Abstract

Most of the recent literature on monetary policy that compares alternative targeting regimes focuses on the traditional interest rate channel. However, several researchers have emphasized on an alternative channel, the cost channel, as a powerful collaborator in the transmission of short run effects of monetary policy. In this paper I incorporate both the traditional and the cost channel of monetary policy in a baseline ‘new Keynesian model and study two targeting regimes --- price-level targeting and nominal income targeting. In light of empirical considerations, I also consider alternative specifications for the aggregate demand side of the economy --- the IS-type relationship and for the aggregate supply side of the economy --- a Phillips curve type. The main result of the paper is that the cost channel matters; with the cost channel operating the volatility of real output increases under both price-level and nominal income targeting. Moreover, nominal income targeting performs better than price level targeting in bringing down the volatility of real output in almost all the specifications of the macro models used in the analysis.

JEL Classification: E30, E32, E52

Keywords: the cost channel, price level targeting, nominal income targeting

I am extremely thankful to Bill Scarth for helping me at the early stage of the project by providing very useful suggestions and comments.
1)- Introduction

In recent years, a consensus has grown in many countries that central banks should primarily focus on policies that promote price stability in the economy, and that a rule-based monetary policy is superior to discretion-based monetary policy actions. Price stability eliminates the costs associated with inflation (the rate of change of prices) and makes the economy more efficient. Moreover, a rule-based monetary policy disciplines the central banks by "tying their hands" and ensures systematic action. This kind of commitment leads to more transparency in the policymaking process and increases credibility and accountability. A number of variables that can be (and have been) used as targets in the conduct of rule based monetary policy to achieve the ultimate target of long-term price stability have appeared in the literature. Some notable examples are: money-growth, exchange rate, nominal income, inflation rate and the price level.

While there is broad understanding regarding the overall monetary policy strategy, the mechanisms through which the monetary policy affects real activity are not completely understood. The traditional view deals with the impact of monetary policy on asset prices such as interest rates (and exchange rates for open economies). This channel operates by affecting the spending decisions of households and firms and thus works through the aggregate demand side of the model. An alternative view, often termed as the credit channel, emphasizes the effect of monetary policy on the production decision of firms either by studying the changes in the lending by banks (the bank lending channel) or by focusing on the changes in the net worth of firms (the broad credit channel). Since this
channel operates by affecting the cost of production and thus the aggregate supply, it is 
sometimes termed as the cost channel of monetary policy transmission mechanism. 
Distinguishing the relative importance of the traditional and the cost channel is useful for 
various reasons.¹ First, it improves our understanding of the link between the financial 
and real sectors of the economy. Second, it provides alternative indicators to help gauge 
the stance of monetary policy and thus increases its ability to offset particular types of 
adverse shocks. Third, a clear understanding of the transmission mechanism has the 
potential to give more information regarding the choice of intermediate targets.

Informed by these observations, especially the last one, the objective of this paper is to 
assess the robustness of policy recommendations for a closed economy in the presence of 
the cost channel of monetary policy. In particular, I study two interest rate based 
monetary policy rules --- price-level targeting and nominal income targeting in a ‘new 
Keynesian model’ that incorporate both the traditional interest rate channel and the cost 
channel of monetary policy transmission mechanism. Most of the literature has, so far, 
concentrated mainly on the traditional channel of monetary policy while assessing 
alternative targeting regimes. However, several researchers like Christiano and 
Eichenbaum (1992), Christiano, Eichenbaum and Evans (1997) and Barth and Ramey 
(2001) have emphasized on the cost channel as a powerful collaborator in the 
transmission of short run effects of monetary policy. By analysing both the traditional 
and the cost channel of monetary policy in one unified framework, this paper is an 
attempt to bridge the gap between these two parallel strands of literature. The paper also 
studies alternative specifications for the aggregate demand side of the economy --- the IS-

¹ For a detailed discussion see Kashyap and Stein (1994)
type relationship and for the aggregate supply side of the economy --- a Phillips curve type relationship that have been proposed recently in the literature in light of empirical considerations. The main result of the paper is that with cost channel operating the volatility of real output increases under both price-level and nominal income targeting. Moreover, nominal income targeting performs better than price level targeting in bringing down the volatility of real output in almost all the specifications of the macro models that I study.

