Nominal Income and Inflation Targeting

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ABSTRACT

In this paper a macro- economic model in the area of monetary policy game theory is extended to one-sided dismissal rules concerning observed nominal output and inflation targets for the central banker. These rules specify firing the central banker if some observed policy targets have been exceeded. Such rules are shown to reduce inflationary bias if the central banker perceives her reappointment chances as being strong and is preferred to discretionary monetary policy. Various policy targets are considered and it is shown that nominal output targeting may be preferred to inflation targeting under certain conditions.

KeyWords: Monetary Policy; Game Theory; Nominal Output Targeting; Inflation Targeting; Full Discretion; Dismissal Rule.

JEL Classification Numbers: E44, E58, G18.

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1. INTRODUCTION

Over the past fifteen years, most major central banks everywhere in the world have assumed monetary policy agendas that embrace either overt or inherent inflation targets.The inflation bias inherent in agents in the economy, when they realize the incentive of monetary authorities to create monetary surprises, is responsible for what is known in this literature as credibility problem of monetary policy. The lawmakers therefore, often, find themselves in the difficult position of trying to set up incentives for the central banks to induce the optimal rate of increase in the money supply in order to stimulate a firm increase in aggregate demand with a low target inflation rate. Recently, there has been an increased interest in targeting nominal output (GDP) rather than inflation. That is, central bankers should use monetary policy to keep a constant growth rate or level of nominal aggregate spending.

In the light of the recent global financial crisis, even though output and employment are looked-for essential policy targets of monetary policy for a healthy economy, central banks should certainly appreciate the development of other tools that can help minimizing the financial stability risks[1], as this can only make their own task simpler and more effective. In particular, the financial crisis has made it clear that the interactions between the financial sector and the aggregate economy imply that monetary policy and financial stability policy are closely entangled.[2] This calls for a stronger case for designing accountability in the public sector, especially the monetary authorities, to lean against credit bubbles (but not asset-price bubbles as such), rather than just washing up after the bubble has erupted by providing the right incentive in terms of reappointment considerations.

Given that the Federal Reserve has already exercised considerable discretion in interpreting its "dual mandate" of price stability and maximum employment, we propose controlling nominal output or inflation rates. Since the initiation of money market innovations in the 1980s, it is often

[1] See Woodford (2012) for an examination of how central banks can help mitigate financial risks.
[2] See Mishkin (2011).

argued, that the monetary authorities have had increasing difficulties monitoring the monetary aggregates. It has also been shown that the velocity function became unstable after 1980. Measurement errors are yet another source of difficulties with controlling monetary aggregates. Therefore, it becomes natural to look for a target which can be easily observed and is less sensitive to monetary policy and its ramifications on the wage setters' expectations.

Furthermore, instead of imposing draconian rules on the central banker, such as to fire her if the monetary aggregate target was not hit exactly, i.e., if total money growth was too high or too low, it seems reasonable to consider "trigger mechanisms" for firing the central banker. The issue then becomes what macro aggregates should be used as trigger variables and how does this affect the central banker's incentive to inflate and to stabilize shocks?

Two likely candidates, inflation and nominal output targeting, are explored as alternative targets for the monetary authorities. First, we assume that the central banker is fired if an observed macro aggregate (i.e., the rate of inflation or the rate of growth of nominal output, which is the sum of the former and the growth rate of real output) has indeed exceeded a target level (the trigger). Second, it is assumed that nominal output targeting is a politically feasible alternative, because it implies a certain unemployment level which may be difficult to justify. For instance, a low growth rate of nominal output implies a high unemployment rate, which is not very popular during bad economic times. Third, it is assumed that the central banker completely offsets the forecast of money demand disturbances (that is, the central banker makes the forecast public information as soon as it knows it). Therefore, the wage setters' expectations of the velocity shocks, δ^e, is equal for all time to d, the central banker’s private forecast of these same shocks. The monetary authority receives some information about the disturbance to money demand after wages are set but before policy actions are taken.Specifically, it has a private forecast of this disturbance, $d_t = E_{CB}\{\delta_t\}$, that satisfies $\delta_t = d_t + \varepsilon_t$,where ε_t is an independently and identically distributed disturbance realized after policy is implemented. The central banker is less able to manipulate its private information to affect the monetary policy (that is, the variabilities of output and inflation attributed to current reactions and reversals of previous reactions to money demand disturbances are eliminated).

Nominal output targeting prevents the central banker from inflating because any attempt to inflate increases both the real output growth and the inflation rates, increasing the rate of growth of nominal output, increasing the likelihood that the central banker may be dismissed. On the other hand, nominal output targeting helps to stabilize the probability of dismissal of the central banker since it targets a more stable variable than the inflation or the monetary base. For example, in the event of a negative supply shock, real output decreases but inflation increases, leaving the nominal output little affected. In the case of a positive supply shock, the rate of real output growth increases and the inflation rate decreases, leaving the sum of the two rates not much affected. This makes nominal output targeting a more forgiving procedure than inflation targeting under either type of supply shocks. In the same vein, inflation targeting helps prevent the central banker from inflating because any attempt to do so will increase its probability of dismissal.

