PRELIMINARY DRAFT, COMMENTS WELCOME

Optimising Microfoundations for Observed Inflation Persistence

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Abstract

Much recent monetary policy literature has searched for structural models suitable for policy analysis that are both based on optimising microfoundations and consistent with the data, especially the persistence that we observe in inflation, output and interest rates. Few models do well on both criteria. The standard (and well microfounded) New Keynesian Phillips curve based on Calvo pricing largely fails to match observed dynamics. Empirical performance is substantially improved by the addition of a lagged inflation term which may be interpreted as reflecting rule of thumb behaviour in price or wage setting but this remains controversial. This paper develops a fully microfounded model of price setting behaviour without rule of thumb effects which, when combined with standard discretionary policy, predicts inflation (and output/interest rate) persistence comparable to that observed. This enhanced data consistency is achieved simply by allowing the probability of a firm changing its price to rise with the time since last price change for 3-5 periods within an otherwise standard New Keynesian model. Stronger dynamics occur because an increasing probability, in contrast to the Calvo constant hazard assumption, implies that lagged as well as current expectations, prices and (crucially) shocks matter for current outcomes.

Key Words

Monetary policy, Phillips curve, Inflation persistence, Microfoundations

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Introduction

A central objective of the monetary policy literature has been the search for structural models of the macroeconomy suitable for use in policy analysis. Key criteria for such a model are that it should be based on plausible optimising microfoundations, both for conceptual coherence and to avoid Lucas critique problems in policy analysis, and that it should be able to account for key features of the data, especially persistence of inflation and output. In general most models currently in use satisfy one or other of these criteria but not both, with much of the debate concentrating on the appropriate specification for the aggregate supply or Phillips curve relationship.[2] The key contribution of this paper is to derive a fully microfounded Phillips curve that can account for at least a large fraction of the persistence that we see in the data. The underlying microfoundations of price setting in the new model are identical to those already in the literature, the innovation being allowance for a more general and arguably more plausible set of time dependent pricing rules. These give rise to a Phillips curve with a much richer inter-temporal structure which in turn gives rise to much stronger endogenous dynamics. Before introducing the new model in more detail we motivate it and place its contribution in context by briefly reviewing the recent literature.

Until fairly recently the standard workhorse model for the Phillips curve was the New Keynesian Phillips curve based on Calvo pricing shown by (1).[3]

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[2]Woodford (2002) and Rudebusch (2002) give excellent summaries of this controversy.

[3]The notation is standard; π, β, y, ε are inflation, the private sector discount factor, the output gap and the cost push or inflation shock term respectively. γ is a parameter. Walsh (1998) amongst others shows the derivation of this relationship.

$$\pi_t = \beta E_t[\pi_{t+1}] + \gamma y_t + \varepsilon_t \qquad (1)$$

While (1) has optimising microfoundations it has increasingly been recognised that it performs very poorly with respect to data consistency, especially its failure to account for the persistence of inflation and output that we observe.[4] Intuitively, under discretionary policy the expectations term on the right hand side of (1) cannot be influenced by policy which means that there are effectively no dynamics in the model. As a result inflation and output respond to the current value of the shock variable only and display no persistence unless the shock itself is persistent. While there may be some persistence in the shock process it is generally considered unlikely that it would be sufficiently persistent to account for observed dynamics.

Given the empirical failure of (1) many analysts have used a hybrid model which adds lagged inflation terms to the Phillips curve above. A common and compact form of this approach is shown by (2) where μ indexes the relative importance of the forward looking expectation term compared with lagged inflation. Values of μ around a third are common (Rudebusch, 2002,

