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ABSTRACT

Does the P* Model Provide Any Rationale for Monetary Targeting?*

The so-called P* model is frequently used or referred to in discussions of monetary targeting. This gives the impression that the P* model might provide some rationale for monetary targeting or for the monetary reference value used by the Eurosystem. The P* model implies that inflation is determined by the level of and changes in the 'real money gap' (the deviation of current real balances from their long-run equilibrium level), and hence that the real money gap is an important indicator for future inflation. Nevertheless, the P* model does not seem to provide any rationale for either a Bundesbank-style money-growth target or a Eurosystem-style money-growth indicator.

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NON-TECHNICAL SUMMARY

The so-called *P** model (developed by Hallman, Porter and Small for the US. and extended by Tödter and Reimers for Germany) is often used (or at least referred to) in discussions of monetary targeting. This may give the impression that the *P** model provides some rationale for money-growth targeting, especially since the *P** model seems to be part of the Bundesbank's view of the transmission mechanism of monetary policy. This short paper examines whether the *P** model indeed provides any such rationale.

Furthermore, in its monetary strategy, the Eurosystem has given a prominent role to a money-growth indicator, the deviation of current M3 growth from a specified reference value, as an indicator of 'threats to price stability'. Using conventional aggregate-supply and aggregate-demand relations, I have previously argued that this money-growth indicator is likely to be an inferior indicator of such threats, and that an inflation forecast is instead the natural indicator. This paper also examines whether the *P** model provides any support for the Eurosystem money-growth indicator.

The main result of the paper is that, although the *P** model gives a prominent role to real balances in forecasting inflation and, hence, to a 'real money gap' as an important indicator, it does not provide any support for either a Bundesbank-style money-growth target or a Eurosystem-style money-growth indicator.

For the *P** model, inflation depends negatively on the lagged 'price gap,' the deviation between the current price level and the long-run equilibrium price level. The latter is the price level that would result with the current money stock if output were equal to potential output and velocity were equal to its long-run equilibrium level. The price gap is the negative of the real money gap, the deviation between current real balances and long-run equilibrium real balances. Thus, the *P** model can be expressed in terms of the real money gap. Then, one-period-ahead inflation forecast depends on current inflation and the current real money gap. The *T*-period-ahead inflation forecast depends on current inflation, the forecast of the sequence of future real money gaps. Thus, the *P** model assigns a dominant role to the real money gap in forecasting inflation.

Nevertheless, this does not provide any rationale for targeting a Bundesbank-style nominal money-growth target (where the money-growth target is set as the sum of an inflation target and a forecast of potential output growth, less an estimated velocity trend). Instead, it can be shown that stabilization of inflation around an inflation target requires a conditional, time-varying money-growth target, which deviates from the Bundesbank-style money-growth target,

depending on the deviation of current inflation from the inflation target and the lagged real money gap.

Thus, it follows that the *P** model does not give any rationale for the Eurosystem-style money-growth indicator either. Indeed, for stabilizing inflation around the inflation target, it is optimal to allow money-growth to deviate from the reference-value most of the time. The current money-growth indicator seems to be an inferior indicator of future inflation deviations from the inflation target.

As far as I know, there is little theoretical support for the *P** model. The empirical support is mixed. Even if the *P** model turned out to be a good description of inflation dynamics and the transmission mechanism of monetary policy for the Euro area, it would still not imply that targeting a Bundesbank-style money-growth target or relying on a European-style money-growth indicator would be appropriate.

1. Introduction

The so-called P^* model (see Hallman, Porter and Small [14]) is often used (or at least referred to) in discussions of monetary targeting (for instance, in Jahnke and Reimers [17], Neumann [21], Tödter and Reimers [27], Tödter and Ziebarth [28] and von Hagen [29]). This may give the impression that the P^* model provides some rationale for money-growth targeting, especially since the P^* model seems to be part of the Bundesbank's view of the transmission mechanism of monetary policy, see Jahnke and Reimers [17]. This short paper examines whether the P^* model indeed provides any such rationale.

