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# REAL APPROACH TO PHILLIPS' CURVE

Since 1958, the year of Phillips' paper «The Relation Between Unemployment and the Rate of Change In Money Wages in the United Kingdom, 1861-1957» publishing, a lot of modifications of the original Phillips' curve have been made, whereas many of them have nearly nothing to do with the relationship described by original Phillips' curve and they are rather inflation models or models of dynamic supply. It is the case of author's «real» version of Phillips' curve, which is derived in this paper, as well. Although «real» Phillips' curve results from Phillips' curve theory it describes a relationship between the labour productivity growth and the unemployment. The paper does not contain only the derivation of «real» Phillips' curve, but also its empirical verification on the data bases of three developed countries, i.e. the USA, the United Kingdom and Denmark.

Начиная с публикации работы Филипса «Взаимозависимость между уровнем безработицы и динамикой заработной платы в Соединенном Королевстве, 1861-1957» в 1958 г., первоначальная кривая Филипса получила значительное количество модификаций, хотя большинство из них не имеют ничего общего с зависимостью, описанной в первоначальной кривой Филипса, и являются скорее инфляционными моделями или моделями динамического изменения предложения. Автором выводится «истинная» версия кривой Филипса. Хотя «истинная» кривая Филипса основывается на теории кривой Филипса, она описывает взаимосвязь между ростом производительности труда и уровнем безработицы. В статье содержится не только вывод «истинной» кривой Филипса, но также ее эмпирическое подтверждение на материале баз данных по трем развитым странам: США, Соединенному Королевству и Дании.

## 1. Introduction

Soon after publishing A. W. Phillips' empirical study «The Relation Between Unemployment and the Rate of Change In Money Wages in the United Kingdom, 1861-1957» the relation between the wage inflation (and consequently the price inflation) and the unemployment was discussed very often. It was caused not only by economic implications but also by politic implications, because Phillips' curve describes the relation between two most monitored values by voters. Since 1958 (the year of Phillips' paper publishing) a lot of modifications and changes of Phillips' curve theory, as a reaction mainly to changes of economic conditions and a consequent erosion of an empirical validity of this relationship, have been created.

Although there are many various approaches to the Phillips' curve, which differ in used presumptions and variables, it is possible to divide them according to assumed causality. The causality can be conceived from unemployment to inflation (e.g. the origin Phillips' curve) or from inflation to unemployment (e.g. the Friedman approach to Phillips' curve).

Phillips postulated that lack of unemployed workers creates a pressure on employers to rise the wages and the surplus of unemployed workers connected with workers' weaker negotiating position allows the reduction of wages or their growth to employers (for details see Phillips, 1958). S. Weintraub modified origin Phillips' curve by equation expressive relationship between wage inflation and price inflation. He supposed that firms set prices of their production on the basis of the price surcharge, which can be expressed by the equation

$$P = K \cdot \frac{W_n}{LP}, \qquad (1.1)$$

where $P$ is a price of production, $K$ is a price surcharge, $W_n$ is a nominal wage and $LP$ is a labour productivity. After reformulation of the equation (1.1) into growth form (by taking a logarithm), whereas the constant price surcharge is assumed, we obtain the form

$$\pi = w_n - lp\,, \qquad (1.2)$$

where $\pi$ is a price inflation, $w_n$ is a growth of nominal wage and $lp$ is a growth of labour productivity. This adjustment leads to the creation of Keynesians form of Phillips' curve, whose equation can be derived from scientific notation of original Phillips' curve

$$w_n = -\alpha \cdot (u - u^*)\,, \qquad (1.3)$$

where $w_n$ is a growth of nominal wage, $\alpha$ is a constant (with positive value), $u$ is a rate of unemployment and $u^*$ is a natural rate of unemployment. By substitution of (1.2) in (1.3) and by rearrangement we obtain the equation (1.4), i.e. equation of Keynesian form of Phillips' curve.[1]

$$\pi = -\alpha \cdot (u - u^*) - lp\,. \qquad (1.4)$$

In 1967 Friedman refused the Keynesians' conception of stable substitute relationship between inflation and unemployment and developed the monetaristic approach to the Phillips' curve. This approach is based on causality from inflation to unemployment[2]. Friedman assumed that in time of inflation overlapping expected inflation firms understand higher revenues (higher than expected revenues) as an effect of increasing demand for their production and they increase production, hire new employees and pay higher nominal wages (which are not so high to cover expenses of inflation and so real wages decrease). Workers interchange the nominal wage growth with the real wage growth and the supply of labour increase. Impact of the inflation increase in short run is the decrease of unemployment and the increase of product as show the equation

