

THE MONETARY TRANSMISSION MECHANISM IN THE UNITED KINGDOM: PASS-THROUGH AND POLICY RULES

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

The existing inflation-targeting countries—Australia, Canada, Chile, Israel, Sweden, and the United Kingdom, 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 policy rules for inflation targeting. For example, recognizing the open-economy dimension, Svensson (1997b) prescribes rules that target some underlying or “domestically-generated” measure of inflation. This has the merit of excluding first-round import-price pass-through effects and hence preventing destabilizing high-frequency

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adjustments in monetary policy. Ball (1999) concludes in favor of a policy rule that targets something akin to a “monetary conditions index”—a weighted average of interest and exchange rates—for similar reasons. Batini and Haldane (1999) find that switching import prices on and off has implications for the shape of the frontier of the trade-off between output variability and inflation variability. Clearly, exchange rate pass-through, as one of the key open-economy monetary transmission channels, has important implications for policy rules for inflation forecast targeting.

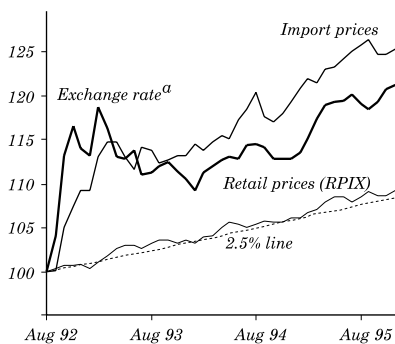
However, all three open-economy models outlined above share the feature that they model the pass-through process—from the exchange rate to import prices and ultimately to retail prices—in a rather stylized fashion. In particular, they assume that this pass-through is full and instantaneous.¹ So, for 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 share of imported goods in the consumption basket (see, for example, Batini and Haldane, 1999). This is clearly an oversimplification. It is also inconsistent with the experience of many countries recently. In many cases, exchange rate pass-through has not been immediate, nor, on occasion, has it been complete.

“Event studies” of countries undergoing large exchange rate changes can be used to illustrate. We first consider two U.K. events of the last decade: the roughly 15 percent depreciation of sterling following its exit from the European Exchange Rate Mechanism (ERM) in September 1992, and the roughly 15 percent appreciation of sterling between September 1996 and April 1997. These cases are illustrated in figures 1 and 2. The figures also show the path of import prices and retail prices, both again indexed to 100 on the base date.

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 six 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 percent 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

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

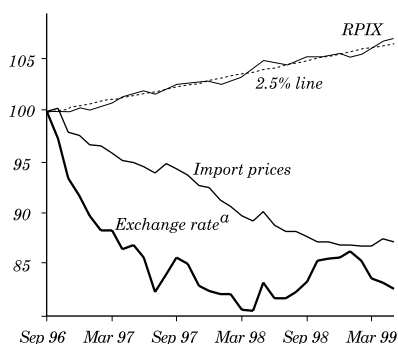
Figure 1. Exchange Rates, Import Prices, and Retail Prices in the United Kingdom after the 1992 Depreciation, Index, August 1992 = 100



Source: Bank of England.

a. An increase represents a depreciation.

Figure 2. Exchange Rates, Import Prices, and Retail Prices in the United Kingdom after the 1996 Appreciation, Index, September 1996 = 100



Source: Bank of England.

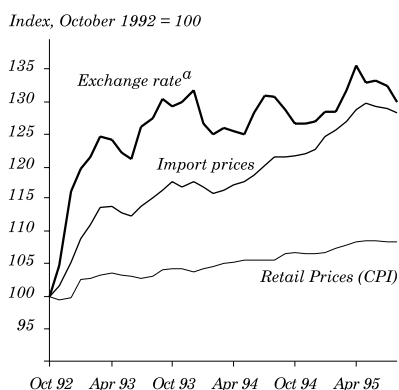
a. An increase represents a depreciation.

over the period. Nevertheless the U.K. 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, especially, retail-price inflation.