Furthermore, in its monetary strategy, the Eurosystem has given a prominent role to a money-growth indicator, the deviation of current M3 growth from a specified reference value, as an indicator of "threats to price stability" (see ECB [9]-[11]). Using conventional aggregate-supply and aggregate-demand relations, Svensson [26] has argued that this money-growth indicator is likely to be an inferior indicator of such threats, and that an inflation forecast is instead the natural indicator. This paper also examines whether the P^* model provides any support for the Eurosystem money-growth indicator.

The main result of the paper is that, although the P^* model gives a prominent role to real balances in forecasting inflation and, hence, to a "real money gap" as an important indicator, it does not provide any support for either a Bundesbank-style money-growth target or a Eurosystem-style money-growth indicator.

Section 2 presents a slight generalization of the basic P^* model. Section 3 relates inflation and real balances. Section 4 derives inflation forecasts for the P^* model. Section 5 specifies a money-demand function. Section 6 compares inflation targeting and money-growth targeting. Section 7 discusses the reaction functions that follow from the two kinds of targeting. Section 8 presents the conclusions.

2. The P^* model

Define (log) velocity v_t by the quantity equation,

$$v_t \equiv p_t + y_t - m_t, \tag{2.1}$$

where p_t, y_t and m_t are the (logs of the) price level, output and (nominal) money, respectively, in period t.

Consider a long-run equilibrium with (log) output equal to (log) potential output, y_t^*, velocity equal to long-run equilibrium (log) velocity, v_t^*, and the (log) price level equal to a long-run equilibrium level (for a given stock of money, m_t), p_t^*, given by

$$p_t^* \equiv v_t^* - y_t^* + m_t. \tag{2.2}$$

Furthermore, in line with the P^* literature, make the assumption that the inflation dynamics are given by

$$\pi_t = (1 - \alpha_{\Delta p})\pi_{t-1} + \alpha_{\Delta p}\Delta p_{t-1}^* - \alpha_p(p_{t-1} - p_{t-1}^*) + \varepsilon_t, \tag{2.3}$$

where $\pi_t \equiv p_t - p_{t-1}$, $0 \leq \alpha_{\Delta p} \leq 1$, $\alpha_p > 0$, $\Delta p_t^* \equiv p_t^* - p_{t-1}^*$, and ε_t is an iid shock with zero mean. Equation (2.3) for given $\alpha_{\Delta p}$ is a slight generalization of the P^* model. Hallman, Porter and Small [14] assumes (2.3) with $\alpha_{\Delta p} = 0$. Tödter and Reimers [27] assume a variant of (2.3) with $\alpha_{\Delta p} = 1$. Neumann [21] also assumes a variant of (2.3) with $\alpha_{\Delta p} = 1$, but with the variables on the right side all dated t.

Thus, according to (2.3), inflation is determined by lagged inflation, π_{t-1}, lagged P^* inflation, Δp_{t-1}^*, and the lagged "price gap," $p_{t-1} - p_{t-1}^*$.

3. Inflation and the real money gap

I find it instructive to express (2.3) in terms of real balances. First, note that

$$p_t - p_t^* \equiv -m_t + p_t + m_t - p_t^* \equiv -(\tilde{m}_t - \tilde{m}_t^*), \tag{3.1}$$

where $\tilde{m}_t \equiv m_t - p_t$ is (log) real balances and $\tilde{m}_t^* \equiv m_t - p_t^*$ is long-run equilibrium (log) real balances, which by (2.2) fulfill

$$\tilde{m}_t^* \equiv -v_t^* + y_t^*. \tag{3.2}$$

Thus, the price gap is the negative of the "real money gap," $\tilde{m}_t - \tilde{m}_t^*$.

Then, using (3.1) and $\Delta p_t^* \equiv \pi_t + \Delta(\tilde{m}_t - \tilde{m}_t^*)$, we can write (2.3) as

$$\pi_t = \pi_{t-1} + \alpha_m(\tilde{m}_{t-1} - \tilde{m}_{t-1}^*) + \alpha_{\Delta m}\Delta(\tilde{m}_{t-1} - \tilde{m}_{t-1}^*) + \varepsilon_t, \tag{3.3}$$

where $\alpha_m \equiv \alpha_p$ and $\alpha_{\Delta m} \equiv \alpha_{\Delta p}$.

