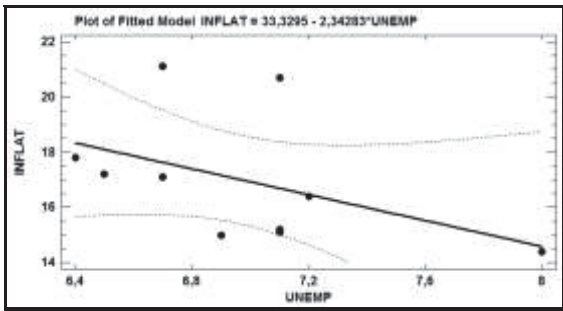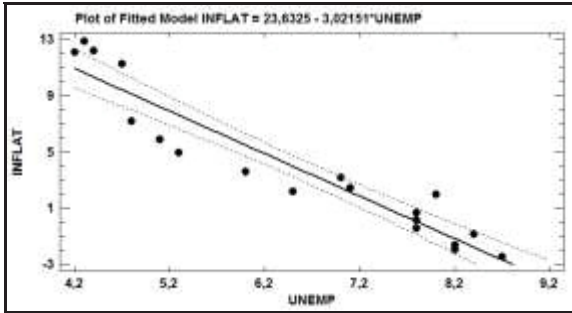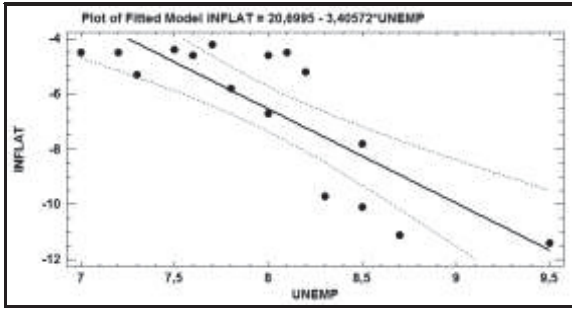

Source: CZSO, own construction

The last cycle, the recovery from the crisis is a period from the first quarter of 2010 to the present. Last published values from CZSO are the first and the second quarters of 2012 and these are preliminary estimates. This development has the character of the accelerating inflation (see Dittmar and Gavin, 2000). Given not enough observations (only 10) and with great variance, the slope in the final regression in Table 1 is statistically insignificant. If we knew more values (the third and the fourth quarters of 2012 would be sufficient), and in the case, that the model would be recalculated, the slope probably would become statistically significant. Meanwhile a correlation between inflation and unemployment rate is only -0.46, i.e. a quite poor indirect dependency. Regression is shown in Fig. 3.

Table 1: Linear regression models for the partial cycles

Linear regression model, situation from the first quarter 2000 to the fourth quarter 2003					Linear regression model, situation from the first quarter 2004 to the fourth quarter 2008				
Par.	**Est.**	**St. Err.**	**T-Stat.**	**Prob.**	**Par.**	**Est.**	**St. Err.**	**T-Stat.**	**Prob.**
c	20.6995	4.96376	4.17013	0.0009	C	23.6325	1.55165	15.2305	0.0000
b1	-3.4057	0.61913	-5.5009	0.0001	b1	-3.0215	0.22793	-13.256	0.0000
Linear regression model, situation from the first quarter 2010 to the second quarter 2012 and the statistical insignificance of slope					Linear regression model, situation from the first quarter 2010 to the fourth quarter 2012 (the third and the fourth quarter 2012 is expectation) and change to statistical significance of slope				
Par.	**Est.**	**St. Err.**	**T-Stat.**	**Prob.**	**Par.**	**Est.**	**St. Err.**	**T-Stat.**	**Prob.**
c	33.3295	11.2946	2.95091	0.0184	C	43.7669	9.15849	4.77884	0.0007
b1	-2.3428	1.61737	-1.4485	0.1855	b1	-3.7830	1.33343	-2.8371	0.0176

Source: author's calculations

Fig. 3: Regression model (RM) for the situation in the Czech Rep. From the first q. 2000 to the fourth q. 2003 (on the top, left), RM for the situation from the first q. 2004 to the fourth q. 2008 (on the bottom, left), RM for the situation from the first q. 2010 to the fourth q. 2012 (on the top, right) and RM for the situation from the first q. 2010 to the fourth q. 2012 (on the bottom, right), where INFLAT is CPI (+ 100 %, the average of 2005 is 100 %) and UNEMP is unemployment rate in %.

