

The Phillips curve – history of thought and empirical evidence*

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The Phillips curve is one of the best known, most discussed and most often used macroeconomic relationships. As a result of the severe, prolonged global recession that unfolded in the wake of the 2007–2008 financial crisis, special attention was paid to the issue of the slope of the curve. In spite of the protracted recession, the decline in inflation remained moderate, and although it reached a much lower level than before, permanent deflation did not occur.

According to most of the empirical studies, flattening of the Phillips curve was observed in the past decades, i.e. the coefficient of the output gap declined significantly. Although this process started prior to the crisis, the crisis amplified it considerably. The main underlying reasons for these developments are attributable to changes in corporate pricing behaviour and to the process of globalisation, as well as to the fact that downward nominal wage rigidities made the Phillips curve even flatter in the low inflation environment following the crisis.

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1. Introduction

The Phillips curve is one of the best known, most discussed and most often used macroeconomic correlations. The Phillips curve captures the correlations between inflation and unemployment as well as between inflation and the output gap. From the views of various schools of economic thought, various Phillips curves may be obtained, which have completely different economic policy implications: while according to the new classical approach, monetary policy is able to influence only inflation and not the real economy, according to the various Keynesian approaches economic policy is able to have an effect on both, but not independently of one another.

In this study, following the discussion of the background of the Phillips curve in terms of history of thought, we examine what characteristics the Phillips curve has empirically, how the crisis of the past period affected the properties of the curve and what consequences it has concerning monetary policy.

* The views expressed in this paper are those of the author(s) and do not necessarily reflect the official view of the Magyar Nemzeti Bank.

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2. The Phillips curve in the economics of the 1950s and 1960s

The equation that captures the correlation between developments in inflation and the real economy can be traced back historically to the study by *Phillips (1958)*. The original article contains an empirical estimation for UK data between 1861 and 1957. The author found stable correlation between nominal wage inflation and unemployment; the higher the wage inflation, the lower the unemployment. Later, *Samuelson and Solow (1960)* found a similar correlation in the case of the United States, although they documented a weaker relation than Phillips.

Whether a similar relationship between inflation and unemployment follows from the negative relation between wage inflation and unemployment is important from two aspects. Firstly, the original Keynesian theory did not deal with the mechanism of price adjustment, and thus the Phillips curve generalised for price inflation could be interpreted as the ‘missing equation’. Secondly, for the activist economic policy typical of the period, a stable relation between inflation and unemployment would have provided an opportunity to set unemployment to a desired level by managing aggregate demand, although at the price of raising inflation to a level higher than before, if necessary.

The majority of economists from that period tended to interpret the Phillips curve as the relation between price inflation and unemployment. Although there had been doubts in connection with that from the very beginning, Samuelson and Solow themselves also cautioned in this regard. Phillips found the relation for a period when inflation was relatively low, and there was no guarantee that the relation would remain stable in the case of higher inflation as well.

3. New classical criticism of the Phillips curve

In their influential studies, *Friedman (1968)* and *Phelps (1968)* criticised the theoretical approach that absolutised the stable Phillips curve and also criticised the economic policy based on that. That criticism was theoretical, but some years after its publication, economic developments confirmed their conjecture. The essence of their criticism is that the empirical Phillips curve is far from being as stable as thought, because an important variable that cannot be observed (or is difficult to observe) is missing from the correlation: inflation expectations.

According to their train of thought, the only reason why monetary policy is able to increase the level of employment by generating inflation is that employees’ inflation expectations underestimate inflation, and thus overestimate their real wages. If, as a result of monetary policy easing, inflation grows faster than nominal wages, it is worthwhile for companies to use more working hours for production, which adds to real economic activity and employment. At the same time, due to

their inaccurate inflation expectations, employees do not perceive that their real wages are declining, and therefore they are ready to do additional work.

However, this outcome is not the final state of equilibrium. Employees gradually adjust their inflation expectations, perceive that higher nominal wages do not mean higher real wages, enforce higher nominal wages, and thus real output returns to the original position. Accordingly, the result of activist economic policy is that inflation is higher, but real output is unchanged in the long run.

In summary, over the long term, monetary policy is unable to stimulate the real economy by generating inflation. The real economy and unemployment have a natural rate determined by technological progress and the institutional environment. The real economy can be diverted from its natural rate in the short run by generating surprise inflation, but with the adjustment of expectations, the economy returns to its natural rate in the long run. If the output gap is defined as the deviation of real GDP from its natural rate, based on the above, in the output gap–inflation plane the long-term relation between them is described by a vertical straight line. Therefore, according to the theory of Friedman and Phelps, the Phillips curve is vertical over the long term.

In the early 1970s, the empirical Phillips curve, which had been believed to be stable, really collapsed in the United States. This was the so-called stagflation period. At that time, economic growth did not accelerate, in spite of the high inflation. This resulted in a considerable increase in the credibility of the argumentation of Friedman and Phelps.

It was the time when the new classical school, which is even more radical than them, became included in the mainstream of economics. Their thoughts are summarised in the inspiring study by *Lucas (1973)*. The new classical school accepts Friedman's argumentation, but has an extreme hypothesis with regard to expectations. In their opinion, expectations are rational. Consequently, expectations adjust themselves to the changed economic policy immediately, and not in the long run. While with Friedman and Phelps it is possible for the economy to deviate from its natural rate through surprise inflation, with rational expectations monetary policy is unable to cause surprise inflation, and thus it is impossible to deviate from the natural rate even in the short run. Monetary policy is practically ineffective.

Formally, the relation between inflation and real economy is expressed by the following new classical Phillips curve:

$$\pi_t = \pi_t^e + by_t + \varepsilon_t, \quad (1)$$

where y_t is the output gap in period t , b is a positive parameter, π_t is inflation, π_t^e means the inflation expectations, and ε_t is a random error term. Since, according to the rational expectations hypothesis, economic agents cannot systematically

make mistakes upon creating the expectations, the deviation of π_t^e from π_t can only be a random variable with zero expected value, which is independent of economic policy. In other words, according to the new classical school, the Phillips curve is vertical already in the short run. Although monetary policy may influence the rate of inflation, it has no impact on real economy. Only random factors that are independent of monetary policy have an effect on the output gap.¹

4. The new Keynesian Phillips curve

As discussed in the previous section, based on the rational expectations hypothesis, new classical economics claimed that the Phillips curve is vertical in the short run as well, and as a result, monetary policy does not have an impact on real output. However, soon after the appearance of the new classical school, several authors pointed out that even if we accept the rational expectations hypothesis, the conclusion corroborating the ineffectiveness of monetary policy is only true if we assume that prices and wages are flexible, i.e. prices and wages react to the changes in demand and supply factors immediately.

