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Resumen

Algunos trabajos recientes han estudiado la eficacia de la fijación de metas de inflación en base a las proyecciones de dicha variable realizando simulaciones de política, derivadas de modelos macroeconómicos empíricos pequeños. Los modelos usados en las simulaciones difieren significativamente en el grado de apertura de la economía, lo que es un importante factor en el análisis. Sin embargo, los modelos de economía abierta típicamente suponen, de un modo estilizado, que el traspaso del tipo de cambio a los precios de importables y a los precios minoristas es completo e instantáneo. Este trabajo modifica el modelo macroeconómico de economía abierta presentado en Batini y Haldane (1999) para acomodar una variedad de representaciones del coeficiente de traspaso, considerando reglas de traspaso que dependen del tiempo y del ciclo económico. Aunque las dinámicas del modelo se ven afectadas, el principal resultado de Batini y Haldane – que fijar la meta de inflación en las proyecciones domina a la fijación de objetivos para la inflación corriente – es robusto a los coeficientes de traspaso considerados.

Abstract

A number of recent papers have used policy simulations from small empirical macro models to assess the efficacy of inflation-forecast targeting. The macro models used to undertake the simulations differ significantly with the assumed degree of openness, an important factor for the analysis. However, the open economy models typically approach the pass-through from exchange rate to import prices and ultimately retail prices in a stylized manner, assuming full and instantaneous pass-through. This paper modifies the open economy macro model presented in Batini and Haldane (1999) to accommodate a variety of pass-through representations, considering time and state-(cycle)-dependent pass-through rules. While the model's dynamics are affected, the main result of Batini and Haldane – that targeting an inflation forecast dominates targeting current inflation – is robust to the assumed rate of pass-through.

This is a revised version of the paper prepared for the Third Annual Conference of the Central Bank of Chile "Monetary Policy: Rules and Transmission Mechanisms", Santiago, Chile, September 20-21, 1999. The views expressed are those of the authors and are not necessarily those of the Bank of England. The authors owe a debt of gratitude to Mike Chui and Richard Pierse whose advice on solution of the models has been invaluable. We would also like to thank Nicoletta Batini, Erik Britton, Prasanna Gai, Steve Millard, Adrian Penalver, Joe Pearlman and Paulo Freitas for helpful comments and suggestions. Any remaining errors are due to us. Email: Alastair.Cunningham@bankofengland.co.uk

1. Introduction

A number of recent papers have used policy simulations from small empirical macro-models to assess the efficacy of inflation-targeting – or, more precisely, inflation-forecast-targeting (Svensson (1997a)). These papers include Svensson and Rudebusch (1999), Svensson (1997c), Ball (1999) and, in a UK context, Batini and Haldane (1999). The macro-models used to undertake these simulations often differ significantly, however. One important source of difference across these models is the assumed degree of openness of the economy. Rudebusch and Svensson (1999) take a closed economy setting; whereas Svensson (1998), Ball (1999) and Batini and Haldane (1999) use an open-economy framework.

The existing inflation-targeters - New Zealand, Canada, Australia, Sweden, the United Kingdom, Chile and Israel, among others - are of course small, open economies. And the exchange rate channel of monetary transmission turns out to have important implications for the design of inflation-targeting policy rules. For example, recognising the open-economy dimension, Svensson (1998) prescribes rules that target some underlying – or "domestically-generated" – measure of inflation. This has the merit that it excludes first-round import-price pass-through effects, and hence prevents destabilising high-frequency adjustments in monetary policy. Ball (1999) concludes in favour of a policy rule which targets something akin to a "Monetary Conditions Index" – a weighted average of interest and exchange rate – for similar reasons. Batini and Haldane (1999) find that switching on and off import prices has implications for the shape of output/inflation variability frontiers. Clearly, exchange rate pass-through, as one of the key open economy monetary transmission channels, has important implications for inflation-forecast-targeting policy rules.

However, all three of the open-economy models outlined above share the feature that they model the pass-through process - from the exchange rate, to import prices and ultimately to retail prices - in a rather stylised fashion. In particular, they assume that this pass-through is full and instantaneous[1]. So, for example, a given exchange rate change leads to an immediate jump in the price level (and hence the inflation rate) by an amount proportional to the imported goods share in the consumption basket (for example, Batini and Haldane (1999)). This is clearly an over-simplification. It is also inconsistent with the experience of many countries recently. In many cases, exchange rate pass-through has been neither immediate nor (on occasions) complete.

Recent "event-studies" of countries undergoing large exchange rate changes can be used to illustrate. We first consider two UK event studies: the roughly 15% *depreciation* of sterling following its exit from the European Exchange Rate Mechanism (ERM) in September 1992; and the roughly 15% *appreciation* of sterling between September 1996 and April 1997. These cases are illustrated in Charts 1 and 2, with the exchange rate indexed to equal 100 on the base date. Also shown on Charts 1 and 2 is the path of import prices and retail prices, with both again indexed to 100 on the base date.

Chart 1 1992 depreciation

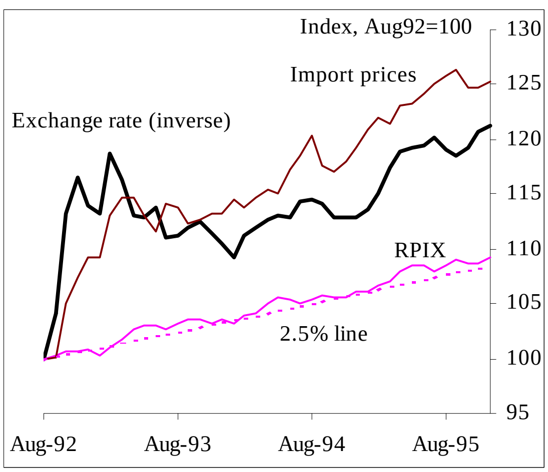
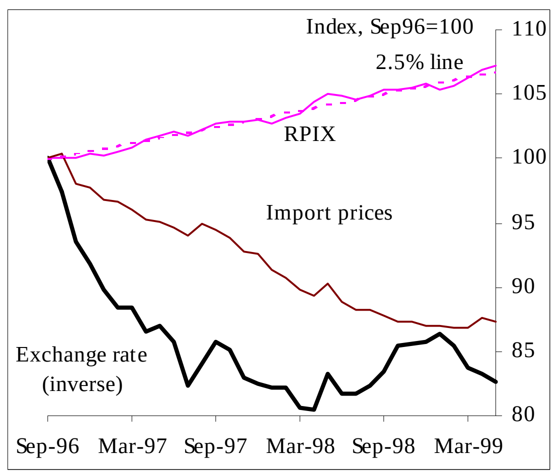


Chart 2 1996 appreciation



Two features are significant. First, import price pass-through was not immediate in either case. This was most notable in 1996-97, but even in 1992 import prices "lagged" behind the exchange rate for around 6 months. Second, the effects of the exchange rate change on retail prices were clearly small in both cases. Again, this was particularly notable following the 1996 appreciation. Retail price inflation (excluding mortgage interest payments) was 2.8% in August 1996 and the same a year later, despite the appreciation. Of course, this exercise is partial as other (domestic) factors will have acted on inflation over the event-study period. But nevertheless the UK

[1] In Ball (1999), there is a one-period lag between a change in the exchange rate and its effect on consumer prices.

experiences of 1992 and 1996-97 suggest that a simple model of full and immediate pass-through may overstate the direct (near-term) impact of exchange rate changes on import prices and retail price inflation.

