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Inflation dynamics: a traditional perspective

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Abstract

We derive a traditional Phillips curve (TPC) under the assumption that a fraction of firms sells output at optimal prices, while the other fraction sells at contract prices. Our derivation delivers a pricing mechanism where inflation depends on expected inflation and the real optimal price, which is the real marginal cost. The parameters of this Phillips curve have a clear structural interpretation in much the same way as its new Keynesian counterpart. Using a Leontief-type technology, our baseline TPC features expected inflation, the labour share, demand pressure and a vector of supply shocks. We estimate this TPC for five developed and five emerging market economies and find that the degree of price rigidity is significant and correctly signed in most of the economies. We conclude that this TPC is a credible rival to its forward-looking new Keynesian counterpart.

JEL classifications: E31

1. Introduction

Modelling the dynamics of inflation remains a sharply contested area in macroeconomics. The two main contending theories of inflation are the new Keynesian Phillips curve (NKPC), popularized by Galí and Gertler (1999) and the Traditional Phillips curve (TPC) expounded by Fuhrer (1995) and Gordon (1997). The strength of the NKPC is that it is derived from explicit intertemporal optimization, and its parameters have a clear structural interpretation. In contrast, as noted by Fuhrer (1995), the greatest weakness of the TPC is its lack of theoretical underpinnings. Galí and Gertler (2003) summarize the criticism of the TPC as follows: 'With the TPC, inflation depends on the output gap and an arbitrary number of lags of inflation. In contrast to the NKPC, the exact specification, of course, is not explicitly guided by theory. Also, the TPC rules out the possibility that beliefs about the future may affect current price setting and, hence, inflation'.

Despite this criticism, empirical research tends to find that the TPC is robust in the sense that its parameters are stable over time (Blinder, 1997). Fuhrer (1995) finds that the TPC produces 'remarkably stable' dynamic simulations. Turner (1997) finds that the instability of the TPC is mainly due to changes in the steady state inflation rate, while Stock and Watson (1999) find that the instability of the TPC is concentrated on the parameters of lagged inflation. However, an important finding by both these studies is that such instability is not significant and it is quantitatively small. Further evidence of the robustness of the TPC is provided by Bajo-Rubio *et al.* (2007) in the case of Spain. Mazumder (2012) also finds that the TPC is robust to changes in policy regimes under different Fed Chairmen. There is even evidence of the stability of the TPC in emerging markets, as found by Mazumder (2011) in the case of India and Dladla and Malikane (2022) in the case of South Africa.

In the light of these strengths of the TPC, it is important that its theoretical underpinnings be explicitly put forward. Indeed, notwithstanding its lack of derivation from firms' optimization, the TPC continues to be used extensively as a tool to gain insight into how the economy works. It is prominent in many studies that estimate the non-accelerating inflation rate of unemployment (NAIRU), for example, Gordon (1997), Laubach (2001), Fabiani and Mestre (2004) and Basistha and Starz (2008). The TPC has also been used to understand the dynamics of inflation since the Great Recession, for example, Ball and Mazumder (2011, 2019), Watson (2014), Coibion and Gorodnichenko (2015) and Blanchard (2016). This continued relevance of the TPC, coupled with critiques of the NKPC, such as those by Rudd and Whelan (2005, 2007), Fair (2008) and Nason and Smith (2008) regarding weak macroeconomic evidence of forward-looking behaviour in the inflation process, provides motivation to revisit the theoretical foundations of the TPC.

In this article, we provide a framework for the theoretical derivation of a structural TPC. The aim of this exercise is to provide the theoretical meaning of the parameters of the TPC. We do so by postulating a simple price formation scheme in which firms sell part of their output at contract prices and the other part at optimal prices. Alternatively, there is a fraction of firms that optimize prices, while the other fraction uses a simple contracting scheme to set prices. This scheme leads to an inflation process in which actual inflation is driven by lagged inflation expectations and the real optimal price. The real optimal price is, in turn, driven by the real marginal cost. This delivers a backward-looking pricing equation with a forcing variable that is similar to the one in Galí and Gertler (1999). Given a Leontief-type production function, our Phillips curve naturally admits an arbitrary number of supply shocks. Lastly, we empirically compare our Phillips curve with its new Keynesian counterpart.

This article is structured as follows: Section 2 derives the backward-looking price Phillips curves from micro-foundations. Section 3 provides empirical evidence of the model. Section 4 concludes.

2. A structural traditional Phillips curve

2.1 The pricing environment

Assume an economy that is populated by monopolistically competitive firms. In this environment, a part of the output that is produced is sold at a price that firms have contracted with some of their customers in the previous period. Another part of the output is sold at the current profit-maximizing spot price to 'walk-in' buyers. Alternatively, there exists a fraction of firms that sell at contract prices, while another fraction sells at optimal prices. This environment implies that:

$$P_t = \upsilon_p P_t^* + \left(1 - \upsilon_p\right) P_t^c \tag{1}$$

where P_t is the average price level, P_t^* is the profit-maximizing price level, P_t^c is the contract price that prevails at time t and $0 < \upsilon_p < 1$ is the fraction of output that is sold at the profit-maximizing price level. Note that in the new Keynesian literature, for example, Galí and Gertler (1999), the parameter υ_p represents the fraction of firms that adjust their prices at time t.