[4]See the discussion in the Clarida, Gali and Gertler (1999) survey article together with a large number of other contributions to the literature including Calvo et. al. (2001), Christiano et. al. (2001), Dotsey (2002), Fuhrer and Moore (1995), Gali and Gertler (1999), Gali et. al. (2001), Jensen (2002), Mankiw (2001), Mankiw and Reis (2002), McCallum (1999), Nelson (1998), Nessen and Vestin (2000), Roberts (1997, 2001), Rudd and Whelan (2001), Rudebusch (2002), Sbordone (2001), Soderstrom et. al. (2002), Steinsson (2000), Taylor (1999), Walsh (2001), Wolman (1999) and Woodford (2002). Some authors (including Gali and Gertler, 1999; Sbordone, 1998; and Gali et. al., 2001) suggest that the empirical failure of (1) can be overcome by using marginal cost rather than the output gap as the driving variable for inflation. This distinction is not relevant for the model presented below where wages are flexible and marginal cost is proportional to the output gap. More generally it may be argued that using marginal cost in the Phillips curve leaves the model incomplete since monetary policy affects the output gap rather than marginal cost directly and hence the links between the two must be specified before policy analysis can be undertaken (Rudebusch, 2002, footnote 9). Gali et. al. (2001) comment that their results in part push back the "mystery" of inflation persistence to the determinants of marginal cost.

surveys the empirical evidence on this), implying a strong weight on lagged inflation for data consistency.

$$\pi_t = \mu\beta E_t[\pi_{t+1}] + (1-\mu)\pi_{t-1} + \gamma y_t + \varepsilon_t \qquad (2)$$

While Phillips curves like (2) have been an empirical success a considerable debate has arisen over the interpretation of the lagged inflation term in relation to optimising behaviour. Most simply this term could be an ad hoc addition for empirical purposes and/or it reflects adaptive expectations of inflation, neither of which are satisfactory for standard reasons. More recently some authors have suggested that this term may arise from near-optimising behaviour in the sense that it may reflect rule of thumb behaviour by some price or wage setters.[5] The extent to which rule of thumb behaviour may be considered an optimising microfoundation is clearly a controversial issue, ideally requiring explicit consideration of the information acquisition and processing constraints faced by agents. While sympathetic to such approaches, the view taken in this paper is that the possibility of rule of thumb microfoundations for (2) is not sufficiently well established to preclude the search for alternatives that are also broadly data consistent but more clearly based on optimising behaviour.[6]

We also note three further potential explanations for inflation persistence that have been put

[5]See Christiano, Eichenbaum and Evans (1999), Steinsson (2000), Amato and Laubach (2000), Sbordone (2001) and Woodford (2002).

[6]Parallel research to the current paper has more critical conclusions for the rule of thumb approach, showing that under adaptive learning (and combined with a standard discretionary policy maker) the coefficients assumed in the typical rule of thumb underlying (2) would tend to zero over time and the lagged inflation term disappear from the Phillips curve. This is because an inflation averse policy maker will tend to choose lower persistence for inflation than that implicit in agents' rules of thumb so the latter will adjust downwards over time with learning in response to the data generated by the model.

forward. The first is the relative real wage contracting structure presented by Fuhrer and Moore (1995) which is generally regarded as not reflecting optimising behaviour (see Taylor, 1999). The second (Erceg and Levin, 2000) explains persistence with adaptive learning by agents in response to a change of policy regime. This model has very explicit microfoundations and is likely to partly explain persistence but it has difficulty in accounting for continued persistence during periods where the policy regime has been fairly stable. Evidence for continued persistence away from major regime changes is provided by sub-sample stability tests of equations such as (2) reported by Soderstrom et. al. (2002) amongst others. Thirdly, Mankiw and Reis (2002) present a model of the Phillips curve which involves a substantial amount of price setting being based on past information and discuss its predictions for inflation persistence. The time structure of the model gives rise to a delayed response of prices and inflation to monetary policy shocks. Hence inflation responds sluggishly to changes in the economic environment but there is no demonstration of persistence in the sense of positive serial correlation in inflation and output in the absence of serial correlation in the driving processes.