The same patterns are evident outside of the UK. Charts 3 and 4 consider the cases of Sweden and Brazil following their exits from fixed exchange rate arrangements (an ECU peg in the case of Sweden in 1992, and a crawling dollar peg in the case of Brazil in 1999). For Brazil, we are not aware of monthly data on import prices and so instead show the path of an index of consumer, wholesale and construction prices (the IGP-M). This measure might be expected to react more rapidly than consumer prices to an exchange rate shock, because tradable goods form a larger part of the basket. In both cases, it is clear that pass-through effects were relatively limited in their downstream effects on import or output or, in particular, retail prices.

Chart 3 Sweden (1992)

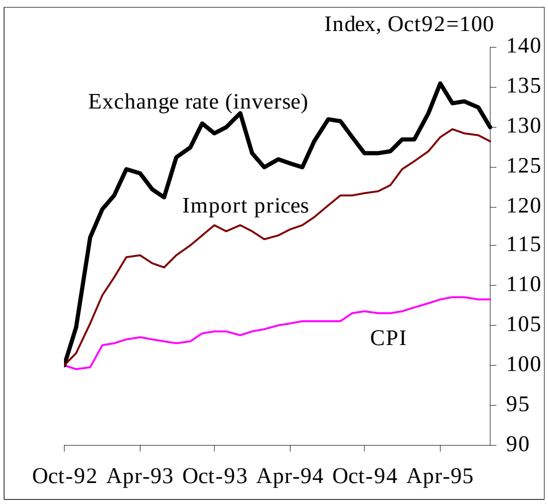
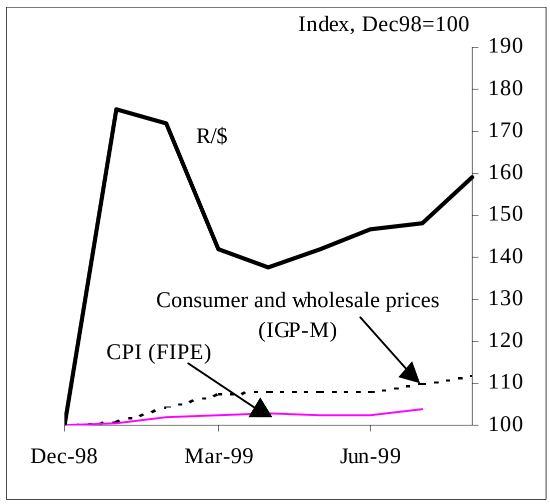


Chart 4 Brazil (1999)



At a theoretical level, it is not surprising that pass-through of exchange rate shocks may take time. Whenever there are costs to changing prices - for example menu costs or the potential to induce search behaviour among consumers - suppliers may prefer to absorb any transient exchange rate perturbations in their mark-ups or margins, see for example Britton et al (1999). Once the exchange rate change is seen to be lasting, it will be passed through, but it may take time for an exchange rate shock to be revealed as lasting. We seek to capture this lagged adjustment feature in the models of pass-through that we present below, by considering various types of *time dependent* pass-through rules.

It is also possible that suppliers' pass-through decisions in the face of exchange rate shocks are affected by the state of the business cycle. Theoretical models can generate either pro or counter-cyclical mark-ups (see, for example, Britton et al (1999)). But in the UK there is some evidence that pro-cyclicality has dominated (Small (1997)). The event studies are consistent with a similar pattern. Table 1 reports four-quarter GDP growth in the quarter preceding the various exchange rate changes for each country. There is a common pattern. All three depreciations occurred at times of weak growth, which with pro-cyclical mark-ups would result in lower prices and perhaps explain a part of the delayed or limited pass-through. The sterling appreciation of 1996 followed a period of relatively rapid growth which could again help explain the slow pass-through. We also seek to capture some of this possible cyclicality in mark-ups in the models presented below, by experimenting with some classes of (business cycle) *state dependent* pass-through rules.

Table 1 GDP growth around exchange rate shocks

	Four-quarter GDP growth in previous quarter
UK 1992 Q2 (depreciation)	-0.7%
UK 1996 Q2 (appreciation)	+2.7%
Sweden 1992 Q3 (depreciation)	-0.9%
Brazil 1998 Q4 (depreciation)	-2.1%

The prime output of this paper is a set of stochastic simulations that we use to assess the performance of various policy rules when the economy is subject to a (representative) set of shocks. Batini and Haldane (1999) argue that, when exchange rate perturbations are passed through fully and immediately to import prices, a strategy of inflation-forecast targeting clearly dominates current inflation targeting and that the "best" forecast feedback horizon is between three and six quarters ahead. In this paper, we ask whether this and other conclusions are robust to alternative, more realistic, models of pass-through.

This paper is planned as follows. Section 2 sets out a simple macro-model, calibrated to UK data and using a particular (restrictive) view of the pass-through process. Section 3 explores the various monetary transmission mechanism channels embedded within that model; and it evaluates the performance of inflation-forecast-targeting policy rules. Section 4 experiments with different, more plausible specifications of the import-price pass-through process, embodying degrees of state and time dependence. It evaluates what effect these different specifications have on the monetary transmission mechanism and on the design of inflation-forecast-targeting rules. Section 5 draws some brief conclusions.

2. A Small Macro-model

This section sets out a baseline macro-model and monetary policy rule. The treatment is brief because the baseline model is almost identical to the one set out in Batini and Haldane (1999). In essence, the model is a linearised, open economy IS-LM model, with rational expectations and Fuhrer-Moore wage contracting. It is set out in equations (1)-(8).