Thus, inflation depends on lagged inflation, the lagged real money gap, $\tilde{m}_{t-1} - \tilde{m}_{t-1}^*$ and when $\alpha_{\Delta m} > 0$, also on the change in the lagged real money gap, $\Delta(\tilde{m}_{t-1} - \tilde{m}_{t-1}^*)$. Compared to conventional backward-looking Phillips curves, where inflation depends on lagged inflation and the output gap, the real money gap simply replaces the output gap. Thus, whereas the discussion about money as an indicator has often centered on the role of real balances for aggregate demand and output (see Meltzer [20]), the P^* model puts real balances firmly in the inflation equation.

4. Inflation forecasts

Let us now consider inflation forecasts in the P^* model. By (3.3), the one-period-ahead inflation forecast can be written

$$\pi_{t+1|t} = \pi_t + \alpha_m(\tilde{m}_t - \tilde{m}_t^*) + \alpha_{\Delta m}\Delta(\tilde{m}_t - \tilde{m}_t^*), \tag{4.1}$$

where, for any variable x, $x_{t+\tau|t} \equiv \mathrm{E}_t x_{t+\tau}$ denotes the forecast of $x_{t+\tau}$ conditional on information available in period t. Furthermore, by solving (4.1) backwards, we can express the T-period-ahead inflation forecast, $\pi_{t+T|t}$, as

$$\pi_{t+T|t} = \pi_t + \alpha_m \sum_{\tau=0}^{T-1}(\tilde{m}_{t+\tau|t} - \tilde{m}_{t+\tau|t}^*) + \alpha_{\Delta m}[(\tilde{m}_{t+T-1|t} - \tilde{m}_{t+T-1|t}^*) - (\tilde{m}_{t-1} - \tilde{m}_{t-1}^*)]. \tag{4.2}$$

Thus, the T-period-ahead inflation forecast depends on current inflation in period t, the forecast of the sequence of real money gaps from period t to $t+T-1$, and the forecast of the change in real money gap from period $t-1$ to period $t+T-1$.

5. Money demand

The money stock in the P^* model is broad money, typically M2 or M3. This is an endogenous variable, imperfectly controlled by the central bank. Similarly, the real money gap is an endogenous variable that can only be imperfectly controlled by the central bank. In practice, the central bank's control over broad money is exercised via control of a short interest rate which then affects the demand for broad money. In turn, the central bank's control over short interest rates is exercised via control over the nonborrowed monetary base, or some component of the nonborrowed monetary base. For practical purposes, it is sufficient to regard a short nominal interest rate as the central bank's instrument. Money is then an endogenous variable, determined by money demand.

Consider a reasonably realistic money-demand function, the error-correction form

$$\Delta\tilde{m}_t = -\kappa_m(\tilde{m}_{t-1} - \kappa_y y_{t-1} + \kappa_i i_{t-1}) + \kappa_1\Delta\tilde{m}_{t-1} + \theta_t, \tag{5.1}$$

where $\kappa_m, \kappa_y, \kappa_i > 0$, $\kappa_1 \geq 0$, i_t is the short nominal interest rate in period t and the central bank's instrument, and θ_t is an iid money-demand shock with zero mean. This money-demand function implies a long-run money-demand function equal to

$$\tilde{m}_t = \kappa_y y_t - \kappa_i i_t, \tag{5.2}$$

where κ_y is the long-run elasticity of real balances with respect to output and κ_i the long-run semi-elasticity with respect the interest rate. In the short run, demand for real balances adjusts to the discrepancy between lagged real balances, $\tilde{m}_{t-1}$, and the long-run real balances, $\kappa_y y_{t-1} - \kappa_i i_{t-1}$, and to the change in lagged real balances, $\Delta\tilde{m}_{t-1}$. Since real balances react with a lag to the central bank's instrument and real balances are also subject to shocks after the instrument is set, the central bank then only has imperfect control over money.[1]