Given the above, the starting point for this paper is that there is a highly unsatisfactory gulf between models with good microfoundations and those with good data consistency, and that progress in this area would put monetary policy research on a much firmer footing. The approach taken is to examine and enrich the assumptions made in deriving optimising time dependent pricing models such as (1) rather than to explore the possible microfoundations for the lagged inflation term in (2). In a time dependent pricing model the two key components are firstly the level at which prices (or wages, though we consider only price setting here) would be set if they were entirely flexible, and secondly the nature of the timing constraints on when prices can be reset.[7] We keep the first of these exactly the same as in the literature, thus making the model fully optimising (subject to the exogenously imposed timing constraints, a standard feature of time dependent pricing) while making the latter more general. In particular the simplifying assumption made by the Calvo (1983) pricing underlying (1) is that after changing a price a firm faces a constant probability of being able to change it again each period thereafter. This contrasts with the Taylor (1979, 1980) approach of prices being fixed for a certain number of periods after which they are reset with probability one. By contrast, the model derived below allows for any set of probabilities of price change over any time horizon, thus encompassing both Calvo and Taylor and more importantly allowing us to model more empirically plausible timing rules than either.[8] A key feature of this general Phillips curve is that as soon as we move away from the Calvo constant probability assumption the prices set in previous periods matter for current inflation.[9] A direct implication is that both expectations formed in the past and (crucially for persistence) past dated shocks become important and together these greatly affect the dynamics of inflation and output predicted by the model. While these dynamics are present in simpler settings such as a four quarter Taylor model it appears that the literature has not highlighted them

[7]It is generally agreed that in principle it would be preferable to have state dependent pricing models but these are often intractable. Dotsey et. al. (1999) summarise and extend recent work in this area.

[8]Key references here are Khan, King and Wolman (2002), Kiley (2002), Dotsey and King (2001), Wolman (1999) and Dotsey (2002).

[9]Mash (2002) discusses this aspect of the Calvo and (2 period) Taylor models in greater detail, showing that the latter (and a hybrid of the two, but not Calvo in its pure form) can account for observed inflation persistence at a one period lag. In relation to that earlier work, the current paper derives a fully general Phillips curve which allows for much longer lead/lag structures. These explain persistence over several quarters which is present in the data. Dotsey (2002) focuses on the empirical testing of backward looking behaviour in equations of the form of (2) when the true model has a much richer time dependent structure of the type explored below. The latter is more general than the Dotsey model, and we compare predicted moments directly with those in the data rather than showing the possibility of false results when testing backward looking effects, but Dotsey's results clearly anticipate in a general sense those we derive below.

before, possibly due to the complexity that results from moving away from Calvo pricing and because there has been a tendency to analyse these models without explicit shocks to price setting even though such shocks are crucial for dynamics.[10]

The paper is structured very simply in that Section 1 derives the generalised Phillips curve and Section 2 demonstrates its ability, when combined with a standard discretionary policy maker, to match observed persistence in inflation and output much more closely than earlier fully microfounded models. Section 3 concludes.[11]

1. The Generalised Phillips Curve

We derive a generalised model of the Phillips curve under time dependent pricing. The structure of the model extends that presented in Dotsey (2002) which in turn relates to that of Wolman (1999). The key generalisation concerns the probability of a firm choosing its price each period as a function of the number of periods since a previous price change. In the Calvo (1983) model this probability is simply constant in all periods whereas in a Taylor model it is zero (ie. prices are fixed with certainty) for a given number of periods before they may be reset with probability one. Dotsey (2002) presents a model in which prices may be fixed for up to three periods, with a probability of price change in the second and third periods greater than zero prior to becoming

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[10]Roberts (1995) for example shows the lag structure of output that arises from a simple Taylor model but not the current and lagged shocks that will also be present unless price or wage setting is deterministic. The structure and timing of shocks and how they enter the Phillips curve are also extremely important for optimal monetary policy and optimal delegation. This paper focuses on Phillips curve microfoundations and empirical fit rather than policy.

[11]Work on section 2 is ongoing, though significant and substantial results are presented in full, and we discuss the initial results of the relevant extensions at the end of the section.

unity in the fourth period, thus generalising the Taylor structure. Mash (2002) presents a slightly different model in which the probability of price change may vary between the first and all subsequent periods after a price change but the latter may be less than one such that the structure is closer to a modified Calvo model rather than a Taylor one in which there is a fixed limit to the number of periods before a price change. The model below encompasses all of these cases.

We start by describing the notation for the probability of price changes before analysing firms' optimal price setting behaviour given those probabilities. We think of a price being reset at the start of a given period, say t=0, with a duration of at least one quarter. Thereafter the probability of price change each period is given by q_1, q_2, q_3 etc.[12] for as many periods as there may be, which may be an infinite number, before (in the finite case) the probability becomes unity and the price may be reset for sure. We denote the last period in which the price may remain fixed by T with a probability of price change in that period of q_T. Hence, allowing for period t=0, prices may remain fixed for T+1 periods. We emphasise firstly that these probabilities may take any values (between zero and unity) and follow any time profile (rising, falling or constant, though the first of these is generally considered the most realistic), and secondly that T can tend to infinity. Together these allow for Calvo type infinite horizon effects as well as Taylor type truncation of the time horizon over which prices may be fixed.

