ECONOMIC POLICY IN THE UK

MACROECONOMIC POLICY

POLICY REACTION FUNCTIONS:

INFLATION FORECAST TARGETING AND TAYLOR RULES

Summary

We compare inflation forecast targeting with a Taylor rule.

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Interest rate "rules" derived from inflation forecast targeting

When the CB targets inflation, and sets policy so that forecast inflation is on target, we saw that we could derive "rules" that tell the CB what level of interest rates it should set. For the case where some weight is put on output, in the model previously set out, based on Svensson (1997), the reaction function was:

$$i_t = \pi_t - \frac{1}{\alpha_1\beta_2}(\pi_t - \pi^*) - \frac{1+\beta_1}{\beta_2} y_t .$$

This implicit interest rate rule has strong similarities with the "Taylor rule", a famous policy guideline which has a completely separate history from inflation forecast targeting. It is useful to compare inflation forecast targeting and the Taylor rule as two different policy descriptions/prescriptions. There is some (sometimes lively) debate in the literature about the connections between the two, and which is better.

What is a "Taylor rule"?

Taylor's rule is a formula developed by Stanford economist John Taylor. It was designed to provide 'recommendations' for how a central bank should set short-term interest rates to achieve both its short-run goal for stabilising the economy and its long-run goal for inflation.

Taylor (1993)[1] estimated **policy reaction functions** and found that monetary policy can often be well approximated empirically by a simple **instrument rule** for interest rate setting. The following is one variant of the **Taylor rule**:

$$i_t = r^* + \pi^* + \beta(\pi_t - \pi^*) + \gamma(y_t - y_N) \qquad (1)$$

where β , $\gamma > 0$; r^* is the average (long-run) real interest rate.

The rule states that the repo rate i_t should be above its long-run level ($r^* + \pi^*$) when:

- actual inflation π_t is above the target π^*
- economic activity y_t is above its "full employment" level y_N (i.e. the output gap is positive)

Is the Taylor rule a good description of how monetary policy operates?

[1] Taylor, John B. 1993. "Discretion Versus Policy Rules in Practice", *Carnegie-Rochester Conference Series on Public Policy*, 39, pp. 195-214.

Estimated Taylor rules put numbers on the parameters β and γ. Taylor (1993) found that β=1.5 and γ=0.5:

$$i_t = r^* + \pi^* + 1.5(\pi_t - \pi^*) + 0.5(y_t - y_N) \qquad (2)$$

Nelson (2000)[2] found coefficients of 1.3 and 0.5 during the period 1992-97 (post-inflation targeting and pre-independence) – similar to those found by Taylor. For previous years, though, the coefficients were very different, with coefficients on inflation much lower than 1 and varying output gap responses.

Note that unless the (long-run) coefficient on inflation is above 1, the inflation target will not be achieved on average (this has been called the "Taylor principle"). In this case, monetary policy would have failed to provide a nominal anchor: effectively, inflation would not be tied down to a fixed value. Nominal interest rates 'naturally' respond one-for-one with increases in inflation (recall the Fisher relation $i_t=r_t+\pi_t$), so a coefficient of exactly unity would mean the central bank was not attempting to counteract inflation movements. It is only when the coefficient on inflation exceeds unity that the central bank is 'leaning against the wind'.

In the literature you may see the equation written as Taylor originally estimated it, namely:

$$i_t = \pi_{t-1} + 2 \quad + 0.5(\pi_{t-1} - 2) \quad + 0.5(y_{t-1} - y_N) \qquad (1')$$

This is simply a rearranged version of (1), with Taylor's numerical assumptions that the Fed effectively followed an inflation target of 2% between 1987 and 1993, and that the long run real interest rate was also 2%. Taylor also used one-period lags to allow for realistic delays in policy response, partly due to the fact that policy decisions are typically responses to data, and data production takes time. To clarify that (1) and (1') have identical forms, replace Taylor's assumed values for the real interest rate and the inflation target with their algebraic representations:

$$i_t = \pi_{t-1} + r^* + 0.5(\pi_{t-1} - \pi^*) + 0.5(y_{t-1} - y_N) \qquad (1')$$

As in (1), the sum of the coefficients on π_{t-1} (or π_t) is 1.5, and the sum of the coefficients on π^* is 0.5.