Plot of Fitted Model INFLAT = 20,8995 - 3,40572*UNEMP

Plot of Fitted Model INFLAT = 23,6325 - 3,02151*UNEMP

Plot of Fitted Model INFLAT = 33,3295 - 2,34283*UNEMP

Plot of Fitted Model INFLAT = 43,7669 - 3,78303*UNEMP

1252

Source: own construction

At the time of writing this study there have not been published yet any preliminary estimates of the inflation rate and the unemployment rate for the third and the fourth quarters of 2012. Looking at the recorded values in Fig. 1, let us imagine that CPI for the third quarter could be 121.8 % and for the fourth quarter could be 122.4 %. Then the unemployment rate could be for example, 6.4 % in the third or 6.05 % in the fourth quarter of 2012. If we use these additional estimated values in linear regression model, we obtain estimates of the regression line, which will be already statistically significant. There is neither autocorrelation, nor heteroscedasticity at the 5% significance level in the model. The correlation between inflation and unemployment rate is -0.67, i.e. a medium strong indirect dependency. Adjusted index of determination *adj.R^2* is 40 %. The final regression is shown in Fig. 3.

2   STOCHASTIC MODELLING OF ANALYZED TIME SERIES

In order to estimate future development of inflation and unemployment rate by sophisticated method, Box and Jenkins approach for stochastic modelling of time series was used. For a time series consumer price indices there was identified ARIMA model (1, 0, 0) and final estimate is shown in Table 2.

Table 2: Estimated parameters of ARIMA models

ARIMA (1, 0, 0) model for Consumer Price Index (inflation rate)					ARIMA (2, 1, 1) model for unemployment rate				
Par.	**Est.**	**St. Err.**	**T-Stat.**	**Prob.**	**Par.**	**Est.**	**St. Err.**	**T-Stat.**	**Prob.**
ar(1)	1.00566	0.00125	806.501	0.0000	ar(1)	-0.4665	0.13125	-3.5543	0.0009
					ar(2)	0.54887	0.12773	4.29705	0.0001
					ma(1)	-0.8825	0.09230	-9.5612	0.0000

Source: author's calculations

The diagnostic tests indicate the absence of autocorrelation and heteroscedasticity at the 5% significance level. From the model above there were constructed the predictions of indices of consumer prices up to the fourth quarter of 2015. This development with 95 % confidence intervals is shown in Table 3 and Figure 4.

Subsequently, there was identified ARIMA model (2, 1, 1) for the time series of unemployment rate and final estimate is shown again in Table 2 above. The diagnostic tests again indicate the absence of autocorrelation and heteroscedasticity at the 5% significance level, and the forecast of unemployment rate up to the fourth quarter of 2015 could be constructed. This forecast is shown in Fig. 4 with calculated confidence intervals. For the purposes of possible further analyses there is the prediction of unemployment rate listed in Table 3. It is important to note that both forecast of the consumer price indices and forecast of the unemployment rates are based on the assumption of ceteris paribus.