It may also be noted that the model allows for easy aggregation of price setters with different probabilities of resetting price (such that the time dependent rules at the firm level are not necessarily stochastic, in which case the probabilities we refer to may be proportions of firms).

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[12]Implicitly q_0=0 since the new price set at the start of period 0 must remain fixed for at least that period.

In addition, where there is an infinite horizon the terms in the Phillips curve my be truncated at the time period when the probabilities become constant (assuming that they do) as in the Calvo model. We develop these points below but for the time being interpret the model in terms of firms facing identical probabilities.

Given these probabilities it is convenient to define the cumulative probability of a price remaining fixed j periods after a price change by Q_j where this is given by (3).

$$Q_j \;=\; \Pi_{i=0}^{j}(1-q_i) \tag{3}$$

We also define firms' discount factor by β, as in (1) above, and two summary parameters by Q (with no subscript) and Q' in (4) and (5).

$$Q \;=\; \Sigma_{i=0}^{T}\beta^{i}Q_i \tag{4}$$

$$Q' \;=\; \Sigma_{i=0}^{T}Q_i \tag{5}$$

We note that the extent to which Q' exceeds unity may be interpreted as an indicator of overall multi-period price stickiness given that Q_0=1.

Having outlined the probabilities of a firm being able to reset its price, we turn to the optimisation decision of a firm that is able to change its price. Here we adopt the relatively simple log linear form (around a zero inflation steady state) that has become standard (see Dotsey, 2002) in that the ideal price that would be set in a period with complete price flexibility between periods (so other periods have no bearing on the current price decision) denoted x* is given by (6). Given x* the firms optimisation problem is the minimisation of V in (7) by the choice of its price, x, that will remain in place for some number of periods in line with the probabilities outlined above.[13]

$$x_t^* = p_t + \gamma y_t + \varepsilon_t \tag{6}$$

$$V_t = E_t \Sigma_{i=0}^{T} \beta^i Q_i (x_t - x_{t+i}^*) \tag{7}$$

Minimisation of (7) gives the first order condition expressed by (8) which simply says that the price which is set should be a discounted and probability weighted average of the ideal flexible prices that are expected to exist over the time horizon of the optimisation.

$$x_t = E_t \Sigma_{i=0}^{T} \frac{\beta^i Q_i}{Q} x_{t+i}^* \tag{8}$$

Substituting from (6) the optimal new price set at time to may be expressed by (9) where the last term relates to price levels and (10) in terms of inflation.

$$x_t = \frac{1}{Q}[\varepsilon_t + \gamma E_t \Sigma_{i=0}^{T} \beta^i Q_i y_{t+i} + E_t \Sigma_{i=0}^{T} \beta^i Q_i p_{t+i}] \tag{9}$$

$$x_t = \frac{1}{Q}[\varepsilon_t + \gamma E_t \Sigma_{i=0}^{T} \beta^i Q_i y_{t+i} + p_t + E_t \Sigma_{i=1}^{T} \Sigma_{j=i}^{T} \beta^i Q_j \pi_{t+i}] \tag{10}$$

Given (10), the Phillips curve is derived from the appropriate expression for the price level given the probabilities above which is shown by (11) and substituting into this (10) for each x_t to give (12) where the term z_t is given by (13).

