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Relative Price Adjustment and the UK Phillips Curve

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Abstract

We find that measures of the distribution of relative price changes are significant when included in a standard model of the UK Phillips curve based on time dependent price adjustment. Since the inclusion of these variables is not implied by this model but is implied by a state-dependent model of price adjustment or by a time-dependent model with allowance for heterogeneity among price-setters, we conclude that the familiar time-dependent model does not provide a complete account of the Phillips curve.

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1. Introduction

The Phillips curve is a key macroeconomic relationship, central to explanations of movements of inflation and output over the business cycle. Recent debates over whether the relationship has shifted in response to changes in monetary policy regimes and over whether using the output gap or the share of labour in national income provides the superior model, attest to the continuing importance of the Phillips curve and the enduring interest of economists in it.

The theoretical foundations of the Phillips curve are controversial. The standard model of the New Keynesian Phillips Curve, used extensively in modern macroeconomic analysis, is derived from a time-dependent model of price adjustment, in which, with a fixed probability, firms may be able to adjust prices costlessly in each period. Although this approach has some well-known weaknesses, (eg Mankiw, 2001) it does yield a tractable analytic expression for inflation whose structural parameters can be estimated. It has therefore become the standard model of the Phillips curve used in macroeconomic analysis (for a recent exposition, see Gali, 2008).

An alternative model is based on the idea of state-dependent price-setting, in which firms can adjust price at any time but must pay a fixed cost in order to do so. Although this approach is known to be immune to some of the weaknesses of time-dependent models and is arguably more consistent with firm-level survey evidence on price adjustment (eg Blinder, 1994), solving the models has been a formidable challenge; to date, estimable structural models have only been proposed in a few special cases (e.g. Golosov and Lucas, 2007, Nakamura and Steinsson, 2008). An alternative approach has extended the standard time-dependent model to explicitly model heterogeneity in the speed of price adjustment across sectors. This model is also complex (eg Carvalho, 2006) and has not as yet been estimated on aggregate data. This has made it difficult to assess estimates of the standard time-dependent model alongside estimates of alternative models.

This paper adopts a different approach to testing the adequacy of time-dependent models of the Phillips curve. We take a standard time-dependent empirical model of the Phillips Curve and test for the addition of variables implied by a state dependent model. Insignificance of these variables would suggest that, for all the doubts over its' theoretical foundations, the time dependent model provides an adequate empirical model. Significance would highlight the importance of developing an alternative model.

The additional variables we consider are the variance and skew of the distribution of relative changes in the components used to construct the aggregate price index. We cannot be sure that these would enter a state dependent model of the Phillips curve until a general solution is developed. However they are plausible candidates for inclusion. Fixed costs of price adjustment are a key characteristic of state-dependent models. Firms choose whether or not to adjust price and are more likely to do so if their relative price is too far out of line; this is more likely when relative price changes are more variable or skewed. Evidence that these measures of the distribution of relative price changes factors are relevant to inflation has been provided by Ball and Mankiw (1994, 1995), who use a state-dependent model of price adjustment (see also Domberger, 1987, and Debelle and Lamont, 1997). Inclusion of these variables in a Phillips curve relationship based on state-dependent pricing is therefore a logical next step. However these factors have no relevance the standard time-dependent

Phillips curve model, where price adjustment is costless for firms able to do so, rendering the decision of whether or not to adjust price irrelevant.

We test these ideas using UK data. We begin by estimating an up-dated version of the time-dependent open economy Phillips curve of Batini et al (2005) and then test for the inclusion of the variance and skew of relative price changes. We find that these variables are significant and have little effect on estimates of other variables, which remain significant. We conclude that the standard time-dependent model does not provide a complete account of the Phillips curve.

2. Empirical Model

The hybrid New-Keynesian Phillips curve is the standard time-dependent structural empirical model of the relationship between inflation and output. The model is

$$\pi_t = (1-\theta)\pi_{t-1} + \theta\delta E_t\pi_{t+1} + \gamma mc_t \qquad (1)$$

where π is the inflation rate and mc is the proportional deviation of marginal cost from it's steady-state value. First proposed by Gali and Gertler (1999), the model is derived from an economic structure in which identical monopolistically competitive firms with constant returns production functions are able to adjust price in any period with probability λ. A proportion of firms able to change price do so in an optimal, forward-looking manner; the others follow a backward-looking rule of thumb. In the resultant Phillips curve the marginal cost parameter γ is a function of λ and the discount factor δ while θ reflects both λ and the proportion of firms who reset prices optimally (see Gali and Gertler, 1999, and Gali, 2008, for detailed expositions).