With this money-demand equation, long-run equilibrium real balances are given by

$$\tilde{m}_t^* \equiv \kappa_y y_t^* - \kappa_i i^*, \tag{5.3}$$

where potential output, y_t^*, and the long-run equilibrium interest rate, i^*, are substituted into the long-run money-demand equation (5.2). Here, the long run equilibrium interest rate is given by

$$i^* \equiv r^* + \hat{\pi}, \tag{5.4}$$

where r^* is the long-run equilibrium level of the real interest rate and $\hat{\pi}$ is an inflation target and the long-run equilibrium inflation rate. Both r^* and $\hat{\pi}$, and hence $\hat{\pi}$, are here assumed to be constant.[2]

It follows from (5.1) that velocity is given by

$$v_t \equiv y_t - \tilde{m}_t = y_t - \tilde{m}_{t-1} + \kappa_m(\tilde{m}_{t-1} - \kappa_y y_{t-1} + \kappa_i i_{t-1}) - \kappa_1 \Delta\tilde{m}_{t-1} - \theta_t, \tag{5.5}$$

whereas the long-run equilibrium velocity is given by

$$v_t^* = (1 - \kappa_y) y_t^* + \kappa_i i^*. \tag{5.6}$$

The long-run equilibrium price level, p_t^*, is then given by

$$p_t^* = -\kappa_y y_t^* + \kappa_i i^* + m_t. \tag{5.7}$$

[1] See Browne, Fagan and Henry [3] for a survey of European money-demand functions. This money-demand function is estimated and used by Rudebusch and Svensson [22] in discussing the performance of monetary targeting in the U.S. It is estimated for Euro-area data by Gerlach and Svensson [13].

[2] If there is a trend Δy^* in y_t^* and/or a trend Δi^* in i_t^* (the latter due to a trend in r_t^* and/or $\hat{\pi}_t$), the equation (5.1) should include a constant, $\Delta\tilde{m}_t = \kappa_0 - \kappa_m(\tilde{m}_{t-1} - \kappa_y y_{t-1} + \kappa_i i_{t-1}) + \kappa_1 \Delta\tilde{m}_{t-1} + \theta_t$, where the constant is given by $\kappa_0 = (\kappa_y \Delta y^* - \kappa_i \Delta i^*)/(1 - \kappa_1)$. In order to reduce clutter, this constant has been deleted.

6. Strict inflation targeting and the money-growth target or indicator

Consider now the simple case of "strict" inflation targeting, when the central bank's only objective is to stabilize inflation around the inflation target, $\hat{\pi}$.[3] With the above money-demand equation, the central bank can affect real balances in period $t+1$, by setting the instrument in period t. By (3.3), real balances in period $t+1$ affects inflation in period $t+2$. Clearly, the optimal policy under strict inflation targeting is then to set the interest rate such that the two-period-ahead inflation forecast, $\pi_{t+2|t}$, conditional on information available in period t, equals the inflation target,

$$\pi_{t+2|t} = \hat{\pi}. \tag{6.1}$$

By leading (4.1) one period and taking expectations in period t, we get the two-period-ahead inflation forecast as

$$\pi_{t+2|t} = \pi_{t+1|t} + \alpha_m(\tilde{m}_{t+1|t} - \tilde{m}^*_{t+1|t}) + \alpha_{\Delta m}\Delta(\tilde{m}_{t+1|t} - \tilde{m}^*_{t+1|t}). \tag{6.2}$$

Combining (6.1) and (6.2) and solving for $\tilde{m}_{t+1|t}$ gives

$$\tilde{m}_{t+1|t} = \tilde{m}^*_{t+1|t} - \frac{1}{\alpha_m + \alpha_{\Delta m}}(\pi_{t+1|t} - \hat{\pi}) + \frac{\alpha_{\Delta m}}{\alpha_m + \alpha_{\Delta m}}(\tilde{m}_t - \tilde{m}^*_t). \tag{6.3}$$

The right side of (6.3) is a forecast of the state-dependent level of real balances in period $t+1$ that is consistent with strict inflation targeting. We can interpret this as a conditional intermediate target for real balances in period $t+1$.