Taking π_{t-1} over to the LHS of (1') gives an equation for the real Federal funds rate (the nominal rate minus inflation). Taylor's rule says that the real Fed funds rate should be raised 0.5 percentage points for every percentage point inflation rises above target, and should also be raised 0.5 percentage points for every percentage point actual output rises above potential.

Research for other countries, including the UK, has found a significant *lagged dependent variable*: i_{t-1} appears on the right hand side, as an additional regressor, with a positive coefficient significantly less than unity. A reasonable interpretation of this is that central banks (including the BoE), conduct *interest rate smoothing*: they deliberately make gradual interest rate changes, reducing potentially damaging interest rate volatility. In the long-run (if there were no changes in inflation, the target, or the output gap), given that that lagged dependent variable has a coefficient<1, this smoothing would peter out, so the long-run equation would look exactly like (1).

The Taylor rule is acknowledged by all to be a simple approximation to actual policy behaviour. It represents a complex process with a small number of parameters.

The Taylor rule is often thought of as a good approximation. Empirical work for the US suggests that the Taylor rule does a fairly accurate job of *describing* how monetary policy actually has been conducted during the past decade under Fed Chairman Greenspan.

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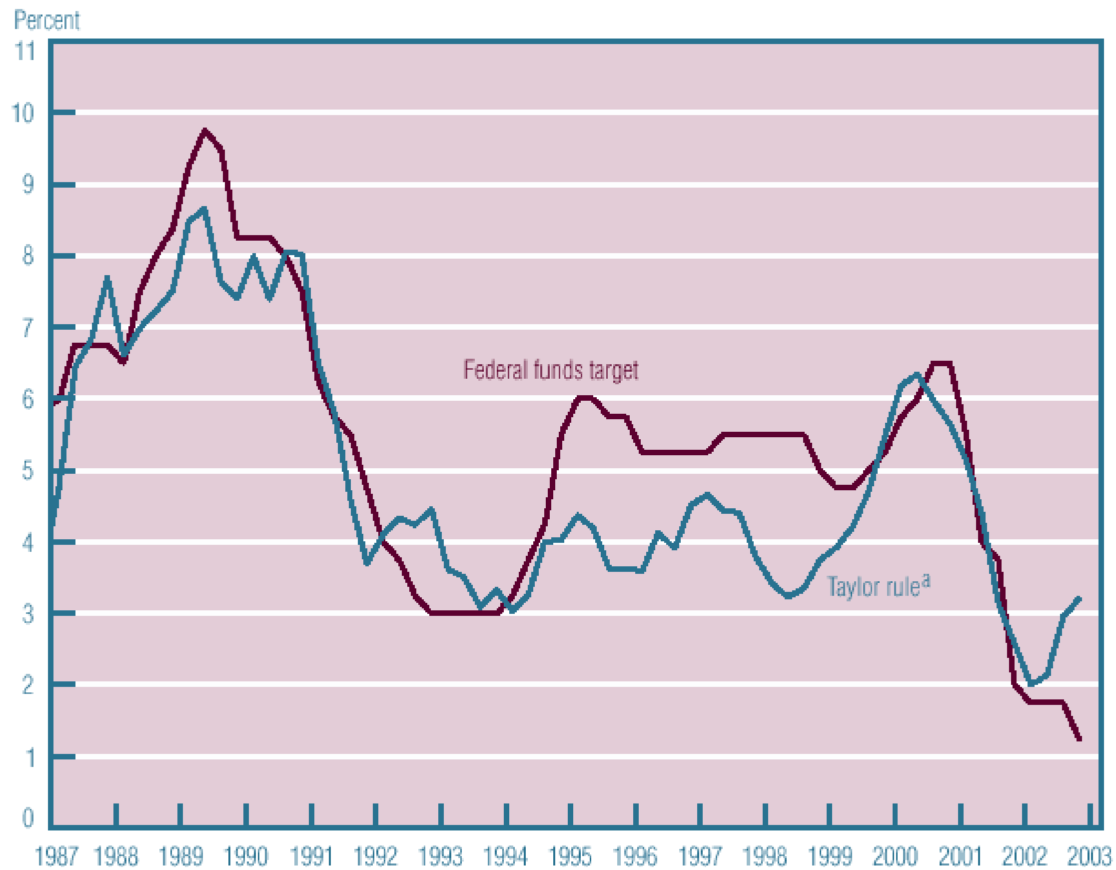
[2] Nelson, Edward 2000. "UK monetary policy 1972-97: a guide using Taylor rules", Bank of England Working Paper 120.