In order to conduct a credible, pre-committed and transparent policy, the central banks usually announce a particular nominal anchor that serves as an intermediate target that helps in attaining the goal of long run price stability. One such nominal anchor is a price-level target. Although it is quite similar to inflation targeting (that has become extremely popular in recent years in many developed countries; see Bernanke and Mishkin (1997) for details)) and share many of its benefits, the two rules have a fundamental difference. Under inflation targeting, the monetary authority let bygones be bygones while under price level targeting they attempt to remedy the past failures. More specifically, if there is an unexpected increase in prices then according to price level targeting the monetary authority will attempt to deflate prices back to the original in order to prevent the base drift in the price level, while under inflation targeting no action will be taken and the new level of prices would be maintained. This means that the long-term price level is more certain under price level targeting while it may wander around randomly over long periods under inflation targeting. However, short-term price volatility (and thus output volatility) may be higher under price-level targeting because unexpected rises in the price
level will be followed by attempted reductions in the price level. The literature on the relative benefits of price-level targeting is divided. In some recent papers like Svensson (1999), Dittmar, Gavin and Kydland (1999), Dittmar and Gavin (2000), Vestin (2000) and Carlstorm and Fuerst (2002) price-level targeting is preferred over inflation targeting, while previous papers like Fischer (1994), Haldane and Salmon (1995) and Kiley (1998) have shown opposite results. As Mishkin (2001) has correctly pointed out that the results in favour of or against a price level target are very model specific, especially regarding the specification of the Phillips curve. In particular, the assumptions about private sector’s inflation expectations entering the Phillips curve, amount of persistence in the output gap and whether policy is conducted under a commitment rule or in a discretionary fashion play important roles in determining the desirability of price level targeting.

Nominal income targeting is another desirable strategy for monetary policy as it shares many positive features of inflation targeting. But, the most attractive feature of nominal income targeting is that it is closely related to both real output and prices --- the two variables that central bank seem to care about most. In addition, nominal income targeting allows the monetary policy to adjust to offset disturbances to both aggregate demand and aggregate supply. For example, in case of an adverse demand shock (that would cause both real output and prices to go below target), policymakers would ease monetary policy that would return nominal income (the product of real income and prices) to target. Similarly, an adverse supply shock results in falling real output and

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2 For an in-depth analysis of the conditions under which price level targeting would be preferred over inflation targeting see Barnett and Engineer (2001).
rising price levels. This could pose a dilemma if central bank is pursuing price level targeting. Stabilizing the price level would mean further decline in real output. Nominal income targeting would help policy makers resolve the dilemma as it places equal emphasis on stability of both real output and price level.\textsuperscript{3} Frankel and Chinn (1995) have shown nominal income targeting to be superior to money-growth, exchange rate and price level targeting in a simple time-consistent model of monetary policy. More recently, several contributions in the literature have been made that study the stability properties of the nominal income-targeting regime. Two key papers in this regard are Ball (1997) and McCallum (1997). Using a backward looking macro model, Ball (1997) has forcefully argued that “nominal income targets are not merely inefficient, but also disastrous: they imply that output and inflation have infinite variances”. Svensson (1997) replicates Ball’s instability result and suggests that it is the stylised fact that policy affects real output before inflation that Ball builds into his model that lies at the heart of the instability result. Challenging the negative assessment of nominal income targeting, McCallum (1997) has shown that Ball’s instability result is not robust; it critically depends on the specification of the Phillips curve relationship.\textsuperscript{4} Using a forward-looking model McCallum demonstrates that nominal income targeting does not generate instability. Using a Philips curve with mixed expectations, Dennis (2001) have shown that the nominal income targeting will not generate instability as long as inflation expectations contain some element of forward-looking component. More recently Rudebusch (2002),

\textsuperscript{3} The case in favour of nominal income targeting has been well documented in Hall and Mankiw (1994).

\textsuperscript{4} The issue of the importance of Phillips curve or the supply side of the economy for the performance of nominal income targeting is not new; it has been previously highlighted by Bean (1983) and West (1986).
however, has shown that nominal income targeting performs poorly after taking into account of the range of model and data uncertainty that policy makers face.

It is evident from the above discussion that a case for or against price level targeting and nominal income targeting rely critically on how inflation expectations are formed in the Phillips curve or more generally on the specification of the model. For this reason, I evaluate the performance of price-level targeting and nominal income targeting in a series of macroeconomic models. In particular, I study two specifications for the IS relationship and three different specification for the Phillips curve relationship. In addition, I also explore the implications of adding the supply side effects (the cost channel) of interest rates to each specification. This consideration provides an additional contribution in the ongoing debate between choosing an appropriate targeting regime. It has been argued in the literature that such effects can be significant in evaluating the performance of monetary policy. (Myatt and Scarth (2002)). Thus, the analysis not only allows for a direct comparison between price-level and nominal income targeting in a range of macroeconomic models, but also highlights the importance of the transmission mechanism of monetary policy.