Let us express (6.3) as a conditional intermediate target for *nominal* money-growth,

$$\begin{aligned}\Delta m_{t+1|t} &\equiv \Delta\tilde{m}_{t+1|t} + \pi_{t+1|t} \\ &= \hat{\pi} + \Delta\tilde{m}^*_{t+1|t} - \frac{1-\alpha_m-\alpha_{\Delta m}}{\alpha_m + \alpha_{\Delta m}}(\pi_{t+1|t} - \hat{\pi}) - \frac{\alpha_m}{\alpha_m + \alpha_{\Delta m}}(\tilde{m}_t - \tilde{m}^*_t).\end{aligned} \tag{6.4}$$

Thus, we can define

$$\widehat{\Delta m_{t+1|t}} \equiv \hat{\pi} + \Delta\tilde{m}^*_{t+1|t} - \frac{1-\alpha_m-\alpha_{\Delta m}}{\alpha_m + \alpha_{\Delta m}}(\pi_{t+1|t} - \hat{\pi}) - \frac{\alpha_m}{\alpha_m + \alpha_{\Delta m}}(\tilde{m}_t - \tilde{m}^*_t) \tag{6.5}$$

as a conditional nominal money-growth target that is consistent with strict inflation targeting. This money-growth target is "conditional" in the sense that it depends on the current and lagged state of the economy, more precisely the deviation between the one-period-ahead inflation

[3] As in Svensson [25] and [24], by *strict* inflation targeting I mean minimizing an intertemporal loss function, $\mathrm{E}_t(1-\delta)\sum_{\tau=0}^{\infty}\delta^\tau L_{t+\tau}$, where $0<\delta<1$ is a discount factor and the period loss is given by $L_t = \frac{1}{2}(\pi_t - \hat{\pi})^2$. That is, inflation is the only variable entering the loss function.

forecast (which is predetermined under (3.3) and (5.1) and cannot be affected by the central bank) and the current real money-gap, $\tilde{m}_t - \tilde{m}_t^*$.

Let us now contrast this conditional money-growth target with the Bundesbank money-growth target, or the Eurosystem reference value for money growth. Until Germany joined the EMU, each December, Bundesbank calculated its money-growth target for the coming year, as the sum of an inflation target (over the years called "unavoidable inflation," "normative" inflation or "medium-term price assumption"), a forecast of potential output growth, less an estimated velocity trend. The Eurosystem currently calculates its reference value for M3 growth in the same way (see European Central Bank [10]). Thus, the Bundesbank money-growth target and the Eurosystem reference value, $\Delta m^*_{t+1|t}$, are given by

$$\Delta m^*_{t+1|t} = \hat{\pi} + \Delta y^*_{t+1|t} - \Delta v^*_{t+1|t} \equiv \hat{\pi} + \Delta \tilde{m}^*_{t+1|t}, \tag{6.6}$$

where we have used (3.2).[4] This is an "unconditional" money-growth target, in the sense that it only depends on potential output growth and the velocity trend, which from the point of view of monetary policy are either exogenous or change only slowly with the current state of the economy.

It follows that the discrepancy between the conditional money-growth target (6.5) and the unconditional money-growth target (6.6) is given by

$$\widehat{\Delta m_{t+1|t}} - \Delta m^*_{t+1|t} = -\frac{1-\alpha_m-\alpha_{\Delta m}}{\alpha_m+\alpha_{\Delta m}}(\pi_{t+1|t}-\hat{\pi}) - \frac{\alpha_m}{\alpha_m+\alpha_{\Delta m}}(\tilde{m}_t - \tilde{m}_t^*).$$

This discrepancy can be interpreted in two ways. First, it shows that there is a tradeoff between stabilizing inflation around the inflation target $\hat{\pi}$ and stabilizing money-growth around the unconditional money-growth target (6.6). Thus, minimizing inflation variability around the inflation target would require a variable conditional money-growth target and generally lead to higher than minimum variability of money-growth. Minimizing money-growth variability around an unconditional money-growth target would generally lead to higher than minimum variability of inflation. The tradeoff between stabilizing inflation and stabilizing money-growth is empirically estimated for U.S. data in Rudebusch and Svensson [22] and found to be substantial.

