Traditional Inflation Dynamics

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Abstract

We derive a traditional Phillips curve under the assumption that firms optimize their prices in the context where a fraction of their output is contracted on previous prices, and where they face potential losses and gains from such contracts. Our derivation delivers an augmented exact specification that is of an accelerationist type. Specifically, our baseline TPC features one lag of inflation and the labour share, two lags of the output gap and one lag of supply shocks. With rule-of-thumb behaviour considered, our traditional Phillips curve admits higher lags of these variables. We estimate these traditional Phillips curves for six developed and five emerging market economies and find that the degree of price rigidity is significant and has the correct sign. We conclude that this optimization-based traditional Phillips curve is a credible rival to its forward-looking new Keynesian counterpart.

Keywords: Traditional price Phillips curves, backward-looking behaviour.
JEL Codes: E12, E24, E31, E32.

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), popularised by Galí and Gertler (1999) and the Traditional Phillips curve (TPC) expounded by Fuhrer (1995) and Gordon (1997). The strength of the new Keynesian Phillips curve is that it is derived from explicit intertemporal optimisation and its parameters have

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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) summarise 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 (see Mazumder (2011) for the case of India).

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' optimisation, the TPC continues to be used as a tool to gain insight into how the economy works. It is prominent in many studies that estimate the NAIRU, e.g. 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 during the Great Recession, e.g. Ball and Mazumder (2011) and Watson (2014). This continued relevance of the TPC, coupled with critiques of the new Keynesian Phillips curve such as those by Rudd and Whelan (2007), provides motivation for a revisit of the theoretical foundations of the TPC.

In this paper, we provide an optimisation-based framework for the derivation of a structural traditional Phillips curve. The aim of this exercise is to place backward-looking Phillips curves on the same theoretical footing as forward-looking Phillips curves. The novelty of the results in this paper is that the "deep" parameters of our TPC bear a similar interpretation to the ones in new Keynesian models, which permits a detailed comparison between the two perspectives in future research. Furthermore, our derivation of the TPC from profit-maxisation may be viewed as the first step towards grounding empirically-oriented backward-looking models similar to that of Svensson (1997) on a theoretical footing.

The paper is structured as follows: Section 2 derives the backward-looking price Phillips curves from microfoundations. Section 3 provides empirical evidence of the model. Section 4 concludes.

2. A structural traditional Phillips curve

2.1 The baseline case

Assume identical firms that operate in a low inflation environment where variations in prices are of such a magnitude that they do not significantly affect the level of demand faced by each firm. We index each firm in this environment by j. Since firms are identical, we assume that the price set by each firm is the same as the aggregate price level P_t. In terms of technology, assume that in the short-run, there is no substitution among inputs, and that firms use a Leontief technology of the form:

$$Y_{jt} = \min\left(L_{jt}, X_{1t}, ..., X_{nt}\right) \tag{1}$$

Eq.(1) implies fixed input requirements in production such that : $X_{it} = \delta_i Y_{jt}$, where X_{it} is the amount of non-labour input i required in production and δ_i is the input requirement coefficient. This assumption allows us to incorporate real prices of non-labour inputs in the Phillips curve in a simple way, e.g. energy and imports prices, as in Gordon (1997, 2011). The economic implication of this assumption is that labour is not the only variable input and these non-labour inputs enter as complements to labour in production.

The representative firm engages in one-period contracts so that, at a point in time t, it produces real output Y_{jt} and contracts to sell a fraction of this output τ_p at price P_t in time $t+1$. The rest of the output $(1-\tau_p)\, Y_{jt}$ and the increment ΔY_{jt+1} will be sold at P_{t+1}. The fraction τ_p is analogous to the

Calvo (1983) probability of no price change and is thus a measure of price rigidity. We can then write the real revenue of the firm at time t as follows:

$$R_{jt}^{p} = \Delta Y_{jt} + (1 - \tau_p)\, Y_{jt-1} + \tau_p \left(\frac{P_{t-1}}{P_t} \right) Y_{jt-1} \tag{2}$$

