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# The anti-Phillips curve

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## Abstract

There is no Phillips curve in the United States, i.e. unemployment does not drive inflation at any time horizon. There is a statistically robust *anti-Phillips* curve - inflation leads unemployment by 10 quarters. Apparently, the anti-Phillips curve would be the conventional one, if the time would flow in the opposite direction. Several tests for cointegration do not reject the hypothesis that there exist a long-term equilibrium relation between inflation and unemployment in the US.

The cointegrating relation between inflation and unemployment is not the proof of causality, however, and both variables are driven by the same external force. Also presented are some statistical evidences that there exist conventional Phillips curves in Germany and France, but there is no causality link between unemployment and inflation as well.

Key words: the Phillips curve, inflation, unemployment, causality

JEL classification: E24, E31, E52, E58

## Introduction

The Phillips curve is a fundamental axiom of the mainstream economics that links inflation to unemployment. In some modern models, like the new Keynesian Phillips curves, other measures of economic activity may be used instead of unemployment. The process behind the curve is so crystal clear from the point of view of common wisdom, as introduced by A.W. Phillips (1958) and elaborated by several generations of economists, that it has been easily accepted by major schools of economic thought. Even central banks of the most advanced and richest countries do not hesitate to use the Phillips curve in the prediction of price growth for purposes of inflation targeting, which is the Holy Grail of monetary policy (Kohn, 2008). The only problem is left for both theorists and practitioners – the Phillips curve does not work (Atkeson and Ohanian, 2001). Essentially, even the simplest approach “tomorrow as today” gives better or comparable predictions when the most elaborated model based on the Phillips curve (Stock and Watson, 2008). At best, the input of from unemployment or any other measures of economic activity in the prediction of inflation at time horizons of one to two years is between 10 and 15 percent (Piger and Rasche, 2006). The residual 85 to 90 percent is explained by autoregressive properties of inflation itself. In other words, the accuracy of inflation prediction depends critically on the predominant frequency in its spectrum. At time horizons sufficiently larger than the predominant period, one should not observe any sound prediction.

There are two possible explanations of the absence of reliable correlation between inflation and unemployment in the United States. One is banal – there is no link at all. Second explanation is a more productive one – both variables are driven by some external force. The failure of the Phillips curve is caused by the difference in time lags of inflation and unemployment behind this driving force. We have found that in such developed countries as the United States, Japan, Germany, France, Canada, and Austria this force is the change in the level of labor force (Kitov, 2006ab, 2007a-d; Kitov, Kitov, and Dolinskaya, 2007ab, 2008). In the US, the lag of inflation behind the change in labor force is 2.5 years, and the lag of unemployment is 5 years. Accordingly, the inflation leads the unemployment by 30 months. One can formulate such order in time as an *anti-Phillips* curve. Due to the time lag, the unemployment could be by mistake considered as a consequence of the inflation. This strict sequence in time is not *causality*, however. The cause for both variables is of the same origin, but the inflation/unemployment sequence varies between countries.

The main objective of this paper is to reveal the existence of an anti-Phillips curve in the United States and to estimate its statistical properties, including the conduction of appropriate tests for cointegration. It is also important to demonstrate that the presence of a cointegrating relation between inflation and unemployment is not the proof of causality and both variables are driven by the same external force. In support to this conclusion, we present some statistical evidences that there exist conventional Phillips curves in such developed countries Germany and France.

### The anti-Phillips curve

We start with plotting of quarterly readings of inflation and unemployment, as measured by the US Bureau of Labor Statistics (<http://www.bls.gov/data/>) and the Bureau of Economic Analysis (<http://bea.gov/national/nipaweb/>), respectively. Straight away, Figure 1 reveals the existence of the anti-Phillips curve. In order to highlight the lead of inflation, represented by GDP deflator (*DGDP*), ahead of unemployment (*UE*), the latter is scaled, displaced, and shifted by 2.5 years ( $t+2.5$ ) or 10 quarters back relative to its true time:

$$DGDP(t) = 1.444*UE(t+2.5) - 0.0488 \quad (1)$$

Both the slope and free term in (1) are determined by visual fit only, but with keeping the average residual very close to 0. Overall, we tried matching the amplitude and timing of the

highest peaks in 1973 and 1980 by the trail-and-error method, with the emphasis on the latter one. The consideration behind this approach is obvious – to obtain the best results one should always fit the measurements with the highest signal-to-noise ratio.