2)- The Baseline ‘new Keynesian’ Model

The model is defined by equations (1) through (4). These equations define (respectively) the “new” IS relationship (aggregate demand), the “new” Phillips curve (aggregate supply), monetary policy, and the exogenous cycle in autonomous spending. The
definition of variables, and a more detailed description of the structure are given following the equations.

\[ \dot{y} = \alpha (r - \bar{r}) + \beta \dot{a} \]  
\[ \dot{p} = -\lambda (y - \bar{y}) + \psi (a - \bar{a}) - \kappa y (r - \bar{r}) \]  
\[ p + \mu y = 0 \]  
\[ a = \bar{a} + \delta \sin(t) \]

All variables except the interest rate \( r \) and the time index \( t \) are the natural logarithms of the associated variable. Dots and bars above a variable denote (respectively) the time derivative, and the full-equilibrium value of that variable. All coefficients (the Greek letters) are positive. The variables are: \( a \) – autonomous spending, \( p \) – the general price level, \( r \) – the domestic real interest rate, and \( y \) – the level of real output.

Before discussing each equation in turn, let me briefly talk about the continuous-time specification. Discrete-time specifications are more common, but following this practice can involve model properties being dramatically dependent on small changes in assumptions concerning information availability. For example, consider the original “policy relevance” paper by Sargent and Wallace (1976). The central conclusion in this study does not emerge if it is assumed that the information available to agents when deciding how much to spend is the same as what is now usually assumed (that is, when the assumption involved in McCallum and Nelson (1999) is invoked). Also, if the McCallum and Nelson analysis (p. 309) is reworked with the information-availability
assumption used by Sargent and Wallace, the entire undetermined coefficients solution procedure breaks down (with restrictions on structural, not reduced form, coefficients being called for). A continuous-time specification precludes such unappealing problems from developing.

Equation (1) is the “new” IS relationship which states that the rate of change of real output depends positively on the real interest rate and on the rate of change of autonomous spending. The motivation for such a relationship can be appreciated by referring to a dynamic general equilibrium macro model with optimising economic agents. I start with a log-linear approximation of the economy’s resource constraint: $y = \alpha c + \beta a$, where ‘$c$’ is the log of consumption expenditure, ‘$a$’ is the log of the autonomous spending. The parameters ‘$\alpha$ ’ and ‘$\beta$ ’ are the steady-state ratios of household spending and autonomous spending to total real output respectively. The Ramsey model is used to model forward-looking domestic households. If the instantaneous utility function involves separable terms, log consumption and the square of labour supply, the first-order conditions are $\dot{c} = r - \bar{r}$, and (ignoring constants) $n = w - p - c$. ‘$n$’ and ‘$w$’ denote the log of employment and the nominal wage. Equation (1) follows by taking the time derivative of the resource constraint and substituting in the Euler equation for consumption. The labour supply function is used below. For detailed derivation and discussion, see Clarida, Gali and Gertler (1999), McCallum and Nelson (1999), Kerr and King (1996) and Walsh (2003). Almost all the models being referred to are set in discrete-time with rational expectations. I use a continuous-time deterministic setting so that rational expectations and perfect foresight mean the same thing. The focus
of this paper is not the “derivation” of the IS relationship with rich dynamics and firm microfoundations, but to exploit this tractable model of aggregate demand with a variety of aggregate supply specifications to analyse various monetary policies in the presence of the cost channel of monetary policy.

Equation (2) is the “new” Phillips curve that relates the rate of change of inflation to the output gap, autonomous-spending gap and the real rate of interest. This relationship essentially captures the supply side of the economy and can be derived by incorporating nominal price rigidities using Calvo’s (1983) model of sluggish price adjustment and imperfect competition ala Dixit and Stiglitz (1977) in a dynamic general equilibrium macro model. Only proportion \((1 – \tau)\) of firms can change prices at each point in time. Firms minimize the undiscounted present value of the squared deviations between the log of marginal cost \((mc)\) and price \((p)\). Many authors have shown that optimal behaviour at the individual firm level leads to \(\dot{p} = -[(1 – \tau)^2 / \tau] (mc - p)\) at the aggregate level. To represent this price-adjustment process in a format that resembles the traditional Phillips curve, I follow King (2000) and replace real marginal cost with the output gap (and any other term that emerge as relevant given that I have autonomous spending and supply-side effects of interest rate in the model). In order to incorporate the cost channel I assume that firms pay workers in advance before the proceeds from the sale of output are received, and must borrow to finance these payments. This is a standard assumption in the literature that explicitly analyzes the supply-side effects (the cost channel) of monetary policy. (e.g., Christiano and Eichenbaum (1992)). The cost channel makes firms’ marginal cost depend directly on the rate of interest. I assume a standard Cobb-
Douglas production function of the form \( Y = N^\theta \). Thus, in log terms, \( y = \theta n \) and the marginal product of labour, \( MPL \), equals \( \theta Y/N \). Now, the marginal cost is defined as \( MC = W(1 + r)/MPL \); we can (ignoring constants) approximate the log of real marginal cost by \( mc - p = w - p + r - y + n \). Equation (2) is then derived in three more steps. Use the labour supply function, the production function and the resource constraint to eliminate \((w - p), n \) and \( c \) by substitution; define units so that, in full equilibrium, all prices are unity (so that \( \bar{m}c - \bar{p} = 0 \)); and substitute out the deviation of real marginal cost from its full-equilibrium value. The coefficients in (2) have the following interpretations: 
\[
\lambda = (1 - \tau)^2 ((2/\theta) + (1/\alpha) - 1) / \tau, \quad \psi = (1 - \tau)^2 \beta / \alpha \tau, \quad \gamma = (1 - \tau^2) / \tau
\]
Thus parameters ‘\( \lambda \)’, ‘\( \gamma \)’ and ‘\( \psi \)’ are functions of “deep” parameters like the fraction of firms adjusting their prices, labour’s exponent in the production function and ‘\( \alpha \)’ and ‘\( \beta \)’. The parameter ‘\( \kappa \)’ is introduced to capture the cost channel of monetary transmission. By setting \( \kappa = 0 \), I can close this channel.