The same patterns are evident outside of the United Kingdom. Figures 3 and 4 consider the cases of Sweden and Brazil following their exit 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 a monthly data series for 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.

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

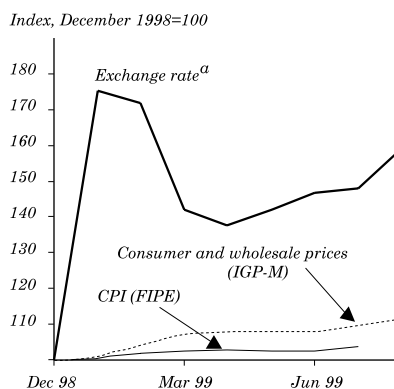
Figure 3. Exchange Rates, Import Prices, and Retail Prices in Sweden after Exit from Fixed Exchange Rates, Index, October 1992 = 100



Source: Bloomberg.

a. An increase represents a depreciation.

Figure 4. Exchange Rates, Import Prices, and Retail Prices in Brazil after Exit from Fixed Exchange Rates, Index, December 1998 = 100



Source: Bloomberg.

a. An increase represents a depreciation.

search behavior among consumers—suppliers may prefer to absorb any transient exchange rate perturbations in their markups or margins (see, for example, Britton, Larsen, and Small, 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 markups (see, for example, Britton, Larsen, and Small, 1999). But in the United Kingdom 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. All three depreciations occurred at times of weak growth, which with pro-cyclical markups would result in lower prices and perhaps help explain a part of the delayed or limited pass-through.

Table 1. GDP Growth Preceding Exchange Rate Shocks in Selected Countries and Episodes

<i>Country and period</i>	<i>Direction of exchange rate change</i>	<i>GDP growth in previous quarter (percent)^a</i>
United Kingdom, 1992Q2	Depreciation	-0.7
United Kingdom, 1996Q2	Appreciation	+2.7
Sweden, 1992Q3	Depreciation	-0.9
Brazil, 1998Q4	Depreciation	-2.1

Sources: Bloomberg; U.K. Office for National Statistics.

a. Growth over the previous four quarters.

The sterling appreciation of 1996, in contrast, 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 cyclical-ity in markups in the models presented below, by experimenting with some classes of (business cycle) *state-dependent* pass-through rules.

The principal output of this paper is a set of stochastic simulations, which 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. The paper is organized as follows. Section 1 sets out a simple macroeconomic model, calibrated to U.K. data and using a particular (restrictive) view of the pass-through process. Section 2 explores the various monetary transmission mechanism channels embedded within that model and evaluates the performance of policy rules based on inflation forecast targeting. Section 3 experiments with different, more plausible specifications of the import-price pass-through process, embodying degrees of state and time dependence. It evaluates the effect these different specifications have on the monetary transmission mechanism and on the design of inflation forecast targeting rules. Section 4 briefly draws some conclusions.

1. A SMALL MACROECONOMIC MODEL

This section sets out a baseline macroeconomic model and monetary policy rule. The treatment is brief because the baseline model is almost identical to that set out in Batini and Haldane (1999). In essence, the model is a linearized, open-economy IS-LM model, with rational expectations and Fuhrer-Moore wage contracting:

$$y_t = \alpha_1 y_{t-1} + \alpha_2 y_{t+1} + \alpha_3 U_{t-1} + \alpha_4 T_{t-1} + \varepsilon_{1t} , \quad (1)$$

$$m_t - p_t^c = \beta_1 y_t + \beta_2 i_t + \varepsilon_{2t} , \quad (2)$$

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

$$p_t^d = \frac{1}{2}(w_t + w_{t-1}) , \quad (4)$$

$$w_t - p_t^c = \chi_0 \left[(w_{t+1}) - (p_{t+1}^c) \right] + (1 - \chi_0)(w_{t-1} - p_{t-1}^c) + \chi_1 y_t + \varepsilon_{4t} , \quad (5)$$