Janet Yellen, then Fed Reserve Governor, said in the January 1995 FOMC meeting “It seems to me that a reaction function in which the real funds rate changes by roughly equal amounts in response to deviations of inflation from a target of 2 percent and to deviations of actual from potential output describes reasonably well what this committee has done since 1986. … If we wanted a rule I think the Greenspan Fed has done very well following such a rule, and I think that is what sensible central banks do.”

The graph below compares the value of the Fed funds rate predicted by the above Taylor rule (1’) and compares it against the actual Fed funds target (i.e. the repo rate). The Taylor rule tracks broad movements in the repo rate quite well, although there are some large and persistent mis-predictions. Note that the fit up to 1993 – the period over which Taylor estimated his equation and obtained his coefficients – is very good. But one of the tests of a good model is its ability to predict ‘out-of-sample’. Although many studies (including Taylor’s original work) have found that the Taylor rule does fit well in econometric terms, this ‘fit’ explains ‘only’ 80% of interest rate movements in this example. In other words, 20% is unexplained by the output gap and inflation.



Source: Carlstrom and Fuerst (2003)

Conclusion: surprisingly good model, given small number of variables. Seems a good parsimonious model of policy.

Should monetary policy operate according to a Taylor rule?

Clearly, if viewed prescriptively, the rule provides guidance (via the size of the parameters β, γ) to policymakers on how to balance the potentially competing considerations of inflation and output deviations.

Defenders of the Taylor rule (including the man himself) say he never meant it as a mechanical rule, but only as a guideline. Policymakers are allowed to deviate from it, but would need to justify such deviations. Policy could respond to other variables too, although inflation and the output gap are the only ones policy should *consistently* respond to, according to the Taylor rule. Svensson is critical of this, arguing that the guidance provided by the Taylor rule is "incomplete" and "too vague to be operational": "some deviations are allowed, but *there are no rules for when deviations from the instrument rule are appropriate*" (2003, p.3).

There are several *practical problems* with the implementation of a Taylor rule (Bofinger, 2001, sec 8.5.3). The Taylor rule requires that (in the 'steady state' when inflation is at target and output is at the natural level) the repo rate be set equal to the long-run (or steady state) real interest rate plus inflation (see (1')). The real interest rate is not observable and measuring/estimating it is not easy, so deciding the 'normal' (or 'neutral') level of nominal rates is difficult too. Bofinger points out that deciding what inflation measure to use, and measuring the output gap, also present practical obstacles to the Taylor rule.

It is worth noting that rather than using actual values of inflation (and output) to adjust policy according to the Taylor rule, some have suggested using forecasts of these variables. But the theoretical arguments for doing so are not strong, and no significant empirical advantage has been found (see Bofinger, 2001, sec 8.5.4).

Inflation forecast targeting versus instrument rules

How does the Taylor rule (an instrument rule) differ from the policy reaction function that can be derived from the Svensson model (which is based on inflation forecast targeting)? Svensson thinks they are very different. He thinks that policy is not well described by the Taylor rule, and nor should policymakers follow a Taylor rule. McCallum and Nelson vigorously defend instrument rules and attack the notion of targeting rules.

We begin by defining terms, then we make a couple of points, and then we turn to the academic debate.