(1) $$y_t = \alpha_1 y_{t-1} + \alpha_2 y_{t+1} + \alpha_3 r_{t-1} + \alpha_4 q_{t-1} + \varepsilon_{1t}$$

(2) $$m_t - p^c_t = \beta_1 y_t + \beta_2 i_t + \varepsilon_{2t}$$

(3) $$s_t = E_t(s_{t+1}) + i_t - i_t^f + \varepsilon_{3t}$$

(4) $$p^d_t = 1/2\,[w_t + w_{t-1}]$$

(5) $$w_t - p^c_t = \chi_0 [E_t(w_{t+1}) - E_t(p^c_{t+1})] + (1 - \chi_0)[w_{t-1} - p^c_{t-1}] + \chi_1 y_t + \varepsilon_{4t}$$

(6) $$p^c_t = \phi\, p^d_t + (1 - \phi)\, p^m_t$$

(7) $$r_t = i_t - E_t(\pi_{t+1})$$

(8) $$q_t = s_t + p^c_t - p^{c\,f}_t$$

All variables, except interest rates, are in logs and all behavioural relationships are expressed as deviations from equilibrium. For simplicity, and consistent with a small economy representation, we normalise foreign prices and interest rates ($p^{c\,f}_t$ and i_t^f) to zero. We also normalise to zero the foreign exchange risk premium in (3) and the (implicit) mark-up in (4).

Equation (1) is a standard IS curve, with real output, y_t, depending negatively on the ex-ante real interest rate and the real exchange rate, as defined by equations (7) and (8). A rise in the real exchange rate (q_t) represents an appreciation and hence pushes demand downwards (α_4<0), as does a rise in the real interest rate (r_t), (α_3<0). Output also depends on lags of itself, reflecting adjustment costs[2]. ε_{1t} is a vector of aggregate demand shocks.

[2] We switch off the forward-looking term, setting α_2=0 in the simulations.

Equation (2) is an LM curve with conventional arguments: a nominal interest rate, capturing portfolio-balance; and real output, capturing transactions demand[3]. ε_{2t} is a vector of velocity shocks. Equation (3) is an uncovered interest parity condition, with $E_t(.)=E(.|(\Omega_t)$, where Ω_t is the information set available at time t and E is the mathematical expectations operator. The shock vector ε_{3t} comprises foreign interest rate shocks and other noise in the foreign exchange market, including shocks to the exchange risk premium.

Equations (4) and (5) define the model's supply side. They take a Fuhrer and Moore (1995a) form. Equation (4) is a mark-up equation, with domestic output prices (in logs, p^d_t) a constant mark-up over weighted average contract wages (in logs, w_t) in the current and preceding period. Equation (5) is the wage contracting equation. Wage contracts last two periods[4]. Agents in today's wage cohort bargain over relative real consumption wages (where p^c_t are log consumer prices and $\pi_t = p^c_t - p^c_{t-1}$). Today's real contract wage is some weighted average of the real contract wage of the "other" cohort of workers: that is, wages already agreed in the previous period and those expected to be agreed in the next period. The benefit of this specification is that it generates inflation persistence, rather than price-level persistence as in the standard two-period Taylor (1979) contracting model.

We do not impose symmetry on the lag and lead terms in the contracting equation, as in the standard Fuhrer and Moore (1995b) model. Instead we allow a flexible mixed lag/lead specification, which nests Fuhrer and Moore as a special case[5]. The lag/lead weights are restricted to sum to unity, however, to preserve price homogeneity in the wage-price system (a vertical long-run Phillips curve). Also in the wage contracting equation is a conventional output gap term, capturing tightness in the labour market. The shock vector (ε_{4t}) captures disturbances to the natural rate of output and other supply shocks.

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[3] McCallum and Nelson (1997) show that this form of the LM curve can also be derived as the reduced-form of an optimising stochastic general equilibrium model. Because monetary policy operates through an interest rate rule, the money demand equation is essentially redundant.

[4] We could have lengthened the contracting lag - for example to four periods, which in our calibration is one year - to better match real-world behaviour. But two lags appeared to be sufficient to generate the inflation persistence evident in the data, when taken together with the degree of backward-lookingness embodied in the Phillips curve.

[5] See Blake and Westaway (1996). This flexible mixed specification is found in Fuhrer (1997) to be preferred empirically.

Equation (6) simply defines the consumption price index, comprising domestic goods (with weight ϕ) and imported foreign goods (with weight 1- ϕ).

To close this system, we need to specify processes for import prices ($p^m{}_t$) and for nominal interest rates (i_t, the policy instrument). For import prices, Batini and Haldane (1999) use the simplest possible closure rule:

(9) $$p^m{}_t = -s_t$$

So exchange rate changes are immediately and fully passed-through to retail prices with a depreciation (fall in s) raising import prices. This is clearly a restrictive specification, as evidenced in section 1. In particular, it assumes that the mark-ups of foreign exporters, domestic wholesalers and domestic retailers do not change following an exchange rate adjustment. We explore the effects of relaxing these assumptions in section 4.

For interest rates, we specify an inflation forecast-based policy rule of the form:

(10) $$r_t = \gamma\, r_{t-1} + (1-\gamma)\, r_t^* + \theta\, [E_t\, \pi_{t+j} - \pi^*]$$

where r_t^* denotes the equilibrium value of real interest rates; and π^* is the inflation target. The equilibrium real interest rate and the inflation target are normalised to zero in the simulations.

According to the rule, the monetary authorities control nominal interest rates (i_t) so as to hit a path for the short-term real interest rate (r_t). Short real rates are in turn set relative to some steady-state value, determined by a weighted combination of lagged and equilibrium real interest rates. The novel feature of the rule, however, is the feedback term. Deviations of expected inflation - the feedback variable - from the inflation target - the policy goal - elicit remedial policy actions.

The policy choice variables for the authorities are the parameter triplet $\{j,\theta,\gamma\}$. The parameter γ dictates the degree of interest rate smoothing (see Williams (1997)). θ is a policy feedback parameter. Finally, j is the targeting horizon of the central bank when forming its forecast. The central bank sets interest rates in response to the expected deviation of inflation from target j periods ahead. This does not mean that rates are set to bring inflation back to target j periods out, since that depends on the smoothing and feedback coefficients as well. The horizon of the inflation forecast

(j) and the size of the feedback coefficient (θ), as well as the degree of instrument smoothing (γ), dictate the speed at which inflation is brought back to target following inflationary disturbances. Because they influence the inflationary transition path, these policy parameters clearly also have a bearing on output dynamics.