$$p_t^c = \phi p_t^d + (1 - \phi) p_t^m , \quad (6)$$

$$U_t = i_t - (\pi_{t+1}) , \quad (7)$$

$$T_t = s_t + p_t^c - p_{t'}^c . \quad (8)$$

All variables except interest rates are in logarithms, and all behavioral relationships are expressed as deviations from equilibrium. For simplicity, and consistent with a small-economy representation, we normalize foreign prices and interest rates ($p_{t'}^c$ and i_t^f) to zero. We also normalize to zero the foreign exchange risk premium in equation (3) and the (implicit) markup in equation (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 downward ($\alpha_4 < 0$), as does a rise in the real interest rate, r_t ($\alpha_3 < 0$). Output

also depends on lags of itself, reflecting adjustment costs.² ε_{1t} is a vector of aggregate demand shocks.

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 $E_t(\cdot) = E(\cdot | \Omega_t)$, 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 the form laid out in Fuhrer and Moore (1995a). Equation (4) is a markup equation, with domestic output prices (in logarithms, p_t^d) a constant markup over weighted-average contract wages (in logarithms, w_t) in the current and the 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_t^c are log consumer prices and $\pi_t = p_t^c - p_{t-1}^c$). Today's real contract wage is some weighted average of the real contract wage of the "other" cohort of workers: that is, those whose wages have already been agreed in the previous period and those whose wages are 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 and lead weights are restricted to sum to unity, however, to preserve price homogeneity in the wage-price system (a vertical long-run Phillips curve).

2. We switch off the forward-looking term, setting $\alpha_2 = 0$ in the simulations.

3. McCallum and Nelson (1997) show that this form of the LM curve can also be derived as the reduced form of an optimizing 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 behavior. 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.

Also in the wage contracting equation is a conventional output gap term, capturing tightness in the labor market. The shock vector (ϵ_{4t}) captures disturbances to the natural rate of output and other supply shocks.

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

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

$$p_t^m = -s_t, \quad (9)$$

so that exchange rate changes are immediately and fully passed through to retail prices, with a depreciation (a fall in s) raising import prices. This is clearly a restrictive specification, as evidenced in the introduction. In particular, it assumes that the markups 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 3.

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

$$U_t = \gamma U_{t-1} + (1 - \gamma) U_t^* + \theta (\pi_{t+j} - \pi^*), \quad (10)$$

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 normalized 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-term 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 $\{\gamma, \theta, \gamma\}$. 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 (1997b) in that it is a simple feedback rule for the policy instrument, rather than a complicated, optimal targeting rule. At the same time, however, the simple forecast-based rules we consider do have some clear similarities to 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 set out in equations (1) through (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 parameterization is shown in table 2.

Some 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 it 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 United Kingdom (Blake and Westaway, 1996). The import share in the consumption basket is

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 stabilization, their closest analogue is Svensson's flexible inflation forecast targeting rule.

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

Table 2. Model Parameters

<i>Parameter</i>	<i>Value</i>	<i>Description</i>
<i>IS curve</i>		
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
<i>LM schedule</i>		
β_1	1.0	Output elasticity of money demand
β_2	-0.5	Nominal interest semielasticity of money demand
<i>Wage setting</i>		
λ_0	0.2	Forward-looking “weight” on wage bargain
λ_1	0.2	Short-run Phillips curve slope
<i>Consumer prices</i>		
ϕ	0.8	Share of domestically produced goods in the consumption basket
<i>Policy rule</i>		
θ	0.5	Forecast feedback parameter
γ	0.5	Smoothing parameter
j	8	Forecast horizon

Sources: Authors' calculations.

set at 0.2 ($\phi = 0.8$), broadly in line with existing shares.⁸ On the policy rule we set $\gamma = 0.5$ (some, but not too much, interest rate smoothing) and $\phi = 0.5$. For 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 that the Bank of England aims to align with the inflation target when setting interest rates in the United Kingdom (King, 1996).