Table 3: Estimated values of CPI and unemployment rate

The forecast of the development of Consumer Price Index (inflation rate) in the Czech Republic				The forecast of the development of unemployment rate (in %) in the Czech Republic			
Period	Forecast	Lower 95.0% limit	Upper 95.0% limit	Period	Forecast	Lower 95.0% limit	Upper 95.0% limit
Q3 2012	121.785	119.854	123.717	Q3 2012	7.02504	6.27926	7.77082
Q4 2012	122.475	119.735	125.214	Q4 2012	6.65386	5.36107	7.94665
Q1 2013	123.168	119.803	126.532	Q1 2013	7.00542	5.15737	8.85348
Q2 2013	123.865	119.969	127.761	Q2 2013	6.63769	4.33874	8.93664
Q3 2013	124.566	120.197	128.934	Q3 2013	7.00220	4.26217	9.74222
Q4 2013	125.271	120.472	130.070	Q4 2013	6.63032	3.52608	9.73456
Q1 2014	125.980	120.781	131.178	Q1 2014	7.00387	3.53794	10.4698
Q2 2014	126.693	121.119	132.266	Q2 2014	6.62550	2.85462	10.3964
Q3 2014	127.410	121.481	133.338	Q3 2014	7.00703	2.92736	11.0867
Q4 2014	128.131	121.864	134.398	Q4 2014	6.62137	2.27712	10.9656
Q1 2015	128.856	122.264	135.448	Q1 2015	7.01070	2.39415	11.6272
Q2 2015	129.585	122.680	136.490	Q2 2015	6.61740	1.76494	11.4699
Q3 2015	130.319	123.111	137.526	Q3 2015	7.01456	1.91628	12.1128
Q4 2015	131.056	123.555	138.558	Q4 2015	6.61342	1.30057	11.9263

Source: author's calculations

Fig. 4: The forecast of the development of CPI (INFLAT - inflation rate) in the Czech Rep. from the third q. 2012 to the fourth q. 2015 (+100 %, the average of 2005 is 100 %), *left picture and* **the forecast of the development of unemployment rate in the Czech Rep. from the third q. 2012 to the fourth q. 2015,** *right picture*
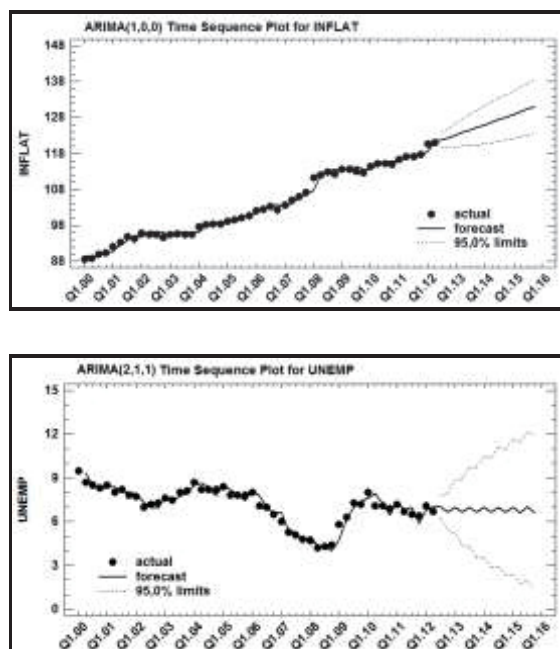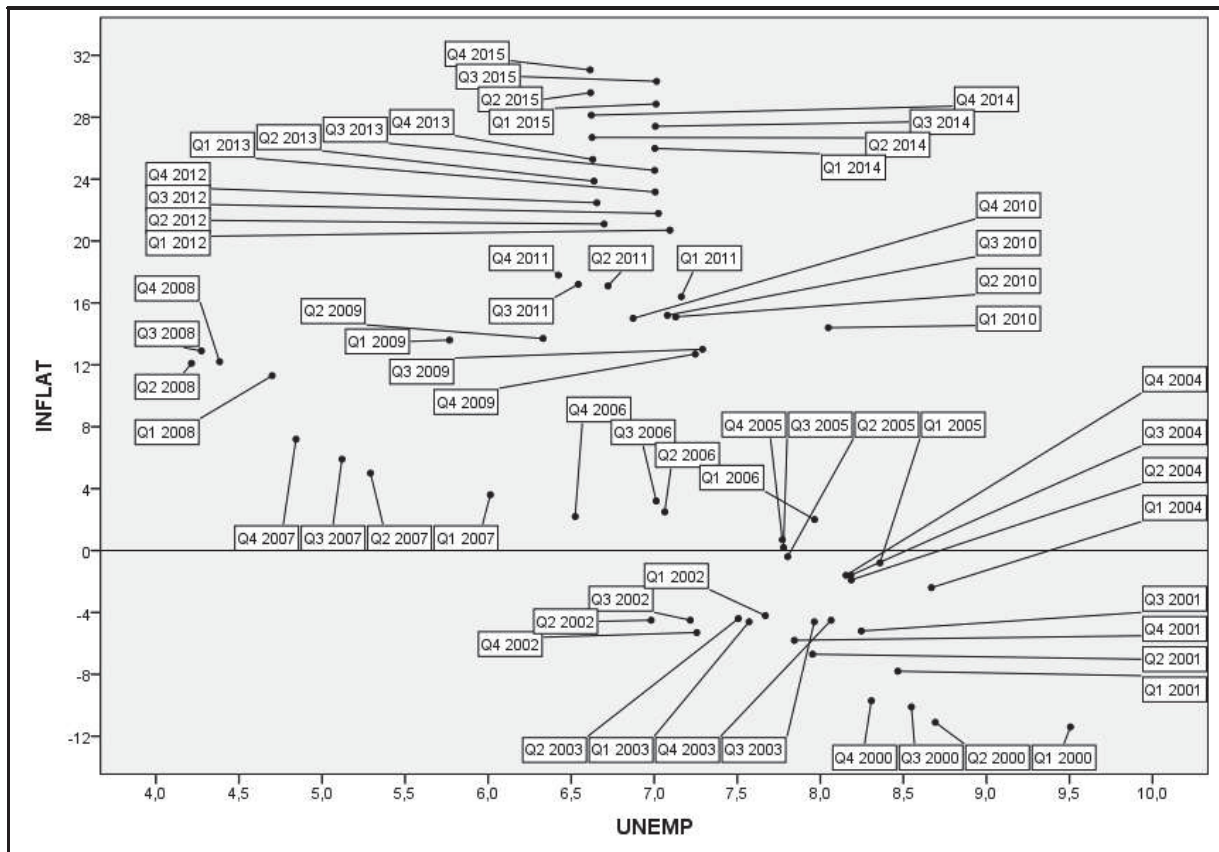