Effectively, the unemployment lags behind the GDP deflator by 2.5 years. The mean difference between the observed and predicted inflation is  $8.3E-5$  for the period from 1960Q1 to 2006Q2: one can use the reading of inflation only 10 quarters back from 2008Q4 (the last reading currently available). The anti-Phillips curve in its scatter-plot form is displayed in Figure 2 (left panel). The goodness-of-fit is 0.49 and the slope of the linear regression curve is 0.42. Due to the presence of random (measurement) errors in both independent and dependent variable, the slope is underestimated relative to that in Figure 1:  $1/1.444=0.69$ .

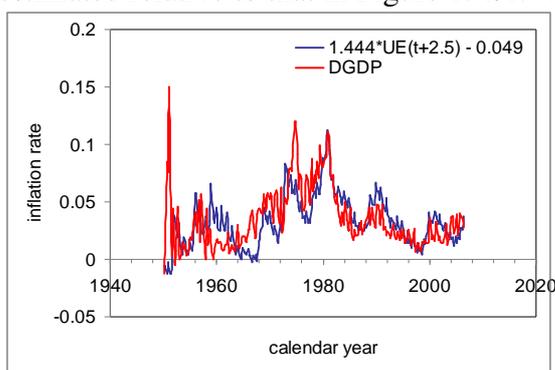


Figure 1. GDP deflator (*DGDP*) vs. scaled and lagged unemployment (*UE*) in the United States between 1950Q1 and 2006Q2. The *DGDP* and unemployment time series are represented by quarterly readings (226 in total). The scaled unemployment is shifted by 2.5 years ahead (10 quarters), i.e. actual readings start from 1952Q3.

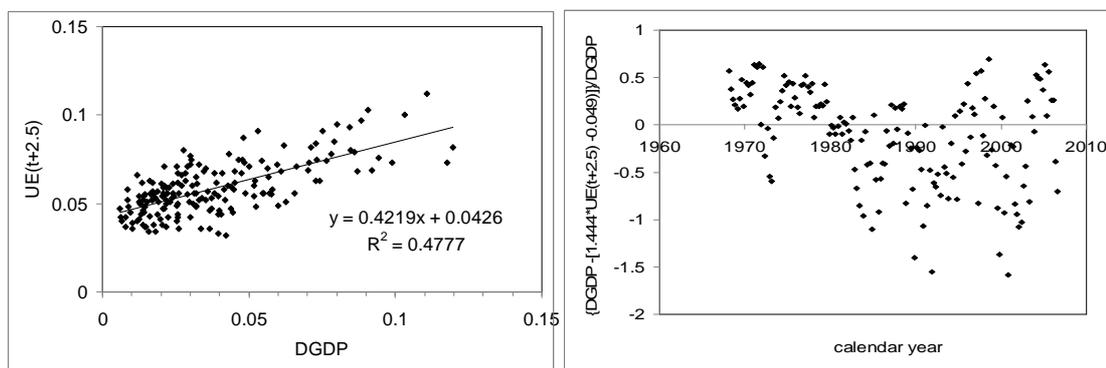


Figure 2. **Left panel:** scatter plot: the *DGDP* vs. unemployment for the years between 1960Q1 and 2006Q2. The slope obtained by linear regression is slightly underestimated: 0.42 instead of  $1/1.444=0.69$ , as related to the uncertainty of the *DGDP* and unemployment estimates. This scatter plot is a textbook example of the anti-Phillips curve. **Right panel:** the residual of the observed and predicted *DGDP* normalized to *DGDP* between 1968Q1 and 2006Q2. The average relative residual is -0.11 with standard deviation of 0.5. The scatter is higher in the 1990s and 2000s supporting the conclusion by Stock and Watson (2007) that inflation is getting harder to predict.

An important characteristic of the overall consistency is the residual of the observed and predicted *DGDP*. The right panel of Figure 2 depicts this residual as normalized to the *DGDP* between 1968Q1 and 2006Q2. Such normalization allows a different view on the residual as related to the ratio of signal and noise. When amplitude of a signal is high relative to that of noise, one can expect lower relative residuals because the input of the noise is negligible. When the noise is of the amplitude of the signal, one should observe a higher scattering in the residual due to partly stochastic character of the noise. The average residual in Figure 2 (right panel) is -0.11 with standard deviation of 0.5. The scatter is higher in the 1990s and 2000s supporting the conclusion of Stock and Watson (2007) that inflation is getting harder to predict. The cause is

likely related to the constant level of absolute error in the measurements of inflation and unemployment and, thus, objective.