where R_{jt}^{p} is real revenue. Eq. (2) is derived from noting that $Y_{jt} = \Delta Y_{jt} + Y_{jt-1}$, i.e. current output is incremental output plus past output. Over and above production costs, the firm incurs losses due to lack of price flexibility imposed by the one-period contract. The assumption that there are costs associated with contracts is due to Rotemberg (1982) and is used by new Keynesian economists as an alternative to the Calvo-based derivation of the Phillips curve (see e.g. Batini et al.(2005), Fuhrer et al.(2009:16)). Assume an amount equal to χ_p of last period output is demanded at the current price but the firm can only sell it at last period's price because of the contract. Then the real loss from the contract is:

$$\Theta_{jt}^{p} = \tau_p \chi_p \left(\frac{P_t - P_{t-1}}{P_t} \right) Y_{jt-1}, \tag{3}$$

where $\chi_p > 0$. The firm's objective is to maximise discounted expected profits, given the nominal wage and aggregate demand Y_{jt} by choosing the optimal price. This problem can be stated as follows:

$$\max_{P_t} \Pi_{jt} = E_t \sum_{k=0}^{\infty} \beta^k \left(R_{jt+k}^{p} - \frac{W_{t+k} L_{jt+k}}{P_{t+k}} - \frac{Y_{jt+k}}{P_{t+k}} \sum_{i=1}^{n} \delta_i P_{it+k} - \Theta_{jt+k}^{p} \right) \tag{4}$$

where Π_{jt} is real aggregate profits of the firm, W_t is the nominal wage, L_{jt} is the level of employment which is determined by demand, given the real wage, P_{it} is the price of input i and n is the number of non-labour inputs and β is the discount factor. The first order condition for price-setting yields the following relationship:

$$-\psi\left(\frac{P_{t-1}}{P_t}\right)Y_{jt-1}+\frac{W_tL_{jt}}{P_t}+\left(\sum_{i=1}^{n}\frac{\delta_iP_{it}}{P_t}+\psi E_t\left(\frac{P_t}{P_{t+1}}\right)\right)Y_{jt}=0, \tag{5}$$

where we have set $\psi=\beta\tau_p\left(1+\chi_p\right)$ for compactness. Denote the labour share in firm j by S_{jt}, we can then write eq.(5) as follows:

$$E_t\left(1+\pi_{t+1}\right)^{-1}Y_{jt}=\frac{1}{\beta}\left(1+\pi_t\right)^{-1}Y_{jt-1}-\frac{Y_{jt}}{\beta\psi}\left(S_{jt}+\sum_{i=1}^{n}\delta_ip_{it}\right), \tag{6}$$

where π_t denotes the price inflation rate and $p_{it}=\frac{P_{it}}{P_t}$ is the relative price of non-labour inputs. Assume that $\beta=\left(1+g_0\right)^{-1}$, where g_0 is the steady state growth rate of the economy. This assumption can be motivated from Fisher's relation. Following the standard new Keynesian literature, e.g. Galí and Gertler (1999), we linearise eq.(6) around the zero-inflation steady state and aggregate across firms to obtain the following Phillips curve relation:

$$E_t\pi_{t+1}=\pi_t+a_s\widehat{s}_t+a_y\widehat{y}_t-\widehat{y}_{t-1}+\sum_{i=1}^{n}a_{pi}\widehat{p}_{it}, \tag{7}$$

where $\widehat{s}_t$ is the percentage deviation of the labour share from the steady state, $\widehat{p}_{it}$ is the percentage deviation of real input prices from the steady state and $\widehat{y}_t$ is the percentage deviation of output from potential:

$$\begin{aligned}
a_s &= \frac{S_0}{\beta\tau_p\left(1+\chi_p\right)},\; a_{pi}=\frac{\delta_ip_{i0}}{\beta\tau_p\left(1+\chi_p\right)},\\
a_y &= \left[1+\frac{1}{\beta\tau_p\left(1+\chi_p\right)}\left(S_0+\sum_{i=1}^{n}a_{pi}\right)\right]
\end{aligned}$$

Eq.(7) can be interpreted as the backward-looking Phillips curve taken one-step ahead, as in Svensson (1997). It is different from the new Keynesian

Phillips curve in three respects. Firstly, the forward-looking term is now on the left hand side. Secondly, the change in the output gap appears on the right hand side together with the labour share. Thirdly, in contrast to new Keynesian derivations, inflation persistence arises from optimisation in the context of one-period contracts as opposed to persistence being a result purely of rule-of-thumb price setting.