$$u^* - u = \lambda \cdot (\pi - \pi^e)\,, \qquad (1.5)$$

where $u^*$ is a natural rate of unemployment, $u$ is a rate of unemployment, $\lambda$ is a constant (with positive value), $\pi$ is an inflation and $\pi^e$ is an expected inflation. In long run employees and firms discover their monetary illusion, the adjustment of inflation expectations and nominal wages happen and unemployment go back at its natural level.

**2. «Real» version of Phillips' curve**

As mentioned above we distinguish two conceptions of Phillips' curve according to assumed causality of the relationship between real processes in the labour market and inflation. Older conception postulates that real changes in the labour market influence inflation (through pricing by price surcharge), whereas newer one perceives inflation as an impulse which affects real processes in the labour market. However, in reality one way causality relationships do not exist, because there are only mutual relationships among all values. It is the reason why author of this paper tries to create the model of «real» Phillips' curve, which understands above mentioned conceptions as two sides of one coin, i.e. they are not mutually conflicting, because the real sector of economy influences the nominal one, which influences the real sector back as will be shown below. The nominal sector of economy is only «mediator» of real processes and its role in short run only is given by neutrality of money in long run.

For creation of «real» version of Phillips' curve it is necessary to assume that firms set prices on the basis of price surcharge to labour costs as show equation

$$P = K \cdot \frac{W_n}{LP}\,, \qquad (2.1)$$

where $P$ is a price of production, $K$ is a price surcharge, $W_n$ is a nominal wage and $LP$ is a labour productivity. After reformulation the equation (2.1) into growth form (by taking a logarithm), whereas the constant price surcharge is assumed, we obtain a form

$$\pi = w_n - lp\,, \qquad (2.2)$$

where $\pi$ is a price inflation, $w_n$ is a growth of nominal wage and $lp$ is a growth of labour productivity. Let us assume that firms determine

[1] Keynesians assume constant or null labour productivity growth and so the unemployment rate is crucial factor influencing inflation. In the model of «real» Phillips curve derived below the author suppose that changes in the labour productivity growth are crucial factor of determination of inflation. The absence of expected inflation (in comparison with monetaristic approach) matches the idea of stable Phillips' curve without any shifts.

[2] This causality (not the mechanism of Phillips' curve functioning) is accepted by other economic schools as well (e.g. New Classic Macroeconomics or New Keynesians).

growth of nominal wages on the basis of expected growth of labour productivity ($lp^e$) and expected inflation ($\pi^e$), i.e.

$$w_n = lp^e + \pi^e, \qquad (2.3)$$

whereas expectations of employees (or more precisely labour unions) are the same. By substitution of (2.3) in (2.2) and by rearrangement we obtain the equation (2.4) which reflects mutual relationship between the inflation and the labour productivity growth.

$$\pi - \pi^e = lp^e - lp\,. \qquad (2.4)$$

By substitution of (2.4) in the equation of Friedman's approach to short run Phillips' curve

$$u^* - u = \lambda \cdot (\pi - \pi^e), \qquad (2.5)$$

where $\lambda$ is a constant (with positive value) and $u^*$ is a natural rate of unemployment, and by small rearrangement we obtain an equation

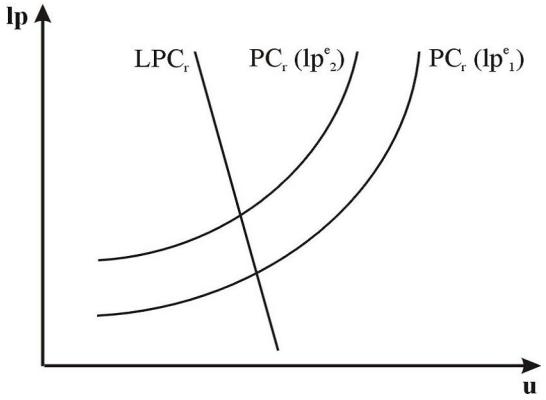
$$u - u^* = -\lambda \cdot (\pi - \pi^e) = \lambda \cdot (lp - lp^e), \qquad (2.6)$$

which shows mutual relationships among the labour productivity, the inflation and the unemployment. By eliminating the middle term in the equation (2.6) we obtain the equation of the short run «real» Phillips' curve ($PC_r$)

$$u - u^* = \lambda \cdot (lp - lp^e)\,. \qquad (2.7)$$

$PC_r$ curves in the figure are represented for various levels of expected labour productivity growth ($lp^e$). Whereas it can be supposed that in short run the expectations are changing very slowly, if at all, the expectations can be considered constant. The same assumption is adopted for natural rate of unemployment, which is changing only in long run.