The rule considered here differs from those in Svensson (1998) in that it is a simple, feedback rule for the policy instrument, rather than a complicated, optimal targeting rule. At the same time, the simple forecast-based rules we consider do have some clear similarities with Svensson's optimal inflation-forecast-targeting rules. Monetary policy under both rules seeks to offset deviations between expected inflation and the inflation target at some horizon[6]. More concretely, even simple forecast-based specifications can be considered "encompassing" rules, with respect to transmission lags, output and information (Batini and Haldane (1999)).

The model, (1)-(10), is calibrated rather than estimated, with parameters chosen to match (loosely) the simulation properties of the Bank of England's medium-term forecasting model on a quarterly basis (see Bank of England (1999)). The baseline parameterisation is shown in Table 2.

Table 2: Model parameters

	Value	
IS curve		
α_1	0.8	Autoregressive element
α_2	0.0	Forward-looking element
α_3	-0.5	Real interest elasticity of aggregate demand
α_4	-0.2	Real exchange rate elasticity of aggregate demand
LM schedule		
β_1	1.0	Output elasticity of money demand
β_2	-0.5	Nominal interest semi-elasticity of money demand
Wage-setting		
χ_0	0.2	Forward-looking "weight" on wage bargain
χ_1	0.2	Short-run Philips curve slope
Consumer prices		
ϕ	0.8	Share of domestically produced goods in the consumption basket
Policy rule		
θ	0.5	Forecast Feedback parameter
λ	0.5	Smoothing parameter
j	8	Forecast horizon

[6] In particular, since the rules we consider allow flexibility over both the forecast horizon (j) and the feedback parameter (θ) - both of which affect output stabilisation - their closest analogue is Svensson's flexible inflation-forecast-targeting rule.

One or two of the parameter settings are worth touching on[7]. In the wage-contracting equation, (5), we set the forward-looking component equal to 0.2. Up to a point, this weight is rather arbitrary - and indeed may change over time. The weight we choose is close to that found empirically in the United States by Fuhrer (1997) and generates plausible paths from the impulse responses in the UK (Blake and Westaway (1996)). The import share in the consumption basket is set at 0.2 (ϕ=0.8), broadly in line with existing shares[8]. On the policy rule, we set γ=0.5 (some, but not too much, interest rate smoothing) and θ=0.5. On the forecast horizon we set j=8 periods, which corresponds to a horizon of two years since the model is calibrated to match quarterly data. This is around the inflation forecast horizon which the Bank of England aims to align with the inflation target when setting interest rates in the UK (King (1996)).

3. The Monetary Transmission Mechanism and Policy Frontiers

In this section we illustrate some features of the model, specifically the channels of monetary policy transmission and the performance of various inflation forecast-based policy rules in the face of structural shocks. We begin with some deterministic impulse responses from the model, before turning to stochastic analysis.

(a) The Monetary Transmission Mechanism in the UK

Using the baseline parameterisation and model, we can explore the dynamics of the monetary policy transmission mechanism in the UK by considering a one-off permanent displacement of the inflation target[9]. Charts 5 and 6 (overleaf) show the paths of the output gap and inflation following a one percentage point lowering of the inflation target; the responses are shown as percentage point deviations from base.

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[7] A more detailed explanation of the calibration is given in Batini and Haldane (1999).

[8] An alternative calibration would weight import prices according to the (larger) share of consumption comprised of tradable goods. This calibration would reflect the potential impact of competition within the traded goods sector, but might be better developed in a more complex two-sector model. At a qualitative level, we would expect a higher weight on import prices to accentuate any differences between the simulation properties of the pass-through specifications discussed in Section 4.

[9] The model is solved using the Winsolve package designed by Richard Pierse, and uses a stacked Newton solution algorithm.

Chart 5 Output gap Response

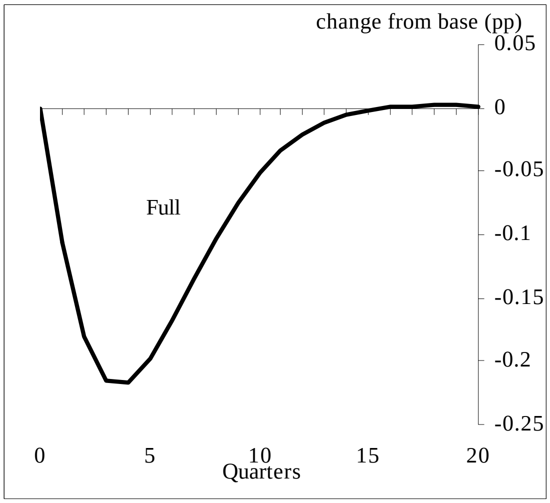
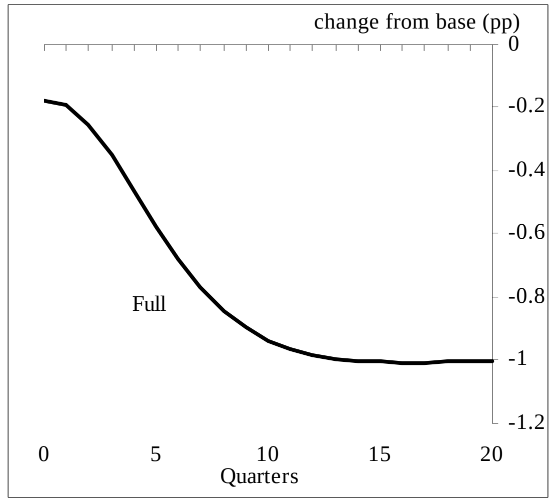


Chart 6 Inflation Response



Several features are worth noting:

First, the monetary transmission process embodies significant lags. It takes around 14-16 periods (or around 4 years) for inflation to reach its baseline and for the output gap, once opened, to be closed. This is roughly in line with VAR-based simulation results for the UK (eg, Dale and Haldane (1995)) and other developed countries (for example, Sims (1992)).

Second, the implied sacrifice ratio from the model (cumulative loss of output for a 1pp reduction of annual inflation) is around 0.4%. This is a little on the low side. Output responses are probably "too small".

Third, and by contrast, the response of the inflation rate is if anything "too big". In particular, the step fall in the inflation rate in the first period is inconsistent with VAR-based studies of the historical price level response following monetary policy tightenings. The size of this jump is the direct result of the restrictive (full and immediate) import price pass-through assumption we have imposed.

The monetary transmission mechanism in this model comprises four channels, two operating directly on the price side (the aggregate supply curve), and two indirectly through the quantity side (the aggregate demand curve). The four channels are: the real interest rate channel; the real exchange rate channel; the import price pass-through channel; and the expectational channel. The first two are the quantity channels, operating through the aggregate demand equation (1), and the second two the price channels.