[13] For the time being we assume that all firms which change their prices at t may do so with full information up to and including that date. This is varied later in the section to allow for some "ex ante" price setting, or alternatively contemporaneous price setting based on information up to only one or two periods prior to the price change.

$$p_t = \Sigma_{i=0}^{T} \frac{Q_i}{Q'} x_{t-i} \tag{11}$$

$$\pi_t = \Sigma_{k=0}^{T} \frac{Q_k}{(Q'-1)Q} [\varepsilon_{t-k} + \gamma y_{t-k} + z_{t-k}] - \Sigma_{k=1}^{T-1} \Sigma_{j=k+1}^{T} (\frac{Q_j}{Q'-1}) \pi_{t-k} \tag{12}$$

$$z_{t-k} = E_{t-k}[\gamma \Sigma_{i=1}^{T} (\beta^i Q_i y_{t-k+i} + \Sigma_{i=1}^{T} \Sigma_{j=i}^{T} \beta^j Q_j \pi_{t-k+i}] \tag{13}$$

From (12) it may be seen that in the generalised Phillips curve inflation depends on the current and past values of output, the shock variable, lagged inflation (with negative coefficients) and, in the z terms, current and past forward looking expectations of future (from the point of view of the date of the expectations) output gaps and inflation. Hence each value of the summation parameter, k, corresponds to the influence on inflation of different cohorts of prices set k periods ago. Past cohorts matter for as long as Q_k is non-zero.[14]

Intuitively, ignoring other terms for the time being, inspection of (12) shows that serial correlation in inflation may arise from the presence of current and lagged shock terms. For example, suppose there is an inflation increasing shock at some time s. This shock will first appear as ε_t but will impact positively on inflation for T+1 periods since it will appear successively as the t-1, t-2 etc. shock term. Given that outcomes in models of this kind are linear and additive in each realisation of the shock variable the positive covariance in inflation which will result from this single shock will appear at the aggregate level when many possible shocks are allowed for.

[14]A Phillips curve of the same form results from probabilities of price change which vary up to k periods ahead but remain constant (but not necessarily unity) thereafter in which case the dimension of the Phillips curve truncates at k in the same way. Demonstration of this to be added.

Before turning more formally to the empirical implications of (12) we note two extensions of the model. Firstly, the derivation above from probabilities to optimal price setting to aggregation of those prices into the Phillips curve is additive in nature. As a result it is straightforward to show that a similar form for the Phillips curve arises if we combine many different price setters with different probabilities of price change. The Phillips curve in this case is comparable to (12) with T+1 given by the longest possible duration of the least flexible price and all coefficients effectively weighted averages of those above for each set of firms with common probabilities.[15]

Secondly, a more substantial change is to allow for some new prices to be set in advance or based on lagged information. We assume that a proportion S_0 of firms set prices as above while proportions S_1 and S_2 (=1-S_0-S_1) set their prices based on information sets up to one or two periods prior to the price change.[16] In these cases the firms will choose prices such that the expected value of (9) at t-1 and t-2 is satisfied. We assume that the shock variable ε_t is common to all these firms. Following similar steps to those above these decisions may be aggregated to give (14) in which the new z terms are shown by (15).

$$\pi_t = \frac{1}{Q' - S_0} \left[\begin{array}{c} \Sigma_{k=0}^{T} \frac{Q_k}{Q} [\varepsilon_{t-k} + S_0 \gamma y_{t-k} + z_{t-k}] \\ -\Sigma_{k=1}^{T-1} \Sigma_{j=k+1}^{T} Q_j \pi_{t-k} - (S_1 + S_2) \Sigma_{k=1}^{T} Q_k \pi_{t-k} - S_2 \Sigma_{k=0}^{T} Q_k \pi_{t-k-1} \end{array} \right] \qquad (14)$$

[15]Detail to be added.

[16]For simplicity we assume that all these firms face a common set of price change probabilities. Relaxing this assumption is straightforward but results in a cumbersome expression for the Phillips curve.

$$z_{t-k} = \begin{array}{l} S_0 E_{t-k}[\gamma\Sigma_{i=1}^{T}(\beta^i Q_i y_{t-k+i} + \Sigma_{i=1}^{T}\Sigma_{j=i}^{T}\beta^j Q_j \pi_{t-k+i}] \\ +S_1 E_{t-k-1}[\gamma\Sigma_{i=0}^{T}\beta^i Q_i y_{t-k+i} + \Sigma_{i=1}^{T}\Sigma_{j=i}^{T}\beta^j Q_j \pi_{t-k+i} + \pi_{t-k}] \\ +S_2 E_{t-k-2}[\gamma\Sigma_{i=0}^{T}\beta^i Q_i y_{t-k+i} + \Sigma_{i=1}^{T}\Sigma_{j=i}^{T}\beta^j Q_j \pi_{t-k+i} + \pi_{t-k} + \pi_{t-k-1}] \end{array} \tag{15}$$

We discuss the implications of (14) further below but it may be noted that if S_1 and/or S_2 are positive a greater proportion of the determinants of inflation are predetermined and hence inflation will respond more sluggishly to policy. This increases its inertia in the sense of a sluggish response as well as its persistence in the sense of serial correlation over time.