2. THE MONETARY TRANSMISSION MECHANISM AND POLICY FRONTIERS

This section illustrates certain features of the model, specifically the channels of monetary policy transmission and the performance

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 3.

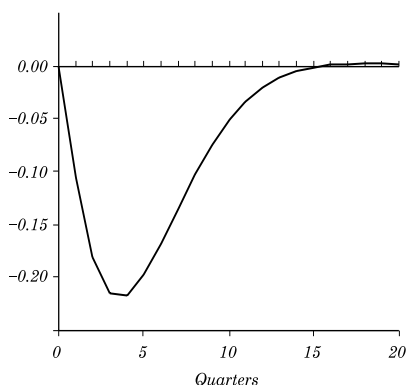
of various inflation forecast-based policy rules in the face of structural shocks. We begin with some deterministic impulse responses from the model before turning to stochastic analysis.

2.1 The Monetary Transmission Mechanism in the United Kingdom

Using the baseline parameterization and model, we can explore the dynamics of the monetary policy transmission mechanism in the United Kingdom by considering a one-time permanent displacement of the inflation target.⁹ Figures 5 and 6 show the paths of the output gap and inflation following a 1-percentage-point lowering of the inflation target; the responses are shown as percentage-point deviations from the base.

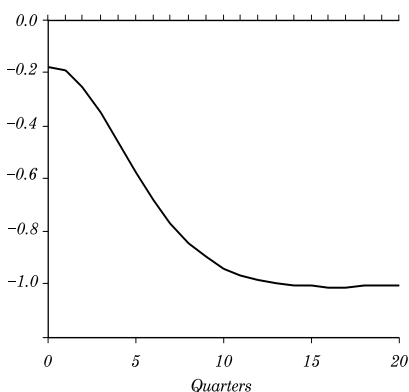
Several features are worth noting. First, the monetary transmission process embodies significant lags. It takes around fourteen to sixteen periods (or around four years) for inflation to reach its baseline

Figure 5. Impulse Response of the Output Gap to a 1-Percentage-Point Lowering of the Inflation Target^a
Percentage points



Source: Authors' calculations.
a. Change from baseline.

Figure 6. Impulse Response of the Inflation to a 1-Percentage-Point Lowering of the Inflation Target^a
Percentage points



Source: Authors' calculations.
a. Change from baseline.

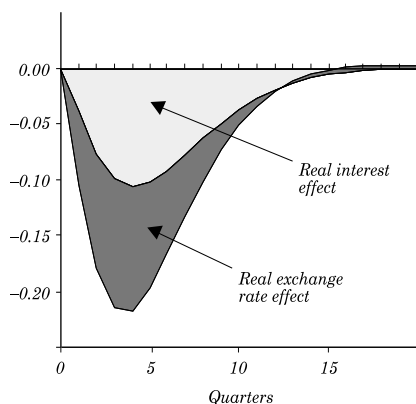
9. The model is solved using the Winsolve package designed by Richard Pierse and uses a stacked Newton solution algorithm.

and for the output gap, once opened, to be closed. This is roughly in line with vector autoregression (VAR)-based simulation results for the United Kingdom (see, for example, Dale and Haldane, 1995) and other developed countries (see, for example, Sims, 1992). Second, the sacrifice ratio implied by the model (the cumulative loss of output for a 1-percentage-point reduction of annual inflation) is around 0.4 percent. 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 are the price channels. Figures 7 and 8 illustrate the marginal effects of these four channels on the impulse response paths of output and inflation, respectively, for the same 1-percentage-point disinflation experiment.¹⁰ Looking first at output effects, we see that the marginal contribution of the real interest rate and real exchange rate channels is roughly equal in the United Kingdom. The real exchange rate channel is marginally quicker. With regard to inflation effects, figure 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 twofold: the backward-looking element to wage bargaining and the impact of the declining output gap on wages, operating through the short-run Phillips curve.