Charts 7 and 8 illustrate the marginal effects of these four channels on the impulse response paths of output and inflation, for the same one percentage point disinflation experiment[10]. Looking first at output effects, the marginal contribution of the real interest rate and real exchange rate channels is roughly equal in the UK. The real exchange rate channel is marginally quicker. On inflation effects, Chart 8 presents a partial decomposition, switching off any feedback channels, such as the impact of import prices on expectations. Both import prices and forward-looking wage bargaining generate a jump in inflation in the first period. In subsequent periods, the backward-looking elements dominate, and to an increasing extent. These backward-looking elements are essentially two-fold: the backward-looking element to wage bargaining and the impact of the declining output gap on wages, operating through the short-run Philips curve.

Chart 7 Output decomposition

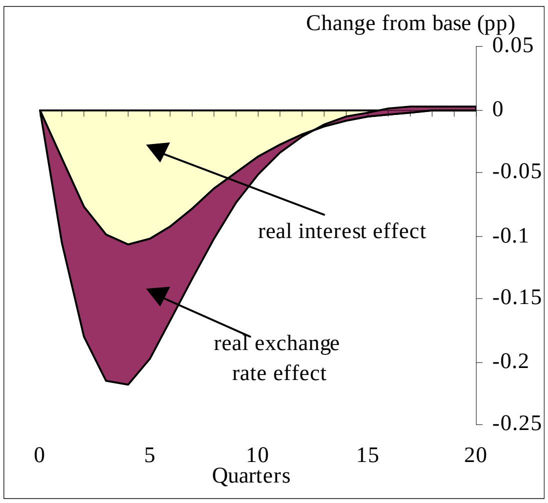
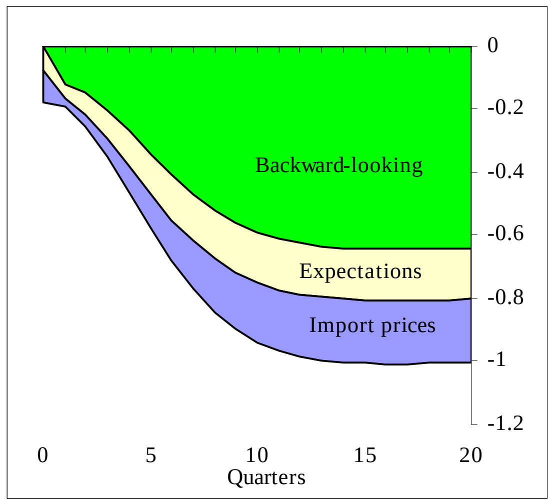


Chart 8 Inflation decomposition



(b) Policy Frontiers

We now turn to some stochastic simulation analysis to evaluate the performance of various inflation-forecast based policy rules of the form (10). In particular, following Taylor (1983), we look at the implications of different policy rules for the variability of the output gap and inflation - the two arguments typically believed to enter policymakers' loss function. Batini and Haldane

[10] The decomposition exercise is partial, in the sense that we do not allow for any feedback effects when calculating the marginal impact of each component. So the charts show the impact of each element on output and inflation given the path of *all* other variables in the disinflation experiment. An alternative approach would have been to solve the model setting selective parameters to zero. In this case, the policy rule would ensure that inflation tended to its new target, so that adjusting the parameters merely alters the shape of the adjustment path.

(1999) experiment with each of the three parameters $\{j,\theta,\gamma\}$ that define the policy rule. Here, we focus on the effects of the inflation forecast feedback horizon, setting $\theta=\gamma=0.5$.

The economy is assumed to be subjected to unanticipated shocks for 100 periods[11]. The shocks are drawn randomly given a covariance matrix of shocks for demand, real wages and the nominal exchange rate. We use a set of shocks derived from the Bank's structural medium-term forecasting model and for the purposes of this paper impose a diagonal covariance matrix. Our results are an approximation, for two reasons. First, we have imposed a diagonal covariance matrix[12], second, the set of shocks is drawn from a model that differs in several respects from the one used in this paper.[13] Ideally, we would have drawn a set of shocks from an econometric representation of our model. This is an area of ongoing research within the Bank.

There are a variety of ways of illustrating the behaviour of various policy rules under stochastic simulation. We plot a sequence of policy frontiers in output/inflation variability space, where variability is the average standard deviation across periods 21-100 and shocks impact for 100 periods. This is designed to capture variability when the economy is subjected to a continuous stream of shocks, hence our exclusion of early quarters when the initial shocks may not have had their full impact. Chart 9 (overleaf) illustrates such a frontier, using the parameterisation of the model and policy rule described earlier, but varying the forecast horizon from zero periods (current period inflation-targeting) to twelve periods (three-year-ahead inflation-forecast-targeting).

The frontier is L-shaped[14]. The shortest forecast horizons generate greater variability of both inflation and, especially, output; with current-period inflation targeting performing particularly poorly. After j=4, inflation volatility increases without any significant reduction in output volatility. Between j=2 and j=4, there is some evidence of an output/ inflation variability trade-off. So the optimal forecast horizon would appear to lie between two and four quarters[15]. In this sense,

[11] The simulations are solved over 180 periods, to enable the model to re-equilibrate after shocks have finished. We only use results for the periods in which shocks are occurring.

[12] This is a slight change from the original Batini-Haldane paper and follows from the change of solution software.

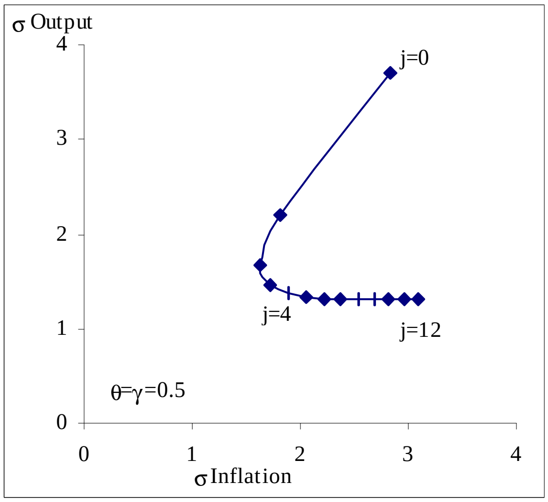
[13] The Bank's medium-term forecasting model is considerably richer (around 20 estimated equations to our 5 key behavioural equations). It is also essentially backward-looking, whereas our model contains forward-looking elements.