Equation (3) defines monetary policy and encompasses both price-level targeting, \( \mu = 0 \) and nominal income targeting, \( \mu = 1 \). Equation (4) depicts the anticipated ongoing cycles in exogenous spending defined by the sine curve. Since the focus of the paper is on the role of the cost channel in affecting the volatility of output under alternative monetary policy regimes, the simplest way to introduce fluctuations in output is to assume that these are caused by exogenous variations in the autonomous spending.

Before analysing the model and discussing the results I briefly talk about the parameter
values that are used in calibrating the model(s) below. Consumption is 80% of the total output, that is, $\alpha = 0.8$. This implies that $\beta = 0.2$. The other summary coefficients for the baseline Phillips curve relationship can be calculated by referring to the corresponding values of the ‘deep’ parameters. For example, if labour’s exponent in the Cobb-Douglas production function is two-thirds ($\theta = 0.67$) and the fraction of firms that are able to adjust their prices once a year is approximately one-fourth ($1 - \tau = 0.27$), then $\lambda = 0.33$, $\psi = 0.03$ and $\gamma = 0.10$.5

3)- Analysis

In this section I derive the reduced form for real output to see how the cost channel affects the amplitude of the cycle in $y$, and to see the relative performance of price-level and nominal income targeting in this regard. I explain this derivation in the baseline case only and assume that the reader can use similar steps to verify the results that I report for other cases in the following sections.

First, take second time derivative of equation (3) and use the result to eliminate $\bar{p}$ in equation 2. Also, use equation (1) to eliminate $r - \bar{r}$ from equation 2. The result is:

$$-\mu \ddot{y} = -\lambda (y - \bar{y}) + \psi (a - \bar{a}) - (k_\gamma / \alpha) \dot{y} + (k_\gamma \beta / \alpha) \dot{\alpha}$$

5 In order to ensure that my results are not dependent on particular values of these parameters, I have considered a range of other parameter values as well. For example, if we assume that the fraction of firms with sticky prices is two-thirds 0.67 rather than 0.73 than the values of all summary parameters change accordingly. In particular, they are: $\lambda = 0.55$, $\psi = 0.05$ and $\gamma = 0.18$. However, the results are not sensitive to these alternative values for various parameters.
Using the undetermined coefficient solution procedure as described in Chiang (1984), the solution for output can be written as:

\[ y = \bar{y} + B[\cos(t)] + C[\sin(t)] \]  

(6)

where \( B \) and \( C \) are arbitrary constants that must be related to the underlying parameters of the model. To solve for \( B \) and \( C \), first take the time derivatives of (6),

\[ \dot{y} = -B \sin(t) + C \cos(t) \] and \[ \ddot{y} = -B \cos(t) - C \sin(t) \] along with the time derivative of (4),

\[ \dot{\alpha} = \delta \cos(t) \] and then substitute these results and equation (4) and (6) in equation (5). The resulting coefficient-identifying restrictions are:

\[ B = \frac{\beta \gamma \delta - \kappa \gamma C}{\alpha (\lambda + \mu)} \]

\[ C = \frac{\alpha^2 \psi (\lambda + \mu) + \beta \delta (\kappa \gamma)^2}{(\kappa \gamma)^2 + \alpha^2 (\lambda + \mu)^2} \]

The amplitude of the cycles in real output that correspond to the ongoing cycles in autonomous spending can be examined by substituting the calibrated expressions for \( B \) and \( C \) in equation (6).