It is important that the contract price be clearly explained. Suppose we are at time $t-1$, and the firms negotiate the contract price P_t^c, at which they will sell the contracted output at time t. In setting the contract price, firms use the prevailing price level at $t-1$ as a reference point and then they apply their expected inflation rate on this reference price to arrive at the contract price. Therefore, the contract price is as follows:

$$P_t^c = \left(1 + \pi_{t-1}^e\right) P_{t-1} \tag{2}$$

where π_t^e is the expected rate of inflation that is applied on the contract price at time t, to be effective at time $t+1$. In Equation (2), the contract price that prevails at time t is negotiated one period earlier, at $t-1$, and the expectation of the inflation rate that is applied to generate that contract price is π_{t-1}^e. Equation (1) can then be written as follows:

$$P_t = \upsilon_p P_t^* + \left(1 - \upsilon_p\right)\left(1 + \pi_{t-1}^e\right) P_{t-1} \tag{3}$$

Divide both sides of Equation (3) by P_{t-1} and express it in terms of the inflation rate:

$$(1 + \pi_t) = \upsilon_p (1 + \pi_t) \frac{P_t^*}{P_t} + \left(1 - \upsilon_p\right)\left(1 + \pi_{t-1}^e\right) \tag{4}$$

Linearizing Equation (4) around a zero steady-state inflation rate implies that $P_t = P_t^*$ at the steady state; therefore, we obtain:

$$\pi_t = \pi_{t-1}^e + \lambda_p \left(p_t^* - p_t\right) \tag{5}$$

where $\lambda_p = \frac{\upsilon_p}{1-\upsilon_p}$ is the measure of price flexibility, which is the inverse of price rigidity due to price contracts. Note that, as $\upsilon_p \to 1$, we have that $\lambda_p \to \infty$, meaning that as the share of output that is sold on the contract price declines, firms change prices more rapidly in response to deviations from optimality. The Phillis curve becomes vertical in the limit. From Equation (5), we further note that price inflation is due to the expected inflation rate that is embedded in the contract price and firms' attempts to align prices with their profit-maximizing level.

2.2 Production and marginal cost pricing

Production in the short run is undertaken on the basis of a Leontief technology such that:

$$Y_t = \min(N_t^{\alpha}, Z_{1t}^{\delta_1}, \ldots, Z_{mt}^{\delta_m}) \tag{6}$$

where N_t is the level of employment and Z_{it} is the amount of the non-labour input i.[1] Real total costs are given by:

$$TC_t = \frac{W_t N_t}{P_t} + \sum_{i=1}^{m} \frac{P_{it}}{P_t} Z_{it} \tag{7}$$

where TC_t is total cost, W_t is nominal wage and P_{it} is the price of the non-labour input i. Using Equation (7), we can write the cost function in terms of output to obtain the following equation:

$$TC_t = \frac{W_t Y_t^{\frac{1}{\alpha}}}{P_t} + \sum_{i=1}^{m} \frac{P_{it}}{P_t} Y_t^{\frac{1}{\delta_i}} \tag{8}$$

[1] For a similar production function, see Flaschel (2009, p. 107) and Batini *et al.* (2005).

Real marginal cost is given by:

$$MC_t = \frac{1}{\alpha}\left(\frac{W_t N_t}{P_t Y_t}\right) + \sum_{i=1}^{m} \frac{1}{\delta_i}\frac{P_{it}}{P_t} Y_t^{\frac{1}{\delta_i}-1} \tag{9}$$

Note that the first term on the RHS of Equation (9) contains the labour share. Therefore, we can write real marginal cost as:

$$MC_t = \frac{1}{\alpha} S_t + \sum_{i=1}^{m} \frac{1}{\delta_i}\frac{P_{it}}{P_t} Y_t^{\frac{1}{\delta_i}-1} \tag{10}$$

where S_t is the labour share. Profit maximization implies that the optimal real price is a constant markup over real marginal cost, so that:

$$\frac{P_t^*}{P_t} = (1+\mu) MC_t \tag{11}$$

The next task is to find a linear approximation for Equation (11). Log-linearizing around the steady state and then applying Equation (5), we obtain:

$$\pi_t = \pi_{t-1}^e + \lambda_p \widehat{mc}_t \tag{12}$$

Note that Equation (12) is similar to the marginal cost-based inflation equation found in new Keynesian literature (see Equation 3 of Galí and Gertler, 1999). The only difference is that the expectations term in Equation (12) is not necessarily forward-looking. Since the markup rate is constant, this allows us to derive the linear approximation for Equation (11) to be:

$$\begin{aligned}\widehat{mc}_t = {} & \frac{S_0}{\alpha MC_0}(s_t - s_0) + \left(\sum_{i=1}^{m} \frac{1}{\delta_i}\left(\frac{1-\delta_i}{\delta_i}\right)\frac{p_{i0} Z_{it}^0}{MC_0 Y_t^P}\right)(y_t - y_t^p) \\ & + \sum_{i=1}^{m}\left(\frac{1}{\delta_i}\right)\frac{p_{i0} Z_{it}^0}{MC_0 Y_t^P}(\tilde{p}_{it} - \tilde{p}_{i,0})\end{aligned} \tag{13}$$

where s_t is the natural log of the labour share, s_0 is the natural log of the steady state level of the labour share, Y_t^P is potential output, y_t is the natural log of output, with y_t^p being the natural log of potential output, Z_{it}^0 is the amount of the non-labour input, $\tilde{p}_{it}$ is the natural log of p_{it}, which is the relative price of the non-labour input and p_{i0} is the steady state relative price of the non-labour input. Note from Equation (9) that at the steady-state, we have:

$$1 = \frac{1}{\alpha}\frac{S_0}{MC_0} + \sum_{i=1}^{m} \frac{1}{\delta_i}\frac{p_{i0} Z_{it}^0}{MC_0 Y_t^P} \tag{14}$$

Let $\vartheta_i = \left(\frac{1}{\delta_i}\right)\frac{p_{i0} Z_{it}^0}{MC_0 Y_t^P}$. For compactness, we can therefore write the linearized real marginal cost as follows:

$$\widehat{mc}_t = \left(1 - \sum_{i=1}^{m}\vartheta_i\right)(s_t - s_0) + \theta(y_t - y_t^p) + \sum_{i=1}^{m}\vartheta_i(\tilde{p}_{it} - \tilde{p}_{i,0}) \tag{15}$$

where $\theta = \sum_{i=1}^{m}\left(\frac{1-\delta_i}{\delta_i}\right)\vartheta_i$. Substitute the deviation of real marginal cost from the steady state in Equation (12) to obtain:

$$\pi_t = \pi_{t-1}^e + \lambda_p\left(1 - \sum_{i=1}^{m}\vartheta_i\right)(s_t - s_0) + \lambda_p\theta\left(y_t - y_t^p\right) + \sum_{i=1}^{m}\lambda_p\vartheta_i\left(\tilde{p}_{it} - \tilde{p}_{i,0}\right) \tag{16}$$

This is the TPC similar to the one found in Fuhrer (1995). Note that its slope depends on the elasticity of output with respect to the material input and the share of the material input cost in the total output. The higher the share of material inputs in production and the smaller the elasticity of output with respect to the material inputs, the larger the slope of the Phillips curve. The slope also depends on λ_p. A higher λ_p implies increased price flexibility in response to real marginal costs.