[14] Note that we do not perfectly replicate the j-loci of the original Batini-Haldane model. This follows from a combination of factors, such as our imposition of a diagonal variance-covariance matrix and the change in solution software (and in particular the software's treatment of unanticipated shocks).

[15] Output variance continues to decline as we move beyond j=4, but as the chart shows, this decline is negligible.

targeting an inflation forecast "beats" setting policy reactively to current inflation. Once we allow for the fact that central banks in practice feed back from annual inflation rates, while our model-based feedback variable is a quarterly inflation rate, then the optimal forecast horizon implied by our simulations is close to that used by inflation-targeting central banks in practice (of around six to eight quarters). Furthermore, it is worth noting that a 2-4 period optimal forecast horizon is not the same as saying that policymakers should aim to return inflation to target within a year. Instead, the horizon is the period at which policymakers should be concerned with inflation-target deviations and start to react. Inflation will return to target some time later.

Chart 9 Output-inflation Variability



What explains these results? Monetary policy has its maximal marginal impact on output after around a year. When policymakers react to inflation with a shorter lag, the (integral of the) real interest and exchange rate changes necessary to hit the target is therefore high relative to other forecast horizons. So the result of focusing on short forecast horizons is that monetary policy is forced into over-reacting, and as a result introduces a dynamic of its own. The costs of this "overreaction" in monetary policy are felt particularly by output rather than by inflation. This stems partly from the full pass-through assumption, which means that, through the import price channel, even late-reacting monetary policy can exercise significant leverage over inflation, through its influence on the exchange rate. The cost of these actions is a significant destabilisation of output, however, as real interest rates and the real exchange rate are forced to over-adjust.

Longer-horizons smooth out these adjustments in real interest and exchange rates. Monetary policy reacts pre-emptively, thereby damping output variability at the same time as securing effective inflation control. Too long a forecast horizon, however, results in monetary policy doing too little to damp period-by-period inflation fluctuations. These fluctuations in inflation become embedded in the wage-bargaining process and inflation variability rises at lengthy forecast feedback horizons.

4. Alternative Models of Pass-Through

The baseline model assumes full and immediate import price-through, which we know from the event studies to be counter-factual. In this section we outline some alternative pass-through specifications, and explore their implications for the transmission mechanism and policy rule frontiers. None of these specifications represent a well-articulated theoretical model of the margins behaviour of foreign exporters, domestic wholesalers or domestic retailers. Rather, they are meant as a summary statistic of the pass-through process, or "*rules of thumb*" for margins behaviour motivated by some of the stylised facts outlined earlier on.

(a) Alternative Pass-Through Specifications

We consider four alternative pass-through specifications, replacing equation (9) with:

Import and domestic prices identical - *"large economy"*

(9a) $$p^m_t = p^d_t$$

Slow pass-through

(9b) $$p^m_t = p^m_{t-1} - \psi_1 (s_t + p^m_{t-1})$$

Dynamic error correction - Bank medium-term model

(9c) $$p^m_t = p^m_{t-1} - \psi_1 (s_t + p^m_{t-1}) - \psi_2 \Delta s_t$$

Cyclical mark-up

(9d) $$p^m_t = p^m_{t-1} - \psi_1 (s_t + p^m_{t-1}) - \psi_2 \Delta s_t + \psi_3 y_t$$

(i) Import and domestic prices identical - "large economy"

Equation (9a) is the polar-opposite of the base case and treats import prices identically to domestic prices. This variant was included in the original Batini-Haldane paper largely for expositional purposes, and termed the "no pass-through" case. It might be justified in a world in which importers continuously adjust their margins to equate import and domestic prices in local currency terms, irrespective of exchange rate changes; perhaps because the economy is "large" with significant domestic competition in the tradable goods market. There is some (indirect) pass-through, however, as any exchange rate shock affects output and thence domestic and import prices. We term this specification a "large economy" pass-through variant[16].

(ii) Slow pass-through

Equation (9b) allows for a graduated - rather than immediate - response of import prices to exchange rate changes. This is an error-correcting specification, whereby the level of import prices adjusts gradually to the level of the exchange rate, at a rate ψ_1 per period. In the simulations below, we set ψ_1=0.7 which mimics the 1-period ahead response of import prices to a step change in the nominal exchange rate in the Bank of England's medium term macro-econometric model.

Equation (9c) additionally includes the contemporaneous change in the exchange rate to capture the impact effect of an exchange rate change. For the simulations below, we set ψ_1=0.15 and ψ_2=0.55, to exactly mimic the impulse response from the macro-econometric model. Equations (9b) and (9c) collapse to the base case setting ψ_1=1 and ψ_2=0.

(iii) Cyclical mark-up and pass-through

This variant is designed to reflect the potential impact of output on supplier behaviour. Equation (9d) builds on the dynamic error correction specification, as this mimics the specification of the Bank of England's macro-econometric model. So (9d) maintains the error-correction specification for pass-through, but in addition allows for a cyclical effect on importers' margins. When output is above potential, the upward pressure on import prices will augment any increase in import prices following a depreciation and reduce any decreases following an appreciation.

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[16] Note though that the real exchange rate still exerts pressure on demand through equation (1).

Of course, there is no reason to expect importers to be the only suppliers to set mark-ups on a cyclical basis. So we also adjust the domestic price equation (4) to incorporate a pro-cyclical mark-up:

(4d) $$p^d_t = 1/2\,[w_t + w_{t-1}] + \psi_3\, y_t$$

Recent work at the Bank of England suggests some evidence of pro-cyclical margins behaviour in the UK (Small (1997)). In the simulations below, we set ψ_3=0.15. The calibration is based loosely on the Bank's medium term macro-econometric model and draws on pro-cyclical elements of both the retail price and import price equations. ψ_1 is set equal to 0.15 and ψ_2 is 0.55, as in (9c). Of course, the evidence of pro-cyclical mark-ups is not conclusive and some theoretical models generate counter-cyclical mark-ups. There is clearly scope for further experimentation with this specification, as empirical research provides firmer conclusions about the cyclicality of margins behaviour.

(b) Impact on the Transmission Mechanism

(i) Full and immediate pass-through vs "large economy"

Charts 10 and 11 (overleaf) compare the inflation and output trajectories following a displacement of the inflation target under the immediate and "large economy" pass-through cases. When import and domestic prices are equated, the initial jump in inflation all but disappears. This occurs because there is no direct effect on consumer prices from the spot exchange rate jump associated with the displacement of the inflation target. And the absence of a direct price effect holds back inflation expectations. The resulting trajectory is more in line with counterfactual VAR-studies of the monetary transmission process in the UK. The output trajectories are similar in the two cases[17].