We can show, by applying the method proposed by Sargent (1987: Chapter 9), that eq.(7) is indeed a backward-looking Phillips curve. Let the linear combination of forcing variables be $z_t = \left(a_s \widehat{s}_t + a_y^{'} \widehat{y}_t - \widehat{y}_{t-1} + \sum_{i=1}^{n} a_{pi} \widehat{p}_{it} \right)$. Therefore we can write eq.(7) as follows:

$$\left(L^{-1} - 1\right) \pi_t = z_t \tag{8}$$

where L^{-1} is the lead operator. Solving for π_t we have:

$$\pi_t = \left(\frac{1}{L^{-1} - 1} \right) z_t = \left(\frac{L}{1 - L} \right) z_t = \sum_{i=1}^{\infty} L^i z_t = \sum_{i=1}^{\infty} z_{t-j} \tag{9}$$

Thus, eq.(7) implies that the fundamental inflation rate depends on past realisations of the forcing variables, contrary to the new Keynesian approach.

We now turn to the structural interpretation of the parameters. If all output is sold at current prices, i.e. no contracts, the Phillips curve becomes vertical since $\tau_p = 0$. In this instance prices are fully flexible. This result is consistent with the idea that in the long run, where prices are fully flexible, the Phillips curve assumes a vertical shape. This result is analogous to the effect of the Calvo probability parameter on the slope of the new Keynesian Phillips curve (see the coefficient of marginal cost in Galí and Gertler (1999) and Galí (2000) in particular). Furthermore, if there is an increase in χ_p the slope of the Phillips curve would fall. The intuition for this is that current prices do not fully adjust to "excess demand" because part of current output is contracted at previous period prices.

Flowing from this interpretation, it follows that even if firms enter into one period contracts, i.e. $0 < \tau_p < 1$, if in period t the portion of aggregate demand that is due to customers who are willing and able to pay at current prices does not exceed $(1-\tau_p) Y_{t-1} + \Delta Y_t$, then the contract will not effectively generate price rigidity. This is the case because firms could meet aggregate demand at prevailing market prices. Thus as long as $\chi_p > 0$ the contract will effectively create price rigidity. We therefore interpret the combination $\tau_p \left(1+\chi_p\right)$ as a measure of "effective price rigidity".

Our price Phillips curve features speed-limit effects captured by lagged output gap. The recognition of this term in Phillips curve literature is highlighted by Mehra (2004) and Gordon (2011). Mehra in particular finds that the inclusion of the change in the output gap in the hybrid specification boosts the significance and size of the backward-looking term in the new Keynesian model.

Let $\eta_t = \pi_t - E_{t-1}\pi_t$ be the expectational error. Then, as in Galí (2000) among others, we can write eq.(7) as the backward-looking Phillips curve as follows:

$$\pi_t = \pi_{t-1} + a_s \widehat{s}_{t-1} + a_y \widehat{y}_{t-1} - \widehat{y}_{t-2} + \sum_{i=1}^{n} a_{pi} \widehat{p}_{it-1} + \eta_t \tag{8}$$

Eq.(8) is the *structural Traditional Price Phillips curve*, which implies a *positive* correlation between inflation and the one-lagged output gap. It explains the observation by Mehra (2004), although he conducts his analysis within the new Keynesian setup, that the omission of supply shocks may be responsible for the finding that the output gap is irrelevant to inflation dynamics. In our case, if supply shocks and the labour share are omitted, then $\sum_{i=1}^{n} a_{pi}$ does not appear in a_y, the output gap parameter becomes 1, i.e. the change in the output gap would enter the Phillips curve with a co-efficient of 1 and there would be no additional level effects of the output gap on inflation.

2.2 The general case

Generally, the literature on the traditional Phillips curve deploys a specification that features higher lags of the variables that are on the right hand side of eq.(8) (see Fuhrer (2011), Gordon (2011), Mazumder (2011)). It is therefore appropriate that we specify the TPC in a manner that comes close to these more general specifications. In order to do so, we now assume that there are two types of firms. One type optimises its price-setting so that the law of motion of its price level is governed by eq.(8). Another type uses a rule of thumb. The aggregate price level is therefore determined by:

$$p_t = (1 - \omega)\, p_t^* + \omega p_t^r, \tag{9}$$

where $(1 - \omega)$ is the fraction of firms that optimise, p_t^* is the optimal price level and p_t^r is the rule-of-thumb price level. There are a number of rules-of-thumb that can be specified to describe the behaviour of non-optimising firms. In this paper, we assume a rule-of-thumb followed by non-optimising firms as follows:

$$p_t^r = p_{t-1}^r + \gamma(L)\pi_t^*, \tag{10}$$

where $\gamma(L)$ is a polynomial lag operator. Eq.(10) says that rule-of-thumb firms attempt to mimick optimising firms; they inflate their prices according to the combination of past optimal inflation rates[1]. If $\gamma < 1$ then non-optimising firms partially index their prices to previous optimal inflation, and if $\gamma = 1$ there is full indexation. Besides the price rigidity parameter, partial indexation to previous optimal inflation adds further sluggishness to the inflation rate in response to shocks. From eq.(8), we also know that:

$$\pi_t^* = \pi_{t-1} + a_s \widehat{s}_{t-1} + a_y \widehat{y}_{t-1} - \widehat{y}_{t-2} + \sum_{i=1}^{n} a_{pi} \widehat{p}_{it-1} + \eta_t. \tag{11}$$

Combining eqs.(9) and (10), we observe that $\pi_t = (1 - \omega)\, \pi_t^* + \omega\gamma(L)\pi_t^*$. Therefore we can write the aggregate inflation rate as follows:

[1]Not that an adaptive scheme of the following form: $p_t^r = p_{t-1}^r + \gamma\left(p_{t-1}^* - p_{t-1}^r\right)$, yields similar results as eq.(10), except that the weights on past optimal inflation rates exponentially decline as follows: $\pi_t^r = \gamma \sum_{j=0}^{\infty} (1-\gamma)^j\, \pi_{t-j}^*$.

$$\pi_t = \lambda(L)\pi_{t-1}+a_s\lambda(L)\widehat{s}_{t-1}+a_y\lambda(L)\widehat{y}_{t-1}-\lambda(L)\widehat{y}_{t-2}+\sum_{i=1}^{n}a_{pi}\lambda(L)\widehat{p}_{it-1}+\lambda(L)\eta_t \tag{12}$$

where $\lambda(L) = (1-\omega) + \omega\gamma(L)$. Eq.(12) is a generalised traditional Phillips curve which features higher lags on the right hand side; it is similar to Gordon's (2011) triangle specification. By deriving the general model in this way, researchers in the TPC literature can now specify their Phillips curves with the guidance of theory.

3. Empirical results

3.1 Estimates of the TPC

We are now in a position to estimate the parameters of our TPC. For purposes of this exercise we consider six developed and five emerging market economies. For the six developed economies we have: the United States, United Kingdom, Canada, Germany, France and Australia. For the five emerging market economies we have: Brazil, Mexico, Poland, South Korea and South Africa.

Data is sourced from the International Financial Statistics database and where there are gaps, we used the OECD database and country statistical offices. The data is quarterly with a sample from 1970:1–2012:2 for developed economies. For emerging markets (except South Africa) the data starts from 1995–2012:2. Inflation is measured using the CPI, supply shocks are measured by the import price or the real effective exchange rate, food and energy price deflators all drawn from the OECD database. Real output is measured by real GDP. Percentage deviations from trend are derived using the HP-filter following Gwin and van Hoose (2008).

Table 1 presents calibrated parameters for each country. We calibrate the steady state labour share as the average of historical data. The discount factor is the inverse of the average gross rate of economic growth. Similarly we estimate the steady state supply shock variables as historical averages. Table 2 presents estimations of the baseline TPC. The parameter of interest is the inverse of the degree of effective price rigidity denoted by ψ^{-1}. Estimates of the inverse of price rigidity are significant and have the correct sign across all countries. In terms of supply shocks Australia, Canada and France exhibit wrong signs and the rest of the countries exhibit correct signs. From these results, we find that the US has the most rigid prices in our sample of countries, because ψ^{-1} is the smallest. Brazil appears to have the highest price flexibility in the sense that ψ^{-1} is the highest.