Second, the discrepancy shows that the Eurosystem money-growth indicator,

$$\Delta m_t - \Delta m^*_{t|t-1}, \tag{6.7}$$

[4] This is a simplification, in order to reduce clutter. If the period is a quarter, the money-growth target is $\Delta_4 m^*_{t+4|t} = 4\hat{\pi} + \Delta_4 y^*_{t+4|t} - \Delta_4 v^*_{t+4|t} \equiv 4\hat{\pi} + \Delta_4 \tilde{m}^*_{t+4|t}$, where $\Delta_4 x_t \equiv x_t - x_{t-4}$.

the deviation of current money-growth from the reference value,[5] is likely to be an inferior indicator of future inflation deviations from the inflation target. This can be seen more directly by expressing the deviation of the two-period-ahead inflation forecast from the inflation target as a function of this money-growth indicator. Subtracting $\hat{\pi}$ from (6.2) and rewriting gives

$$\pi_{t+2|t} - \hat{\pi} = \pi_{t+1|t} - \hat{\pi} - (\alpha_m + \alpha_{\Delta m})\Delta\tilde{m}^*_{t+1|t} + \alpha_m(\tilde{m}_t - \tilde{m}^*_t) + (\alpha_m + \alpha_{\Delta m})\Delta\tilde{m}_{t+1|t}.$$

Taking expectations of (5.1), substituting for $\Delta\tilde{m}_{t+1|t}$, collecting all terms involving $\Delta\tilde{m}_t$, and replacing $\Delta\tilde{m}_t$ by $\Delta m_t - \pi_t$ then gives, after some algebra,

$$\begin{aligned}\pi_{t+2|t} - \hat{\pi} \;=\;& \pi_{t+1|t} - \hat{\pi} - (\alpha_m + \alpha_{\Delta m})\Delta\tilde{m}^*_{t+1|t} - \alpha_m\tilde{m}^*_t + (\alpha_m + \alpha_{\Delta m})\kappa_m(\kappa_y y_t - \kappa_i i_t) \\ &+ [\alpha_m - (\alpha_m + \alpha_{\Delta m})\kappa_m]\tilde{m}_{t-1} - [\alpha_m + (\alpha_m + \alpha_{\Delta m})(\kappa_1 - \kappa_m)](\pi_t - \Delta m^*_{t|t-1}) \\ &+[\alpha_m + (\alpha_m + \alpha_{\Delta m})(\kappa_1 - \kappa_m)](\Delta m_t - \Delta m^*_{t|t-1}). \qquad (6.8)\end{aligned}$$

Here the last term in (6.8) isolates the effect of the current money-growth indicator, (6.7), on the deviation of the two-period-ahead inflation forecast from the inflation target. It seems fairly obvious that the relation between that deviation and the money-growth indicator is tenuous, to say the least. The inflation forecast is affected by much more than the money-growth indicator. At least, the sign of this effect is likely to be positive, though, since empirically $0 < \kappa_m < \kappa_1$ is typical.

Thus, using the money-growth indicator as indicating deviations of the inflation forecast from the inflation target disregards the other determinants of the inflation forecast in (6.8). Furthermore, the partial effect of the indicator may even be negative. Thus, the money-growth indicator is likely to be a misleading indicator of "risks to price stability." Instead, as argued in Svensson [26], the best indicator of such risks seems to be the deviation between the two-period-ahead inflation forecast and the inflation target for unchanged interest rate, $i_t = i_{t-1}$. This deviation then indicates deviations from the inflation target unless the instrument is changed.

7. Reaction functions

Finally, let us note what the reaction functions for the short interest rate are under strict inflation targeting and strict money-growth targeting with the Buba-style money-growth target (6.6).[6]

[5] Again, this is a simplification to reduce clutter. If the period is a quarter, the money-growth indicator can be written as $\Delta_4 m_t - \Delta_4 m^*_{t|t-4}$, or rather, to judge from Eurosystem announcements, as a three-month moving average of this expression.

[6] Strict money-growth targeting with a money-growth target $\widehat{\Delta m_t}$ means minimizing an intertemporal loss function as in footnote 3 but with a period loss function given by $L_t = \frac{1}{2}(\Delta m_t - \widehat{\Delta m_t})^2$. That is, money growth is the only variable entering the loss function.

Under the P^* model, summarized by (2.3) or (3.3), these reaction functions clearly depend on the assumed money-demand function, (5.1).