[17] Output is driven by the real interest and exchange rates (equation (1)). Real interest rates are driven by an inflation forecast, in this case 8 periods ahead. By that horizon, any direct price level effects of the exchange rate have fed through so the real interest rate response to the inflation target displacement is similar under the two specifications. And, since the interest rate response is similar, the real exchange rate also follows a similar profile.

Chart 10 Output gap

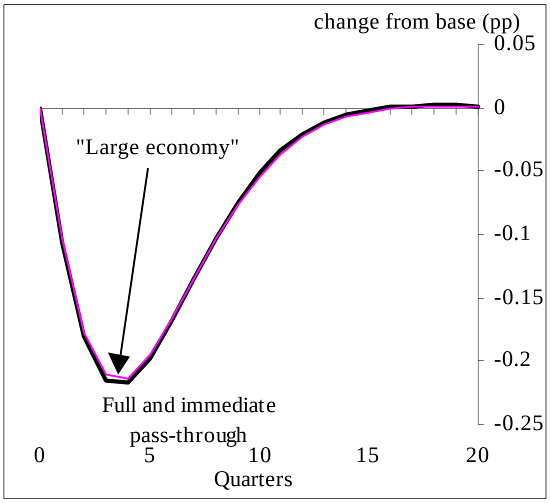
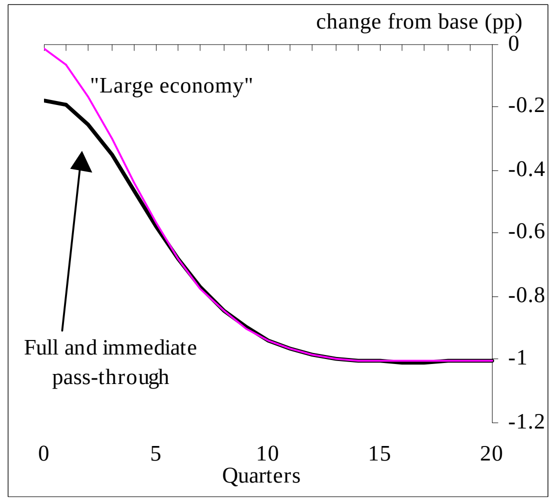


Chart 11 Inflation



(ii) Slow pass-through

The delayed pass-through variants produce a smaller initial jump in inflation than in the base case, but a larger jump than under zero pass-through. This is unsurprising, since there is now some (if limited) import price response to the exchange rate jump. The effect of the delayed pass-through variants are better illustrated by considering the impulse response of consumer prices to a nominal exchange rate shock (here a 1pp appreciation).

Chart 12 (overleaf) compares the inflation impulse under full pass-through and the slow pass-through case in equation (9b). In the full pass-through base case, the exchange rate shock in period 1 leads to an immediate step down in import prices, as well as a jump in wages due to the contemporaneous and forward-looking elements of the nominal wage equation. In the second period, the jump in inflation is reversed, as the spot exchange rate jumps back towards its initial value. When import prices adjust more slowly, the initial jump in consumer prices is smaller, but so is the subsequent reversal. So the variant generates a similar terminal price level, but a very different trajectory for inflation in the early periods - an initial overshoot then undershoot in the base case and a more graduated response in the variant.

Chart 12 Slow pass-through

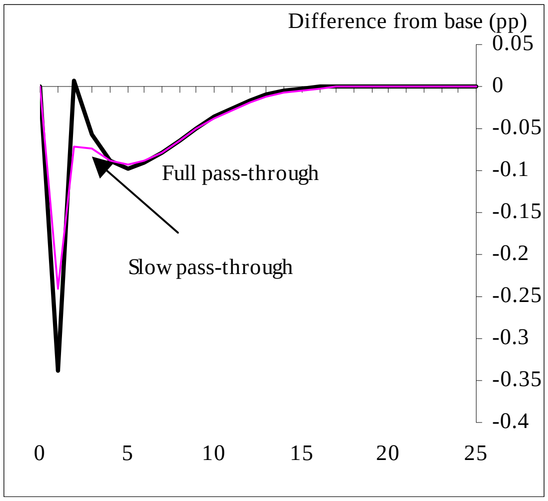


Chart 13 Slow pass-through with jump

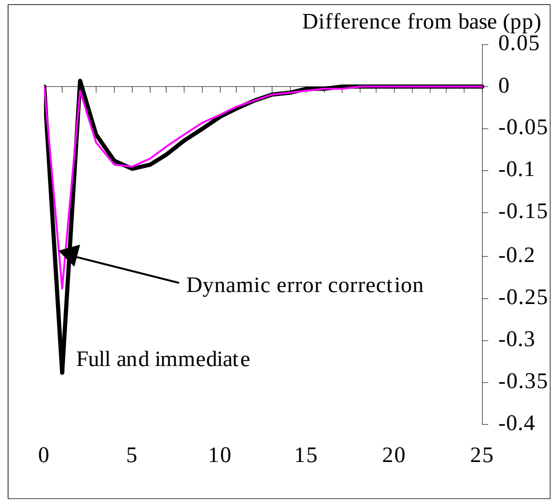
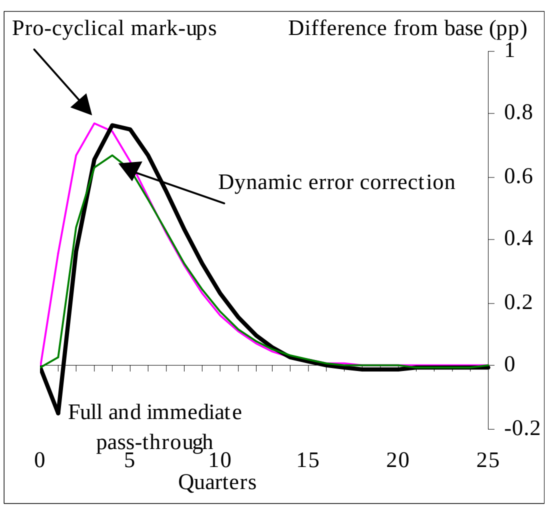


Chart 13 repeats the exercise for the dynamic error correction equation (9c) which includes a term in the change in the spot exchange rate. The initial jump in consumer prices is the same as under the slow pass-through variant, but in period 2 consumer prices jump back further. This follows from the jump response of import prices to a change in the nominal exchange rate.