Some definitions:

- McCallum and Nelson (2005) = McCN
- Svensson (2003) = S2003
- Svensson (2005) = S2005
- Instrument rule = formula for setting a controllable instrument variable in response to currently observable variables (McCN and S2005)
- Specific targeting rule
  = a condition to be fulfilled by the central bank's target variables (or forecasts thereof) (S2005 p.614)
  = a first-order optimality condition derived from a specific objective function for the central bank and a specific model of the economy (McCN)
  e.g. "Choose i_t such that $E_t\pi_{t+2} = \pi^*$" as in the Svensson model discussed previously
  e.g. Choose i_t such that $\pi_{t+1|t} - \pi^* + \frac{\lambda}{\alpha_y}\left(y_{t+1|t} - y_{t|t-1}\right) = 0$, as in the model set out below, from S2005.
- Ignore discussion of the term "general targeting rule" – it's not a very useful concept, and has not been used in a consistent way in the literature.

A couple of points:

- The Taylor rule is an explicit rule for interest rates, whereas the reaction function from the Svensson model is implicit.
- In the Svensson model, what really drives policy is the difference between the inflation forecast and the target (and the output gap forecast if the CB cares about output). The underlying reason that inflation deviations and the output gap appear in the implicit interest rate rule under inflation forecast targeting is that they are involved in the forecasting model for inflation. In contrast, under the Taylor rule, they matter in themselves.

Svensson versus McCallum and Nelson

S2003 claims that targeting rules are superior to instrument rules for various reasons (see below). Most points are rebutted by McCN, and then defended by S2005.

In relation to points (1)-(4), McCN claim that "all four of the objections to instrument rules emphasized by Svensson are equally applicable – or equally inapplicable – to targeting rules" (p.601).

1. S2003: Simple instrument rules don't contain enough relevant variables
"[a] *first* obvious problem for a Taylor-style rule … is that, if there are other important state variables than inflation and the output gap, it will not be optimal … For a smaller and more open economy [than the US], the real exchange rate, the terms of trade, foreign output, and the foreign interest rate seem to be the minimal essential state variables that have to be added" [for the rule to be optimal] (S2003 p. 442).

- McCN counter this by saying that the other variables may not be important, and cite two well-known models (Clarida, Gali and Gertler (2001) and McCallum-Nelson (1999)) which are open-economy models but don't (need to) contain terms other than the interest rate, output and the inflation rate (McCN p.600).

2. S2003: Simple rules don't allow any role for judgement
"A *second* problem, is that a commitment to an instrument rule does not leave any room for judgmental adjustments and extra-model information…" (S2003 p. 442). S2003 argues that if the CB followed a Taylor rule, the coefficients would be known/decided upon, and all the CB would have to do to set interest rates is measure the output gap and inflation each period. Svensson contrasts this with the large number and complexity of factors considered in actual monetary policy making, e.g. the BoE Inflation Report, that determine what happens to UK interest rates. S2003 argues that "targeting rules have the important advantage that they allow the use of judgement and extra-model information" (Svensson (2003), p.55).
[Consider the role played by the forecasting process in an inflation targeting regime. How important is this in inherently allowing judgement, due to its complexity (or imprecision?). Could/should a similar process be involved when an instrument rule is used?]

- Contrary to this, McCN claim that judgement has a role under instrument rules: "for example, the instrument could be set above (or below) the rule-indicated value when policymaker judgments indicate that conditions, not adequately reflected in the central bank's formal quantitative models, imply different forecasts and consequently call for additional policy tightening (or loosening)." (p.600)

S2005 argues that McCN's idea of judgement involves substantial discretion (over what conditions to take into account and how to estimate their impact). "McCallum and Nelson seem to believe that a commitment is consistent with discretionary adjustments, an obvious contradiction" (S2005 p.616).

3. S2003: Simple rules don't allow policymakers to react to new information about the transmission mechanism or shocks

- McCN claim that it is possible to 'commit to a procedure rather than a formula' (p.601), i.e. to commit to a framework within which changing instrument rules can be applied.

4. S2003: No central bank has committed to an instrument rule
Svensson asks why no Central Bank promises to follow a Taylor rule, despite the benefits it could apparently bring: credibility would be very high for a CB that made such a promise and published the relevant Taylor rule coefficients, as the output gap and inflation etc are easily measurable.
[Contrast this transparency and low-cost accountability with the difficulty of monitoring and judging the Bank of England's forecasting process. But also consider whether transparency could be maintained if the judgement discussed in point 2 were allowed.]