However, in the case of sticky prices and wages the ineffectiveness of monetary policy cannot be proven. Prices and wages are sticky if they are fixed for a longer period of time, and under certain conditions they remain unchanged even if demand or supply changes. *Fischer (1977)* and *Taylor (1980)* showed that if prices/wages are fixed for at least two time periods (quarters), monetary policy is able to influence the real economy.

Calvo (1983) prepared a similar model, which, as it can be handled well technically, became the basis of the new Keynesian dynamic stochastic general equilibrium (DSGE) models, which became popular starting from the 1990s. The so-called new Keynesian Phillips curve can be deduced from Calvo's model. The special feature of the new Keynesian Phillips curve is that although it is based on rational expectations, trade-off still exists between output and inflation in the short run. In the long run, however, monetary policy becomes ineffective in the new Keynesian models as well, because in the case of an arbitrary monetary policy action, prices gradually adjust themselves to the changed situation.

For a more accurate understanding of the above, it is worth looking at Calvo's model in more detail. The fundamental assumption of the model is that a random process regulates the number of time periods during which a given firm sets the price of its product. Let γ be the probability that a given company's current output price remains valid in the next time period as well. The greater γ , the stickier the

¹ Similar argumentation can be applied to any economic policy that is based on influencing aggregate demand. Accordingly, it can be applied to fiscal policy as well. However, it is not valid in the case of economic policies that influence structural factors and aggregate supply. Consequently, even in the new classical case it cannot completely be stated in general that economic policy is ineffective.

prices. Accordingly, the probability that the given company will set a new price in the next period is $(1-\gamma)$. We assume that γ does not depend on since when the current price has been valid.

It follows from the above that if a firm sets the price of its product at a given time t , the optimally determined price is described by the following (log-linearised) formula:

$$p_t = (1 - \beta\gamma) \sum_{i=0}^{\infty} (\beta\gamma)^i MC_{t+i}, \quad (2)$$

where $0 < \beta < 1$ is the discount factor of the owner of the company. According to the above expression, if a firm sets a new price (p_t) at date t , in the case of an optimum choice the new price equals the weighted sum of the current and future expected marginal costs (MC_{t+i}), where the weight of an item declines with the distance in time it refers to. The weights are the functions of parameters β and γ . If $\gamma = 0$, i.e. pricing is flexible, we obtain the price = current marginal cost formula, which is a well-known formula of standard microeconomics. The above price formula of the Calvo model is its generalisation: as the price determined at date t will probably remain valid in the future as well, it is optimal if it is the function of not only the current but also of the future expected marginal costs. However, the further a future date, the less probable that the price chosen now will be valid then. Therefore, the expected marginal costs of later dates have smaller and smaller weights in the formula.

It can be demonstrated that if there are similar firms in the economy, and they set their prices according to the Calvo model, and the same γ applies to all of them, the following relationship will be true for aggregate inflation:

$$\pi_t = \beta\pi_{t+1}^e + \frac{(1-\gamma)(1-\beta\gamma)}{\gamma} \omega mc_t + \varepsilon_t, \quad (3)$$

where π_t is inflation at date t , π_{t+1}^e is the expectation for inflation at time $t+1$, mc_t is the real marginal cost (nominal marginal cost divided by the price level), while ω positive parameter measures to what extent the optimum price of a given company depends on aggregate variables and to what extent on the relative position of the competitors' prices.² If the choice of the optimum price of the company primarily depends on aggregate factors, the value of ω is high, but if the position of competitors is also important, the value of ω is relatively low.³

The importance of formula (3) is that it establishes a relation between real marginal cost, which characterises the state of the real economy, and developments in

² The findings of Rotemberg (1982; 1983) are similar on the basis of a different model, where the cost of the price change is a quadratic function of the size of the price change.

³ According to the terminology that is often used in literature, ω is the index of the degree of strategic complementarity.

inflation. In this sense it can be considered a quasi Phillips curve, even if the output gap or unemployment is not among the variables.

The economic interpretation of equation (3) is worth thinking over in an intuitive manner. Equation (3) is obtained by aggregating and rearranging equation (2), which represents the pricing behaviour of individual firms. According to equation (2), in the case of sticky prices, expectations for future marginal costs also matter upon determining the price. In the aggregate equation (3) derived from it, these expectations are represented in a compact form by the term π_{t+1}^e .

The real marginal cost sensitivity of the developments in inflation, i.e. the slope of the quasi Phillips curve (3), depends on the degree of price stickiness, i.e. γ . The intuitive explanation for this is as follows: if pricing is nearly flexible, i.e. γ is close to 0, the weight of the terms concerning the future is low in formula (2). Therefore, if the current marginal cost changes, the new prices of firms that are preparing for repricing will strongly react to the change in the marginal cost. In addition, if prices are flexible, many firms reprice their products at all points in time. The result of these two impacts is that the aggregate price index, and thus inflation as well, will react strongly to the change in the aggregate real marginal cost.

By contrast, if prices are very sticky, i.e. γ is close to 1, the weight of the current marginal cost in formula (2) is relatively low, and the firms that are changing their prices react to the changing of the current marginal cost only slightly when determining the new price. Moreover, in this case, only a few firms want to change prices at any time. As a result, inflation will also react modestly to the change in the aggregate real marginal cost.

Summarising the above, the stickier the prices, the smaller the coefficient of the real marginal cost, i.e. the flatter the quasi Phillips curve. In other words, the coefficient of the real marginal cost is monotonously declining in γ .

In addition to price stickiness, parameter ω also affects the slope of the quasi Phillips curve. Intuitively, this is also easy to explain. If the decisions of the optimally repricing firms are fundamentally determined by aggregate economic developments and not by the competitors' behaviour, i.e. if the value of parameter ω is high, new individual prices, and thus inflation as well, react strongly to the aggregate real marginal cost. In contrast, if ω is low, i.e. the competitors' prices are also important for those who choose new prices, they take into account that, due to sticky prices, some competitors do not change their prices, and therefore they also take a smaller step as a response to the changes in aggregate economic indicators (for example, they increase their prices to a lesser extent, to prevent their consumers from preferring the competitors). Consequently, in this case the reaction of inflation to the aggregate real marginal cost is relatively weak.