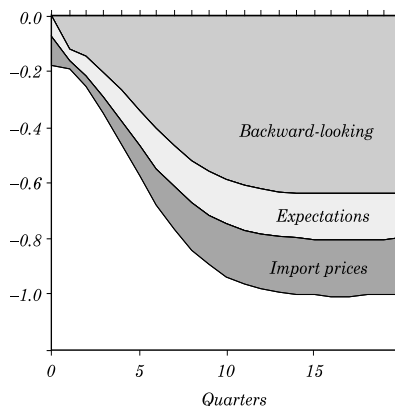
10. The decomposition exercise is partial, in the sense that we do not allow for any feedback effects when calculating the marginal impact of each component. So the figures show the impact of each element on output and inflation given the paths of *all* other variables in the disinflation experiment. 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.

Figure 7. Decomposition of Impulse Response Path of Output
Percentage points^a



Source: Authors' calculations.
a. Change from baseline.

Figure 8. Decomposition of Impulse Response Path of Inflation
Percentage points^a



Source: Authors' calculations.
a. Change from baseline.

2.2 Policy Frontiers

We now turn to some stochastic simulation analysis to evaluate the performance of various inflation forecast-based policy rules of the form of equation (10). In particular, following Taylor (1999), 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 (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 $\theta = \gamma = 0.5$.

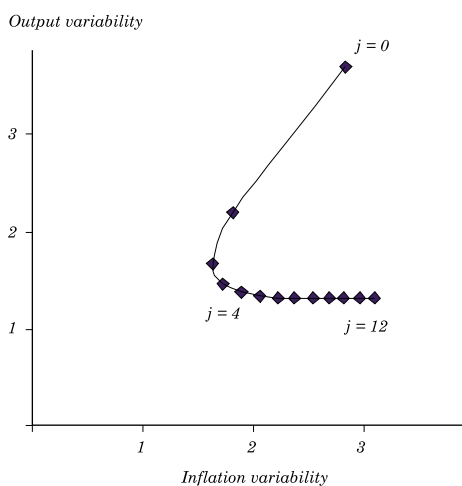
The economy is assumed to be subjected to unanticipated shocks for 100 periods.¹¹ The shocks are drawn randomly given a covariance matrix of shocks for demand, real wages, and the nominal exchange rate. We use a set of shocks derived from the Bank of England's structural medium-term forecasting model. Our results are an approximation, for two reasons. First, we have imposed a diagonal covariance

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

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 of England.

The behavior of various policy rules under stochastic simulation can be illustrated in a variety of ways. We plot a sequence of policy frontiers in output variability-inflation variability space, where variability is the average standard deviation across periods 21 to 100 and shocks exert their impact for 100 periods. This is designed to capture variability when the economy is subjected to a continuous stream of shocks; hence we exclude the early quarters when the initial shocks may not have had their full impact. Figure 9 illustrates such a frontier, using the parameterization 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).

Figure 9. Locus of Policy Frontiers in Output-Inflation Variability Space



Source: Authors' calculations.

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

13. The Bank of England's medium-term forecasting model is considerably richer (with around twenty estimated equations to our five key behavioral equations). It is also essentially backward-looking, whereas our model contains forward-looking elements.

The resulting 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 a trade-off between output variability and inflation variability. So the optimal forecast horizon would appear to lie between two and four quarters.¹⁵ In this sense, targeting an inflation forecast dominates setting policy reactively to current inflation. Once we allow for the fact that central banks in practice feed back from annual inflation rates, whereas our model-based feedback variable is a quarterly inflation rate, the optimal forecast horizon implied by our simulations is close to that used by inflation-targeting central banks in practice. That horizon is around six to eight quarters. Furthermore, it is worth noting that adopting a two-to-four-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 deviations from the inflation target and start to react. Inflation will return to target some time later.

What explains these results? Monetary policy has its maximal marginal impact on output after about 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 overreacting, and as a result it introduces a dynamic of its own. The costs of this overreaction 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 destabilization of output, however, as real interest rates and the real exchange rate are forced to overadjust.