Source: CZSO, author's calculations, own construction

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 5. It is clear that the estimates reflect the zone of potential unemployment rate and rather an acceleration of inflation over time is observed, which is in line with the assumption of the long-term vertical Phillips curve. 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 the Phillips curve have never worked or worked poorly.

Fig. 5: The development of the Phillips curve for the Czech Rep. from the first q. 2000 to the fourth q. 2015, (the third q. 2012 and the fourth q. 2015 is forecast–future long term equilibrium), where INFLAT is CPI (+ 100 %, the average of 2005 is 100 %) and UNEMP is unemployment rate in %

Source: CZSO, author's calculations, own construction

REFERENCES

- Box, G.E.P., Jenkins, G., (1970): *„Time series analysis: Forecasting and control"*, San Francisco, Holden-Day.

- Dittmar, R., Gavin, W.T., (2000): What Do New-Keynesian Phillips Curves Imply for Price-Level Targeting? *Federal Reserve Bank of St. Louis Review*, p. 21-30.

- Friedman, M. (1968) "The Role of Monetary Policy." *American Economic Review* (March) 58 (1), 1-17.

- Kiley, M.T., (1998): Monetary Policy under Neoclassical and New-Keynesian Phillips Curves, with an Aplication to Price Level and Inflation Targeting. *Board of Governors of the Federal Reserve System, Working Paper*, p. 1-20.

- King, T.B., Morley, J. (2007): "In Search of the Natural Rate of Unemployment," *Journal of Monetary Economics*. May, 54: 550-564.

- King, R. G., Watson, M.W., (1994): "The Post-War US Phillips Curve: A revisionist econometric history," *Carnegie-Rochester Conference Series on Public Policy* 41.

- Kydland, F.E., Prescott, E.C., (1977): Rules Rather than Discretion: The Inconsistency of Optimal Plans. *Journal of Political Economy*, no. 3, p. 473-491.

- Lee, J., Nelson, Ch.R., (2007): "Expectation Horizon and the Phillips Curve: The Solution to an Empirical Puzzle," *Journal of Applied Econometrics*, 22: 161- 178.

- Phelps, E., (1967): "Phillips Curves, Expectations of Inflation, and Optimal Inflation over Time", *Economica* 135 : 254-281.

- Phillips, A.W., (1958): The Relation Between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861-1957. *Economica*, no. 5, p. 283-293.

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