We expect monetary policy to affect the slope of the Phillips curve by affecting the magnitude of λ_p. If monetary policy achieves the stability of prices and costs, a conducive environment for the establishment of long-term contracts is created, so that price changes become infrequent. This point is made by Ball *et al.* (1988). This will tend to decrease the magnitude of λ_p, consequently reducing the slope of the Phillips curve. Ball and Mazumder (2011) also show that variations in the slope of the Phillips curve are closely tied to the level and variance of inflation.

In their conclusion about the possible causes of the flattening of the Phillips curve, Kuttner and Robinson (2010) write, 'While globalisation may alter the relationship between the output gap and marginal costs, it is unclear why it would alter the link between marginal costs and inflation in a way that corresponds to a flattening of the Phillips curve'. Equation (16) provides some clarity on this issue. If globalization, which entails the liberalization of trade, causes the relative decline in the share of the value of material inputs in total output as firms are free to source material inputs from the cheapest parts of the global economy through global value chains as pointed out by Auer *et al.* (2017), then the Phillips curve could flatten.

We can express this Phillips curve in terms of the unemployment rate. Consider the production function in Equation (6). We have that:

$$\frac{Y_t}{Y_t^p} = \frac{\left[(1-u_t)L_t\right]^{\alpha}}{\left[(1-u^*)L_t\right]^{\alpha}} \tag{17}$$

where L_t is the labour force, u_t is the unemployment rate and u^* is the NAIRU. Log-linearizing Equation (17), we obtain:

$$\left(y_t - y_t^p\right) = -\alpha(u_t - u^*) \tag{18}$$

Replacing the output gap with the unemployment rate gap, we obtain the following Phillips curve:

$$\pi_t = \pi_{t-1}^e + \lambda_p\left(1 - \sum_{i=1}^{m}\vartheta_i\right)(s_t - s_0) - \lambda_p\alpha\theta(u_t - u^*) + \sum_{i=1}^{m}\lambda_p\vartheta_i\left(\tilde{p}_{it} - \tilde{p}_{i,0}\right) \tag{19}$$

Equation (19) is the TPC with the unemployment rate gap as the measure of demand pressure.

3. Empirical evidence

We are now in a position to estimate the parameters of our TPC. For purposes of this exercise, we consider five advanced and five emerging market economies. For the five advanced economies, we have Australia, Canada, European Union (EU), UK and the USA. For emerging market economies, we have Czech Republic, South Africa, South Korea, Turkey and Poland. Emerging markets, in particular, were chosen on the basis of the availability of data on the labour share. The data are sourced from the FRED database.

In terms of variable construction, the inflation rate is calculated as the annualized rate so that $\pi_t = p_t - p_{t-4}$, where p_t is the natural log of the consumer price index. The gaps are derived using the Hodrick–Prescott filter. The output gap is measured using the deviation of the natural log of the gross domestic product from its Hodrick–Prescott filtered trend. For the supply shocks, we use the real effective exchange rate.

Regarding the empirical specification, it should be stated that Equations (16) and (19) provide exact specifications that can be tested empirically. These equations are based on the idea that firms enter into one-period contracts in the goods market. However, the average contract period is likely to exceed one quarter. As Fabiani *et al.* (2006) have found in the case of the EU, approximately 70% of the firms, except in Germany and Luxembourg, change their price once a year—meaning that the contracts last for more than a quarter. Blinder *et al.* (1998) found that more than 90% of firms do not change prices more than once a year. This complicates the correspondence between the lag structure that is theoretically postulated and the one that holds empirically.

Table 1 presents the sample period and the lag specifications for each of the Phillips curve specifications for each economy. As can be observed, some of the specifications admit the labour share at lag 4. Most of the economies in the sample admit 0 or 1 lag of the output and the unemployment rate gap. The same situation obtains for the real effective exchange rate. Further, note that in the estimations, the autoregressive lags were chosen to be of order 5.

Table 2 reports the full sample estimates of the Phillips curve; in particular, Table 2 reports results for Equation (16). Note that for Australia the parameters have the wrong signs for the degree of price flexibility. This perverse result for Australia is consistent with the one obtained by Abbas and Sgro (2011) who find insignificant and sometimes wrongly signed coefficients on the labour share, in the NKPC. The same observation obtains for Canada, since the price flexibility parameter carries a negative sign. This is in contrast to the findings by Demers (2003), which bear a positive sign on the output gap. However, in a later study by Abbas *et al.* (2016), which reviews and updates empirical advances on the NKPC, there are instances where the real marginal cost parameter is either insignificant or carries a negative sign for Canada.

The results for the UK, USA and EU are as expected from theory. The parameters carry the correct signs and they are significant. Note, however, that for the EU the real effective exchange rate carries the wrong sign, but it is not significant. The price flexibility parameter is correctly signed across the three economies; it ranges between 0.11 and 0.20, which means that between 80 and 89% of the output is sold at contract prices. If these results were interpreted in terms of firms, they imply that, for example, 84% of firms in the USA price their goods and services using contracting, which is not far from the number reported by Blinder *et al.* (1998), who report that more than 90% of firms do not change prices more than once a year. We find the same results for the EU—89% of the firms engage in contract price-setting. This estimate is higher than the one in Fabiani *et al.*'s (2006) survey, about which they state, 'In all countries except Germany and Luxembourg, approximately 70% of the respondents adjust their price a maximum of once a year'.

For emerging markets, note that for the Czech Republic and Turkey, price flexibility is high relative to advanced and some of the emerging markets in the sample. The parameter

Table 1. The lag structure of the Phillips curve specifications

	Sample (quarterly)	Labour share	Output gap	Unemployment rate gap	Real effective exchange rate
Advanced economies					
Australia	1975–2019	4	1	9	1
Canada	1982–2019	0	0	0	4
EU	1996–2019	4	1	1	0
UK	1979–2019	0	0	1	1
USA	1980–2019	0	0	0	0
Emerging economies					
Czech Republic	1996–2020	0	0	0	0
Poland	1997–2020	1	0	0	0
South Africa	1970–2020	0	0	4	0
South Korea	1994–2020	4	0	0	0
Turkey	1999–2020	0	1	1	0

Note: Autoregressive lags are 5 throughout all regressions.
Source: Author's estimates.