The slope of the short run «real» Phillips' curve (thereinafter $PC_r$) is positive, because the labour productivity growth exceeding the expected labour productivity growth (with the nominal wage growth given by the firm) implies the decrease of the inflation rate. Lower inflation in conjunction with given nominal wage growth mean a raise of real wage growth. The real wage growth is so equivalent to the labour productivity growth. The firm with null economic profit (the monopolistic competition




«Real» Phillips' curve

is assumed as evidently the most widespread) uses its revenues only for reproduction of capital and labour. The growth of the relative costs of one factor can be realized only at the expense of the other one or by a decrease of relatively more expensive factor's quantity.[3] The result of the labour productivity growth overlapping the expected labour productivity growth in short run will be, paradoxically, an increase of unemployment rate, which will be strengthened by economic inactive individuals' entry into the labour market as a consequence of real wages increase and so an increase of work motivation. The starting point in the figure 2.1 is the intersection of the long run «real» Phillips' curve (thereinafter $LPC_r$), whose slope is negative, with the short run «real» Phillips' curve (thereinafter $PC_r$) constructed for expected labour productivity growth $lp^e_1$, whose slope is positive. This point (the intersection) corresponds to the long run equilibrium, which the firm reaches for null economic profit in. The increase of the labour productivity growth overlapping the expected labour productivity growth implies, as was stated above, the rise of unemployment rate and shift along the $PC_r$ ($lp^e_1$) upward. If the shock in the form of the unexpected labour productivity growth is only

[3] The increase of real wages together with keeping the number of firm's employees constant would lead to a decrease of revenues hitting on reproduction of capital, including floating capital, which could endanger firm functioning. Other alternatives are keeping present real wages level and present number of employees, but more productive employees will refuse this variant and they will leave the firm, or accepting the increase of real wages at the expense of the number of employees.

temporary[4] the shift along $PC_r$ ($lp^e_1$) downward (to the intersection with $LPC_r$) happens in next periods. If the shock in the form of the unexpected labour productivity growth is a beginning of the permanent increase of the labour productivity growth[5], then adjustments of firms' expectations happen during next periods, which is in the figure 2.1 represented by the shift of the curve $PC_r$ ($lp^e_1$) into position $PC_r$ ($lp^e_2$). The new equilibrium is in the intersection of $LPC_r$ and $PC_r$ ($lp^e_2$), but the level of unemployment rate is lower than in the case of starting point (previous situation), i.e. the intersection of $LPC_r$ and $PC_r$ ($lp^e_1$), which is given by negative scope of $LPC_r$. With the adjustment of expectations of the labour productivity growth up and the inflation rate down (which have no effect on nominal wages' rate of growth if changes of expectations of the labour productivity growth and the inflation are equal) in the case of the permanent increase of the labour productivity growth the modifications of customer's contracts in order to increase an amount of demanded goods, the investments in the new market acquiring and in the industrial capacity expansion occur. The reason why this expansion proceeds is the fact that firms know that if the unexpected labour productivity growth occurs only in their case, they could rise their market share through expansion, but if the labour productivity growth is common to the whole economy they can not refuse to expand, because it would lead to the decrease of firm's market share. The expansion is boosted by possibility of using the labour productivity growth in the international trade as well. It could be assumed that extend of a change in unemployment due to the expansion will be greater than extend of laying off in the period before the modifications of customer's contracts, with respect to natural firms' tendency to enlarge, especially at the expense of other firms, which rise their chance of surviving and possibilities to practise some monopolistic practices. The extent of this expansion impacts the slope of the $LPC_r$ curve.