Note that if \( \kappa = 0 \), that is, if the cost channel is not operating, \( B = 0 \). Thus, only the reduced-form parameter \( C \) represents the amplitude of the cycle in real output. It is straightforward to verify that the amplitude of the cycle in real output decreases as \( \mu \) increases, that is, changes from zero to one. This is the first main result of the paper.
Result 1: In a baseline ‘new Keynesian’ model, nominal income targeting performs better as compared to price-level targeting in terms of reducing the volatility of real output.

To investigate the role of the cost channel, I set $\kappa = 1$. The results are reported in table 1.

Table 1: Output effects --- Baseline ‘new Keynesian’ model

<table>
<thead>
<tr>
<th>Amplitude of ongoing cycle in real output</th>
<th>Cost channel closed ($\kappa = 0$)</th>
<th>Cost channel operating ($\kappa = 1$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price-level targeting ($\mu = 0$)</td>
<td>0.061</td>
<td>0.123</td>
</tr>
<tr>
<td>Nominal Income targeting ($\mu = 1$)</td>
<td>0.016</td>
<td>0.036</td>
</tr>
</tbody>
</table>

Two sets of results are worth noting. First, the volatility of real output goes up in the presence of cost channel irrespective of the monetary policy regime. This result is consistent with the claims of many empirical papers like Barth and Ramey (2001) that there are important supply side effects of monetary policy. Second, nominal income targeting still out-performs price-level targeting.

Result 2: In a baseline ‘new Keynesian’ model with the cost channel the volatility of real output increases. However, nominal income targeting still performs better in terms of reducing the volatility of real output.
4)- Extension I: Alternative Specifications of the Phillips Curve

It has been pointed out by many researchers that ‘the new Keynesian Phillips curve’ based on Calvo’s (1983) sticky price model generates inertia in the price level and not the inflation rate and that this is inconsistent with stylized facts on inflation dynamics. The empirical evidence (for example, Nelson (1998)) indicates that inflation responds sluggishly to economic shocks. The ‘new Keynesian Phillips curve’ implies that inflation is determined by the current output gap and current expectations of future inflation. Inflation is, therefore, very flexible and responds immediately to monetary policy shocks and hence does not accord with stylized facts. In order to capture the inflation persistence found in the data, it is common to augment the basic forward-looking inflation adjustment equation with the addition of lagged inflation. Fuhrer and Moore (1995) is one such example. Mankiw and Reis (2001) suggest an alternative approach, which departs from the assumption of sticky prices and replaces it with that of sticky information. According to their model of price adjustment firms gather and process the information about the state of the economy slowly over time. Unlike the sticky price model, prices are always changing but firms are slow to update their pricing strategies in response to new information. Empirical research of Gali and Gertler (1999) and Fuhrer (1997) have generally found that when lagged inflation is added to the basic ‘new Keynesian Phillips curve’, its coefficient is statistically and economically significant. Since the debate over the relative benefits of price-level and nominal income targeting rests critically on the specification of the Phillips curve, it is a worthwhile exercise to redo the analysis with these more general specifications for the Phillips curve.
If the weight on the lagged inflation term is assumed to be 0.5, then the Fuhrer and Moore (1995) type Phillips curve can be written as follows:

\[
\dot{p} = -2\lambda(y - \bar{y}) + 2\psi(\alpha - \bar{\alpha}) - 2\kappa\gamma(r - \bar{r}) \tag{2a}
\]

Following a similar solution procedure as outlined in the previous section I can derive the coefficient-identifying restrictions. The quantitative results for the calibrated version of the model are reported in table 2.

**Table 2: Output effects --- ‘new’ IS relationship with Fuhrer-Moore’s Phillips curve**

<table>
<thead>
<tr>
<th>Amplitude of ongoing cycle in real output</th>
<th>Cost channel closed (κ = 0)</th>
<th>Cost channel operating (κ = 1)</th>
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<tbody>
<tr>
<td>Price-level targeting</td>
<td>infinity</td>
<td>0.178</td>
</tr>
<tr>
<td>(μ = 0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal Income targeting</td>
<td>0.021</td>
<td>0.067</td>
</tr>
<tr>
<td>(μ = 1)</td>
<td></td>
<td></td>
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</table>

It is clear for table 2 that both result 1 and 2 carry over to this more general case. In fact, the cost channel is more potent in effecting the volatility of real output. Another point to note is that volatility of output goes to infinity when the cost channel is not operating. This result can be interpreted as being consistent with the observation made by Barnett and Engineer (2001): “….. price-level targeting is desirable only for a purely forward looking specification of the Phillips curve”.