Table 2. Full sample estimates of the Phillips curve (output gap)

	υ_p	θ	ϑ	λ_p
Advanced economies				
Australia (1972Q2–2019Q2)	−0.18*	3.02	0.27	−0.16*
	(0.08)	(4.05)	(0.25)	(0.06)
Canada (1981Q1–2019Q2)	−0.21*	4.82**	0.86*	−0.17*
	(0.06)	(2.69)	(0.31)	(0.04)
EU (1996Q2–2019Q1)	0.11*	1.05*	−0.03	0.12**
	(0.05)	(0.49)	(0.06)	(0.07)
UK (1979Q2–2019Q2)	0.20*	3.90*	0.84*	0.25*
	(0.02)	(1.21)	(0.16)	(0.04)
USA (1980Q1–2019Q3)	0.16*	5.91*	0.91	0.18*
	(0.03)	(2.71)	(0.34)	(0.0)
Emerging economies				
Czech Republic (1996Q1–2020Q4)	0.29*	0.71*	0.55*	0.43*
	(0.04)	(0.23)	(0.10)	(0.07)
Poland (1995Q2–2020Q4)	0.16*	5.43**	0.95*	0.18*
	(0.03)	(2.97)	(0.16)	(0.04)
South Africa (1970Q1–2020Q2)	0.17*	3.13*	1.09*	0209*
	(0.02)	(0.99)	(0.16)	(0.03)
South Korea (1991Q1–2020Q4)	0.18*	3.09*	0.75*	0.06*
	(0.05)	(0.91)	(0.17)	(0.02)
Turkey (1998Q2–2020Q1)	0.29*	1.09*	0.92*	0.41*
	(0.04)	(0.41)	(0.26)	(0.08)

Note: Heteroscedastic and autocorrelation consistent (HAC) std. error in parentheses.
* Significant at 5%.
** Significant at 10%.
Source: Author's estimates.

for price flexibility is 0.29 for the Czech Republic and Turkey. This means that, for these economies, 71% of the output sold is based on contracted prices.

How robust are these results when the unemployment rate gap, instead of the output gap, is used? To answer this question, we first estimate the parameter α in Equation (18) and then use this estimate to calibrate the parameter in the estimation of Equation (19). Table 3 provides the estimates of α. Most of the estimates exceed 1, meaning that output

Table 3. Estimated elasticity of output with respect to labour

	α
Emerging economies	
Czech Republic (1996Q1–2020Q4)	−1.57*
	(0.22)
Poland (1995Q1–2020Q4)	−0.61*
	(0.11)
South Africa (1994Q1–2020Q4)	−0.29*
	(0.13)
South Korea (1990Q1–2020Q4)	−2.13*
	(0.23)
Turkey (2005Q1–2020Q4)	−2.43*
	(0.31)
Advanced economies	
Australia (1966Q3–2019Q2)	−1.27*
	(0.09)
Canada (1961Q1–2019Q3)	−1.42*
	(0.14)
EU (1995Q1–2020Q4)	−2.59*
	(0.24)
UK (1960Q1–2019Q2)	−1.75*
	(0.13)
USA (1960Q1–2019Q3)	−1.69*
	(0.06)

Note: Std. errors in parentheses.
* Significant at 5%.
** Significant at 10%.
Source: Author's estimates.

responds more than proportionately to changes in employment, except for Poland and South Africa.

Table 4 reports the results for Equation (19). The results for the degree of price flexibility are broadly similar for advanced economies. For example, for the USA, υ_p is estimated to be 0.11 for both the output gap and the unemployment rate gap specifications, which means that 89% of firms engage in contract price-setting, a figure that is very close to that reported by Blinder *et al.* (1998). A similar result holds emerging markets, except for South Africa and Turkey, where the parameter is twice as much as in the output gap specification, in the unemployment rate gap specification.

In relation to the other parameters in Tables 2 and 4, they are different. This difference could be due to the fact that the relationship between output and unemployment could contain terms that capture persistence, as is the case with dynamic versions of Okun's law (see Ball *et al.*, 2017). Another reason for the discrepancies could be due to the quality of the data, especially as it relates to the unemployment rate. For example, measures of the unemployment rate based on household surveys, are unlikely to precisely mirror developments in production, a problem which is exacerbated by sampling errors. Despite the discrepancies in the magnitudes of the parameters, the signs of the parameters in Tables 2 and 4 are similar.

It is of concern that some of the economies display perverse results, e.g. Australia, Canada and South Korea exhibit negative signs on the price flexibility parameter. Further research is required to uncover the factors that could be causing this. Nevertheless, it is possible that the specifications that we have used are not adequate. For example, in estimating the Phillips curve, the same lag structure was used across the economies. Secondly, the supply shock variable may not be sufficient to capture the broad array of supply shocks that

Table 4. Full sample estimates of the Phillips curve (unemployment rate gap)

	υ_p	θ	ϑ	λ_p
Advanced economies				
Australia (1972Q2–2019Q2)	−0.11*	2.14**	0.13**	−0.10*
	(0.05)	(1.27)	(0.07)	(0.04)
Canada (1981Q1–2019Q2)	−0.12*	−0.71	−0.34*	−0.11*
	(0.05)	(0.60)	(0.17)	(0.04)
EU (1996Q2–2019Q1)	0.10*	1.12*	0.00	0.12*
	(0.05)	(0.51)	(0.08)	(0.06)
UK (1979Q2–2019Q2)	0.09*	2.64*	0.43*	0.09*
	(0.03)	(0.91)	(0.13)	(0.03)
USA (1980Q1–2019Q3)	0.11*	1.37*	0.10	0.12*
	(0.03)	(0.47)	(0.11)	(0.04)
Emerging economies				
Czech Rep. (1996Q1–2020Q4)	0.17*	0.86**	0.48*	0.21*
	(0.06)	(0.46)	(0.14)	(0.09)
Poland (1995Q2–2020Q4)	0.11*	2.22*	0.29*	0.12*
	(0.03)	(1.10)	(0.11)	(0.03)
South Africa (1970Q1–2020Q2)	0.18*	3.16**	0.17*	0.22*
	(0.05)	(1.92)	(0.07)	(0.07)
South Korea (1991Q1–2020Q4)	−0.06*	1.29*	0.33*	−0.06*
	(0.01)	(0.70)	(0.10)	(0.01)
Turkey (1998Q2–2020Q1)	0.15*	0.93*	0.53*	0.18*
	(0.06)	(0.37)	(0.21)	(0.07)