The goodness-of-fit is relatively low, however. The high scatter in Figure 2 is directly mapped into large root-mean-square forecasting error (RMSFE), as presented in Table 1 for the empirical anti-Phillips curve. In normal situation, the *DGDP* would be used to predict the *UE*, but since we follow the conventional economic concept and the reversed time direction, i.e. the anti-Phillips curve, we predict the *DGDP* using future readings of the *UE*. Therefore, we obtain a pseudo out-of-sample forecast, i.e. the forecast when "..., one simulates standing at a given date and performing all model specification and parameter estimation using only the data available at that date, then computing the *h* period ahead forecast" (Stock and Watson, 2008), but from the future into the past. Otherwise, it is a standard pseudo out-of-sample forecast. (When forecasting the *UE* using the *DGDP*, one is fully complying with the definition of pseudo out-of-sample forecast.)

Table 1. Comparison of the RMSFE obtained in this study to those reported by Stock and Watson (2008) for the same periods. Time horizons are 2.5 and 1 year, respectively. RMSFE for the *DGDP* MA(5) has a time horizon of 2 years.

Period	Length, quarters	RMSFE, % anti-Phillips	RMSFE, % MA(5) DGDP-UE	RMSFE, % SW UC-SV
1960Q1-1967Q4	32	2.04	2.00	0.72
1968Q1-1976Q4	36	2.54	2.68	1.76
1977Q1-1984Q4	32	1.81	1.80	1.28
1985Q1-1992Q4	32	1.56	1.05	0.70
1993Q1-2000Q4	32	1.00	0.72	0.41
2001Q1-2006Q2	22	1.35	1.23	0.57

The unobserved component-stochastic volatility (UC-SV) model developed by Stock and Watson (2007) has a somewhat smaller RMSFE at a one year horizon than our model at a 2.5-year horizon. Stock and Watson (2008) have split the period between 1960 and 2007 into several segments (see Table 1) in order to investigate the change in relative performance of various models over time. For the most recent periods, RMSFE was 0.41% and 0.57%. Our model provides 1% and 1.35%, respectively.

One of possible reasons for the scatter and larger RMSFEs consists in a higher measurement noise associated with quarterly measurements. The *DGDP* is prone to continuous revisions by the Bureau of Economic Analysis. The unemployment is measured in the Current Population Surveys covering only 60,000 households. Both variables suffered numerous changes in definitions over the past 60 years, which sometimes make them incompatible through time. Therefore, the overall fit between the *DGDP* and *UE* should not be too high and one needs to use some additional tools to suppress the measurement noise.

Moving average is a well-know tool to reduce the influence of high-frequency noise. We have applied a five-quarter (centered) moving window (MA(5)) to smooth the *DGDP* time series. As a result, the horizon of pseudo out-of-sample forecast is now 8 quarters, or 2 years. The prediction error has been sufficiently reduced, however, especially in the past 25 years, when the measurement noise was the highest in relative terms. The RMSFE at a two-year horizon is only 0.72% between 1993 and 2000 compared to 0.41% for the UC-SV model at a one-year horizon. At this stage, *no* autoregressive properties of both time series have been used yet. This is the pure statistical link between the *DGDP* and *UE*.

The anti-Phillips curve is not designated to kill the conventional Phillips curve, but to be used for the prediction of the rate of unemployment in the United States using inflation. Figure 3 illustrates this possibility. Since the 1980s the *DGDP* and *UE* have been moving synchronously (with 10 quarter shift) and the next move in the unemployment in the US should be down, from the height it climbed in the end of 2008 and the beginning of 2009. Accurate prediction of such a

sudden and deep fall would be a good validation for relationship (1). This event should happen because both variables are driven by the change in labor force (Kitov, 2006ab; Kitov, Kitov, and Dolinskaya, 2007b).

We have also tested the link between the GDP deflator and unemployment for the presence of cointegration relation. First, we used the difference of the measured and predicted *DGDP* between 1960Q1 and 2006Q2 (186 readings) obtained by visual fit as a proxy to the residual of corresponding linear regression. The augmented Dickey-Fuller test for unit root with lags up to 4 gave test statistics of -3.64 with the 1% critical value of -3.48. At this level of confidence, one can reject the hypothesis of the presence of unit root in the difference. The Phillips-Perron unit root tests resulted in  $z(\rho)=-54.0$  (1% critical value -13.4) and  $z(t)=-5.6$  (1% critical value -2.6). Therefore, both tests demonstrate that the difference between the observed and predicted *DGDP* is an  $I(0)$  process and the variables are likely to be cointegrated.