(iii) Cyclical mark-ups

We illustrate the impact of the pro-cyclical mark-ups variant (9d) by comparing the inflation impulse following a one-period shock to output (here a 1pp rise) with the impulse when import price pass-through is full and immediate (baseline case) and under the dynamic error correcting case (9c) which forms the base for the new equations. The impulses are shown in Chart 14.

Chart 14 Inflation and pro-cyclical mark-ups



When pass-through is full and immediate, the monetary policy tightening that follows the shocks leads to a nominal exchange rate appreciation which is sufficient to reduce inflation in the first quarter. But thereafter the exchange rate depreciates while the output shock takes time to unwind, so inflation rises. When pass-through is slow, inflation rises in the first quarter, as import prices do not fall sufficiently to offset the upward pressure on wages that operates via the Philips curve. And when margins are pro-cyclical, there is further upward pressure on prices. Under this variant, the initial rise in consumer prices is significant, at around a third of the initial output impulse, and far speedier than in the other pass-through cases.

In the long run, monetary policy adjusts to bring inflation to target, regardless of the specification. Similarly, import price pass-through is full in the long run, regardless of the specification. Pro-cyclicality of mark-ups does not have a long term impact on import prices, because policy adjusts to close any output gap.

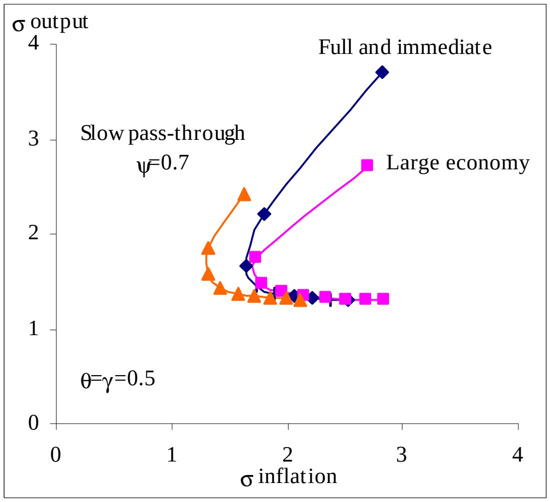
(c) Impact on Policy Frontiers

Do the various pass-through specifications have a significant impact on the policy frontiers generated by stochastic simulations? We repeated the 100-period stochastic simulations for the various import-price variants, for j=0 to j=8.

(i) Rate of pass-through

Chart 15 (overleaf) compares j-loci under the full and immediate pass-through (baseline), "large economy" (equation (9a)) and slow pass-through (equation (9b)) specifications. We have also carried out stochastic simulations for equation (9c), but the results are qualitatively very similar to the simple slow pass-through case.

Chart 15 j-loci as the rate of pass-through varies



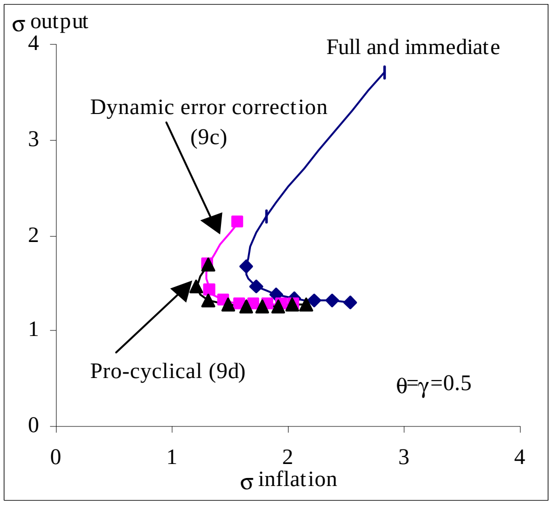
The main conclusion of the full and immediate pass-through model holds in the large economy case. So the optimal feedback horizon is greater than zero and inflation forecast targeting is better than targeting current inflation. But the output cost of focusing on very short horizons is reduced somewhat. This is because exchange rate disturbances (which have the greatest magnitude in our variance matrix) no longer feed though immediately to inflation and so do not "require" an interest rate response. As a result, real interest rates and hence output are less volatile. It remains the case, however, that responding to inflation forecasts rather than outturns still delivers sizeable benefits in an output/ inflation variability sense.

This is also the case when pass-through is slow. The j-loci remain L (or even "C") - shaped. However, in the slow pass-through case both inflation and output variability are damped. The output cost of choosing short forecast horizons is lower because of the reduced impact of exchange rates on consumer prices (and hence monetary policy). Slowing the rate of pass-through also reduces the volatility of inflation at all horizons. Exchange rate shocks have a lesser impact on inflation (if not the price level), so less inflation becomes embedded in wages.

(ii) Cyclical pass-through

Finally, we consider j-loci when economy-wide mark-ups (for both domestic and import prices) are pro-cyclical in addition to slow import price pass-through, using specifications (9d) and (4d). We compare this with the full and immediate pass-through case and the slow pass-through with jump case (9c).

Chart 16   j-loci with cyclical mark-ups



When we add procyclical mark-ups, output variability becomes further compressed at short horizons. Output variance is compressed because output shocks now matter more for inflation and hence are subject to more of an offsetting policy response. So monetary policy implicitly attaches a relatively higher "weight" to output shocks as opposed to wage or exchange rate shocks. Interestingly, however, this output volatility gain comes without greatly disturbing inflation control. Inflation volatility is affected by offsetting factors. Procyclical mark-ups raise the inflation response to output shocks[18]. But, offsetting this, changes in the real interest rate now have a greater impact on inflation, making it easier to bring inflation back to target when forecast horizons are short. Because of this second effect, shorter forecast horizons - perhaps as little as two periods ahead - appear to be around the "best" forecast horizon.

[18] As well as increasing the inflationary impact of any exchange rate shocks (via their impact on output)

5. Conclusions

We have considered alternative specifications of import-price pass-through in terms of their impact on the monetary policy transmission mechanism and on the operation of inflation-forecast based rules. Under these alternative specifications, it remains the case that looking forward - responding to forecasts rather than inflation outturns - makes sense. However, pass-through assumptions do appear to have implications for the feasible sets of inflation/ output variability points. Moreover, in some circumstances, for example procyclical mark-ups, it may also suggest that a shorter forecast horizon may be appropriate.

We have focused on just one of the transmission channels for monetary policy, albeit an important one for small, open economy inflation targeters. It would be interesting to consider the robustness of these conclusions to varying assumptions about the nature of the monetary policy transmission mechanism. For example, how are inflation forecast targeting rules affected by different assumptions about policy credibility? These and other questions are left as a task for future research.

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