14. Note that we do not perfectly replicate the j -loci of the original Batini and 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 figure shows, this decline is negligible.

Longer horizons smooth out these adjustments in real interest and exchange rates. Monetary policy reacts preemptively, thereby damping output variability at the same time that it secures 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.

3. ALTERNATIVE MODELS OF PASS-THROUGH

The baseline model assumes full and immediate import-price pass-through, which we know from the event studies to be counterfactual. 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 margin behavior 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 margin behavior motivated by some of the stylized facts outlined earlier.

3.1 Alternative Pass-Through Specifications

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

$$p_t^m = p_t^d, \text{ (identical import and domestic prices) ,} \quad (9a)$$

$$p_t^m = p_{t-1}^m - \Psi_1 (s_t + p_{t-1}^m) , \text{ (slow pass-through) ,} \quad (9b)$$

$$p_t^m = p_{t-1}^m - \Psi_1 (s_t + p_{t-1}^m) - \Psi_2 \Delta s_t , \text{ (slow pass-through with dynamic error correction) ,} \quad (9c)$$

$$p_t^m = p_{t-1}^m - \Psi_1 (s_t + p_{t-1}^m) - \Psi_2 \Delta s_t + \Psi_3 y_t , \text{ (slow pass-through with cyclical markup) .} \quad (9d)$$

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, through output, domestic and import prices. We term this specification a large-economy pass-through variant.¹⁶

Equation (9b) allows for a graduated rather than an 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 of ψ_1 per period. In the simulations below we set $\psi_1 = 0.7$, which mimics the one-period-ahead response of import prices to a step change in the nominal exchange rate in the Bank of England’s medium-term macroeconomic model.

Equation (9c) adds to this specification the contemporaneous change in the exchange rate, to capture the effect of an exchange rate change. For the simulations below we set $\psi_1 = 0.15$ and $\psi_2 = 0.55$, to exactly mimic the impulse response from the macroeconomic model. Equations (9b) and (9c) collapse to the base case setting $\psi_1 = 1$ and $\psi_2 = 0$.

Finally, the variant in equation (9d) is designed to reflect the potential impact of output on supplier behavior. It builds on the dynamic error correction specification, as this mimics the specification of the Bank of England’s macroeconomic model, but in addition it 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 decrease following an appreciation.

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

$$p_t^d = \frac{1}{2}(w_t + w_{t-1}) + \Psi_3 y_t \quad (4a)$$

16. Note, however, that the real exchange rate still exerts pressure on demand through equation (1).

Recent work at the Bank of England suggests some evidence of pro-cyclical margins behavior in the United Kingdom (Small, 1997). In the simulations below we set $\psi_3 = 0.15$. The calibration is based loosely on the Bank's medium-term macroeconomic 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 equation (9c). Of course, the evidence of pro-cyclical markups is not conclusive, and some theoretical models generate counter-cyclical markups. There is clearly scope for further experimentation with this specification, as empirical research provides firmer conclusions about the cyclicity of margin behavior.

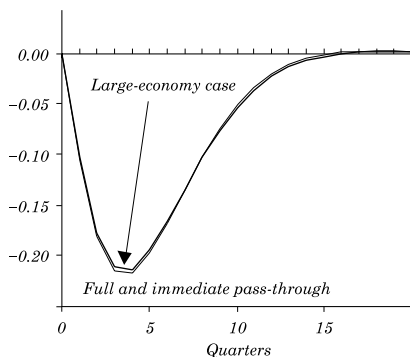
3.2 Impact on the Transmission Mechanism

The "large Economy" specification. Figures 10 and 11 compare the trajectories of inflation and output 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 United Kingdom. The output trajectories are similar in the two cases.¹⁷

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 (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 1-percentage-point appreciation). Figure 12 compares the inflation