**3. Empirical verification of «real» Phillips' curve concept**

The verification of the «real» Phillips' curve concept is based on the equation for short run «real» Phillips' curve, i.e. equation (2.7). As constant natural rate of unemployment ($u^*$) and constant expected labour productivity growth ($lp^e$) is assumed in the short run, the equation (2.7) can be transformed into a form

$$u = \lambda \cdot lp\,, \qquad (3.1)$$

which corresponds to the short run relationship between the unemployment rate and the labour productivity growth without any shifts of the $PC_r$ curve. The equation (3.1) can be modified into the form

$$u = \alpha + \beta \cdot lp + \varepsilon\,, \qquad (3.2)$$

which can be estimated by OLS method of regression analysis, where $u$ is an unemployment rate, $\alpha$and $\beta$ are regression coefficients, $lp$ is a labour productivity growth and $\varepsilon$ is a stochastic component of the equation. Correlation coefficients[6], which allow faster but not so detailed orientation in the relationship between the unemployment rate and the labour productivity growth, were counted as well.

For the estimation of equation (3.2) and for the calculation of correlation coefficients data for the United Kingdom, the USA and Denmark, as three developed countries of various extents, were used. Data were obtained from the annual macroeconomic database AMECO (created by European Union). The unemployment rate is quantified according to Eurostat definition, the labour productivity is counted as GDP (at 1995 market prices) divided by the number of employees in economy. For the examination of legitimacy of constant price surcharge assumption the calculation of

[4] Temporary unexpected labour productivity growth can be caused by e.g. innovations or investments whose effects on productivity growth are greater than expected, work effort ect.

[5] Permanent increases of the labour productivity growth can be caused mainly by human capital accumulation, which produce positive externalities, because through the human capital accumulation new knowledge and thoughts are created and they consequently became a part of the knowledge stock – the determinant of the technology level. That means that although the private returns of human capital can be decreasing, the social ones are not, i.e. in the case of the human capital is not valid the rule of decreasing returns, even they can be increasing (according to e.g. Romer, Lucas).

[6] Pearson correlation coefficients significant at 0,05 level.

**Table. Results of regression and correlation analysis**

| United kingdom | | | | USA | | | | Denmark | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Period | Correlation coefficient | R2 (Adjusted R2) | β coeficient (t-statistic) | Period | Correlation coefficient | R2 (Adjusted R2) | β coeficient (t-statistic) | Period | Correlation coefficient | R2 (Adjusted R2) | β coeficient (t-statistic) |
| 1961-1968 | 0,736434 | 0.542903 (0.466721) | 0.156610 (2.669518) | 1962-1966 | 0,925549 | 0.856773 (0.809030) * | 0.709588 (17.93158) | 1964-1973 | 0,670934 | 0.450051 (0.381307) * | 0.072094 (3.784447) |
| 1969-1972 | 0,961921 | 0.925324 (0.887987) * | 0.652133 (13.08073) | 1969-1973 | 0,810962 | 0.658226 (0.544301) * | 0.561641 (4.079426) | 1974-1976 | 0,879585 | 0.774202 (0.548404) * | 0.337145 (3.689154) ** |
| 1974-1977 | 0,954259 | 0.910481 (0.865722) * | 0.547277 (5.604776) | 1974-1981 | 0,718342 | 0.515880 (0.435194) | 0.414296 (2.528563) | 1981-1983 | 0,962936 | 0.927399 (0.854799) | 0.178346 (3.574073) ** |
| 1980-1983 | 0,993639 | 0.987237 (0.980856) * | 0.952449 (19.96081) | 1983-1987 | 0,905602 | 0.820000 (0.760000) * | 1.074207 (5.504721) | 1985-1992 | 0,723205 | 0.524653 (0.445429) | 0.956327 (2.573396) |
| 1985-1990 | 0,921818 | 0.850188 (0.812735) | 1.205148 (4.764471) | 1990-1995 | 0,690788 | 0.477250 (0.346562) | 0.502702 (1.910977) ** | 1994-1998 | 0,879738 | 0.772442 (0.696589) | 0.885363 (3.191149) |
| 1991-1997 | 0,759856 | 0.577155 (0.492587) * | 0.999068 (2.922532) | 1996-2000 | 0,449657 | 0.204054 (-0.061261) * | 0.698663 (2.216685) ** | 2001-2004 | 0,973898 | 0.948063 (0.922095) * | 0.608167 (8.282536) |
| 2000-2002 | 0,946535 | 0.897165 (0.794329) * | 0.220267 (5.373250) ** | 2001-2003 | 0,967126 | 0.935923 (0.871846) * | 0.952828 (8.535706) ** | 2005-2007 | 0,999882 | 0.999675 (0.999349) * | 1.457859 (83.04132) |
| 2004-2006 | 0,564797 | 0.316887 (-0.366225) * | 0.146901 (1.053218) ** | 2004-2007 | 0,874536 | 0.763600 (0.645399) * | 0.311350 (7.733830) | | | | |
| | | | | | | | | | | | |
| 1961-2007 | 0,016849 | 0.000286 (-0.021930) * | 0.034765 (0.121557) ** | 1961-2007 | -0,010527 | 0.000111 (-0.022109) * | -0.011216 (-0.085608) ** | 1961-2007 | -0,329566 | 0.108705 (0.088898) * | -0.536995 (-2.607597) |