The real marginal cost included in equation (3) can be defined as follows:

$$mc_t = (1 - \alpha)(\chi_w w_t + \chi_z z_t + \chi_x x_t - A_t) + \alpha p_t^m, \quad (4)$$

where w_t is the real wage, z_t is the real rental rate of capital, x_t is the volume of the company's real output, and A_t is the measure of productivity, whereas p_t^m is the real price of imported inputs, and α , χ_w , χ_z , χ_x are non-negative parameters that depend on the production function.

The quasi Phillips curve represented by formula (4) can be converted into a Phillips curve in the traditional sense. Let us assume that $\alpha = 0$, i.e. it is a closed economy. Then, under certain conditions, equation (3) can be expressed with the help of the output gap,

$$\pi_t = \beta \pi_{t+1}^e + \frac{(1 - \gamma)(1 - \beta\gamma)}{\gamma} \omega \kappa y_t + \varepsilon_t \quad (5)$$

where y_t is the output gap and κ is a positive parameter that depends on the wage elasticity of labour supply and the preferences of the representative household.

If it is not a closed economy, marginal cost (4) can be approximated by the expression $mc_t = \kappa(1 - \alpha)y_t + \alpha p_t^m$. Using this, the quasi Phillips curve can be expressed as follows:

$$\pi_t = \beta \pi_{t+1}^e + \frac{(1 - \gamma)(1 - \beta\gamma)}{\gamma} \omega [\kappa(1 - \alpha)y_t + \alpha p_t^m] + \varepsilon_t \quad (6)$$

In the literature, formula (5) is called new Keynesian Phillips curve, but below we refer to expression (6) as well by using this name.

The main features of the new Keynesian Phillips curve are as follows:

- i. Firstly, *unlike* in the new classical case, monetary policy is able to have an impact on the real economy through inflation in the short run. In the new classical Phillips curve, the output gap depends on the difference between π_t and π_t^e , and if rational expectations are assumed, the deviation of inflation at date t of time from the relevant expectation can only be caused by unforeseeable shocks that are independent of economic policy. By contrast, in the new Keynesian Phillips curve, the output gap depends on the difference between the expectations concerning *current* (π_t) and *future* (π_{t+1}^e) inflation. And the difference between the two may differ in the short run even with rational expectations, and this difference may be influenced not only by random shocks, but by monetary policy as well. If economic policy changes, and according to economic agents' expectations future inflation will deviate from the current inflation, exactly

as a result of the changed monetary policy, according to the new Keynesian Phillips curve it will have an impact on the real economy as well.

- ii. Secondly, in the long run, the effect of inflation on the real economy is neutral, *like* in the new classical case. Namely, with rational expectations (if certain stability conditions exist), in the case of any shock, following the occurrence of the shock, π_t and π_{t+1}^e converge to the same value; therefore, in the long run they will not have an effect on the output gap.
- iii. Thirdly, the slope of the Phillips curve, i.e. the coefficient of the output gap, depends on the degree of price stickiness. The stickier the prices (i.e. the greater γ), the flatter the Phillips curve. A flatter Phillips curve implies that the same change in the real economy has a lower impact on inflation. However, if prices are flexible, i.e. $\gamma = 0$, the Phillips curve will be vertical in the short run as well, i.e. $y_t = 0$ in expected value. Consequently, we are back to the new classical case, in which monetary policy is unable to influence the real economy.

The intellectual importance of the new Keynesian Phillips curve is that the expectations were successfully integrated in the theory in such a manner that it is in harmony with the widespread opinion that monetary policy is able to influence the real economy. However, it is important to note that the new Keynesian Phillips curve is basically a supply relation. Accordingly, the behaviour of the economy cannot be described precisely with the help of the Phillips curve alone. It has to be complemented with aggregate demand relations and a monetary policy rule.

However, the form of the new Keynesian Phillips curve represented by equations (5) and (6) is not completely problem free. Namely, its feature that it does not contain a backward-looking inflation term (π_{t-1}) is hard to reconcile with empirical experiences concerning the developments in inflation, i.e. that inflation is a slowly changing and rather persistent process.

This problem is resolved by the version of the new Keynesian Phillips curve in *Smets and Wouters (2003)*. This approach is based on a different concept of sticky prices. In the original Calvo model, a company either chooses a new price optimally or leaves the already existing one unchanged. In the amended model, it chooses a new price either optimally or by following a simple rule of thumb. While the idea behind the approach to sticky prices according to Calvo is that it is not worth changing the prices at each time period because it is costly, according to the amended approach it is not the price change that has a cost but the optimum determination of the prices, as the collection of the necessary information and the performance of calculations require resources.

All this is formalised as follows. A random process regulates the frequency of the time periods when a given company optimally determines the price of its product.

Let us use $(1-\gamma)$ to indicate the probability that a firm will optimally set the price of its product in the next time period. Consequently, the probability that it will follow a simple rule of thumb at date $t+1$ is γ . It is assumed that the rule of thumb is an indexing scheme based on past inflation: $p_{t+1} = p_t(1+\pi_{t-1})^\nu$, where $0 < \nu < 1$ is the degree of indexation. It is assumed again that γ is independent of when a company priced optimally last.⁴

On the basis of these assumptions the connection between inflation and the real economy can be described by the following formula:

$$\pi_t = \frac{\beta}{1+\beta\nu} \pi_{t+1}^e + \frac{\nu}{1+\beta\nu} \pi_{t-1} + \frac{(1-\gamma)(1-\beta\gamma)}{(1+\beta\nu)\gamma} \omega m c_t + \varepsilon_t \quad (7)$$

Similarly to the above, the aforementioned quasi Phillips curve can also be expressed as

$$\pi_t = \frac{\beta}{1+\beta\nu} \pi_{t+1}^e + \frac{\nu}{1+\beta\nu} \pi_{t-1} + \frac{(1-\gamma)(1-\beta\gamma)}{(1+\beta\nu)\gamma} \omega \kappa y_t + \varepsilon_t \quad (8)$$

or as

$$\pi_t = \frac{\beta}{1+\beta\nu} \pi_{t+1}^e + \frac{\nu}{1+\beta\nu} \pi_{t-1} + \frac{(1-\gamma)(1-\beta\gamma)}{(1+\beta\nu)\gamma} \omega \left[\kappa(1-\alpha)y_t + \alpha p_t^m \right] + \varepsilon_t \quad (9)$$

Equations (8) and (9) are called hybrid new Keynesian Phillips curves.