2. REVIEW OF LITERATURE

The literature related to the time-inconsistency problem of optimal monetary policy describes the credibility problem of discretionary monetary policy, or what is known as the inflation bias problem. It comprises three parts. First, the credibility problem under perfect information was analyzed by the seminal article of Kydland-Prescott (1977) who used a model of wage setters, specifying the nominal wage in a labor contract, prior to the setting of the monetary policy for the period, in the hope of illustrating the time-inconsistency problem. The central bank, wanting a higher level of employment than the wage setters, would be expected to inflate away some of their real wage in order to achieve a higher level of employment. In anticipation, the wage setters set the nominal wage high. Consequently, the central bank would find it optimal to inflate the real wage down to the level wanted by wage setters. The non-cooperative solution to this monetary game results in an inefficient inflation bias. In this model, wage setters' expectations influence their current decisions. Even though consistent, discretion results in excessive rates of inflation without a reduction in unemployment. Barro-Gordon (1983a,b) in the same vein investigated the credibility problem of the central bank which was concerned with building a reputation.

Second, studies of the credibility problem with aggregate production and/or demand shocks, which have since become common in the theory of discretionary monetary policy, altered the Barro-Gordon (1983a) model by adding aggregate production and/or money demand shocks to the perfect information assumption. The central bank's preferences and incentives could be brought to change through the appointment of a more conservative central banker in Rogoff (1985) or through legislative means. In his model, Rogoff shows how an inflation-averse central banker can reduce the inflationary bias in policy-making and concludes that a required tradeoff between inflation and output stabilization should exist. Lohmann (1992) examines the optimal design of a central bank that can credibly commit to a low-inflation policy while keeping flexibility in responding to external random shocks.

The third branch in the literature uses an incentive contract and incorporates private or asymmetric information in the decision-making process and analyzes its effects. For example, Canzoneri (1985) modified Barro-Gordon by adding private information to the central banker on money demand shocks; he suggested that the central bank could then be forced, by the legislative approach, to adopt a cooperative solution which is time-consistent, yielding the optimal output stabilization and a lower inflation bias than Rogoff's (1985) if the incentive-compatibility constraints prevail. Garfinkel and Oh (1993) extends Canzoneri's (1985) two-period analysis of a targeting procedure to a multi-period setting. The targeting limits the flexibility of the monetary authority, which is measured in terms of its ability to react to current shocks and/or the length of the targeting horizon, to achieve its output and inflation stabilization goals. The gain from targeting is measured in terms of credibility, i.e. the lack of inflation surprises.

Goodfriend (1986) disagrees that Canzoneri' s (1985) assumption that the central banks should be given private information on money demand because he does not think that it provides a socially desirable service. Barro (1986) assumes that economic agents do not know the central bank's type and allows for current policy actions to influence the probability that the policy-maker is of one type and affect the way people learn about the policy-maker's true type. Walsh (1993) has argued for the institutional design of a central bank to be compensated according to its effort in bringing down inflation by means of a contingent targeting rule formerly agreed upon with the government. This rule is generally suboptimal in the presence of supply shocks.

Svensson (1997) has argued that inflation targeting should be implemented as inflation forecast targeting because of lags in the effect of monetary policy on inflation and because of flawed regulation of inflation by the central bank. Svensson (2003) provides an analysis of tools guidelines in an inflation targeting situation. Goodfriend (2005) favors making the long-run inflation target explicit and encouraging the Fed to target inflation within the long-run range in the short run. He recalls the importance of having the option to use strict inflation targeting to lead to efficient countercyclical stabilization policy. Walsh (2007) investigates the extent to which central banks should make private information such as short-run targets public.

Svensson (2009) argues that increased transparency in monetary policy is needed in order to provide the private sector with a better understanding of monetary policy and to assist the private sector in forming better and more rational expectations. It is also noted that there is a hierarchical mandate for central bankers, in the sense that there is an explicit central-bank target only for the average inflation rate and the central bank cannot do anything about the average output variability or resources utilization; hence under flexible inflation targeting there is both a hierarchical and a dual mandate, and there is no conflict between the two.

Fackler and McMillin (2011) use a model similar to Svensson (2003) to derive the real time output-inflation variability tradeoff available to the central bank under inflation forecast targeting and estimate how this tradeoff has changed over time. Walsh (2011) entertains raising the average target for inflation and switching to price-level targeting as a way of overcoming the constraint the zero lower bound on nominal interest rates has imposed on monetary policy. An advantage of price-level targeting, knowledge that prices will return to a target level, is its ability to imitate an optimal commitment policy in a discretionary setup as shown by one of the first authors to evaluate price-level targeting, namely, Vestin (2006). Libich (2008) shows that explicit inflation target can serve as a commitment device to ensure low inflation and high credibility. Huang, Meng and Xue (2009) show that, with endogenous investment, virtually all monetary policy rules that set a nominal interest rate in response only to expected future inflation induce real indeterminacy in many standard models. Niskanen (2009) proposes the Fed targets nominal final sales to domestic purchasers. The Economist (2011, November 1, 68) believes a nominal GDP target has some advantages over an inflation target, especially in responding to supply side shocks.

Svensson's (2009) model does not explicitly include supply shocks and does not provide for any adjustment of the target. Therefore, the central banker is assumed to be dismissed with certainty if the target was not exactly hit. Often, supply shocks hit the economy and because the central banker is not allowed "forgiveness", she under-stabilizes them. Moreover, the magnitude of these shocks may make hitting the target almost impossible. Under these circumstances, the central banker must care infinitely about reappointment in order for her to abide by the targeting constraint. Even if the central banker tries to abide by the targeting constraint, the observed variations in money growth rates and the ensuing variations in inflation rates will be, at least, wide. This possibility may help explaining why the targeting procedures are not popular in practice, with the exception of a few cases. Many times central bankers, when faced with stringent constraints, will inflate excessively in anticipation of a high probability of leaving office.