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Mankiw and Reis’ (2001) specification of the supply side of the economy can be described by the following set of equations:

\[ \dot{p} = \lambda (y - \bar{y}) - \psi (a - \bar{a}) + \kappa \dot{p}^* + \dot{\eta} + \dot{\eta}^* \]  

\[ \ddot{p}^* = \phi (\dot{p} - \dot{p}^*) \]  

\[ \ddot{y} = \phi (\dot{y} - \dot{y}^*) \]  

\[ \ddot{r} = \phi (\dot{r} - \dot{r}^*) \]  

The two new parameters ‘\( \phi \)’ and ‘\( \eta \)’ respectively represent the fraction of firms that obtain new information and the coefficient of rate of change of output in the Phillips curve. Khan and Zhu (2002) have estimated the key structural parameters of Mankiw and Reis’ paper. Accordingly, I pick \( \phi \) and \( \eta \) to be 0.25 and 0.37 respectively.

A similar solution procedure is used to derive the coefficient-identifying restrictions, but I only report the quantitative results for the calibrated version of the model in table 3.

**Table 3: Output effects --- ‘new’ IS relationship with Mankiw - Reis’ Phillips curve**

<table>
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<th></th>
<th>Amplitude of ongoing cycle in real output</th>
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<tr>
<td></td>
<td>Cost channel closed (( \kappa = 0 ))</td>
</tr>
<tr>
<td>Price-level targeting (( \mu = 0 ))</td>
<td>0.185</td>
</tr>
<tr>
<td>Nominal Income targeting (( \mu = 1 ))</td>
<td>0.016</td>
</tr>
</tbody>
</table>
Once again the volatility of real output increases under both price-level and nominal income targeting when the cost channel is operating. This time the difference between the performance of nominal income targeting regime and price-level targeting regime is more pronounced; nominal income targeting performs far better in keeping the volatility of output low. Comparing the results of table 2 and 3, a point can be made (with some caution) that it is the structure of the model regarding how the backward looking behaviour is introduced that is important and not just the backward looking behaviour itself.

5)- Extension II: Alternative Specification of the IS Relationship

In all the three models discussed above, I have studied various specifications for the Phillips curve relationship combined with the ‘standard’ Ramsey type specification of the aggregate demand relationship or the IS curve. In this section I consider the change in the specification of the aggregate demand relationship and then combine it with the three different specifications of the Phillips curve. This exercise would be useful in shedding more light on the robustness of the results derived above. In particular, I introduce a lag output term in the IS function. The motivation for doing this modification is taken from the works of Fuhrer (2000) and Amato and Laubach (2001).

Fuhrer (2000) and Amato and Laubach (2001) have pointed out that the standard Ramsey type Euler Equation for consumption (which gives rise to an IS-type relationship) fails to capture the dynamics of the aggregate output. Fuhrer (2000) allow for habit formation in
preferences while maintaining the assumption of optimal consumption choice on the part of consumers. Amato and Laubach (2001), on the other hand, introduce the ‘rule of thumb’ behaviour on the part of a fraction of the household; the remaining fraction of the household is able to optimize their consumption in a usual fashion. Their modification to the standard consumer problem is justified on the grounds that it is costly to reoptimize every period. Both these modifications, introducing habit persistence and incorporating ‘rule of thumb behaviour’, leads to a lagged output gap term with some positive weight in the IS equation. Thus, it can be considered as a ‘hybrid’ version used by Ball (1997) and McCallum (1997).

If the weight on the lagged output term is taken as 0.5, then the ‘hybrid’ IS relationship can be written in continuous time as:

\[ \dot{y} = 2\alpha (r - \bar{r}) + 2\beta \dot{a} \]  

(1a)

The quantitative results for the calibrated version of the models that combine this hybrid IS relationship with the three specifications of the Phillips curve discussed above are reported in table 4, 5 and 6.

<table>
<thead>
<tr>
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<th>Amplitude of ongoing cycle in real output</th>
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<tbody>
<tr>
<td></td>
<td>Cost channel closed (κ = 0)</td>
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<tr>
<td>Price-level targeting</td>
<td></td>
</tr>
<tr>
<td>(μ = 0)</td>
<td>0.061</td>
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<tr>
<td>Nominal Income targeting</td>
<td></td>
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<tr>
<td>(μ = 1)</td>
<td>0.015</td>
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</table>
Table 5: Output effects --- ‘hybrid’ IS with Fuhrer-Moore’s Phillips curve