In the hybrid new Keynesian Phillips curve, the greater the degree of indexation ν , the higher the weight of the backward-looking inflation term. In the special case when $\nu = 0$, we get back to the original new Keynesian Phillips curve (equations 5 and 6). The slope of the Phillips curve depends on the same factors as in the case without indexation. The only difference is that the degree of indexation also affects the slope of the curve. The higher the degree of indexation, the flatter the Phillips curve.

It is true for the hybrid new Keynesian Phillips curve as well that in the short run monetary policy is able to affect the real economy, but over the long term this curve is also vertical, i.e. over the long term, monetary policy is able to influence the rate of inflation only. This latter assertion is modified to some extent if downward rigidity of nominal wages is introduced.

Originally, Keynesian economics deduced from the rigidity of nominal wages and not from that of prices that monetary policy may have a real impact. Moreover,

⁴ A similar model can be found in *Christiano et al. (2005)*, but the authors assume that $\nu = 1$.

they did not simply assume the stickiness of wages, but the downward rigidity of wages; see *Tobin (1972)*. Emphasis shifted in the direction of price stickiness later.

At the same time, the assumption of downward wage rigidities was based on not strict empirical analyses, but rather on anecdotal opinion. By contrast, new classical economics expressly refused the assumption of any nominal rigidity, although these arguments were not empirical either, but logical. The concept of downward wage rigidities was revived in the late 1980s, as an increasing amount of empirical evidence supporting this assumption could be found; see the overview of these empirical analyses by *Akerlof et al. (1996)*.

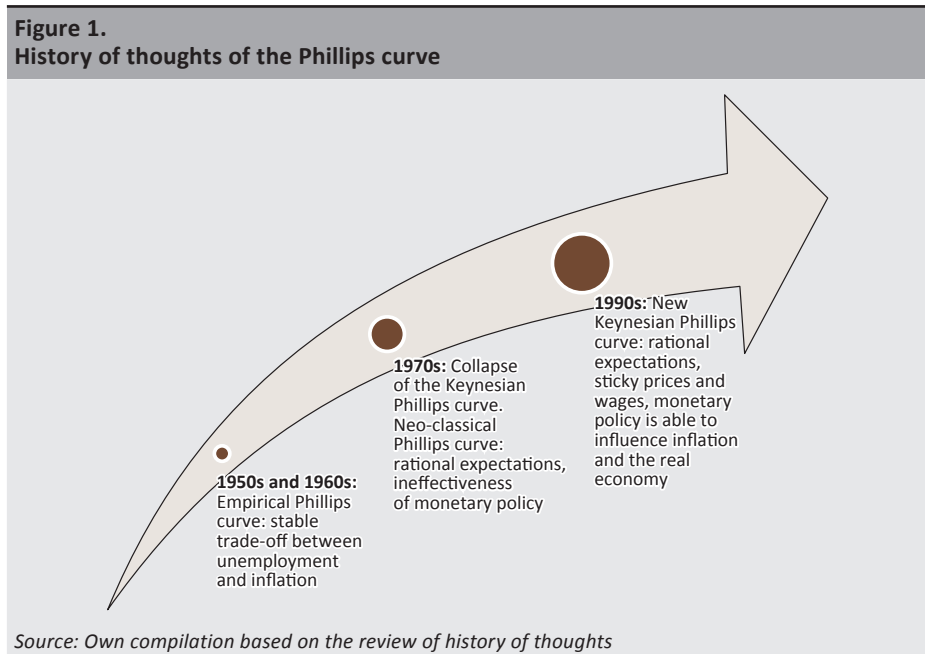
The consequence of downward wage rigidities is that the Phillips curve is not completely vertical over the long term either, so it is not true that over the long term any level of inflation can be reconciled with the natural rate of unemployment or output. In the case of downward wage rigidities, a very low level of inflation can only be maintained over the long term if unemployment is higher than its natural rate. This is one of the reasons why central banks do not pursue full price stability, but have a low, although not zero, inflation target.

Intuitively, it can be explained as follows. For the sake of simplicity, let us assume that the developments in prices are exclusively determined by wages, and the real wage clears the labour market, except when attaining the equilibrium real wage would require the reduction of the nominal wage. In this case, nominal wage remains constant, and quantitative adjustment takes place in the labour market, or if the quantitative adjustment is large enough (many people lose their jobs), some nominal wage decline is tolerated. If inflation is relatively high, there is only a very low probability that the downward rigidity of nominal wages binds. Namely, if monetary policy tightening results in a negative shock for the economy and the real wage has to decline, due to the high inflation it may take place even if nominal wages are increased. Accordingly, in a case like this, wages (as well as prices) adjust flexibly, and thus the behaviour of the economy will be similar to the new classical case, and the Phillips curve will be vertical.

Nevertheless, with the above assumptions we come to completely different conclusions if inflation is very low, close to zero. In this case, if, due to monetary policy tightening, labour market equilibrium requires the reduction of real wages, it could take place only with declining nominal wages. Therefore, wages remain unchanged, and quantitative adjustment takes place, and if it is sufficiently significant, a slight nominal wage decline may take place. As a result, inflation declines slightly, but at the price of a high real loss. Accordingly, while the Phillips curve is almost vertical with high inflation, it is almost horizontal in the case of low inflation.

The above intuitive reasoning is corroborated by formal models as well, such as the static model of *Akerlof et al. (1996)* or the dynamic one of *Benigno and Ricci (2011)*.

In summary: The empirical Phillips curve used in the 1950s and 1960s ‘collapsed’ during the stagflation of the 1970s. New classical economics gave an answer to this phenomenon by taking into account the impacts of inflation expectations, and a new Phillips curve approach was proposed, which, in turn, implied the ineffectiveness of monetary policy. New Keynesian economics accepted that expectations play a key role, but with the introduction of nominal rigidities it showed that in the short run monetary policy is able to affect both inflation and real economy. Moreover, in the case of downward wage rigidities, in a low inflation environment monetary policy is not neutral over the long term either. The history of thought outlined here is summarised in Figure 1.