Our motivation follows the policy-making process described by Svensson (2003 and 2009), in which the monetary authority picks the ‘best’ path and applies a targeting rule in a structural model. The goal of this paper is to extend the model presented in Svensson (2009) in analyzing a targeting procedure to investigate the scope of flexibility, in terms of the ability to react to current shocks[3], in the presence of aggregate supply shocks, that should be given to the central bank facing a tradeoff between output and inflation stabilization and reappointment objectives. Flexible targeting is entertained in this paper with an explicit quadratic loss function in the output gap and

3 The case where unusually large supply shocks hit the economy is not dealt with here (See Lohmann 1992).

inflation rate; the costs and benefits of this procedure are discussed. Even though the benefits of targeting may make it look socially desirable, one needs to caution that it may increase the probability of retention by too much. For instance, if the central banker perceives his/her reappointment chances in the next period as being too strong ,wide swings in the trigger variables may be observed and/or the inflationary bias of discretionary policy may be re-instated.

Section 3 describes a model of monetary policy with private information and supply shocks for three main cases: inflation targeting and nominal output targeting each with a central banker's dismissal clause if the target was exceeded, and the fully discretionary case (no dismissal) of the central banker. After the general solution to each case is presented, it is compared to the other two cases based on the criteria of the inflationary bias, the output and the inflation variability for a logistic probability distribution of the retention. Section 4 examines the model under a no dismissal rule, full discretion, one period targeting regime. Section 5 discusses the dismissal rule, full discretion regime. Finally, Section 6 offers some concluding remarks and possible extensions of the analysis.

3. MODEL

The model presented here investigates the efficacy of dismissal rules. The aim of those dismissal rules is to obtain a better outcome than that achieved without them and with full discretion. Of particular interest is the issue of stabilization of shocks. In this paper, it is assumed that the monetary authority shares its private information with wage setters. The results in this paper build on the ideas of Walsh (2011), Svensson (2009) while using the analytical techniques developed in Walsh (1995) and Fratianni, M., Von Hagen, J. and Waller, C.(1997). The notation in this paper is similar to Arayssi (1996).

The equation for output is given by:

$$y = y^n + \theta(\pi - \pi^e) + u \qquad (1)$$

where, y is the logarithm of output,

y^n is the logarithm of natural output,

π is the inflation rate,

π^e is the wage setters' expectation of inflation conditional on information available at the end of the previous period,

u is a random aggregate supply disturbance with mean zero and variance σ_u^2 and

θ is the elasticity of output with respect to the unanticipated inflation.

Inflation is given by:

$$\pi = g - d - \varepsilon - u \qquad (2)$$

where the whole supply shockis allowed to impact the inflation equation , and g is the growth rate of money, the monetary authority's instrument which is implemented both after the supply shock hits the economy and the public sets the wage rate. In contrast to wage setters, the monetary authority receives some information about the disturbance to money demand after wages are set but before policy actions are taken. Specifically, it has a private forecast of this disturbance, d_t, and ε_t is an independently and identically distributed disturbance realized after policy is implemented. This forecast error has a zero mean , a finite variance σ_ε^2 and no correlation with d_t. Similarly, the latter is independently and identically distributed with a zero mean and finite variance σ_d^2.

A. Inflation Targeting:

The inflation targeting tries to link the dismissal of the central banker with exceeding a government chosen inflation rate[4]; if exceeded, the central banker terminates his/her contract with the government and he/she is dismissed from office. Assume that the inflation dismissal rule is given by:

$\pi \leq a$, where **a** is a constant; this condition is sufficient for the retention of the central banker.[5]

[4] The optimal choice of the trigger value is not dealt with here.

[5] This model specification arguably allows for **a** to be increased in a financial crisis like the one in 2008, thus reaping the benefits of a higher inflation target when the zero lower bound

Equivalently, one can write this condition as :

$$g - d - u - a \leq \varepsilon$$

Assume that ε , the forecast error, has a cumulative density function F(ε) . The likelihood measure of the forecast error being larger than the quantity [g-d-u-a] is the probability of retention (PR) of the central banker and is given by:

$$PR(\varepsilon) = F(\varepsilon \geq g - d - u - a) = 1 - F(\varepsilon \leq g - d - u - a) . \quad (3)$$

The supply shock is observed by the central banker when choosing g; hence, it is realized and not a random variable in this problem. A positive supply shock increases the probability of retention, for a given g, d and **a**, since it reduces the inflation rate; a negative supply shock decreases that probability. Holding other things constant, an increase in g, decreases that probability. In contrast, an increase in the forecast of money demand disturbances, d, or in the trigger **a** increases the probability of retention.

The central banker's loss function consists of two main components: the expectation of the output and inflation variabilities and the central banker's own disutility form losing the job in the next period. Assuming that the central banker must fulfill the condition for his retention in each period, the loss function is equivalent to a series of single period choices of the money growth rate to minimize:

$$ELF = E\left(\left(\frac{y - ky^n}{\theta}\right)^2 + f\,\pi^2\right) - PR \bullet A \bullet b \quad (4)$$

$$ELF = E\left((g - g^e - \delta + \delta^e + (\theta^{-1} - 1)u - y^*)^2 + f(g - \delta - u)^2\right) - PR \bullet A \bullet b \quad .$$

The logarithm of the socially desirable output level is represented by ky^n, with k>1 (this reflects the notion that the central bank desires to bring output beyond its natural level). Y* is the complement of the deviation of the natural level of output from the socially desired output, normalized by θ, or,

becomes a binding constraint. However, one has to be reminded of the sizable variations in real variables that may result.