<table>
<thead>
<tr>
<th></th>
<th>Amplitude of ongoing cycle in real output</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Cost channel closed ($\kappa = 0$)</td>
</tr>
<tr>
<td>Price-level targeting $\mu = 0$</td>
<td>infinity</td>
</tr>
<tr>
<td>Nominal Income targeting $\mu = 1$</td>
<td>0.62</td>
</tr>
</tbody>
</table>

Table 6: Output effects --- ‘hybrid’ IS with Mankiw and Reis’ Phillips curve

<table>
<thead>
<tr>
<th></th>
<th>Amplitude of ongoing cycle in real output</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Cost channel closed ($\kappa = 0$)</td>
</tr>
<tr>
<td>Price-level targeting $\mu = 0$</td>
<td>0.048</td>
</tr>
<tr>
<td>Nominal Income targeting $\mu = 1$</td>
<td>0.013</td>
</tr>
</tbody>
</table>

A stark difference between the results reported in table 2 and table 5 is that now the volatility of output is infinite under price level targeting and much higher under nominal income targeting in the presence of the cost channel. Moreover, the performance of nominal income targeting regime is not much different with or without the cost channel. Thus, the initial results do not hold completely when an alternative specification of the IS relationship is considered. This contradicts the claim made by McCallum (1997) that it is only the specification of the Phillips curve that is important, whether or not the IS relationship is re-specified. This point is strengthened even more when results of table 6
are compared with the results of table 3; the amplitude of output is quite different under price-level targeting.

6)- Extension III: A More General Monetary Policy Rule

So far the analysis implicitly assumed that in response to the ongoing cycles in autonomous spending the central bank adjusted its policy instrument in an infinitely aggressive fashion. Depending on the value of parameter ‘\( \mu \)’, the central bank used its one degree of freedom to either focus entirely on achieving its price-level target or the nominal income target. This behaviour could lead to excessive volatility in the policy instrument. Thus, while this scenario was treated as a baseline case, this section provides a more general specification of the monetary policy rule that incorporates the aggressive response only as a special case. In particular, I replace equation (3) of the baseline case with the following monetary policy reaction function.

\[
  i = \bar{i} + \Omega (p + \mu y - 0)
\]  

(3a)

According to this rule, the central bank adjusts the nominal interest rate above its steady-state value whenever either the price level is above its target (assumed to be zero, with \( \mu = 0 \)), or the nominal income is above its target (also assumed to be zero, with \( \mu = 1 \)). Thus, as before, price-level targeting is involved when \( \mu = 0 \) and nominal income targeting is considered when \( \mu = 1 \). However, now I can consider various degrees of ‘leaning against the wind’ in both cases. For example, \( \Omega = 1 \) depicts the case when the
central bank is conducting monetary policy in a ‘modest’ manner. On the other hand, Ω approaching infinity would give me the baseline case when central bank responds in an ‘aggressive’ manner.

Here, I only explain the solution procedure in the baseline ‘new Keynesian’ model with the general monetary policy rule. For other cases, only the quantitative results for the calibrated version of the model with Ω = 1 are reported in table 7 and 8.

First, I substitute equation (3a) and the relationship \( r = i - \dot{p} \) in equation (1) to get:

\[
\dot{y} = \alpha \Omega p + \alpha \Omega \mu y - \alpha \dot{p} + \beta \dot{\alpha}
\]  

(7)

Also, I substitute equation (3a) and \( r = i - \dot{p} \) in equation (2) and eliminate \( p \) using equation (7) to yield:

\[
\ddot{p} = -\lambda (y - \bar{y}) + \psi (a - \bar{a}) - (\kappa \gamma / \alpha) \dot{y} + (\kappa \gamma \beta / \alpha) \dot{\alpha}
\]  

(8)

Now, by taking the appropriate number of time derivatives of equation (7) and using equation (8) to eliminate \( \ddot{p} \), I get the following third order differential equation:

\[
\ddot{y} = -\alpha \lambda \Omega (y - \bar{y}) + \alpha \psi \Omega (a - \bar{a}) + (\alpha \lambda - \kappa \gamma \Omega) \dot{y} + (\alpha \mu \Omega + \kappa \gamma) \ddot{y} + (\kappa \gamma \beta \Omega - \alpha \psi) \dot{\alpha} \\
- \kappa \gamma \beta \dot{\alpha} + \beta \ddot{\alpha}
\]  