Note: HAC std. errors in parentheses.
* Significant at 5%.
** Significant at 10%.
Source: Author's estimates.

the economies experienced. In the above estimations, the real effective exchange rate is used throughout to capture supply shocks. However, shocks arising from variables such as oil prices (see Fuhrer, 1995) and administered prices could be important. Gordon (2011) adds food, energy and import prices in the Phillips curve to capture supply shocks.

3.1 Robustness analysis: inflation targeting and the global economic crisis

The economies that are subject to the analysis all follow inflation targeting. It is useful to investigate the impact of this policy framework on the inflation-output trade-off. We expect that if inflation targeting led to low and stable inflation, then firms should tend to enter more into contracts, leading to a decline in λ_p. It is primarily through this channel that monetary policy can lead to the flattening of the Phillips curve. Indeed, as pointed out by Nakamura and Steinsson (2008) and Coibion and Gorodnichenko (2015), there is evidence of a decline in the frequency of price changes, which may have led to some flattening of the Phillips curve.

In order to conduct a formal test of the effect of inflation targeting on the Phillips curve, we use a dummy variable for each country, which takes the value of 0 prior to the adoption of inflation targeting and 1 after the adoption of inflation targeting. The effect of inflation targeting is not limited to the slope of the Phillips curve, but it is also tested for other parameters as well. Table 5 presents the results. In this table, D_θ denotes the dummy variable associated with the parameter θ, D_ϑ is the dummy variables associated with ϑ and D_{λ_p} is associated with λ_p.

For advanced economies, we find that inflation targeting appears to have had no significant impact because none of the dummy variables are significant, except for the UK and to some extent the USA. For the UK, there was an increase in θ combined with a decline in λ_p. For the USA, only ϑ appears to have decreased, while the other parameters remained fairly

Table 5. Pre and post inflation targeting (output gap)

	IT Adoption	θ Pre	D_θ Post	ϑ Pre	D_ϑ Post	λ_p Pre	D_{λ_p} Post
Advanced							
Australia (1972Q2–2019Q2)	1993	1.56	−0.12	0.05	0.35	−0.11*	0.04
		(1.12)	(2.66)	(0.12)	(0.47)	(0.10)	(0.10)
Canada (1981Q1–2019Q2)	1991	3.30*	17.59	0.30*	0.01	0.28*	−0.34
		(1.62)	(214.23)	(0.14)	(2.69)	(0.07)	(0.34)
EU (1996Q2–2019Q1)	1998	–	–	–	–	–	–
		–	–	–	–	–	–
UK (1979Q2–2019Q2)	1992	1.14*	0.87*	0.11*	0.24	0.36*	−0.30*
		(0.31)	(1.00)	(0.05)	(0.21)	(0.12)	(0.13)
USA (1980Q1–2019Q3)	2012	4.84*	−5.43	0.76*	−0.90**	0.22*	0.06
		(1.92)	(3.75)	(0.29)	(0.53)	(0.04)	(0.17)
Emerging economies							
Czech Republic (1996Q1–2020Q4)	1998	0.58	0.13	0.89*	−0.41	0.56*	−0.10*
		(1.14)	(1.10)	(0.28)	(0.28)	(0.08)	(0.12)
Poland (1995Q2–2020Q4)	1998	1.09	3.17	0.44*	0.42**	−0.37*	0.17
		(0.90)	(2.29)	(0.19)	(0.21)	(0.11)	(0.12)
South Africa (1970Q1–2020Q2)	2000	1.89	2.36	1.10*	0.03	0.18*	0.03
		(1.52)	(2.06)	(0.19)	(0.05)	(0.04)	(0.05)
South Korea (1991Q1–2020Q4)	1998	0.96**	2.91**	0.43**	−0.13	0.25*	−0.17*
		(0.57)	(1.50)	(0.23)	(0.24)	(0.05)	(0.05)
Turkey (1998Q2–2020Q1)	2002	1.47*	−1.06	0.38*	0.10	0.73*	−0.25**
		(0.46)	(0.66)	(0.09)	(0.17)	(0.12)	(0.14)

Note: HAC std. errors in parentheses.
* Significant at 5%.
** Significant at 10%.
Source: Author's estimates.

stable. As for emerging markets, there is evidence of a decline in price flexibility λ_p after the adoption of inflation targeting for the Czech Republic, South Korea and Turkey. For South Korea, the parameter θ has increased, because the dummy variable is positive and significant. This is the same pattern of results as for the UK.

The results therefore suggest that during the period of inflation targeting, either price flexibility declined or there was no significant change in the degree of price flexibility. There is no evidence that during this period, there was a significant increase in price flexibility. This lack of evidence could be due to the fact that many of the economies in our sample adopted inflation targeting after inflation had become more stable due to other factors than inflation targeting itself. Thus, it is possible that this environment of more stable inflation might have caused the Phillips curve to be flatter before the adoption of inflation targeting.

The next set of results shows what happened to the Phillips curve after the global financial crisis. We also use a dummy variable that takes the value of 0 prior to the global crisis, and 1 after the crisis. Specifically, we set the point of the crisis at 2010Q1. Table 6 provides the results. For advanced economies, price flexibility appears to have increased, where the dummy variable is significant. This occurs in those economies that have a perverse sign for λ_p, which is Australia and Canada. However, for the rest of the economies, the global crisis did not have a statistically significant impact on price flexibility.