5. Coefficients of the Phillips curve in a changing economic environment

The size of the coefficients and the degree of the slope of the Phillips curve have important economic policy implications. In a low inflation environment, a flat Phillips curve helps economic policy. In this case economic policy may stimulate economic growth while inducing negligible additional inflation. Or in a reversed case, if the economy is hit by a negative shock, it does not result in a deflationary spiral.

On the other hand, in a high inflation environment a flat Phillips curve causes difficulties for economic policy. In this case, if economic policy wants to cut inflation, and does not succeed in reducing inflation expectations, it can only be achieved by a major reduction of real economic activity, i.e. the sacrifice ratio of disinflation is high.

In view of the above, it is important to understand what factors influence the coefficients of the Phillips curve and how the change in the economic environment affects these. The effects of two factors are examined in this section: (i) firstly, the effects of the change in the inflation environment. (ii) Secondly, the effects of globalisation.

First, we examine how the inflation environment affects the three key parameters of the new Keynesian Phillips curve, i.e. γ , which represents the degree of price stickiness, ν , which is the degree of indexation and ω , which measures the sensitivity of pricing decisions to competitors' prices.

In a high inflation environment, where prices change quickly, it is not worth maintaining prices for a long time, which justifies relatively frequent repricing, i.e. γ will be relatively small. Besides, even if a company does not price optimally in a given period of time, knowing that the general price level will increase in the given period, it will also raise its prices roughly by as much as the rate of inflation, and if it does not prepare an accurate forecast, it will estimate the rate of inflation on the basis of past inflation, and thus the value ν of will be relatively high.

High inflation environment affects the value of parameter ω as well. The study by *Mackowiak and Wiederholt (2009)* shows that if optimal decision making is costly and a choice has to be made whether to decide mainly on the basis of macroeconomic or microeconomic information, in the case of high and volatile inflation it is better to concentrate on the macroeconomic factors during optimal pricing, and accordingly in this case the value of ω will be relatively high.

Summarising the above, in the case of high inflation the weight of the backward-looking term in the Phillips curve is expected to be high. Moreover, if prices are sufficiently flexible, the coefficient of the output gap will also be relatively high, which means that inflation can be reduced with a relatively small real economy sacrifice. This is in line with the empirical observation that if there is political will and credibility, the reduction of two-digit inflation to one-digit is usually a relatively simple task that can be performed relatively quickly.

If there is price stability, i.e. in a low and predictable inflation environment, it is not important to index to past inflation, especially if inflation expectations are anchored due to a credible monetary policy. Therefore, the value of ν may be close to zero. As the average change in prices is smaller, if a company does not reprice

optimally, it makes a smaller mistake; therefore, the motivation for regular optimal repricing is lower, i.e. the value of γ may be relatively high. Besides, in the case of low inflation, sector specific information regarding the behaviour of competitors appreciates during decision making, while the weight of macroeconomic factors depreciates. Accordingly, the value of ω will be low.

Based on the above, in a low inflation environment, if inflation expectations are anchored (for example in the case of a successful inflation targeting regime), the weight of the forward-looking inflation term will be high, while that of the backward-looking term will be low in the Phillips curve. In addition, if prices are sufficiently sticky, the coefficient of the output gap will be low, i.e. the Phillips curve will be flat. In the case of downward wage rigidities, the curve will become even flatter in parallel with a close-to-zero inflation rate. All of this is in line with the observation that the further reduction of relatively low inflation is possible only with significant real sacrifice.

The following presents an examination of how globalisation affects the coefficients of the Phillips curve. Trade relations become stronger as a result of globalisation. One of the consequences is that often better-quality and/or cheaper foreign inputs are used for production instead of the domestic input used before. As a result, in real marginal cost equation (4), α , the weight of foreign input will grow, and therefore, in the new Keynesian Phillips curves (6) and (9) the coefficient of output gap y_t will decline, i.e. the curve will be flatter.

At the same time there is another impact as well, which is examined in *Sbordone (2007)*. Accordingly, another effect of globalisation is that a company in a given sector will have multiple competitors. One of the consequences is that as a result of changing a given firm's individual price, the demand for the firm's products changes to a greater extent than in the case of fewer competitors (for example, in the case of a price increase, demand for the products of a monopoly falls to a lesser extent than if the same price increase was implemented by a company in a competitive market). Accordingly, the presence of multiple competitors stemming from globalisation reduces the size of ω , as the importance of aggregate economic indicators relatively depreciates from the point of view of the given firm compared to the impact of the decisions of the competitors in the sector. At the same time, the price sensitivity of demand is relevant in terms of the optimal pricing decision only as far as the changing demand affects the marginal cost of the given company. The lower the degree of decreasing returns in the firm's production function, the lower the impact of demand on the marginal cost. *Sbordone* argues that, as a result of stronger competition, the demand sensitivity of marginal cost declines, which, in turn, adds to ω , as it devalues the role of competitors and raises the weight of macroeconomic developments. *Sbordone* examined the result of these two impacts with the help of a calibrated model; according to his findings,

the second impact is stronger, i.e. ω increases as a result of globalisation, and the Phillips curve will be steeper.

At the same time, *Guilloux-Nefussi (2015)* challenges the correctness of Sbordone's assertions. In her opinion, globalisation cannot simply be described by the fact that there will be more competitors in the market. More productive firms will have greater opportunities in a larger market, and will be able to have a higher share in export markets. Consequently, due to their size they will be less sensitive to competitors' decisions, which reduces ω , i.e. globalisation eventually still points to the flattening of the Phillips curve.

6. Empirical results

Although the new Keynesian Phillips curve that is based on the Calvo pricing provides a versatile theoretical framework, it becomes really practicable if it is possible to measure the parameters of the curve empirically.

One of the first attempts to do so was made by *Gali and Gertler (1999)*. Their analysis did not focus on economic policy; they primarily wanted to know whether they would be able to estimate significant parameters whose sign is consistent with the theory. Therefore, the estimated equation did not include the output gap, but it included the real marginal cost, which is a more fundamental notion from the aspect of the theory.