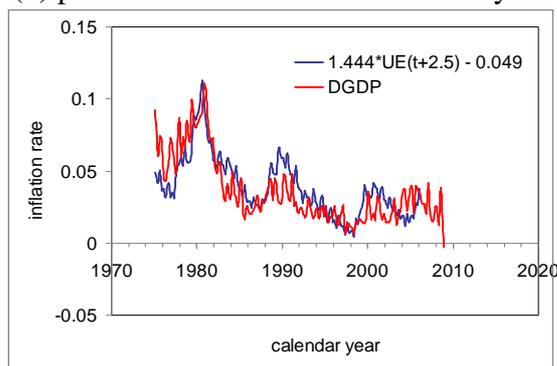


Figure 3. Comparison of the *DGDP* and scaled unemployment in the United States between 1975Q1 and 2008Q4. A sudden and deep drop in the *UE* is expected in 2009-2010.

The Johansen (1988) approach allows both the test for cointegration and the determination of its rank. With the maximum lag included in the underlying VAR model of 1 and trend specification “rconstant” we have obtained the eigenvalue of 0.15 and rank 1. Corresponding statistics is as follows: trace statistics 6.4 (1% critical value 13.0, 5% critical value 9.2), SBIC=-13.39 and HQIC=-13.4 – both maximum at rank 1. Hence, one cannot reject the hypothesis that there exist a cointegrating relation between the *DGDP* and unemployment. In other words, there exists a long-term equilibrium relation between these two variables with the *DGDP* leading the unemployment by 10 quarters, and the linear regression shown in Figure 2 is valid.

All in all, the anti-Phillips curve revealed for the United States practically prohibits predicting inflation by using unemployment. On the contrary, the existence of a cointegrating relation allows improving the prediction of unemployment using its own autoregressive properties and those of inflation. The best VECM with the largest lag of one quarter predicts the rate of unemployment with RMSFE of 0.6 percent at 10 quarters horizon. The VAR provides  $R^2=0.84$  and RMSFE also of 0.6 percent at the same horizon. Therefore, the anti-Phillips curve is much more practical than its counterpart.

The anti-Phillips curve is a specific feature of the US economy, however. Other countries demonstrate rather the presence of conventional Phillips curves. Figure 4 illustrates the link between inflation (*DGDP*) and unemployment in Germany, where the former variable lags behind the latter one by one year. Correspondingly, the slope obtained by linear regression is negative. The relation obtained by visual fit is as follows:

$$UE(t+1) = -1.477 * DGDP(t) + 0.1147$$

for the years between 1971 and 2008. Linear regression gives a slope of -1.50 with  $R^2=0.86$ . Therefore the Phillips curve in Germany is a reliable relationship between inflation and

unemployment. Both are driven by the same external force – the change in labor force level (Kitov, 2007c).

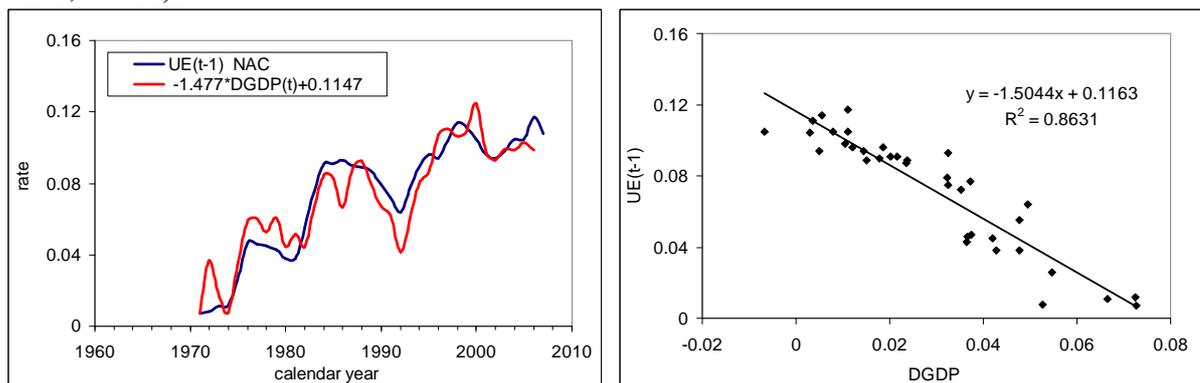


Figure 4. The anti-Phillips curve in Germany is a conventional Phillips curve with inflation lagged behind unemployment by one year.