For emerging markets, the degree of price flexibility tends to decline for South Korea and the Czech Republic after the crisis, which suggests that firms in these economies increasingly sold their output at contract prices. In other countries, there is no significant impact of the global crisis on price flexibility. There is also no evidence of significant change because of the crisis for the other parameters.

Table 6. Pre and post global financial crisis (output gap)

	θ Pre	D_θ Post	ϑ Pre	D_ϑ Post	λ_p Pre	D_{λ_p} Post
Advanced						
Australia (1972Q2–2019Q2)	−0.27	72.26	0.35**	0.44	−0.21*	0.20*
	(1.96)	(422.96)	(0.19)	(0.35)	(0.05)	(0.09)
Canada (1981Q1–2019Q2)	1.26**	2.34	0.46*	0.13	−0.28*	0.09*
	(0.71)	(3.16)	(0.15)	(0.22)	(0.06)	(0.08)
EU (1996Q2–2019Q1)	−0.49	2.08	−0.09	−0.02	−0.09	0.18
	(0.75)	(3.30)	(0.14)	(0.33)	(0.07)	(0.19)
UK (1979Q2–2019Q2)	2.61**	−0.10	0.60*	−0.50*	0.10**	0.21
	(1.44)	(0.09)	(0.29)	(0.09)	(0.05)	(0.97)
USA (1980Q1–2019Q3)	5.48*	−7.33	0.65*	−0.24	0.21*	0.05
	(2.07)	(5.34)	(0.33)	(0.49)	(0.04)	(0.10)
Emerging economies						
Czech Rep. (1996Q1–2020Q4)	0.46*	−1.54	0.37*	0.55	0.33*	−0.37*
	(0.19)	(3.58)	(0.10)	(1.41)	(0.09)	(0.15)
Poland (1995Q2–2020Q4)	6.90	−3.96	1.01*	−0.23	0.18*	0.06
	(4.48)	(5.87)	(0.18)	(0.30)	(0.04)	(0.16)
South Africa (1970Q1–2020Q2)	2.93*	0.19	1.07*	2.29	0.21*	−0.11
	(1.32)	(5.30)	(0.16)	(3.00)	(0.03)	(0.07)
South Korea (1991Q1–2020Q4)	1.10**	3.00	0.31*	−0.35	0.17*	−0.12*
	(0.59)	(4.19)	(0.12)	(0.47)	(0.07)	(0.10)
Turkey (1998Q2–2020Q1)	0.81*	0.85	0.54*	0.49*	0.54*	−0.21
	(0.33)	(1.83)	(0.23)	(0.19)	(0.21)	(0.25)

Note: HAC std. errors in parentheses.
* Significant at 5%.
** Significant at 10%.
Source: Author's estimates.

3.2 The effect of alternative inflation expectations formation

The inflation expectations formation process that emerges from the theory of the TPC is not as prescriptive as the new Keynesian approach, which strictly permits one lead and one lag in their hybrid specifications as Galí and Gertler (2003) noted. This lack of strict prescription allows great flexibility to explore which of the inflation expectations processes best describes the data. Thus, instead of being a weakness, this lack of prescription in the TPC approach is a strength that allows a researcher to seek a process that best describes the data.

In the previous sections, we had assumed that inflation expectations are described by an autoregressive process. In the following tables, we report results where we assume that inflation expectations are formed following an 8-quarter moving average process and a process where inflation expectations are partially anchored on some constant rate. Table 7 reports the results. We observe that for both advanced and emerging market economies, λ_p is fairly robust to changes in the inflation expectations process. Except for a few economies, the estimates for λ_p do not vary much across the two expectations formation processes.

However, θ appears to be the most sensitive to the change in the inflation expectations process in many countries. For example, this parameter changes from 2.36 to 1.94 in the case of the USA and it changes from 2.54 to 2.63 in the case of Australia. For South Africa, it changes from 2.61 to 3.06. The ϑ is also robust in some economies but not to the same extent as θ, such as the UK and the USA. However, it is not stable for other economies as well. For Poland, it moves from 0.62 to 0.37.

Overall, therefore, we can conclude that the parameter for price flexibility is robust to changes in the inflation expectations process. If there is instability in the parameters of the TPC, it is likely due to changes in θ and ϑ, brought about by changes in the inflation expectations formation process.

Table 7. Full sample estimates of the Phillips curve (output gap)

	θ	ϑ	λ_p	γ	θ	ϑ	λ_p
	Pure moving average expectations			**Hybrid expectations**			
Advanced economies							
Australia (1975Q1–2019Q2)	2.54	0.10	−0.25*	0.89*	2.63**	0.14	−0.21*
	(1.55)	(0.08)	(0.11)	(0.06)	(1.51)	(0.10)	(0.09)
Canada (1982Q1–2019Q2)	−1.26	−0.46	−0.24*	0.80*	−0.62	−0.38**	−0.24*
	(0.83)	(0.28)	(0.11)	(0.09)	(0.67)	(0.20)	(0.11)
EU (1996Q2–2019Q1)	1.55*	−0.04	0.28*	0.79*	1.62*	−0.02	0.25*
	(0.61)	(0.07)	(0.12)	(0.14)	(0.68)	(0.08)	(0.12)
UK (1979Q2–2019Q2)	2.74*	0.35*	0.34*	0.95*	2.62*	0.33*	0.35*
	(1.00)	(0.14)	(0.15)	(0.09)	(0.99)	(0.15)	(0.15)
US (1979Q2–2019Q1)	2.36*	0.30**	0.29*	0.83*	1.94*	0.30*	0.32*
	(1.08)	(0.17)	(0.13)	(0.04)	(0.50)	(0.10)	(0.08)
Emerging economies							
Czech Republic (1995Q1–2020Q4)	0.55*	0.37*	0.77*	0.77*	0.53*	0.33*	0.77*
	(0.27)	(0.12)	(0.31)	(0.15)	(0.25)	(0.12)	(0.19)
Poland (1997Q4–2020Q4)	0.98	0.62*	0.26*	0.89*	1.78**	0.37*	0.11*
	(0.77)	(0.20)	(0.12)	(0.02)	(0.90)	(0.14)	(0.04)
South Africa (1995Q2–2020Q3)	2.61*	1.12*	0.13**	0.92*	3.06*	0.94*	0.14*
	(1.27)	(0.57)	(0.07)	(0.04)	(1.37)	(0.47)	(0.07)
South Korea (1994Q2–2021Q4)	0.48**	0.14*	0.34*	0.77*	0.89*	0.19*	0.32**
	(0.28)	(0.04)	(0.06)	(0.10)	(0.33)	(0.04)	(0.06)
Turkey (1999Q1–2020Q1)	0.60**	0.51*	0.75*	0.81*	0.67**	0.45*	0.64*
	(0.33)	(0.24)	(0.31)	(0.06)	(0.37)	(0.20)	(0.25)

Note: HAC std. errors in parentheses.
* Significant at 5%.
** Significant at 10%.
Source: Author's estimates.