Table 3 presents estimates of the generalised TPC. All the countries in our sample admit only one lag of the optimal inflation rate in the rule-of-thumb, i.e. the empirical rule-of-thumb is $p_t^r = p_{t-1}^r + \gamma_1 \pi_{t-1}^*$. Interestingly, except for the US and Brazil, the price rigidity parameter ψ^{-1} is not significantly different from the baseline case. In the case of the US and Brazil, we find that ψ^{-1} substantially rises from 0.12 (US) and 0.51 (Brazil) to 0.22 and 0.70 in the respective countries. Given the high statistical significance of ω and γ_1 in both countries, we conclude that the baseline TPC in this case misses some significant dynamics of inflation in these countries. Note that our estimates of ω are comparable to those found by Galí and Gertler (1999), and they suggest that the majority of firms are optimising.

The indexation to previous optimal inflation by non-optimising firms is high. In the US, Australia and Canada, we report full indexation. In the rest of the countries, non-optimising firms partially index their prices to previous optimal inflation. Comparing these estimates of γ_1 to Gali and Gertler (1999), we see that their "degree of price stickiness" takes the same values as our indexation parameter. This may be due to the fact that we use a different rule-of-thumb to describe the behaviour of non-optimising firms. Overall, from the structural perspective, and judging from the behaviour of the price rigidity parameter for Brazil and the US, it is prudent to test if higher lags on the right hand side are admitted before a researcher decides to use the baseline structural TPC model.

Table 1: Full sample calibrations

	Aus	Can	Fr.	Ger.	UK	US	Brazil	Mexico	Poland	S.Africa	S.Korea
β	0.93	0.93	0.94	0.97	0.94	0.93	0.95	0.95	0.93	0.97	0.93
S_0	0.44	0.57	0.63	0.69	0.62	0.68	0.53	0.43	0.53	0.55	0.71
p_{m0}		1.25					1.12*	0.96*	0.95*	1.14*	1.15
p_{e0}			0.92	1.29							
p_{f0}	0.99				1.06	1.05					

*Real effective exchange rate.

Table 2: Estimates of the baseline traditional Phillips curve

	Aus	Can	Fr.	Ger.	UK	US	Brazil	Mexico	Poland	S.Africa	S.Korea
ψ^{-1}	0.22^* (0.10)	0.16^{**} (0.09)	0.15^* (0.08)	0.21^* (0.08)	0.13^{**} (0.07)	0.12^* (0.06)	0.51^* (0.16)	0.15^* (0.07)	0.16^{**} (0.09)	0.18^* (0.08)	0.18^* (0.09)
δ_m		0.05^* (0.02)					0.11^* (0.02)	0.06 (0.04)	0.05^* (0.02)	0.04^* (0.01)	0.09^* (0.03)
δ_f	-0.06 (0.05)				0.28^* (0.06)	0.08^* (0.04)					
δ_e			-0.08^* (0.02)	-0.05^* (0.02)							
R^2	0.91	0.88	0.97	0.72	0.95	0.92	0.70	0.97	0.92	0.91	0.44
$\chi^{2\dagger}_{(4)}$	0.05	0.01	0.07	0.88	0.26	0.78	0.70	0.08	0.07	0.00	1.00
$ARCH(4)^\dagger$	0.86	0.32	0.46	0.58	0.01	0.05	0.34	0.19	0.51	0.89	0.93
$JB^\dagger$	0.94	0.94	0.13	0.95	0.00	0.16	0.95	0.96	0.78	0.98	0.00

†Probability. *Significant at 5%, **Significant at 10%.

Table 3: Estimates of the generalised traditional Phillips curve

	Aus	Can	Fr.	Ger.	UK	US	Brazil	Mexico	Poland	S.Africa	S.Korea
ψ^{-1}	0.20* (0.06)	0.15** (0.09)	0.18* (0.08)	0.21* (0.08)	0.21* (0.08)	0.22* (0.08)	0.70* (0.21)	0.18* (0.08)	0.27* (0.13)	0.21* (0.08)	0.15* (0.06)
ω	0.23* (0.10)	0.22* (0.07)	0.22* (0.08)	0.22* (0.08)	0.18* (0.05)	0.35* (0.06)	0.27* (0.09)	0.22* (0.10)	0.44* (0.07)	0.14* (0.07)	0.39* (0.07)
γ_1	1.00 (0.00)	1.00 (0.00)	0.92* (0.05)	0.92* (0.05)	1.01* (0.07)	0.86* (0.08)	0.80* (0.11)	0.62* (0.19)	0.62* (0.19)	0.92* (0.08)	0.82* (0.07)
δ_m		0.05* (0.02)					0.14* (0.03)	0.08* (0.04)	0.10* (0.03)	0.04* (0.01)	0.09* (0.02)
δ_f	0.06 (0.05)				0.33* (0.06)						
δ_e			−0.09* (0.02)	−0.05* (0.02)		−0.04* (0.02)					
R^2	0.92	0.88	0.97	0.72	0.95	0.80	0.71	0.97	0.97	0.92	0.69
$\chi^{2\dagger}_{(4)}$	0.00	0.00	0.00	0.88	0.00	0.02	0.00	0.02	0.00	0.00	0.00
$ARCH(4)^{\dagger}$	0.89	0.17	0.18	0.58	0.02	0.00	0.07	0.24	0.04	0.85	0.53
$JB^{\dagger}$	0.93	0.52	0.08	0.95	0.00	0.44	0.67	0.59	0.75	0.85	0.70