We use two measures of marginal cost: in terms of (1) we assume $mc_t = \phi_1\sigma_t + \phi_2 y_t$, where σ is the share of labour payments in national income (constructed using the adjustments described in Batini et al 2005) and y is the output gap. Batini et al (2005) use the labour share as their primary measure of marginal cost, regarding the output gap as an indicator of cyclical variations in the mark-up of price over marginal cost. The empirical model below is consistent with this, but the slightly different formulation above allows us to side-step the controversy over whether the labour share or the output gap is the better measure of marginal cost (Gali et al, 2005, Rudd and Whelan, 2005) by including both. Our baseline empirical model of the hybrid Phillips curve is then

$$\pi_t = \beta_1\pi_{t-1} + \beta_2\pi_{t+1} + \beta_3\sigma_t + \beta_4 y_t + \varepsilon_t \qquad (2)$$

where ε is the error term which arises from substituting expected future inflation in terms of the realised inflation rate at time t+1, $\beta_1 = (1-\theta)$, $\beta_2 = \theta\delta$, $\beta_3 = \gamma\phi_1$ and $\beta_4 = \gamma\phi_2$. If the time-dependent model is sufficient, then the addition to (2) of variables implied by a state-dependent model should be rejected. To test this we consider the augmented model

$$\pi_t = \beta_1\pi_{t-1} + \beta_2\pi_{t+1} + \beta_3\sigma_t + \beta_4 y_t + \beta_5 sd_t + \beta_6 sk_t + \varepsilon_t \qquad (3)$$

where sd and sk are the standard deviation and skew of relative price changes, defined below.

3. Data and Estimations

We use quarterly data for 1987Q1-2007Q4, obtained from the UK Office of National Statistics database. Our variables are defined consistent with Batini et al (2005); inflation is the proportional change in the Retail Price Index; the labour share is the log ratio of total compensation of employees (including employer's social security contributions) to Gross Value Added at basic prices (excluding taxes and subsidies) and the output gap is the proportional difference between real gross value added and its' Hodrick-Prescott trend.

For the computation of relative price changes we use data on 75 sub-components of the RPI. Price changes for each components is given by,

$$\pi_{it} = \left(\frac{P_{it}}{P_{it-1}} - 1 \right) \times 100 , \tag{4}$$

Therefore total inflation at time t is obtained as the weighted mean of price changes of the components,

$$\pi_t = \sum_{i=1}^{N} W_{it} \pi_{it} , \tag{5}$$

where W_{it} is the weights, obtained through the adjustment of fixed weights with respect to relative price change of component *i*:

$$W_{it} = w_i \times \frac{P_{it}}{P_t} . \tag{6}$$

Using the information above, we compute skewness and kurtosis of the cross-sectional price changes:

$$sd_t = \frac{\sum_{i=1}^{N} W_{it} (\pi_{it} - \pi_t)^3}{\sigma^3} \quad , \qquad sk_t = \frac{\sum_{i=1}^{N} W_{it} (\pi_{it} - \pi_t)^4}{\sigma^4} \quad , \tag{7}$$

Where $\sigma = \sqrt{\sum_{i=1}^{N} W_{it} (\pi_{it} - \pi_t)^2}$.

After obtaining the relative price change variables, we estimated the models (2) and (3) by GMM using the small sample correction approach of Den Haan and Levin (2000) which is more efficient in small samples. In our estimates e used a fixed set of instruments comprising four lags of inflation, the labour share, output gap, real per capita wages and changes in food and real oil prices. For each model we report Sargan over-identification test statistics for instrument validity.