Table 8 provides estimates with the unemployment rate gap as the activity variable. The results are similar to those in Table 7, in that λ_p is fairly stable in the face of changes in the inflation expectations process, although θ and ϑ are less so. Again, the USA displays the largest changes in the parameter θ from 2.08 to 1.67. Amongst emerging markets, the largest change is in Poland, which is from 1.01 to 4.19.

Three key results emerge from the above analysis. The estimate of price flexibility from our Phillips curve appears to be robust to changes in the inflation expectations formation process, while the other parameters are less stable. The effects of the global economic crisis on the parameters of the TPC have not been significant in a number of economies. Lastly, the transition to inflation targeting appears to have flattened the slope of the curve in some economies by reducing price flexibility, especially in emerging markets, while in others there is no evidence that inflation targeting has reduced price flexibility. These results hold regardless of whether we use the output gap or the unemployment rate gap as a measure of economic activity.

4. Comparison with the forward-looking Phillips curve

One of the motivations of this article is to formulate a TPC so that it is a credible alternative to its new Keynesian counterpart. We now provide an empirical investigation of whether the TPC provides better results than the NKPC. We therefore estimate the NKPC on the assumption that expectations are purely forward-looking, and on the assumption that inflation expectations are partially anchored to some target.

Table 8. Full sample estimates of the Phillips curve (unemployment rate gap)

	θ	ϑ	λ_p	γ	θ	ϑ	λ_p
	Pure moving average expectations			Hybrid expectations			
Advanced economies							
Australia (1975Q1–2019Q2)	3.61*	0.10**	−0.27*	0.95*	3.76**	0.09	−0.25*
	(1.36)	(0.06)	(0.08)	(0.06)	(1.97)	(0.09)	(0.11)
Canada (1982Q1–2019Q2)	−0.99	−0.48**	−0.25*	0.80*	−0.42	−0.38**	−0.25*
	(0.81)	(0.25)	(0.11)	(0.12)	(0.75)	(0.21)	(0.1)
EU (1996Q2–2019Q2)	1.10*	0.00	0.39*	0.73*	1.14*	0.02	0.35*
	(0.33)	(0.05)	(0.15)	(0.14)	(0.35)	(0.06)	(0.13)
UK (1979Q3–2019Q2)	4.74*	0.69*	0.26*	0.93*	4.46*	0.63*	0.27*
	(1.96)	(0.27)	(0.12)	(0.06)	(1.63)	(0.22)	(0.11)
USA (1980Q1–2019Q3)	2.08**	0.27	0.30**	0.80*	1.67*	0.25	0.35*
	(1.06)	(0.22)	(0.17)	(0.09)	(0.75)	(0.17)	(0.16)
Emerging economies							
Czech Republic (1995Q1–2020Q4)	1.14*	0.47*	0.66*	0.70*	1.51*	0.48*	0.55*
	(0.53)	(0.16)	(0.26)	(0.08)	(0.58)	(0.14)	(0.14)
Poland (1997Q4–2020Q4)	1.01	0.51*	0.33*	0.57*	4.19*	0.47*	0.30*
	(1.62)	(0.17)	(0.11)	(0.07)	(1.26)	(0.14)	(0.09)
South Africa (1995Q2–2020Q3)	1.89**	0.15*	0.76*	0.50*	2.43**	0.26*	0.56*
	(1.00)	(0.05)	(0.23)	(0.12)	(1.36)	(0.10)	(0.21)
South Korea (1990Q4–2020Q1)	−3.09	0.29*	−0.14*	0.88*	−3.15*	0.29**	−0.14*
	(1.39)	(0.15)	(0.04)	(0.11)	(1.44)	(0.15)	(0.04)
Turkey (2005Q3–2020Q1)	1.11**	0.36	0.36*	1.12*	1.07*	0.33*	0.39*
	(0.56)	(0.25)	(0.13)	(0.27)	(0.46)	(0.17)	(0.11)

Note: HAC std. errors in parentheses.
* Significant at 5%.
** Significant at 10%.
Source: Author's estimates.

Table 9 provides the results. The first striking result is that, throughout, the parameter λ_p carries a wrong sign and where it has a correct sign, as for Australia, it is not significant. The second result that stands out is that the parameter γ which is supposed to be less than 1, tends to be greater than 1 in most economies. The degree of expectations anchoring to target is $(1-\gamma)$, with $\gamma > 1$; then we have a perverse degree of anchoring. When considering the stability of the parameters across different inflation expectation formation processes, we also observe that the results are broadly similar to those obtained from the TPC. Therefore, the NKPC is not more stable than its traditional counterpart.

The above results show that the Phillips curve with forward-looking expectations, whether pure or partially anchored, is not consistent with the data. Furthermore, if there were changes in the inflation expectations formation process, there is no evidence that the Phillips curve with forward-looking expectations is more stable than the one with backward-looking expectations.