2. Observed Inflation Persistence

Having derived a very general model of the Phillips curve under time dependent pricing we explore its implications for the dynamics of inflation and output. For this it is necessary to make assumptions about policy behaviour in response to shocks in the model since observed outcomes are a combination of the underlying model and policy behaviour. We assume that the policy maker acts under discretion rather than commitment and that they minimise a standard loss function shown by (16) which is quadratic in inflation and output with a relative weight on the latter given by λ. We do not allow for possible interest rate smoothing but also present results where the policy maker targets annual average inflation rather than period inflation in (16) where we think of each period being a quarter.

$$L_t = E_t \Sigma_{t=0}^{\infty}\beta^t(\pi_t^2 + \lambda y_t^2) \tag{16}$$

We combine (16) with the Phillips curve (12)[17] and derive optimal policy using the MSV approach outlined in McCallum and Nelson (2000) adapted for the much more complex Phillips curve here.[18] Having derived optimal policy we present the results in Table 1 where we focus on the serial correlation properties of inflation and output summarised by the simple correlation coefficients predicted by different models between inflation/output and their lagged values with lags of 1-4 periods in each case. We focus on these indicators of persistence since they have been the key empirical failing of the Calvo model (1) and a central focus of the literature.

The first row in this table marked "data" reproduces the information in Soderstrom et. al. (2002) which reports these figures for US data. We use inverted commas since the actual data on which these estimates are based will include the effect of IS and other shocks not considered here but nevertheless it is indicative of the dynamics in the data which we would like a model to approach. We initially consider the top half of the table, corresponding to standard inflation targeting using (16). The failure of the Calvo model (1) to match the dynamics in the data is shown by the first row. The second row reports the serial correlation properties given by the Calvo hybrid model (2) above assuming a value of μ of 0.3 which is a common value in the literature. The serial correlation properties of this model are less strong than the "data" but clearly much closer to it than the pure Calvo model. The next set of results reports the predicted dynamics from simple Taylor models with successively longer periods before prices are changed. We report these not because of any claim that they are the best model(s) but simply to show the

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[17]Research on the implications of (14) is ongoing and we note preliminary results below rather than reporting them formally.

[18]Detail to be added. Key parameter assumptions are γ=0.15 and λ=0.2 though the results presented are no sensitive to these, except in the case of the Calvo hybrid model (2).

effects of adding in greater numbers of cohorts into the Phillips curve (12) in a simple way. It may be seen that a 2-period Taylor model can account for inflation and output persistence at one lag but not beyond that. As additional cohorts are allowed for, persistence is seen at longer lags which we take to be indicative of the potential explanatory power of the approach taken in this paper of enriching the "cohort effects" in the Phillips curve by allowing for time varying probabilities of price change. It should be emphasised that a substantial proportion of prices being fixed for four or more quarters is empirically supported (Taylor, 1999) though of course many will change more frequently.

The first row of the top half of the table shows the results for the Phillips curve (12) above where we assume that the probabilities of price change follow the sequence from q_0-q_6 (0, 0.1, 0.11, 0.25, 0.67, 0.5, 1). These probabilities correspond to proportions of prices remaining fixed for 1, 2... periods of (0.1, 0.1, 0.2, 0.4, 0.1, 0.1) which is close to what the microeconomic evidence on price changing would suggest (references to be added). We find that our results are not sensitive to these assumed values as long as a fairly high proportion of prices are likely to remain fixed for 3-5 quarters. Turning to the figures in Table 1 we see that this model predicts significantly positive inflation and output persistence, close to that predicted by the Calvo hybrid model which is under consideration due to its empirical properties, and towards that found in the data. From the discussion in the introduction it may be emphasised that these dynamics have proven elusive in previous microfounded models.

The bottom half of Table 1 considers the same set of models but with annual rather than quarterly inflation targeting. Soderstrom et. al. (2002) suggest that this may be the appropriate description of actual policy behaviour given the prevalence of annual rather than quarterly inflation targets.