$y* = \frac{(k-1)y^n}{\theta}$. [6] The first and second terms in equation (4) represent the dual part of the mandate of the central banker to maximize employment (i.e., minimize the variance of the output gap) and maintain price stability (i.e., minimize variance of inflation). There is substitution between the variance of inflation and the variance of the output gap, with **f** being the welfare loss from inflation and the marginal rate of substitution of output-gap variance for inflation variance in equation (4) above.[7] Another factor, A ,is an independent parameter of the central banker's current decisions, is the expected rent that is derived from holding office in the next time period; b is the weight (or discount factor) on the central banker's own welfare.Therefore, the third term in equation (4) represents the expected utility that the central banker derives from being reappointed to her job and serves as an incentive not to exceed the target policy rate. [8] For analytical convenience, suppose that $[g - u - d - a]$ has a logistic distribution, then

$$PR[\ \varepsilon\ ] = PR[g\ - u - d - a] = \frac{1}{1 + e^{(g-u-d-a)}}\ . \qquad (5)$$

The central banker's retention probability decreases[9] when the money growth rate is higher than both the publicly observed forecast of money demand disturbances and the output shocks and vice versa. This is consistent with the notion that central bankers in this scenario do well when they do not increase money by more than the forecasted money demand disturbances and the output shocks, so as to keep inflation from growing. On the contrary, they do poorly when they increase it by more than the sum of the forecasted money demand shock and the output shock. The fact that the coefficient to the quadratic term (C) in the logistic function in Appendix A changes sign as the trigger **a**changes sign means that the money growth variability can have either a positive or a negative effect on the central banker's probability of retention. The reason for this can be seen by looking at cumulative density functions for central bankers which shows the relationship between

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[6] Walsh (2011) has used a quadratic loss function to represent the objective for inflation targeters with similar arguments.

[7] See Svensson (2009)andFackler and McMillin (2011) for more analysis of this point.

[8] It is assumed that the central banker derives sufficient utility from being in office in order to make the chance of being dismissed counterbalance the incentive to inflate.

[9] See Appendix A for a derivation of the following, this result is implied by the fact that -B<0 for all values of **a**,

PR and g in Figure 1 below.

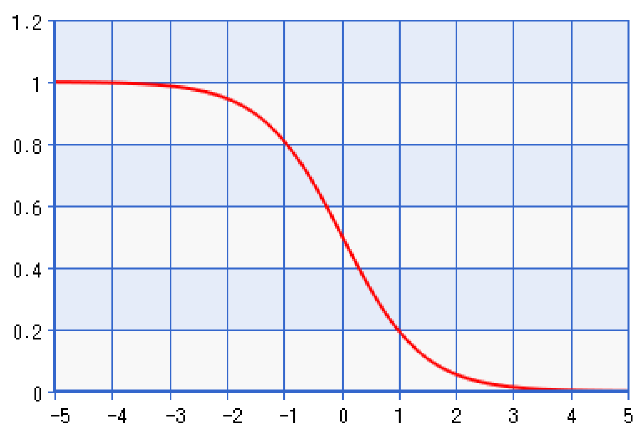
a. Cumulative density function for strong central bankers:

Probability of retention (PR)

g-u-d = $\varepsilon - \varepsilon_0$

b. Cumulative density function for same as challenger central bankers:

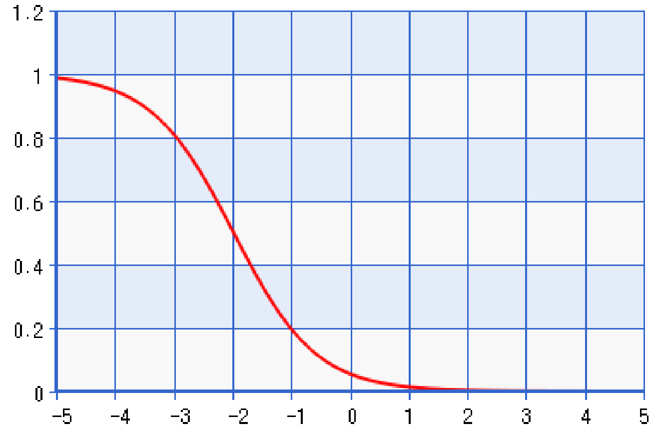
Probability of retention (PR)



g-u-d = $\varepsilon - \varepsilon_0$

c. Cumulative density function for weak central bankers:

Probability of retention (PR)



$g-u-d = \varepsilon - \varepsilon_0$

Figure 1. Cumulative Density Functions for central bankers.

As a probability measure, PR is monotonically decreasing in g; it is concave when [g-d-u-**a**]<0 and is convex when the inequality is reversed. Therefore, if **a**>0, PR is concave at the point g=d+u, and a positive output shock and/or a positive public forecast of the money demand disturbance will cause a smaller marginal increase in the PR than the marginal decrease caused by such negative shocks. Since **a** >0 corresponds to a "strong" central banker, this means that negative transitory shocks hurt strong central bankers more than positive shocks help them. The opposite holds if **a**<0 and PR is convex at g=d+u, i.e., positive public forecast of money demand shocks and positive output shocks increase the marginal retention probability of a weak central banker more than negative shocks reduce it. As a result, strong and weak central bankers have different perceptions of output and forecast of money demand disturbances stabilization. Strong central bankers are "risk averse" and want output shocks and forecast of money demand disturbances to be stabilized. In contrast, weak central bankers are "risk loving" and prefer such shocks not to be stabilized.