5. Conclusion

Modelling inflation dynamics remains a deeply contested area of research in macroeconomics. The new Keynesian approach to modelling inflation dynamics, which emphasizes forward-looking behaviour and optimization-based derivation of structural relationships, has emerged as dominant. However, there are serious challenges with this approach. These range from lack of significance of forward-looking behaviour as noted by Rudd and Whelan (2005, 2007), Fair (2008) and Nason and Smith (2008), unstable out-of-sample

Table 9. Full sample GMM estimates of the NKPC (output gap)

	θ	ϑ	λ_p	γ	θ	ϑ	λ_p
	Pure forward-looking expectations			**Hybrid expectations**			
Advanced economies							
Australia (1973Q1–2019Q1)	−17.13	−0.31	0.02	0.96*	−3.84	0.03	0.05
	(54.84)	(1.35)	(0.05)	(0.02)	(4.49)	(0.23)	(0.04)
Canada (1982Q1–2019Q2)	0.69*	0.36*	−0.12**	0.80*	1.36	0.40*	−0.15*
	(0.83)	(0.09)	(0.10)	(0.09)	(0.97)	(0.14)	(0.04)
EU (1997Q1–2018Q2)	0.46*	−0.03	−0.13*	1.09*	0.68*	−0.04	−0.19*
	(0.21)	(0.06)	(0.03)	(0.04)	(0.20)	(0.04)	(0.06)
UK (1980Q1–2019Q1)	1.90**	0.47*	−0.12*	1.05*	1.70*	0.40*	−0.14*
	(0.70)	(0.14)	(0.06)	(0.02)	(0.54)	(0.11)	(0.06)
USA (1965Q1–2019Q2)	1.34*	0.20*	−0.16*	1.04*	1.19*	0.16**	−0.18*
	(0.55)	(0.10)	(0.07)	(0.02)	(0.53)	(0.09)	(0.09)
Emerging economies							
Czech Republic (1997Q1–2020Q3)	0.34*	0.54*	−0.31*	1.04*	0.35*	0.49*	−0.34*
	(0.11)	(0.09)	(0.06)	(0.03)	(0.13)	(0.08)	(0.06)
Poland (1996Q1–2020Q3)	2.19**	1.20**	−0.07**	1.09*	2.48*	0.83*	−0.11*
	(1.25)	(0.61)	(0.04)	(0.02)	(0.83)	(0.20)	(0.03)
South Africa (1971Q1–2020Q2)	1.55*	0.09	−0.17*	1.03*	1.53*	0.13*	−0.17*
	(0.29)	(0.0.09)	(0.03)	(0.02)	(0.30)	(0.10)	(0.04)
South Korea (1995Q1–2021Q3)	1.63*	0.15**	−0.13*	1.01*	2.96**	0.13	−0.07**
	(0.65)	(0.09)	(0.05)	(0.06)	(1.61)	(0.12)	(0.04)
Turkey (1999Q1–2020Q1)	0.51*	0.35*	−0.60*	1.04*	0.42*	0.36*	−0.68*
	(0.12)	(0.04)	(0.21)	(0.03)	(0.13)	(0.05)	(0.29)

Note: Std. errors in parentheses.
* Significant at 5%.
** Significant at 10%. Instruments: 4 lags of inflation, labour share gap output gap and the real effective exchange rate.
Source: Author's estimates.

dynamic simulations and poor forecasting ability (Gordon, 2011) and estimation problems relating to weak identification as found by Mavroeidis (2005), Nason and Smith (2008) and Rudd (2021).

On the other hand, the TPC does not suffer from these problems. In fact, it appears to perform better than its new Keynesian counterpart (Gordon, 2011). While the major criticism of the TPC is that it is not derived from optimization principles, and so it has weak theoretical underpinnings, what tends to be found empirically is that its parameters are remarkably stable, for example, Fuhrer (1995) and Mazumder (2011, 2012). Hence, this Phillips curve has been used to address a number of policy and theoretical questions. For example, it has been used to estimate the Nairu, for example, Gordon (1997), Laubach (2001), to provide empirical characterization of the inflation process (Stock and Watson, 1999) and to investigate the issue of 'the missing disinflation' in the USA, for example, Ball and Mazumder (2011, 2019), Blanchard (2016) among others.

Given the continued and extensive use of the TPC, this article makes two contributions. Firstly, we provide some theoretical foundations to the TPC by using a simple contracting scheme. The forcing variables of our Phillips curve are derived by linking the real optimal price with real marginal cost. The result is a pricing equation whose expectations component could be purely backward-looking, but with parameters on the forcing variables having as clear a theoretical interpretation as its new Keynesian counterpart. Secondly, we used a Leontief-type technology which allowed us to formulate the real marginal cost so that it features the role of the labour share, demand pressure and a vector of supply shocks as drivers of inflation, as in Batini *et al.* (2005). Our Phillips curve is similar to the one used by Fuhrer (1995), but with theoretical underpinnings.

We estimate this Phillips curve for a number of advanced and emerging market economies. Our findings are that firstly, there is widespread price rigidity across economies. Our results are in line with those of survey studies. For example, the survey by Blinder *et al.* (1998) found that 90% of firms do not change their prices within a year in the USA. Our estimations suggest that 89% of firms price their goods and services using contracting. For the EU, we find a similar result, although survey results suggest a lower value of 70% (see Fabiani *et al.* (2006). Secondly, we also found that the shift to inflation targeting was accompanied by changes in the slope of the Phillips curve for some of the economies—the low and stable inflation environment encouraged the use of contracts, thereby reducing the sloping of the curve, but for other economies this effect was not significant. Thirdly, we found that the impact of the global financial crisis on the Phillips curve also varies across economies, with some economies not significantly affected. Lastly, the price flexibility parameter of our TPC is robust to changes in the expectations formation process, and other parameters are less so. We also found that the NKPC is not consistent with the data, and that it is not more stable than the TPC.

There are at least four directions in which the research on the TPC can be advanced. Firstly, there may be a need to further refine the technology that we used to derive the measure of real marginal cost. In our case, we used the non-linear version of the Leontief technology. Secondly, we have used the real import price or the real effective exchange rate as a measure of a supply shock. As Gordon (2011) has emphasized, there is scope to introduce more supply shocks in order to improve the specification of the model. Thirdly, we have used the same order of the autoregressive component for the various economies. A more detailed specification would use orders that are specific to the inflation process for each economy. Lastly, formal tests of changes in the inflation expectations formation process are important because this process appears to affect the stability of some of the parameters of Phillips curves.

Supplementary material

Supplementary material is available on the OUP website. These are the data and replication files.

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Conflict of interest

There is no conflict of interest in this work.

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