Leading (5.1) one period, taking expectations in period t, and solving for i_t gives

$$i_t = \frac{\kappa_y}{\kappa_i} y_t - \frac{1}{\kappa_i}\tilde{m}_t + \frac{\kappa_1}{\kappa_m \kappa_i}\Delta\tilde{m}_t - \frac{1}{\kappa_m \kappa_i}\Delta\tilde{m}_{t+1|t}. \tag{7.1}$$

Replacing $\Delta\tilde{m}_{t+1|t}$ by $\Delta\widehat{m_{t+1|t}} - \pi_{t+1|t}$ and using (6.5) then gives the reaction function under strict inflation targeting,

$$\begin{aligned} i_t \quad = \quad & \frac{1}{\kappa_m \kappa_i(\alpha_m + \alpha_{\Delta m})}(\pi_{t+1|t} - \hat{\pi}) + \frac{\kappa_y}{\kappa_i} y_t \\ & - \frac{1}{\kappa_i}\tilde{m}_t + \frac{\kappa_1}{\kappa_m \kappa_i}\Delta\tilde{m}_t - \frac{1}{\kappa_m \kappa_i}\Delta\tilde{m}^*_{t+1|t} + \frac{\alpha_m}{\kappa_m \kappa_i(\alpha_m + \alpha_{\Delta m})}(\tilde{m}_t - \tilde{m}^*_t) \end{aligned} \tag{7.2}$$

Replacing $\Delta\tilde{m}_{t+1|t}$ by $\Delta m^*_{t+1|t} - \pi_{t+1|t}$ and using (6.6) instead gives the reaction function under strict money-growth targeting,

$$i_t = \frac{1}{\kappa_m \kappa_i}(\pi_{t+1|t} - \hat{\pi}) + \frac{\kappa_y}{\kappa_i} y_t - \frac{1}{\kappa_i}\tilde{m}_t + \frac{\kappa_1}{\kappa_m \kappa_i}\Delta\tilde{m}_t - \frac{1}{\kappa_m \kappa_i}\Delta\tilde{m}^*_{t+1|t}, \tag{7.3}$$

which, of course, is different from that under strict inflation targeting.

Note that strict inflation targeting does generally *not* result in a reaction function like

$$i_t = i^* + \gamma(\pi_t - \hat{\pi})$$

or

$$i_t = i^* + \gamma(\pi_{t+1|t} - \hat{\pi}).$$

Similarly, strict money-growth targeting does generally not imply a reaction of (or similar to) the form

$$i_t = i^* + \gamma(\Delta m_t - \Delta m^*_{t|t-1}).$$

This illustrates the general principle that it is better to respond to the determinants of the target variables than to the target variables themselves, see Svensson [23].

8. Conclusions

Let us now summarize the conclusions for targeting a Bundesbank-style money-growth target and using a Eurosystem-style money-growth indicator from this examination of the P^* model. First, we have noticed that, for the P^* model, inflation depends on lagged inflation and the level of and changes in the lagged real money gaps, the difference between real balances and long-run equilibrium real balances. Thus, as shown in (6.2), the one-period-ahead inflation forecast depends on current inflation and the current level of and changes in the real money gap. Similarly, the T-period-ahead inflation forecast depends on current inflation, the forecast of the sequence of future real money gaps, and the forecast of the change in the real money gap during the forecast horizon. Thus, the P^* model assigns a dominant role to the real money gap in forecasting inflation.

Nevertheless, this does not provide any rationale for targeting a Bundesbank-style nominal money-growth target (where the money-growth target is set as the sum of an inflation target and a forecast of potential output growth, less an estimated velocity trend). Stabilization of inflation around an inflation target instead requires a conditional money-growth target, (6.5), which deviates from the Bundesbank-style money-growth target, depending on the deviation of current inflation from the inflation target and the lagged real money gap.

Thus, it follows that the P^* model does not give any rationale for the Eurosystem-style money-growth indicator either. Indeed, for stabilizing inflation around the inflation target, it is optimal to allow money-growth to deviate from the reference-value most of the time. The current money-growth indicator seems to be an inferior indicator of future inflation deviations from the inflation target.

The reaction function corresponding to strict inflation targeting (which minimizes the variability of inflation and leads to larger than minimum variability of money growth) will obviously differ from that corresponding to targeting a Bundesbank-style money-growth target (which minimizes the variability of money-growth but leads to a larger than minimum variance of inflation).