They prepared their estimate for the United States, and approximated the real marginal cost with the wage share, while capturing inflation expectations with instrumental variables. Their findings were consistent with the theory. Firstly, they confirmed the importance of inflation expectations; according to their estimates, the coefficient of the backward-looking inflation term is much smaller than that of the forward-looking one. Secondly, the coefficient of the real marginal cost term is significant and positive. Using European data, the findings of the study by *Gali et al. (2001)* are similar.

Their findings were of high importance in terms of the testing of the new Keynesian Phillips curve, but at the same time their method was criticised by many. For example, *Rudd and Whelan (2002; 2007)* call attention to the fact that the applied GMM method tends to overestimate the coefficient of the forward-looking inflation term.⁵

Below is an overview of studies whose focus is not on the methodology, but on the question that is important in terms of practical economic policy, i.e. how the parameters of the Phillips curve change over time.

⁵ In her study, *Lendvai (2005)* prepared a similar estimate for Hungarian data. See also the studies by *Kucséra (2013)* and *(2014)*.

Roberts (2006) estimated the slope of the reduced-form Phillips curve for the data of the United States for two different periods: 1960–1983 and 1984–2002. He found that the slope of the curve declined nearly to half by the second period. The decline in the curve, although not its degree, can be considered robust even in the case of various specifications of the output gap. On the basis of the production function based output gap, the fall is between 30 and 40 per cent depending on the period chosen (1961–1979 or 1961–1983), while applying the output gap used by the US Congressional Budget Office the decline in the slope of the curve is merely between 12 and 23 per cent.

Williams (2006) also tried to estimate the possible change in the slope of the Phillips curve using data for the United States. He carried out the estimation on samples of various periods: the samples started between 1980 and 1999, and always ended with 2006. According to the findings, the slope was much lower in the case of the samples starting in the 1990s than in the case of ones starting in the 1980s.

Boivin and Giannoni (2006) estimated structural VAR models for US data for two different periods: 1959–1979 and 1979–2002. According to their estimate, the slope of the Phillips curve declined by more than 25 per cent between the two periods. In the authors' opinion, the underlying reason for this may have been the increase in price rigidities.

Borio and Filardo (2007) prepared their estimate for 16 developed countries and the euro area starting from 1972. The study called attention to the importance of global developments in terms of changes in inflation. It is important to emphasise that this empirical recognition is fully in line with the theoretical framework of the new Keynesian Phillips curve described in the previous section, as discussed therein. Nevertheless, most of the empirical works did not take the opportunity to examine this theoretical possibility.

This is why the study by Borio and Filardo is interesting; it points out that in terms of the developments in inflation the global factor is of significant importance. In their opinion, the models used for the forecasting of inflation are too country specific, and according to their analysis, models with more global approach are able to better capture the real developments. Based on their findings, the inclusion of the cyclical position of the world economy in the inflation model significantly increases its explanatory power, and in parallel with that the given country's cyclical position may be less relevant in terms of the developments in inflation.

The effects of the increasing globalisation in the world economy on inflation may appear through multiple channels. The development of the telecommunications sector significantly facilitated the geographical relocation of production and the decomposition of the production process into its components. The range of tradable goods expanded, and thus the substitutability of these products

across countries also increased. In addition, for economic agents the removal of the obstacles of foreign trade and financial regulations also contributed to the possibility of benefiting from technological innovations. Moreover, channelling of the countries that used to be based on planned economy into world trade also had a serious impact on the production potential of the global economy. All of these effects contributed to the possibility that global economic factors can more strongly influence developments in inflation in individual countries. In addition, the trend of the shift towards lower inflation can be identified through two channels. Approaching from the production side, a decline in wages may be caused by production relocation into countries with lower wage levels or by higher immigration, while examining from the demand side, the increasingly strong market competition may also result in lower inflation.

In its study, the *IMF (2006)* basically examined what impact globalisation may have had on the developments in inflation in the past decades. For the period of 1960–2004 a model was estimated for 8 developed countries to describe the developments in inflation, and the model is actually an extension of the framework of the traditional Phillips curve. According to the findings, the sensitivity of prices to the output gap really declined in the past decades. Similarly to the study by *Borio and Filardo (2007)*, the authors identify globalisation as the main factor.

At the same time, some dispute the role of globalisation in the flattening of the Phillips curve. In their study, *Ihrig et al. (2008)* estimated a Phillips curve equation for 11 OECD countries for the period 1977–2005. The slope of the Phillips curve estimated for the period 1977–1990 became higher than the one estimated for 1991–2005; accordingly, flattening of the curve is seen here as well. At the same time, in the authors' opinion there is no evidence that this decline is a result of globalisation. The countries where the importance of the domestic output gap declined the most were not the ones where the openness of foreign trade increased the most. In addition, based on the estimates, foreign trade openness did not have a significant impact on the sensitivity of inflation to output.

According to the Phillips curve estimate of *Ball (2006)* for the G7 countries for the period 1971–2005, foreign trade does not play a role in the flattening of the curve, and therefore he rejects the possibility that this phenomenon is caused by globalisation.

As a result of the deep and long-lasting global economic recession that unfolded as a consequence of the 2007–2008 financial crisis, special attention was paid to the issue of the slope of the Phillips curve. The underlying reason is as follows: as a result of the protracted recession, the output gap became negative to an unusual extent in developed countries, but the decline in inflation still remained moderate. Although it reached a much lower level than before, persistent deflation did not occur.

In terms of understanding this phenomenon, the study by *Blanchard et al. (2014)* is of key importance. It is a comprehensive analysis of the issue both in time and space: the Phillips curve was estimated for 20 countries with the help of time series starting in 1960, with variable parameters technique.

The estimated equation is as follows:

$$\pi_t = -\theta_t(u_t - u_t^*) + \lambda_t \pi_{t+1}^e + (1 - \lambda_t)\pi_{t-1} + \mu_t \pi_{mt} + \varepsilon_t \quad (10)$$

where π_t indicates inflation, u_t is the unemployment rate, u_t^* is the natural level of unemployment (the authors do not use the output gap, but they use the unemployment gap, which is closely related to the former), π_t^e represents long-term inflation expectations, π_{t-1} is the one quarter delaying of inflation, while π_{mt} indicates imported inflation compared to inflation (measured as deviation from the average).

Actually, the coefficient of λ_t indicates the stability of inflation expectations, the parameter θ_t is the slope of the Phillips curve, while μ_t reflects the importance of imported inflation.