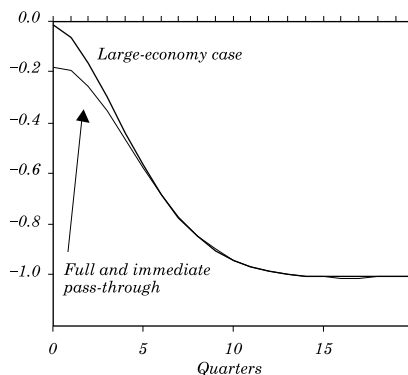
17. Output is driven by the real interest and exchange rates, as in equation (1). Real interest rates are driven by an inflation forecast, in this case eight periods ahead. By that horizon, any direct price-level effects of the exchange rate have fed through, so that the real interest rate response to 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.

Figure 10. Impulse Response of the Output Gap in the Large-Economy Case
Percentage points^a



Source: Authors' calculations.
a. Change from baseline.

Figure 11. Impulse Response of Inflation in the Large-Economy Case
Percentage points^a

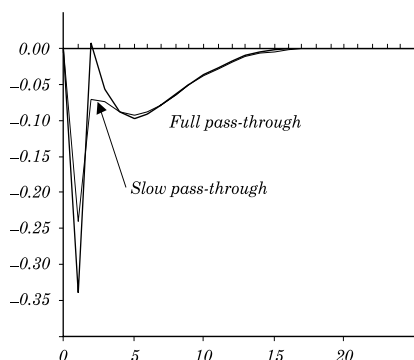


Source: Authors' calculations.
a. Change from baseline.

impulse under full pass-through and in 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 stepdown 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 toward 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 an undershoot in the base case and a more graduated response in the variant.

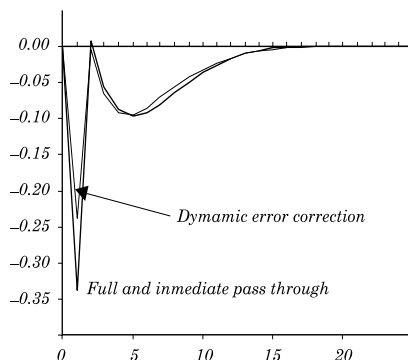
Figure 13 repeats the exercise for the dynamic error correction specification in equation (9c), which includes a term for the change in the spot exchange rate. The initial jump in consumer prices is the same as under the slow pass-through variant, but in period 2 consumer prices jump back further. This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

Figure 12. Impulse Response of Inflation in the Slow Pass-Through Case
Percentage points^a



Source: Authors' calculations.
a. Difference from baseline.

Figure 13. Impulse Response of Inflation in Case of Slow Pass-Through with Jump
Percentage points^a



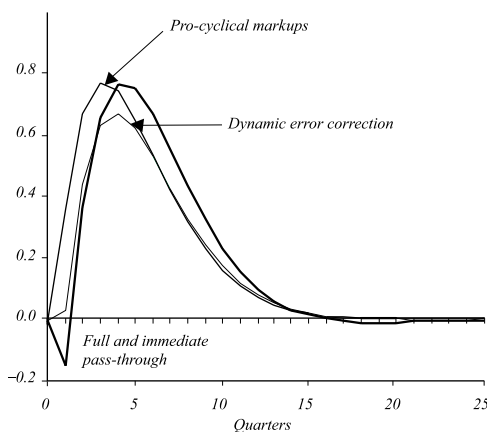
Source: Authors' calculations.
a. Difference from baseline.

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

When pass-through is full and immediate, the monetary policy tightening that follows the shocks leads to a nominal appreciation sufficient to reduce inflation in the first quarter. But thereafter the currency depreciates and 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 Phillips 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

Figure 14. Impulse Response of Inflation under Pro-Cyclical Markups
Percentage points^a



Source: Authors' calculations.

a. Difference from baseline.

pass-through is full in the long run, regardless of the specification. Pro-cyclicality of markups does not have a long-term impact on import prices, because policy adjusts to close any output gap.