B. Nominal Output Targeting:

Nominal output targeting consists of setting the dismissal rule for the central banker based on a government chosen nominal Gross Domestic Product (GDP) growth rate; if that rate was exceeded, the central banker would be dismissed from office. If the growth rate of nominal GDP can be written as the sum of the inflation rate π and the deviation of the current output from the natural output, $y-y^n$, then the nominal GDP growth dismissal rule is given by:

$$\pi + y \leq y^n + a(1+\theta)$$

Therefore, $g + (x-1)d - xu - xg^e - \omega \leq \varepsilon,$ where $x = \frac{\theta}{1+\theta},$ and $\omega = \frac{a}{1+\theta},$ *a constant* ,

a sufficient condition for the retention of the central banker.Assume that ε , the forecast error, has a cumulative density function PR(ε) . The likelihood measure of the forecast error being larger than the quantity $[g+ (x-1)d - xu - xg^e - \omega]$ is the probability of retention of the central banker and is given by:

$$PR(\varepsilon) = P(\varepsilon \geq g + (x-1)d - xu - xg^e - \omega)1 = 1 - P(\varepsilon \leq g + (x-1)d - xu - xg^e - \omega) . \quad (6)$$

The supply shock is observed by the central banker when choosing g; hence, it is realized and not a random variable in this problem. A positive supply shock increases the probability of retention, for a given g, d, g^e and ω, since it reduces the inflation rate; a negative supply shock decreases that probability. Holding other things constant, an increase in g, decreases that probability. An increase in the forecast of money demand disturbances, in the constant ω, or in the expected growth rate of money will increase the probability of retention (see Appendix A).

4. NO DISMISSAL RULE, FULL DISCRETION, ONE PERIOD

Under the full discretionary regime and no dismissal rule, the monetary authority behaves as if it can have no impact on the wage setters' expectations. It minimizes (4) by choice of g conditional on its forecast of the disturbance to money demand, setting PR =1 and taking g^e as given, as if it were not trying to influence g^e or δ^e. The solution is unchanged from the chapters before (see Arayssi 1996, chapter III, section 3 B), except for the term involving the supply shock.

Even though the central banker observes d before wage setters form their expectations, δ^e = d because that information is made public. Wage setters recognize the central banker's incentive to surprise them by inflating so as to increase output above its natural level and, hence, augment the wage growth rate (which is equal to g^e) by just enough to maintain the same real wage. They form g^e by taking unconditional expectation of the central banker's first-order condition given by:

$$(g - g^e - \delta + \delta^e + (\theta^{-1} - 1)u - y^*) + f(g - \delta - u) = 0 \quad . \qquad (7)$$

Since wage setters' expectation of g equals g^e and their expectation of δ equals d, the associated first order condition implies that $g^e = d + \frac{y^*}{f}$, there is an expectation inflation bias in the amount of the output target discounted by expected welfare loss from inflation weight f: y*/f . Substituting g^e back into the first order condition, one can verify that the money growth rate is given by :

$$g = d + \frac{y^*}{f} - [\frac{1}{\theta(1+f)} - 1]u \qquad (8)$$

the inflation rate is given by:

$$\pi = \frac{y^*}{f} - \frac{1}{\theta(1+f)}u - \varepsilon \qquad (9)$$

the output rate is given by:

$$y = y^n + \frac{f}{1+f}u - \theta\varepsilon \qquad (10)$$

the welfare loss from output variation is given by :

$$(\frac{y - ky^n}{\theta})^2 = y^{*2} + \sigma_\varepsilon^2 + \frac{f^2}{\theta^2(1+f)^2}\sigma_u^2 \qquad (11)$$

and the welfare loss from inflation variation under this regime is given by:

$$f\pi^2 = \frac{y^{*2}}{f} + f\sigma_\varepsilon^2 + \frac{f}{\theta^2(1+f)^2}\sigma_u^2 \quad . \qquad (12)$$

Next, we discuss the results under dismissal rule fully discretionary regime.

5. DISMISSAL RULE, FULL DISCRETION, ONE PERIOD

The dismissal rule applied in this section takes the form of an inflation targeting or of a nominal output targeting. Under the full discretionary regime and the dismissal rule, the monetary authority in solving the optimization problem behaves as if g^e was given, while ignoring the impact that it could have on the wage setters' expectations. The monetary authority's problem is given by equation (4) above. It involves minimizing the central banker's expected loss function by choice of the growth rate of money. First, the general- form solution is derived; later, this form is used to find the specific solutions in each targeting regime. Here PR is approximated by a second order Taylor's expansion (for example see equation A1.1 Appendix A). Because wage setters understand the central banker's minimization problem, they form g^e by taking an unconditional expectation of the central banker's first-order condition given by:

$$2(g - g^e - \delta + \delta^e + (\theta^{-1} - 1)u - y^*) + 2f(g - \delta - u) - h \bullet A \bullet b = 0 \quad , \tag{13}$$

where h is the derivative of PR with respect to g. Here again, the wage setters form their expectations, δ^e=d and

$$g^e = d + \frac{y^*}{f} + \frac{h^e \bullet A \bullet b}{2f} \tag{14}$$

where h^e is the wage setters' expectation of h. The added term in the expected money growth, as compared with the no dismissal case, involves the expected derivative of the probability of retention since the dismissal rule affects the anticipated behavior of the central banker. Substituting the value of g^e into (13) and solving for g:

$$g = d + \frac{y^*}{f} + \frac{(h^e/f + h) \bullet A \bullet b}{2(1+f)} - [\frac{1}{\theta(1+f)} - 1]u \quad . \tag{15}$$

A. Inflation Targeting :

The solution obtained above is in a general form. Here, I examine the case where the dismissal rule is of the inflation targeting variety and the probability of retention follows the logistic distribution.