Although the discussion in this paper has been in terms of strict inflation targeting (without any weight on output gap stabilization), it is fairly obvious that the conclusions about the P^* model not providing any rationale for monetary targeting or a money-growth indicator will also hold under more realistic "flexible" inflation targeting, where the loss function also includes some weight on the variability of the output gap.[7]

As far as I know, there is little theoretical support for the P^* model. The empirical support is mixed (see Christiano [6]). Gerlach and Svensson [13] find considerable empirical support for the P^* model for the Euro-area, but no support for the U.S. Even if the P^* model turned out to be a good description of inflation dynamics and the transmission mechanism of monetary policy

[7] A previous version of this paper also examined flexible inflation targeting and confirmed this statement. This requires the specification of how output is determined.

for the Euro area, it would still not imply that targeting a Bundesbank-style money-growth target or relying on a European-style money-growth indicator would be appropriate.

The recent interest in monetary targeting is mainly motivated by the view that monetary targeting is the reason behind Bundesbank's outstanding record on inflation control and the possibility that the Eurosystem would choose monetary targeting as its monetary-policy strategy. However, with regard to whether monetary targeting lies behind Bundesbank's success, as discussed in Svensson [26] for instance, a number of studies of Bundesbank's monetary policy, by both German and non-German scholars, have come to the unanimous conclusion that, in the frequent conflicts between stabilizing inflation around the inflation target and stabilizing money-growth around the money-growth target, Bundesbank has consistently given priority to the inflation target and disregarded the monetary target.[8] Thus, Bundesbank has actually been an inflation targeter in deeds and a monetary targeter in words only. Furthermore, although the Eurosystem has adopted a money-growth *indicator*, it has strongly rejected monetary *targeting* as a suitable strategy, on the grounds that the relations between prices and money may not be sufficiently stable and that the monetary aggregates with the best stability properties may not be sufficiently controllable (see Issing [16]). Furthermore, an extensive and convincing discussion some 25 years ago concluded that intermediate monetary targeting was generally inferior; see, for instance, Kareken, Muench and Wallace [18], Friedman [12] and Bryant [5].[9]

Thus, whereas money-growth targeting is currently hardly a relevant alternative monetary policy, the Eurosystem gives considerable emphasis in its rhetoric, although, so far, not in its practice, to the money-growth indicator, as an indicator of "threats to price stability." Svensson [26], using conventional aggregate supply and aggregate demand equations, has demonstrated that the money-growth indicator is likely to be an inferior indicator of such threats, and that an inflation forecast is instead the best indicator. Assuming instead the P^* model, the present paper arrives at the same conclusions.

Rudebusch and Svensson [22] examine the consequences of monetary targeting in an empirical

[8] This literature includes Neumann [21], von Hagen [29], Bernanke and Mihov [2], Clarida and Gertler [8], Clarida, Gali and Gertler [7] (note a crucial typo: the coefficient for money supply in Table 1 should be 0.07 instead of 0.7), Laubach and Posen [19], and Bernanke, Laubach, Mishkin and Posen [1].

[9] A separate argument for monetary targeting is that it would be preferable when there is considerable model uncertainty. Indeed, Brunner and Meltzer [4] argue that monetary targeting would minimize the maximum loss when there is considerable model uncertainty. (This is an interesting early example of an argument involving "robust control", a minmax approach to optimal control recently discussed by Hansen and Sargent [15].) The Brunner-Meltzer argument remains to be examined rigorously. Furthermore, in practice there seem to be sufficient information about the transmission mechanism for monetary policy to be able to do better than monetary targeting. For example, Bundesbank's deliberate deviations from strict monetary targeting and success in inflation control is strong evidence of this.

model of inflation, output and money for the U.S. They find that monetary targeting in the U.S. would be quite inefficient, in the sense of causing high variability of both inflation and the output gap. They also show that this would, counter to conventional wisdom, also be the case if money demand were completely stable. Gerlach and Svensson [13] examine the empirical indicator properties of monetary aggregates for the Euro area. They find substantial empirical support for the real money gap as an indicator for future inflation, but little support for the nominal money-growth indicator.

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