†Probability. *Significant at 5%, **Significant at 10%.

3.2 Sub-sample stability

Lastly, we consider the sub-sample stability of the parameters. Kuttner and Robinson (2010) note that the literature attributes changes in the slope of the Phillips curve to better anchoring of inflation expectations, globalisation, inadequate measurement of real marginal cost, data quality problems on the labour share and structural changes in price-setting behaviour. Clarida et al.(2000) have also shown that there was substantial change in the conduct of monetary policy in the early 1980s. They find that during the Volcker-Greenspan period monetary policy was more responsive to expected inflation than in the pre-Volcker period. Because of this change in monetary policy some authors, e.g. Roberts (2006), argue that this change contributed to the flattening of the Phillips curve.

Another set of literature attributes the flattening of the Phillips curve to the rise of globalisation in the early 1980's (e.g. Borio and Filardo, 2007). Along these lines, Rogoff (2003) argues that the combination of deregulation and privatisation led to low and stable inflation in the world economy through increased competition. According to Rogoff, the increase in competition in turn led to an increase in price and wage flexibility. The role of globalisation in engendering the flattening of the Phillips curve is also cited by Loungani et al.(2001), Razin and Binyamini (2007) and Musso et al.(2009).

We therefore check if there has been changes in the parameters of the Phillips curves, especially the slope, post 1982. We report the results for those economies that we have sufficient data. Table 3 presents the results.

Table 4: Stability analysis of the baseline traditional Phillips curve

	Aus		France		UK		US		S.Africa	
	Pre-80	Post-82	Pre-80	Post-82	Pre-80	Post-82	Pre-80	Post-82	Pre-80	Post-82
ψ^{-1}		0.31* (0.10)		0.18* (0.08)	0.27* (0.16)	0.01 (0.07)	0.62* (0.00)	0.09** (0.05)		0.36* (0.10)
δ_m										−0.04* (0.01)
δ_f		−0.08 (0.06)			0.30** (0.18)	0.19* (0.05)	−0.07 (0.05)	0.13* (0.05)		
δ_e				−0.09* (0.02)						
R^2		0.87		0.94	0.88	0.87	0.90	0.77		0.93
$\chi^{2\dagger}_{(4)}$		0.14		0.01	0.35	0.07	0.98	0.76		0.00
$ARCH(4)^{\dagger}$		0.71		0.06	0.56	0.10	0.58	0.04		0.65
$JB^{\dagger}$		0.51		0.19	0.79	0.75	0.63	0.75		0.92

†Probability. *Significant at 5%, **Significant at 10%.

The results suggest that after 1982 price rigidity actually fell for Australia, South Africa and to a small extent France. This may support the view by Rogoff (2003) that, in the case of these economies, globalisation may have led to an increase in price flexibility due to competitive pressures. On the other hand, the UK and the US, have experienced a substantial increase in price rigidity, that is to say, their Phillips curve flattened. In the case of the US, Gordon (2011) finds no evidence of the flattening of the Phillips curve, using the triangle model with long lags on the right hand side. In our baseline traditional Phillips curve, we find the opposite result. It should also be noted that our findings differ with those by Fuhrer (1995), who finds remarkable stability of the traditional Phillips curve pre and post 1982.