- McCN counter that no central bank has committed to an explicit objective function, which they claim is a necessary part of commitment to a specific or general targeting rule. They note that at a minimum it would be necessary for the central bank to state explicitly its weight on output deviations in the objective function (λ in Svensson's model), and to use a particular model.

[Is one reason no CB follows a Taylor rule explicitly that it would tie their hands too much, i.e. it would cost too much in terms of lost discretion? Could the same be said for the publication of the parameters of a targeting rule?]

5. S2003: Simple instrument rules don't fit central bank behaviour well
"Even the best empirical fits leave one third or more of the variance of changes in the [interest instrument] rate unexplained" (S2003 p.444).

- McCN counter that (a) explaining two-thirds of the variance of the first-difference of the interest rate is pretty good for a first-differenced variable, and rather cheekily compare this to the 70%+ of the variance of the first difference of each of inflation and the output gap in Svensson's own work with Glenn Rudebusch (1999). McCN also note that (b) when you look at the *level* of the interest rate, almost all variation can be explained by an instrument rule: "Judd and Rudebusch (1998 p.14) report a residual standard deviation of 0.27 for the Greenspan period 1987Q3-1997Q4. Over that span, the standard deviation of the quarterly average funds rate is 1.93 (annual percentage units). Thus, the unexplained fraction of variability is (0.27/1.93)2 = 0.0196" (p.601).

6. S2003: Central banks noted as leading inflation targeters (Bank of England, RBNZ, Bank of Canada) follow procedures that can be better characterised as following a targeting rule than following an instrument rule.

- McCN claim instead that "descriptions of their policy procedures provided by officials and economists of these central banks read more like instrument rules than specific targeting rules" (p.602). They cite two of several short articles in the Bank of Canada *Review* published in the summer of 2002, and various Bank of England and RBNZ documents, all of which refer to the use of an instrument rule or reaction function, and some of which conduct empirical experiments using a variety of different instrument rules. McCN suggest that this focus on instrument rules is supportive of central banks being better described as using Taylor rules.
- [This type of evidence, however, cannot be conclusive. If the reaction function that results from inflation forecast targeting behaviour looks very like a Taylor rule, it is difficult to be certain that central banks exactly what central banks are thinking when they perform such experiments. Furthermore, there is nothing to stop central banks running experiments using techniques they don't employ, nor expressing the way policy is formulated in the simple, readily-understood terms of a Taylor rule. However, the

additional fact that “there is no attempt to evaluate policy using a numerically specified loss function or Euler equation” (p.602) might seem more important. Why, if central banks are inflation forecast targeters, are they not more open about the precise rules they follow?]

S2005 counters McCN to some extent by citing a large and growing number of papers on inflation forecast targeting.

[Again, though, this is not very convincing – there are fashions in publications, and a tendency for relatively new ideas to get a lot of attention initially.]

7. McCallum and Nelson argued in previous papers that instrument rules can be written to satisfy any specific target rule, by increasing the size of the response coefficient on the particular variable (or ‘prevailing condition’) that needs to be adjusted to meet the target. S2003 had claimed that it was unwise and impractical to have very large response coefficients.

- McCN run some simulation experiments and conclude that there is little difference between the performance instrument and targeting rules when policymakers make a ‘mistake’ about economic conditions.

S2005 counters that if the error is not immediately realised, instrument rules can perform very badly. He also points out that whereas targeting rules are by definition optimal, varying the response coefficient in instrument rules finitely (rather than infinitely) can on some occasions only get close to optimality.

8. McCN argue that specific targeting rules are always specific to a particular model, and hence depend on assumptions about the (dynamics of the) model’s IS and Phillips curves and other structural equations (p.599). McCN criticise specific targeting rules because although they are by definition optimal for a certain model, they may well not be optimal for another model. In contrast, they say, instrument rules can be defined outside particular models and tested in a variety of models, and the best instrument rule over the range of models can be selected. McCN give some numerical examples in which the optimal rule in one model gives results in another model that are (sometimes much) more than twice as bad as the optimum for that model (p.599).