The findings suggest that firstly, the stability of long-term inflation expectations has increased significantly since the 1970s, and secondly, the slope of the Phillips curve declined considerably over time. The increase in the anchoring of expectations is especially visible in the results of the USA, where this coefficient has grown significantly since the early 1990s. The decline in the slope of the Phillips curve mostly took place in the period between the 1970s and the 1990s; the coefficient did not decline further during the latest crisis.

Based on *Table 1*, it can also be established that while in 1985 the coefficient of the slope was significant everywhere except for 2 countries, in 2014 already in the case of 16 countries out of the 20 included in the estimate this value is not significantly different from zero. Accordingly, this relation is practically insignificant in statistical terms in most countries.⁶

The findings of the study by *Matheson and Stavrev (2013)* are similar. They estimated the Phillips curve on US data from 1961 to 2012, using a variable parameter model. Based on their results, the Phillips curve describes the developments in inflation in this period well. The parameter of the slope of the Phillips curve declined steadily in the estimation period, and by the very end of the sample it was only half of its value measured in the 1970s. Moreover, the decline in the coefficient can be considered robust for the various specifications of the natural rate of unemployment as well.

⁶ In addition to the changes in the parameters of the Phillips curve, Blanchard et al. also examined whether post-crisis recessions are attributable to hysteresis, and discuss the economic policy implications of this issue. As this is beyond the scope of our study, these issues are not discussed in this paper.

According to their findings, inflation expectations were not anchored in the 1970s; they became increasingly backward-looking and were volatile. However, starting from the 1980s, long-term inflation expectations started to decline before becoming stable at a lower level by the 2000s.

Table 1.
Coefficients on the unemployment gap, in 1985, 2000, 2014

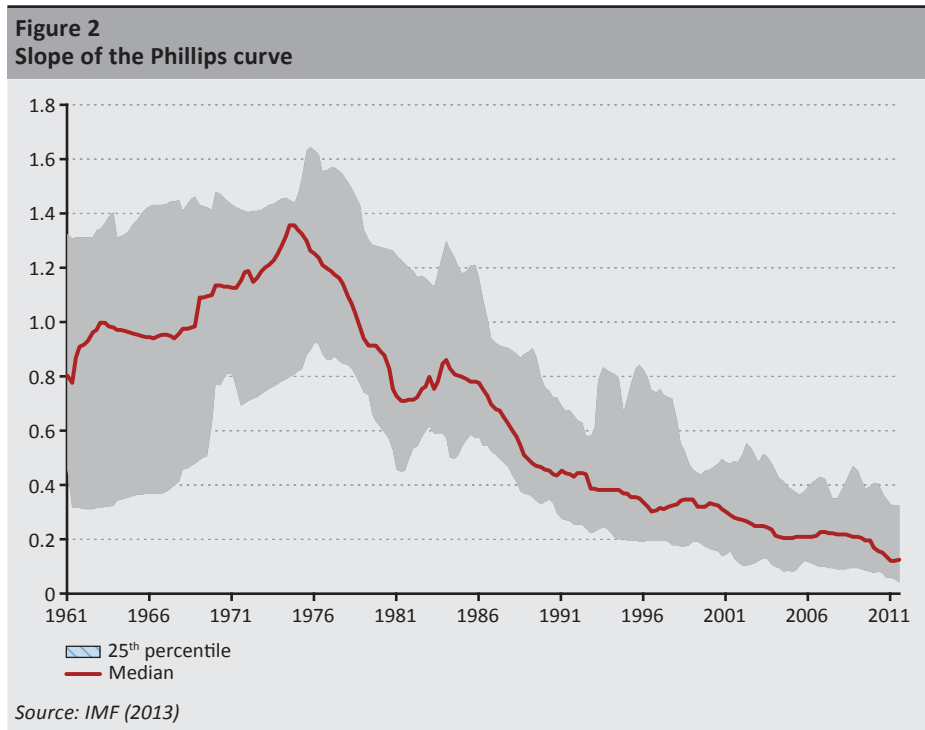
Country	Year	Coefficient	Standard error	Country	Year	Coefficient	Standard error
USA	1985	0.34	0.23	Switzerland	1985	3.32	1.6
USA	2000	0.23	0.18	Switzerland	2000	0.52	1.05
USA	2014	0.16	0.28	Switzerland	2014	0.96	1.24
Japan	1985	4.97	1.67	Sweden	1985	0.73	0.71
Japan	2000	0.78	0.98	Sweden	2000	0.61	0.57
Japan	2014	3.45	2.98	Sweden	2014	0.76	0.94
Germany	1985	0.72	0.18	Belgium	1985	0.67	0.22
Germany	2000	0.17	0.2	Belgium	2000	0.51	0.42
Germany	2014	0.03	0.25	Belgium	2014	0.56	0.76
UK	1985	0.8	0.37	Norway	1985	0.84	0.38
UK	2000	0.02	0.46	Norway	2000	0.43	0.39
UK	2014	0.24	0.94	Norway	2014	0.56	0.64
France	1985	1.11	0.21	Austria	1985	0.59	0.27
France	2000	0.38	0.33	Austria	2000	0.58	0.27
France	2014	0.65	0.42	Austria	2014	0.57	0.28
Italy	1985	1.31	0.34	Denmark	1985	0.58	0.29
Italy	2000	0.04	0.42	Denmark	2000	0.11	0.3
Italy	2014	0.4	0.37	Denmark	2014	0.22	0.39
Canada	1985	0.56	0.21	Ireland	1985	0.72	0.3
Canada	2000	0.35	0.26	Ireland	2000	0.29	0.23
Canada	2014	0.08	0.47	Ireland	2014	0.24	0.4
Australia	1985	0.27	0.31	Greece	1985		
Australia	2000	0.99	0.5	Greece	2000	0.15	0.11
Australia	2014	0.08	0.79	Greece	2014	0.15	0.11
Spain	1985	0.39	0.11	Portugal	1985	1.88	1.12
Spain	2000	0.11	0.14	Portugal	2000	0.38	1.06
Spain	2014	0.18	0.1	Portugal	2014	0.22	0.91
Netherland	1985	0.33	0.13	New-Zealand	1985	1.07	0.59
Netherland	2000	0.34	0.13	New-Zealand	2000	0.1	0.76
Netherland	2014	0.33	0.14	New-Zealand	2014	0.98	1.22

Source: Blanchard et al. (2014)

In addition, they documented the growth in the importance of imported inflation, which is not surprising in view of the increasing import penetration and globalisation, and is in line with the findings of the study by *Borio and Filardo (2007)*.