From the table it may be seen that this change has little impact on the serial correlation of inflation predicted by the new model while significantly raising that of output. The latter is not surprising since Nessen and Vestin (2000) show that average inflation targeting reduces stabilisation bias when forward looking expectations are present which also occurs under output gap (or interest rate) smoothing. The increases in the persistence of output from average inflation targeting also moves the predictions of these models closer towards the higher output persistence in the "data".

Hence our key conclusion from this section is that the generalised Phillips curve (12) above can both approach the endogenous dynamics required for empirical success while remaining fully microfounded.

We briefly note the work in progress on this paper. This is concerned with the implications of some ex ante price setting as encapsulated in (14) rather than (12). With a more gradual response of inflation to shocks (and policy) preliminary results indicate that even a fairly small fraction of ex ante price setters tends to flatten or even make hump shaped the impulse responses of inflation and output predicted by the model. The IRFs are currently "sharks teeth" in that inflation rises (output falls) to a maximum (minimum) value in the same period that a shock occurs. This is out of line with VAR evidence and also tends to restrict the correlation coefficients in Table 1 since the variables of interest head back to zero or target after the sharp initial spike. Using (14) rather than (12) reduces the initial spike relative to the decay process (and can make the IRFs hump shaped if there is enough ex ante price setting) which is both closer to the VAR evidence and also increases the serial correlation predicted. It appears that with plausible amounts of ex ante price setting the correlation coefficients predicted by (14) are significantly higher than those from (12) and raise the figures in Table 1 for the new model close to those in the "data". It may be noted that this effect from ex ante price setting is similar to that reported by Woodford (2002), the difference between this model and his preferred specification being that persistence comes from cohort effects here rather than rule of thumb behaviour in Woodford's model.

3. Conclusion

This paper has addressed the gulf that exists in current monetary policy research between models of aggregate supply or the Phillips curve which are well microfounded and those which can account for important features of the data, especially persistence in inflation and output. It derived a very general model of the Phillips curve in a time dependent pricing setting with a rich set of possible specifications for when firms may reset prices. In the first instance the paper shows that general models of this kind are tractable and allow us to use time dependent pricing rules that are less restrictive and better supported empirically than the constant hazard of the Calvo model or the (0,1) values of Taylor probabilities.

Secondly, enriching the dynamics of price setting in this empirically plausible way allows the resulting model to explain a much higher proportion of the persistence that we see in the data than other fully microfounded models.

Table 1: Simple correlation coefficients between inflation/ output and their values 1-4 periods before.

		Inflation					Output			
		1	2	3	4		1	2	3	4
"Data"	0.65	0.53	0.54	-		0.91	0.83	0.75	-	
Standard inflation targeting:										
Calvo (1)		0	0	0	0		0	0	0	0
Calvo hybrid (2)		0.63	0.40	0.25	0.16		0.63	0.40	0.25	0.10
2-period Taylor		0.42	-0.07	0.01	0		0.31	-0.05	0.01	0
3-period Taylor		0.47	0.27	-0.15	0.01		0.44	0.21	-0.08	0.02
4-period Taylor		0.46	0.35	0.22	-0.15		0.46	0.30	0.14	-0.1
5-period Taylor		0.43	0.36	0.27	0.17		0.46	0.34	0.22	0.09
New model (12)		0.46	0.35	0.18	-0.03		0.49	0.32	0.13	-0.02
Average inflation targeting:										
Calvo (1)		-0.10	-0.05	0.01	0		0.62	0.31	0.08	-0.04
Calvo hybrid (2)		0.63	0.37	0.22	0.12		0.75	0.52	0.32	0.19
2-period Taylor		0.29	-0.26	-0.04	0.02		0.64	0.28	0.04	-0.05
3-period Taylor		0.44	0.27	-0.15	0.01		0.72	0.41	0.16	0.03
4-period Taylor		0.45	0.34	0.21	-0.16		0.76	0.49	0.25	0.08
5-period Taylor		0.42	0.35	0.27	0.17		0.80	0.55	0.32	0.14
New model (12)		0.46	0.35	0.18	-0.03		0.77	0.51	0.27	0.11

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