Targeting rules as ‘structural, robust, and compact’

S2005 argues that targeting rules have an advantage over instrument rules in that they are derived from optimal behaviour of economic agents and policymakers (i.e. are ‘***structural***’), and “correspond to a standard efficiency condition” (p.620). We illustrate this using the model in S2005.

S2005 makes a useful analogy with consumption theory. ‘Old’ consumption models used to model consumption as a simple function of income and the real interest rate, and possibly other variables:

$$C_t = f(R_t, Y_t, ...) \qquad (3)$$

which is “not a structural relationship but a reduced form … whose properties and parameters depend on the whole model of the economy, including the existing shocks and their stochastic properties, the monetary and fiscal policy pursued, and so forth” (S2005 p.617)

Modern consumption theory and empirics instead focuses on the Euler equation that consumption has to fulfil – that is, a first order condition that must be fulfilled for the consumption choice to be optimal. S2005 gives the example of an Euler condition that holds under certain assumptions (for an additively separable utility function of a representative consumer):

$$E_t \frac{\delta U_C(C_{t+1})}{U_C(C_t)} = \frac{1}{1+R_t} \qquad (4)$$

where δ is a discount factor and $U_C(C_t)$ is the marginal utility of consumption. All this says is that the consumer should choose consumption in the current and future period so that the expected marginal rate of substitution of current consumption for future consumption (i.e. the LHS of the equation, which measures the relative utility of discounted future and current consumption) equals the marginal rate of transformation (i.e. the RHS of the equation, which captures the real interest rate at which the consumer could borrow or lend, hence the rate at which they are able to transform current consumption into future consumption). The Euler equation is “more structural, independent of the rest of the model” (S2005 p.617).

S2005 (rather rudely) compares the old consumption function to an instrument rule, and the Euler equation to a targeting rule.

Why is a targeting rule like the Euler equation? Targeting rules such as those suggested by Svensson do try to minimise loss – “the optimal targeting rule is simply, and fundamentally, a restatement of the standard efficiency condition of equality between the marginal rates of substitution and transformation between the target variables” (namely inflation and the output gap) (S2005, p.619). The MRS between inflation and the output gap follows from the form of the loss function, including the relative weight on output λ. The MRT between inflation and the output gap is determined by of the AS relation (equation (1) in the Svensson model previously discussed), including the slope of the short-run Phillips curve (α_1 in that model). (Note that the AD relationship (equation (2)) does not determine the MRT, so the targeting rule is ‘robust’ to changes in the AD relationship.) The parallel seems a good one. The policymaker has preferences over (variation in) inflation and output, just as the consumer has preferences over consumption now and in the future. A decision has to be made how much of output and inflation to have, and the optimal choice will depend on the trade-off that exists in reality between them, which is determined by the structure of the economy (the AS curve), just as the consumer’s optimal choice will depend on the trade-off between consumption now and in the future, which is determined by the real interest rate. So MRS=MRT, a principle that is independent of any model, should drive policymakers’ decisions.

The model set out by Svensson in his 2005 paper does differ from that which we previously discussed. The most important difference is probably that the model is ‘forward-looking’, i.e. it incorporates expectations, which affect current behaviour.

The aggregate supply relation in S2005 tells us that the one-period-ahead ‘inflation plan’ of the private sector, $\pi_{t+1|t}$, depends on expected future inflation, $\pi_{t+2|t} \equiv E_t \pi_{t+2}$, the private sector’s ‘output gap plan’, $y_{t+1|t}$, and private sector ‘judgement’, $z_{t+1|t}$.

$$\pi_{t+1|t} = E[\pi_t] + \delta(\pi_{t+2|t} - E[\pi_t]) + \alpha_y y_{t+1|t} + \alpha_z z_{t+1|t} \qquad (5)$$

(Note that we have changed notation compared with S2005 so that the output gap is represented by y rather than x. We have also moved term $E[\pi_t]$ to the RHS of the equation.)
$\pi_{t+1|t}$ is the private sector’s plan made in period t for inflation in period $t+1$. $E[\pi_t]$ is long run average inflation. δ is a discount factor. z_{t+1} are exogenous random variables and shocks that cause the simple model above to deviate from the true model in period $t+1$, and $z_{t+1|t}$ is the private sector’s expectation in period t of next period’s deviation. Svensson calls this the private sector’s ‘judgement’. α_y is the slope of the short-run Phillips curve, i.e. the short-run trade-off between output and inflation.