In France, the Phillips curve existed before the Banque de France introduced a new monetary policy restricting the emission of money (Kitov, 2007d; Kitov, Kitov, and Dolinskaya, 2007a). Figure 5 displays the observed *DGDP* annual time series and that predicted from unemployment. The latter time series was obtained by the following relationship:

$$DGDP(t) = 1.3*UE(t-4) + 0.155$$

i.e. the inflation lags the unemployment by four (!) years. The goodness-of fit as obtained from linear regression, shown in Figure 5 (right panel), is 0.89 for the years between 1971 (the start of the *DGDP* measurements) and 2007. The Phillips curve was a statistically reliable link between unemployment and inflation; both are driven by the change in labor force level ( $dLF/LF$ ), as Figure 6 demonstrates. The change in labor force also leads inflation by four years, and thus is contemporary with the unemployment. The agreement between the observed and predicted curves is characterized by  $R^2 > 0.9$ .

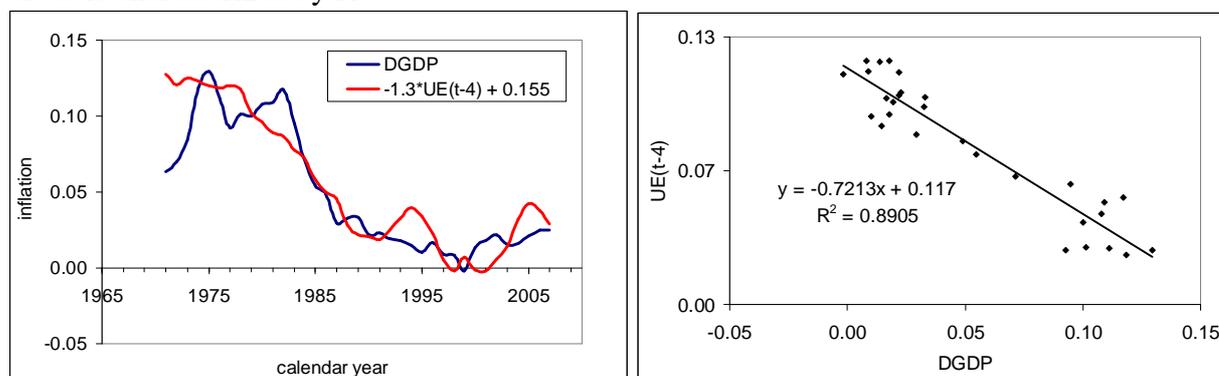


Figure 5. The anti-Phillips curve in France is a conventional Phillips curve with inflation lagged behind unemployment by four years.

The slope of the regression line in Figure 5 is negative. Similar result was obtained for Germany. In both countries, any decrease in unemployment indicates a delayed increase in inflation, and vice versa. The French and German central banks should be very careful in formulating a sound monetary policy. Our analysis demonstrates that inflation does no harm in terms of real economic growth (Kitov, Kitov, and Dolinskaya, 2008), but high unemployment directly affects the sustainability of social development.

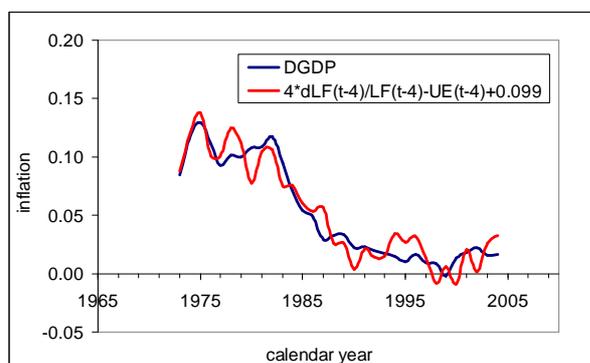


Figure 6. The link between the change in labor force level ( $dLF/LF$ ), unemployment, and inflation in France (Kitov, 2007d).

## Conclusion

In addition to the US, Germany and France we have analyzed the link between the change in labor force, unemployment and inflation in Japan (Kitov, 2007a), Canada (Kitov, 2007b), and Austria (Kitov, 2007d). All these countries and other biggest developed countries (working papers in preparation) demonstrate the presence of similar linear lagged relationships. In several countries, the conventional Phillips curves are observed, but some central banks destroy the statistical link between unemployment and inflation by monetary policy similar to that introduced by the European central bank. All in all, the anti-Phillips curve found in the United States is just a funny peculiarity, not a fundamental bound. The Phillips curve has the same nature.

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