Taking the first derivative, h, of PR in equation (A1.1) with respect to the growth rate of money, I get:

$$h = \frac{\partial(PR)}{\partial g} = -\frac{e^{-a}}{[1+e^{-a}]^2} + \frac{e^{-a}(e^{-a}-1)}{[1+e^{-a}]^3}(g-u-d) \qquad . \qquad (16)$$

Taking wage setters' expectation of h in equation (16) and substituting into (14) above yields the specific expected growth rate:

$$g^e = \frac{2}{N}(y^* - \frac{R}{2}) + d,$$

$$where, \qquad (17)$$

$$N = 2f - \frac{e^{-a}[e^{-a}-1]Ab}{[1+e^{-a}]^3},$$

$$R = \frac{e^{-a}Ab}{[1+e^{-a}]^2}$$

Note that R>0, for all **a**≥ 0 implies N≥ 2**f**. The central banker is expected to fully accommodate its prediction of the money demand disturbance as it did in the no dismissal case. If **a** >0, which corresponds with the case of a strong central banker, there is a reduction in the inflation bias as compared to the no dismissal case. Substituting the value of g^e from (17) into (15) yields the monetary growth rate in this case:

$$g = \frac{2}{N}(y^* - \frac{R}{2}) - (\frac{2\theta^{-1}}{N+2} - 1)u + d \qquad . \qquad (18)$$

Solving for the inflation rate:

$$\pi = \frac{2}{N}(y^* - \frac{R}{2}) - \frac{2}{\theta(N+2)}u - \varepsilon \qquad . \qquad (19)$$

Output can be obtained by:

$$y = y^n + \frac{N}{N+2}u - \theta\varepsilon \qquad (20)$$

Output variability is :

$$(\frac{y - ky^n}{\theta})^2 = y^{*2} + \sigma_\varepsilon^{\ 2} + \frac{N^2}{\theta^2(N+2)^2}\sigma_u^{\ 2} \qquad (21)$$

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and inflation variability is:

$$f\,\pi^2 = \frac{4fy*^2}{N^2} + \frac{fR^2}{N^2} + f\,\sigma_\varepsilon{}^2 + \frac{4f}{\theta^2(N+2\,)^2}\sigma_u{}^2 \;. \qquad (22)$$

The central banker fully stabilizes inflation around its socially desired rate and output around its natural rate. Moreover, if **a** > 0 (that is, if the central banker is strong), N is large and supply shocks are allowed more into output than into inflation in comparison with the no dismissal case. Also if **a** > 0 , output variability is higher (that is, stabilization of these shocks on output is less) than that under no dismissal, full discretion; and inflation variability is less (that is, stabilization of these shocks on inflation is more) than that under no dismissal, full discretion.

B. Nominal Output Targeting:

Here I examine the case where the dismissal rule is of the nominal output targeting variety. Taking the first derivative, h, of PR in equation (6) with respect to the growth rate of money

$$h = \frac{\partial(PR)}{\partial g} = -\frac{e^{-\omega}}{[1+e^{-\omega}\,]^2} + \frac{e^{-\omega}(\,e^{-\omega}-1)}{[1+e^{-\omega}\,]^3}(g+(x-1)d - xu - xg^e\,) \;. \qquad (23)$$

The full accommodation of the central banker to forecasted money demand shocks holds here as with the inflation targeting; ω>0 which corresponds to the strong central banker reflects a reduced inflation bias compared to the no dismissal case. Solving for the inflation rate:

$$\pi = \frac{2}{D}(y* - \frac{L}{2}) + \frac{2(2+f-G-\theta^{-1}\,)+D}{G}u - \varepsilon \qquad (24)$$

Output is:

$$y = y^n + [\frac{-2+2\theta(2+f)+\theta D+G(1-2\theta\,)}{G}]u - \theta\varepsilon \qquad (25)$$

Output variability is:

$$(\frac{y-ky^n}{\theta}\,)^2 = y*^2 + \sigma_\varepsilon{}^2 + [\frac{-2\,\theta^{-1}+2(2+f)+D+G(\,\theta^{-1}-2)}{G}\,]^2\,\sigma_u{}^2 \qquad (26)$$

And inflation variability we get:

$$f\,\pi^2 = \frac{4fy*^2}{D^2} + \frac{fL^2}{D^2} + f\,\sigma_\varepsilon{}^2 + \frac{f}{G^2}[2(2+f-G-\theta^{-1})+D\,]^2\,\sigma_u{}^2 \quad . \tag{27}$$

Let us summarize in Table 1 below the inflation bias, inflation and output variabilities in the three cases examined in this paper. Output and inflation variabilities, the stochastic parts of the output and inflation rates, could be set, by choice of constant **a**=0, to the same output variability and inflation variability under the no dismissal, full discretion regime. However, the inflation bias under inflation targeting is always lower than no dismissal, full discretion inflation bias. On the other hand, if **a**>0 , there is a reduction in the inflationary bias compared with the no dismissal, full discretion regime but at the expense of somewhat more output variability.