The previous version of this equation is reproduced below for comparison purposes:

$$\pi_{t+1} = \pi_t + \alpha_1 y_t + \varepsilon_{t+1} \qquad (5')$$

The aggregate demand equation in S2005 tells us that the one-period-ahead output gap plan depends on the expected future output gap, $y_{t+2|t}$, the expected one-period-ahead 'real interest rate gap', $i_{t+1|t} - \pi_{t+2|t} - r^*_{t+1|t}$, and private sector judgement, $z_{t+1|t}$.

$$y_{t+1|t} = y_{t+2|t} - \beta_r \left(i_{t+1|t} - \pi_{t+2|t} - r^*_{t+1|t}\right) + \beta_z z_{t+1|t} \qquad (6)$$

The 'real interest rate gap' is the difference between the 'natural' long-run interest rate r^* (which is the real interest rate that would apply in a perfectly-competitive economy) and the real interest rate measured by the difference between the expected monetary policy instrument value and the expected inflation rate, $i_{t+1|t} - \pi_{t+2|t}$.

The previous version of this equation is reproduced below for comparison purposes:

$$y_{t+1} = \beta_1 y_t + \beta_2 (i_t - \pi_t) + \eta_{t+1} \qquad (6')$$

S2005 assumes that the central bank conducts *flexible inflation targeting*, and so has the following intertemporal loss function in period t:

$$E_t \sum_{\tau=0}^{\infty} (1-\delta)\delta^{\tau} L_{t+\tau} \qquad (7)$$

The central bank wishes to minimise its expected discounted loss each period τ from now onwards. The period loss (i.e. loss each period) is:

$$L_t = \frac{1}{2}\left[(\pi_t - \pi^*)^2 + \lambda y_t^2\right] \qquad (8)$$

This is exactly the same as the loss function considered previously when the central bank cares about output as well as inflation.

If the central bank can commit to follow the optimal instrument path (i.e. "under commitment", as S2005 puts it), the equilibrium first order condition that minimises the central bank's intertemporal loss function is

$$\pi_{t+1|t} - \pi^* + \frac{\lambda}{\alpha_y}\left(y_{t+1|t} - y_{t|t-1}\right) = 0 \qquad (9)$$

This is the central bank's ***optimal targeting rule*** (or optimal specific targeting rule).

The previous version of this equation is reproduced below for comparison purposes:

$$E_t \pi_{t+2} - \pi^* = -\frac{\lambda}{\delta \alpha_1 k} E_t y_{t+1} \qquad (9')$$

S2005 also argues that this rule is a '***structural***' model of monetary policy, to the extent that the AS and AD relationships are structural (and they are designed to capture optimising price-setting and consumption choice respectively). As noted above, S2005 argues that this optimal targeting rule essentially captures the equality of MRS and MRT – MRS being given by the authorities' preferences (i.e. the loss function, including weight λ on output variability) and MRT by the structure of the economy (i.e. by the aggregate supply relationship (5), including the Phillips curve slope α_y).

S2005 also argues that this rule is '***robust***' to shocks and 'judgement', since the z variables don't enter into the rule.

The final advantage of the optimal targeting rule claimed by Svensson is that it is ‘***compact***’ (i.e. small). S2005 is really implying that targeting rules are more parsimonious than instrument rules. The example of an instrument rule he gives (p.619) is the following:

$$i_{t+1} - r^* - \pi_{t+1|t} = \mu\left[\pi_{t+1|t} - \pi^* + \frac{\lambda}{\alpha}\left(y_{t+1|t} - y_{t|t-1}\right)\right]$$

S2005 would like us to compare this to equation (9) below; the above is indeed more complex. Differences are the response coefficient μ, and arguably the appearance of the interest rate. [Note, though that (9) is the targeting rule, not the implicit interest rate reaction function derivable from the combination of that rule and the model.]