Table 5 assesses the stability of the TPC when higher lags are admitted. The results are qualitatively similar to those we find in the baseline case. The question that now arises is: what is it that makes our results diverge from the findings that dominate TPC literature? One candidate explanation is that the estimated lags on the right hand side of eq.(12) may still be too small, which implies that non-optimising firms may be using higher lags than the ones used in this paper. For example, Gordon's (2011) specification features lags of inflation of up to 24, Fuhrer's (1995) specification has 12 lags of inflation and Mazumder's (2012) specification has 4 lags. Because these model specifications are not guided by theory, in some instances the number of lags of one variables is not the same as that of another variable. Nevertheless it remains an area of future research to confirm if indeed, higher lags deliver the robustness result of the TPC between policy regimes and over time.

Table 5: Stability analysis of the generalised traditional Phillips curve

	Aus		France		UK		US		S.Africa	
	Pre-80	Post-82	Pre-80	Post-82	Pre-80	Post-82	Pre-80	Post-82	Pre-80	Post-82
ψ^{-1}		0.28^{*} (0.12)		0.22^{*} (0.08)	0.30^{**} (0.15)	0.12^{**} (0.07)	0.63^{*} (0.20)	0.11^{**} (0.00)		0.34^{*} (0.10)
ω		0.23^{*} (0.07)		0.23^{*} (0.08)	0.17^{*} (0.10)	0.33^{*} (0.06)	0.33^{*} (0.08)	0.04^{*} (0.00)		-0.01 (0.07)
γ_1		1.00 (0.00)		0.81^{*} (0.17)	1.15^{*} (0.17)	0.88^{*} (0.05)	1.13^{*} (0.07)	0.35 (0.48)		
δ_m										-0.04^{*} (0.01)
δ_f		-0.07 (0.06)			0.41^{*} (0.18)	0.23^{*} (0.05)	-0.05 (0.06)	0.06 (0.05)		
δ_e				-0.09^{*} (0.02)						
R^2		0.89		0.95	0.88	0.88	0.90	0.78		0.94
$\chi^{2\dagger}_{(4)}$		0.00		0.00	0.35	0.00	0.00	0.69		0.00
$ARCH(4)^{\dagger}$		0.98		0.00	0.45	0.97	0.11	0.69		0.64
$JB^{\dagger}$		0.84		0.08	0.89	0.50	0.87	0.94		0.85

†Probability. *Significant at 5%, **Significant at 10%.

4. Conclusion

Traditional price Phillips curves have been severely criticised for their lack of microfoundations. As Galí and Gertler (2003) put it, with the TPC, the exact specification is not explicitly guided by theory. In addition, it is also the case that the parameters of existing TPC specifications have not clear structural interpretation. In this paper we have derived an exact specification of the baseline traditional Phillips curve on the basis of optimisation of firms. Consequently, we have addressed the long-standing criticism of this type of price Phillips curve. By assuming, as new Keynesian derivations of the hybrid Phillips curve do (e.g. Gali and Gertler, 1999), that a fraction of firms use a rule-of-thumb, we are able to derive a general structural TPC model that features higher lags on the right hand side. We therefore argue that it is a mistake to reject the TPC on the grounds that it has no theoretical underpinnings.

From an empirical point of view, estimations of our TPC deliver a significant and correctly signed parameter for the degree of price rigidity. Sub-sample stability tests suggest that in some countries the TPC has become steeper after 1982, while in some countries it has become flatter. In the case of the US, our TPC suggests that the price Phillips curve has substantially flattened, evidence that is in line with the new Keynesian approach (e.g. Roberts, 2006). However, the TPC literature overwhelmingly finds no significant changes in the slope of the Phillips curve (see Fuhrer (1995), Stock and Watson (1999), Gordon (2011) and Mazumder (2012)). One possible explanation for this divergence may be the number of lags that we use to estimate our structural model, combined with the choice of the rule-of-thumb that describes the behaviour of non-optimising firms.

In terms of possible areas for future research, there are some relatively stringent assumptions that we have made in this paper. For example, we assumed complementarity between labour and non-labour inputs in the production process within the context of a simple Leontief technology. It will be worthwhile to explore a case where production technology admits substitution between inputs. Secondly, there is a need to explore empirically, rule-of-thumb behaviour that allows for the "zig-zag pattern" in the signs of the variables on the right hand side as pointed out by Gordon (2011). Thirdly, from an empirical point of view, there is scope to further explore higher lags of the drivers of inflation as a way to address the divergence in the stability results reported in this paper and those results that are found in TPC literature.

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