The findings of the *ECB (2013)* are also in conformity with the above. This study contains separate estimations for the slope of the Phillips curve for the euro area between 1997 and 2013 as well as for wage inflation and inflation, and, based on their findings, in both cases the impact of real economy factors on inflation has declined since the beginning of the crisis.

The study of the *IMF (2013)* estimated the parameters of the Phillips curve on the data of 21 developed countries between 1961 and 2011. It was found that the slope of the Phillips curve has been steadily declining since the mid-1970s (as shown in *Figure 2* as well), while the degree of anchoring of inflation expectations has continuously been increasing since hitting the bottom in the 1970s. However, the authors did not find a clear trend in the sample period in the case of the parameter that measures the importance of global factors.



For the interpretation of the above results that confirm one another, it is worth referring back to the theoretical framework discussed in the previous section. The Phillips curve becomes flatter if prices become stickier (γ increases), while the weight of the forward-looking term will be greater if the degree of indexation, i.e. v , declines. As it was discussed, a stable, low inflation environment where monetary policy effectively influences expectations may induce these changes.

All of this is in line with the fact that in the past two decades in the developed world an increasing number of countries adopted inflation targeting based on the management of inflation expectations, with the help of which they succeeded in creating a low inflation economic environment.

This process had already started prior to the outbreak of the 2007 crisis, but the subsequent protracted recession further reduced the level of inflation, which amplified the developments that had started before. Although the aforementioned studies do not prove it directly, since the outset of the crisis downward wage rigidities also have presumably added to the trend of the flattening of the Phillips curve. As presented in the previous section, downward wage rigidities become important and contribute to the flattening of the Phillips curve when the inflation rate comes close to zero per cent. And, the recent recession was exactly this kind of period.

At the same time, it is attributable not only to the flattening of the Phillips curve that the decline in inflation remained moderate during the crisis in spite of the significant negative output gap. According to the *ECB's (2013)* study, it also played a role that the composition of employment may have changed as a result of the crisis, and since the recession had a negative effect mostly on the low-qualified workers, the ratio of highly qualified people is higher among the employed, which, of course, adds to the level of aggregate wages. In addition, the increase in indirect taxes and administrative prices as a result of the fiscal consolidation may also have raised the level of inflation.

A further possible explanation of why the decline in inflation was not greater during the crisis is that a considerable portion of the observed high unemployment is attributable to long-term effects and not to cyclical ones. Consequently, the negative output gap is smaller, as the output gap is related to cyclical factors. The *IMF (2013)* study examines this argument from an empirical point of view, but rejects it, and is clearly in favour of the flattening of the Phillips curve and the anchoredness of expectations.

In connection with the results discussed so far, it is worth highlighting that if the output gap has only a small effect on inflation, it implies that the stabilisation of inflation requires enormous movements in the output gap. Moreover, if this relation is not only weak but uncertain as well, even significant changes in the

output gap do not necessarily guarantee the control of inflation. Accordingly, monetary policy should focus on output instead of inflation, but it is justified to ask what determines inflation in this case. Based on the results, inflation expectations do, which, in turn, are determined by the anchoring of expectations.

At the same time, the results have ambivalent implications. Although confidence in central banks increased considerably in connection with the achievement of the inflation target, simultaneously with that, central banks' ability to actually attain their objectives declined significantly, raising the question of what will anchor expectations in the future.

The overall picture related to the flattening of the Phillips curve is refined by some further empirical analyses. In his study, *Stevens (2013)* estimated the Phillips curve equation used in the articles by *Blanchard et al. (2014)* as well as *Matheson and Stavrev (2013)* for the euro area from 1980 to 2013, with the help of a somewhat different econometric specification. His main findings are similar to those of the aforementioned authors: the anchoredness of expectations increased, the importance of imported inflation grew, and the slope of the Phillips curve declined in the period under review. Although according to their estimations the slope of the Phillips curve will increase again at the end of the period, it is probably the result of the fact that the movement at the end of the period in the time series is identified by the HP filter as a trend, and therefore the estimate for cyclical unemployment underestimates the fall in demand during the current crisis. Eventually this results in the overestimation of the slope of the Phillips curve at the end of the estimation period.

Riggi and Venditti (2015) prepared an estimate for euro area data from 1999 to 2014. Their results are basically in line with the above, i.e. flattening of the Phillips curve is observed in the long run. At the same time, they claim that the situation changed in 2013 and 2014, and the Phillips curve became steeper. According to the authors, this may stem from changes in the structure of the economy. On the one hand, they mention lower nominal rigidities (more frequent price adjustments) as a possible underlying reason, which may be attributable to the structural reforms of some countries. On the other hand, they think it is possible that it was not the slope of the Phillips curve that changed, but that the output gap may be larger than estimated now.

Oinonen and Paloviita (2014) examined the slope of the Phillips curve in the case of the euro area for the period between 1990 and 2014 using a variable parameter estimation, with three different output gap variables. They found that the slope of the Phillips curve had increased since 2012. However, together with the Phillips curve's becoming steeper, they emphasise that changes in expectations remain one of the most important factors influencing euro area inflation.

7. Conclusions

The equation that captures the correlation between the developments in inflation and real economy developments is called the Phillips curve. Originally, the Phillips curve was a stable empirical relation discovered in the 1950s, which collapsed and became invalid during the stagflation of the 1970s. Nevertheless, complemented with expectations, the Phillips curve has remained a useful analytical tool.

The new Keynesian Phillips curve, which is widely used nowadays as well, captures the relationship between inflation, inflation expectations and the output gap. The coefficient of the output gap, i.e. the slope of the Phillips curve, is of key importance in the equation in terms of economic policy.

According to most of the empirical studies, a flattening of the Phillips curve was observed in the past decades, i.e. the coefficient of the output gap declined significantly. This is mainly attributable to the changes in corporate pricing behaviour and to the process of globalisation. At the same time, there is no guarantee that the trend of flattening will continue; in fact, as a result of certain circumstances, it may even reverse.

In the current low inflation environment, the flat Phillips curve is advantageous for economic policy, because it is possible to induce significant growth with minimum additional inflation.

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