Our estimates are presented in Table 1. Column (i) reports estimates of the model in (2), Column (ii) excludes the output gap, giving a model similar to that of Gali et al (2005), while column (iii) omits the labour share, giving the model preferred by Rudd and Whelan (2005). Column (iv) augments the specification in column (i) with the rate of change of oil and food prices, used by Batini et al (2005) as measures of input price shocks. The estimates provide strong evidence of a Phillips curve relationship. Inflation is both forward- and back-ward looking, with roughly equal weights; this contrasts with Battini et al (2005) where the forward-looking element was dominant. Both measures of marginal cost are significant, whether together or separately. The Sargan test indicates exogeneity of the instruments. Both the standard error and Sargan tests suggest that the models with both measures of marginal cost, in columns (i) and (iv) provide a better fit than the models with only one of these measures.

Having obtained good estimates of a conventional time-dependent Phillips curve, we include the skew and variance of relative price changes. Our estimates are reported in columns (v)-(viii) of Table 1, where we repeat the specification of columns (i)-(iv) but with the addition of these extra variables. The variance and skew are significant in all four specifications. The specification in column (vi), which omits the output gap provides, by some distance, the best fit of all the models considered in Table 1. These estimates provide a strong indication that measures of the distribution of price changes are important components of the Phillips curve relationship.

Table 1: GMM estimation of Phillips Curve Models[a] , 1988: Q2-2007: Q3
Dependent Variable: π_t

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
Constant	-0.342***	-0.145***	0.002***	-0.147**	-0.388***	-0.129***	-0.01***	-0.254**
	(-7.455)	(-3.910)	(10.4)	(-2.321)	(-4.678)	(-4.106)	(-6.389)	(-2.480)
y_t	0.121***	-	0.138***	0.133***	0.158***	-	0.080***	0.089**
	(5.379)	-	(6.107)	(4.214)	(3.756)	-	(4.727)	(2.224)
$lshare_t$	0.081***	0.034***	-	0.035**	0.091***	0.030***		0.053**
	(7.458)	(3.895)	-	(2.334)	(4.689)	(4.076)		(2.495)
π_{t+1}	0.406***	0.589***	0.496***	0.445***	0.198***	0.502***	0.568***	0.341***
	(10.378)	(14.064)	(11.726)	(8.423)	(3.055)	(13.510)	(10.695)	(6.495
π_{t-1}	0.476***	0.473***	0.267***	0.319***	0.369***	0.443***	0.224***	0.362***
	(20.151)	(17.728)	(12.048)	(12.255)	(11.520)	(15.855)	(6.928)	(8.773)
sd_t					0.077***	0.048***	0.080***	0.068***
					(3.599)	(5.678)	(9.680)	(4.445)
sk_t					0.051***	0.033***	0.033***	0.065**
					(4.887)	(4.604)	(8.957)	(2.497)
$\Delta poil_t$				0.0025				0.074
				(1.392)				(1.609)
$\Delta pfood_t$				0.118***				0.002
				(5.862)				(1.382)
S.E.	0.00349	0.00357	0.00350	0.00345	0.00364	0.00337	0.00343	0.00374
$\bar{R}^2$	0.678	0.645	0.655	0.669	0.630	0.683	0.667	0.610
Sargan Test Statistics	15.7	16.3	16.9	15.9	16.9	10.78	14.6	14.1
Prob.	(0.957)	(0.962)	(0.950)	(0.918)	(0.886)	(0.98)	(0.970)	(0.963)

[a] t-values in parentheses.

We experimented with refinements of these models (the estimates are not reported by are available from the authors on request). Following Ball and Mankiw (1994) we included an interaction between the skew and variance terms. We also allowed entered positive and negative values of the skew separately, to allow for asymmetry effects. These effects were significant, suggesting that the effects we investigate have some robustness.

4. Conclusions

This paper investigates whether the popular New Keynesian model, based on time-dependent models of price adjustment, provide a complete account of the Phillips curve relationship. For this purpose, relative price change variables, i.e. standard deviation and skewness, proposed by the menu cost model of Ball and Mankiw (1995), are computed using the sub-components of the RPI and are included as additional regressors in the time dependent price adjustment model of Batini et al (2005).

Our results suggest that measures of the distribution of relative price changes are significant when included in an otherwise standard model of the Phillips curve. Since the inclusion of relative price change variables is implied by a state-dependent model of price adjustment or by a time-dependent model with allowance for heterogeneity among price-setters, we conclude that the familiar time-dependent model does not provide a complete account of the Phillips curve.

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