Source: own calculation.

Note: * The autocorrelation was detected. In these cases the Newey-West standard errors method was used.

** The β coefficient of the labour product growth variable is statistically insignificant.

the inflation and the nominal wages growth was necessary. The inflation rate was counted from national consumer price indexes and the growth of nominal unit labour costs were used[7] in lieu of the nominal wage growth. Data for period 1960-2007 were used, whereas data for years 2005-2007 are the forecast.

From results in the table follow that in short run, most often 3-5 years, there is strong direct proportion between the unemployment rate and the labour productivity growth in all cases, although in two cases for the United Kingdom and Denmark and in three cases for the USA the labour productivity growth is statistically insignificant as a variable explaining the unemployment rate. In longer periods shifts of $PC_r$ curve occur, which correspond to changes in expected labour productivity growth. In the long run the relationship between the unemployment rate and the labour productivity growth should be negative according to the theory described above. The negative relationship was not verified for the United Kingdom, but the β coefficient of the labour productivity growth was statistically insignificant. Negative relationship was verified for the USA and Denmark, but β coefficient was statistically significant only in the case of Denmark.[8]

If the assumption of the constant price surcharge was forsaken the equation (3.2) would be changed into the form (3.3), where regression coefficient γ should be negative and $k$ is the price surcharge growth.[9]

$$u = \alpha + \beta \cdot lp + \gamma \cdot k + \varepsilon . \qquad (3.3)$$

The estimation of equation (3.3) shows that coefficient $\gamma$ was nearly in all cases statistically insignificant and the sign of $\gamma$ was unstable. Only in the USA in periods 1962-1966 and 1990-1995 γ was negative, β was positive and both statistically significant. The problems with statistical significance in other cases were obviously caused by multicolinearity (not in all cases), which probably caused the statistical insignificance not only in the case of γ coefficient, but β coefficient as well. The analysis of the relationship between the labour productivity growth and the price surcharge growth[10] showed that there is no stable statistically significant relationship (but it was positive in overwhelming majority of cases). From the results flow that assumption of the constant price surcharge is acceptable and the price surcharge growth is probably influenced mainly by other, worse quantifiable, variables[11] such as psychological and institutional factors. It can be assumed that in the short run the price surcharge growth partially compensate influences of changes of the labour productivity growth on changes in inflation. It is evident that thoughts and analysis, stated above, concerning the price surcharge growth are only preliminary and it is necessary to pay more attention to understanding the role of the price surcharge growth in the «real» Phillips' curve theory.

**Conclusion**

The «real» approach to the Phillips' curve, which assumes that the nominal sector is only «the mediator» of real processes in economy, was derived in this paper. From the model flows that in the short run the growth of labour productivity influences the unemployment rate in direct proportion, whereas in the long run there is reciprocal proportion. These model results were empirically tested for data of three developed countries of various extents, i.e. the USA, the United Kingdom and Denmark, and they were confirmed.

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[7] For more detailed information about data, please, see AMECO database (http://europa.eu.int/comm/economy_finance/indicators/annual_macro_economic_database/ameco_en.htm).

[8] Results for period 1961-1990 in Denmark show an increase of $R^2$ by up to 0.196050 (adjusted $R^2$ is 0.167337) and β coefficient by up to -0.655024 (t-statistic is -3.181339).

[9] The price surcharge growth was calculated according to equation $k = \pi - w_n + lp$.

[10] The relationship was examined on the basis of the equation $k = \alpha + \delta \cdot lp + \varepsilon$.

[11] There is no influence of the nominal wage growth, because it is null in the short run according to the equation (2.3).

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