Table 1. Inflation Bias, Inflation and Output Variability.

	Π Bias	√ Π Variability	√Y Variability
Y Target	$\frac{2}{D}(y* - \frac{L}{2})$	$\frac{2(2+f-G-\theta^{-1})+D}{G}$	$\frac{-2+2\theta(2+f)+\theta D+G(1-2\theta)}{G}$
Π Target	$\frac{2}{N}(y* - \frac{R}{2})$	$\frac{2}{\theta(N+2)}$	$\frac{N}{(N+2)}$
No Dismissal	$\frac{y*}{f}$	$\frac{1}{\theta(1+f)}$	$\frac{f}{(1+f)}$

<u>N.B.:</u> The inflationary bias is denoted by π Bias in the Table.√πVariability and √YVariability denote the square root of the inflation and output variabilities respectively; values for variability in the Table are given in absolute terms. πTarget and YTarget denote the inflation and nominal GDP targeting regimes respectively. The symbols N and R are as defined in equation (17) above and L, D and G are as defined in equations (A2.1) and (A2.2).

Observe that, if ω>0 (that is, if the central banker is strong), the supply shocks are stabilized more in the output equation and stabilized less in the inflation equation as compared to the no dismissal case. If ω>0, and

$$f \geq \frac{1-2\theta^2}{\theta(1+2\theta)} \tag{28}$$

then output variability is less than or equal to the no dismissal, full discretion output variability; and inflation variability is larger than the no dismissal, full discretion inflation variability for the same condition (28) above. On the other hand, output variability is smaller than under inflation targeting. Also, inflation variability is larger than the one prevailing under inflation targeting (see Appendix C).

Table 2 below summarizes the inflation variability results derived in sections 4 and 5, for the three cases considered, namely no dismissal, inflation and nominal output targeting. In particular, inflation variability under inflation targeting is compared to that under the other two cases for different values of the ratio of the relative weight of inflation variation to output variation in the central banker's objective to the squared elasticity of output with respect to unanticipated inflation, **f**.

Table 2.Inflation Variability.

f	<LL	=LL	>LL
πTgt	< Y Tgt< ND	< Y Tgt = ND	<ND<YTgt

<u>Note:</u> The comparisons made are for ω>0, **a**>0. "LL" $= \frac{1-2\theta^2}{\theta(1+2\theta)}$ from here forward. "ND" denotes the No Dismissal Case, Full Discretion in the Table.

Also, Table 3 below does the same thing for output variability: it compares output variability under the output targeting regime to that under the other two cases for different values of **f**.

Table 3. Output Variability.

f	< LL	= LL	> LL
Y Tgt	ND < Y Tgt< πTgt	= ND< πTgt<	ND< πTgt

Note: The comparisons made are for ω>0, **a**>0. "ND" is as defined in Table 2 above.

If **a**>0 (which assumes that the central banker is strong or that the marginal benefit from using monetary surprises to secure retention is very high), Table 3 above shows that output variability under inflation targeting is always larger than output variability under output targeting since **f**>0. However, inflation variability under inflation targeting, as is shown in Table 2 above, is always lower than that prevailing under nominal output targeting since **f**>0. These results agree with the economic intuition that inflation targeting stabilizes inflation variability (that is reduces that variability) only at the expense of higher output variability, and by the same token, nominal output targeting stabilizes output variability (that is reduces it) only at the expense of higher inflation variability.

Output variability and inflation variability could be set, by choice of constants **a**=ω=0 (i.e., the case where the central banker is the same as the challenger), to the same output variability and inflation variability under the no dismissal, full discretion regime. In this case, the inflation bias under nominal output targeting, equal to the inflation bias prevailing in inflation targeting, would be lower than the no dismissal, full discretion's. Therefore, there are definite gains from implementing a dismissal rule in terms of the reduction in the inflationary bias when the central banker is the same as the challenger.

In the output targeting case, the inflationary bias is reduced compared to the no dismissal, full discretionary case and the stabilization of shocks yields a lower central banker's loss if **f**≥"LL" (i.e., since Table 3 shows that this case corresponds to the lower output variability for this regime) and if the proportion of the supply shock that hits inflation relative to that which hits output is small (that is, inflation variability is very small compared to output variability in the central banker's loss function, as would be necessitated by an elastic aggregate demand curve for example).

Comparing the nominal output targeting to inflation targeting, one finds that the inflationary bias under inflation targeting is larger than under nominal output targeting. Hence, under that condition and if the supply shocks hit inflation less severely than output, nominal output targeting yields a lower loss for the central banker than either inflation targeting or no dismissal, full discretion when **f** is at least "LL".

It can also be inferred from the tables that, for certain parameter intervals (that is **f**< "LL"), the nominal output targeting yields better output stabilization results than the inflation targeting but the inflation stabilization will be worse than that under inflation targeting. Similarly, nominal output targeting only stabilizes inflation better than the no dismissal discretionary solution if **f** is small (that is **f**<"LL", then inflation variability is less than no dismissal's, but output variability under output targeting is more than no dismissal's).