(9)
As before the solution for output is given by equation (6). To solve for B and C, I first take the time derivatives of (6), \( \dot{y} = -B \sin(t) + C \cos(t) \) and \( \ddot{y} = -B \cos(t) - C \sin(t) \) and \( \ddot{y} = B \sin(t) - C \cos(t) \) along with the time derivatives of (4), \( \dot{a} = \delta \cos(t), \ \ddot{a} = -\delta \sin(t) \) and \( \ddot{a} = -\delta \cos(t) \) and then substitute these results and equation (4) and (6) in equation (9). The resulting coefficient-identifying restrictions are:

\[
B = \frac{\delta (\alpha \psi \Omega + \kappa \gamma \beta)}{A_1} - \frac{A_2}{A_1} C
\]

\[
C = \delta A_1 \left( \frac{\beta + \alpha \psi - \kappa \gamma \Omega}{A_1^2 + A_2^2} \right) + \delta A_2 \left( \frac{\alpha \psi \Omega + \kappa \gamma \beta}{A_1^2 + A_2^2} \right)
\]

where, \( A_1 = 1 + \alpha \lambda - \kappa \gamma \Omega \) and \( A_2 = \alpha \Omega (\lambda + \mu) + \kappa \gamma \)

Table 7: Output effects with a general monetary policy rule --- ‘new Keynesian’ IS relationship with the three specifications of the Phillips curve

<table>
<thead>
<tr>
<th></th>
<th>Amplitude of ongoing cycle in real output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost channel closed (( \kappa = 0 ))</td>
</tr>
<tr>
<td><strong>Model # 1</strong></td>
<td></td>
</tr>
<tr>
<td>Price-level targeting</td>
<td>0.196</td>
</tr>
<tr>
<td>Nominal Income targeting</td>
<td>0.152</td>
</tr>
<tr>
<td><strong>Model # 2</strong></td>
<td></td>
</tr>
<tr>
<td>Price-level targeting</td>
<td>0.084</td>
</tr>
<tr>
<td>Nominal Income targeting</td>
<td>0.095</td>
</tr>
<tr>
<td><strong>Model # 3</strong></td>
<td></td>
</tr>
<tr>
<td>Price-level targeting</td>
<td>0.164</td>
</tr>
<tr>
<td>Nominal Income targeting</td>
<td>0.138</td>
</tr>
</tbody>
</table>
Table 8: Output effects with a general monetary policy rule --- ‘hybrid’ IS relationship with the three specifications of the Phillips curve

<table>
<thead>
<tr>
<th></th>
<th>Amplitude of ongoing cycle in real output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost channel closed (κ = 0)</td>
</tr>
<tr>
<td><strong>Model # 4</strong></td>
<td></td>
</tr>
<tr>
<td>Price-level targeting</td>
<td>0.251</td>
</tr>
<tr>
<td>Nominal Income targeting</td>
<td>0.085</td>
</tr>
<tr>
<td><strong>Model # 5</strong></td>
<td></td>
</tr>
<tr>
<td>Price-level targeting</td>
<td>0.241</td>
</tr>
<tr>
<td>Nominal Income targeting</td>
<td>0.195</td>
</tr>
<tr>
<td><strong>Model # 6</strong></td>
<td></td>
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<tr>
<td>Price-level targeting</td>
<td>0.339</td>
</tr>
<tr>
<td>Nominal Income targeting</td>
<td>0.142</td>
</tr>
</tbody>
</table>

A significantly different result emerges when the central bank conducts monetary policy in a modest fashion. The cost channel turns out to be insignificant in affecting the behaviour of output in all the six models that were analysed earlier. However, nominal income targeting still performs relatively better in comparison with the price-level targeting case. The only exception is model # 2 but the difference is negligible.

7)- Conclusion

Many developments in macroeconomic theory, along with actual events, have led the economics profession, academicians and policy makers alike, to adopt rule-based monetary policies geared towards the promotion of long-term price stability. However, the channel(s) through which monetary policy affects real economy are still not well
understood. The results indicate that analysing both the traditional and the cost channel of monetary policy in one unified framework has been worthwhile. They confirm the results of earlier theoretical and empirical research on the potency of supply side effects of monetary policy in effecting the real economy. Moreover, I find strong support for a case in favour of nominal income targeting when compared with price-level targeting as it keeps the volatility of real output low. There is a growing literature that studies and compares the performance of these targeting regimes and a consensus has not been reached yet. Thus, the results of this paper can be considered as an addition to this debate. An important point in this regard is that the specification of both the demand side and the supply side of the model are crucial while analysing various monetary policy targeting regimes.

However, I agree with McCallum when he concluded while comparing the performance of inflation targeting and nominal income targeting, “This demonstration does not establish that nominal income targeting is preferable to inflation targeting or to other rules for monetary policy. To reach such a conclusion would require an extensive combination of theoretical and empirical analyses, conducted in a manner that gives due emphasis to the principle of robustness to model specification, plus attention to concerns involving policy transparency and communication with the public”. The point of this paper was not to attempt any such ambitious undertaking. However, the results can be considered as a small step in that direction.
References