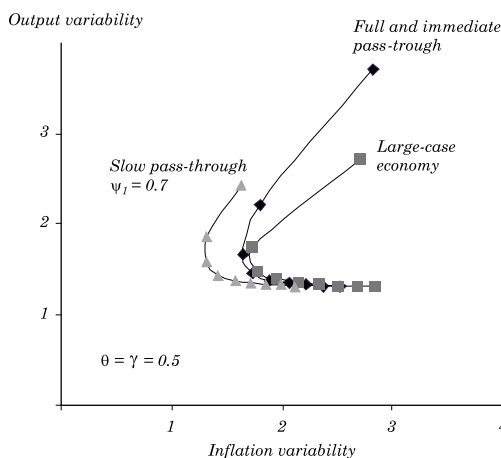
3.3 Impact on Policy Frontiers

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 $j = 8$.

Alternative Rates of Pass-Through. Figure 15 compares j -loci under the full and immediate pass-through (baseline) specification, the large-economy specification in equation (9a), and the slow pass-through specification in equation (9b). We also carried out stochastic simulations for equation (9c), but the results are qualitatively very similar to those in the simple slow pass-through case.

The main conclusion of the full and immediate pass-through model holds true in the large-economy case as well. So the optimal feedback horizon is greater than zero, and inflation forecast targeting is better

Figure 15. Loci of Policy Frontiers under Alternative Pass-Trough Models



Source: Authors' calculations.

than targeting current inflation. But the output cost of focusing on very short horizons is reduced somewhat. This happens because exchange rate disturbances (which have the greatest magnitude in our variance matrix) no longer feed through 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 delivers sizable benefits in terms of the trade-off between output variability and inflation variability.

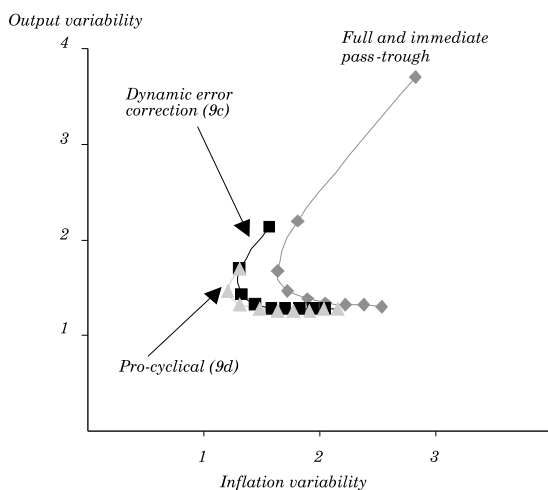
This is also the case when pass-through is slow. The j -loci remain L- (or even C-) shaped. However, in the slow-pass-through case both inflation and output variability are damped. The output cost of choosing short forecast horizons is lower because of the reduced impact of exchange rates on consumer 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 smaller impact on inflation (if not the price level), so less inflation becomes embedded in wages.

Cyclical Pass-Through. Finally, we consider j -loci when economy-wide markups (for both domestic and import prices) are pro-cyclical in

addition to import-price pass-through being slow, using the specifications in equations (9d) and (4d). We compare this with the full and-immediate-pass-through case and the slow-pass-through-with-jump case (9c).

When we add pro-cyclical markups, output variability becomes further compressed at short horizons (Figure 16). 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 greater “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. Pro-cyclical markups 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 the “best.”

Figure 16. Loci of Policy Frontiers under Alternative Pass-Trough Models



Source: Authors' calculations.

18. They also increase the inflationary impact of any exchange rate shocks (via their impact on output).

4. 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—that is, responding to forecasts rather than inflation outturns—makes sense. However, pass-through assumptions do appear to have implications for the feasible sets of points on the inflation-output variability frontier. Moreover, in some circumstances, for example in the case of pro-cyclical markups, 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 inflation targeters in small, open economies. 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 for future research.

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