On the other hand, inflation targeting yields a lower central banker's loss if the proportion of the supply shock that hits output relative to that which hits inflation is small; that is inflation targeting dominates either nominal output targeting or no dismissal, full discretion when f is large (that is, weighing the already small inflation variability in this case, more than the large output variability) and the relative impact of the supply shocks falls higher on inflation than on output.

6. CONCLUSION

In this paper, we expanded on the ability to constrain the central banker's behavior without requiring it to hit a target exactly. It was shown that implementing a dismissal rule (whether an inflation or a nominal output targeting) for the central banker results in a reduction in the inflationary bias if the marginal benefit from using monetary surprises to secure retention is the same as the marginal cost of output variability. Moreover, if the marginal benefit from using monetary surprises to secure retention is very small and the aggregate demand is relatively elastic and the welfare loss from inflation, f,is large enough[10], then nominal output targeting yields a lower inflationary bias and a lower expected utility loss than no dismissal, full discretion. In other words, nominal output targeting dominates no dismissal in this case. If in addition to these three conditions, the inflationary bias is smaller under the nominal output targeting than under the inflation targeting, the nominal output targeting can better prevent the central banker from excessive inflation and yields better overall stabilization of shocks than either inflation targeting or no dismissal.

If the marginal benefit from using monetary surprise to secure retention is very small, and the aggregate demand is relatively elastic, then nominal output targeting dominates inflation targeting. However, these conditions are not all likely to hold in the general case. If, on the other hand, the marginal benefit from surprising the economic agents to secure retention was very small, and the aggregate demand was relatively inelastic, then inflation targeting would yield a lower loss to the central banker than either nominal outputtargeting or no dismissal.

By extending the model of Svensson (2009) we are able to find a form of a constrained targeting by the dismissal chance that is potentially attractive since it discourages the central banker from inflating and minimizes the probability of its dismissal in the presence of aggregate supply shocks. This procedure ties the central banker's performance to observable policy targets, whether the nominal output or the inflation rate, and gives some valuable flexibility creating the best reappointment incentive to the central banker to allow her to effectively hit the desired macroeconomic target. Further extensions of this research could look into the optimal settings of trigger levels in order to discipline the central banker more efficiently.

[10] It satisfies the condition set in equation (28) above.

APPENDIX A

Suppose that the central banker has the same loss function as in equation (4) above, and that $[g + (x-1)d - xu - xg^e - \omega]$ has a logistic distribution, then

$$PR[\varepsilon] = PR[g + (x-1)d - xu - xg^e - \omega] = \frac{1}{1+e^{(g+(x-1)d-xu-xg^e-\omega)}} \quad \text{(A1.1)}$$

In order to derive closed-form solutions, I take a second-order Taylor's expansion of this logistic function around the point $\varepsilon_0 = -\omega$. This yields:

$$PR \approx Q - B(g + (x-1)d - xu - xg^e) + C(g + (x-1)d - xu - xg^e)^2 \quad \text{(A1.2)}$$

where $Q = \frac{1}{1+e^{-\omega}} > 0$, $B = \frac{e^{-\omega}}{[1+e^{-\omega}]^2} > 0$ and $C = \frac{e^{-\omega}(e^{-\omega}-1)}{2[1+e^{-\omega}]^3} \begin{bmatrix} > \\ = \\ < \end{bmatrix} 0 \text{ if } \omega \begin{bmatrix} < \\ = \\ > \end{bmatrix} 0$

APPENDIX B

Substituting the value of h from equation (23) and using the general solution derived earlier in this section (17) and (15) yields the expected growth rate and money growth rate in this case:

$$g^e = \frac{2}{D}(y^* - \frac{L}{2}) + d, \quad D = 2f - \frac{e^{-\omega}[e^{-\omega}-1](1-x)Ab}{[1+e^{-\omega}]^3}, \quad L = \frac{e^{-\omega}Ab}{[1+e^{-\omega}]^2} \quad \text{(A2.1)}$$

$$g = \frac{2}{D}(y^* - \frac{L}{2}) - (\frac{G - D - 2(2+f-\theta^{-1})}{G})u + d, \quad G = \frac{D-2f}{1-x} + 2(1+f) \quad . \quad \text{(A2.2)}$$

Note that L>0, and ω> 0 implies D>2f and G>2(1+f).

APPENDIX C

Output variability is smaller than under inflation targeting for

$$f > \frac{-(e^{-\omega}+1)(1+\theta)(e^{-a}-1)}{(e^{-\omega}-1)\theta(1+2\theta)(e^{-a}+1)}\frac{R}{L} + \frac{(e^{-a}-1)R}{2(e^{-a}+1)} + \frac{1-2\theta^2}{\theta(1+2\theta)},$$

which is always satisfied for f>0. Also, inflation variability is larger than the one prevailing under inflation targeting for

$$f > \frac{\frac{\theta L(e^{-\omega}-1)}{e^{-\omega}+1} + 2(1+\theta) + \frac{(e^{-a}+1)}{(e^{-a}-1)R}(-8(1+\theta) + \frac{2L(e^{-\omega}-1)(1+2\theta+2\theta^2)}{e^{-\omega}+1})}{\frac{e^{-a}+1}{(e^{-a}-1)R}(8(1+\theta) - \frac{2L\theta(1+2\theta)(e^{-\omega}-1)}{e^{-\omega}+1}) + \frac{2\theta L(e^{-\omega}-1)(1+\theta)}{e^{-\omega}+1}},$$

which is always satisfied for f>0.

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