Inflation Contracts, Inflation and Exchange Rate Targeting, and Uncertain Central Bank Preferences

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Abstract

When central bank preferences are uncertain, delegation implemented by inflation or exchange rate targeting may be superior to delegation implemented through an inflation contract combined with an optimal inflation target. Distortion introduced by uncertainty about preferences into stabilization of shocks is largest under the contract regime. With targeting regimes this distortion is reduced by government increasing incentives to stabilize the targeted variable if uncertainty about preferences increases. A central banker with a populist bias improves outcomes under exchange rate targeting and the contract/optimal inflation target regime by reducing the distortion in stabilization induced by uncertain preferences.

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Briault, Haldane and King (1997) argue that if there is anything over which central banks possess information not available to other agents then it is about their preferences. It is shown in the literature on dynamic inconsistency in monetary policy that uncertainty about central bank preferences establishes stabilization bias in discretionary policy and creates variability in inflation bias.¹ An important finding in this research is that delegation of the conduct of monetary policy to a central bank whose preferences are uncertain by means of a linear inflation contract may improve the outcome attainable by society.² Research has also proceeded on the use of inflation targeting as a means of dealing with the dynamic inconsistency problem.³ Greenspan (2004) and King (2004) argue that inflation targeting, whether by an explicit inflation target or not, plays an important role in containing inflation. In addition, Reinhart and Rogoff (2004) show that in recent times, the most common exchange rate regimes have been pegged and crawling pegged regimes, and Calvo and Reinhart (2002) document that many countries have a fear of

¹ When central bank preferences are uncertain Briault et al. (1997) and Schaling and Nolan (1998) analyze the advantages that may accrue from conservativeness and delegation, Lossani et al. (1998) show that delegation may less attractive than a fixed rule with an escape clause, and Muscatelli (1998) and Walsh (1999) analyze gains that may ensue to allowing a central bank to announce its own targets. Eijffinger et al. (2000; 2003) and Beetsma and Jensen (2003) consider the trade-off of inflation fighting credibility and efficient stabilization when central bank preferences are uncertain. On related issues, Chortareas and Miller (2003) consider the effects of delegation through contracts when central bank reaction to the contract is uncertain.

² In the absence of uncertainty concerning central bank preferences, Persson and Tabellini (1993) and Walsh (1995) establish that a linear inflation contract can replicate the equilibrium under optimal commitment. Lockwood (1997) and Svensson (1997) show that when there is persistence in employment a state contingent contract can replicate the commitment equilibrium. Beetsma and Jensen (1998), Muscatelli (1998; 1999), and Schaling et al. (1998) consider the relative effectiveness of delegation through contracts and optimal inflation targets in improving outcomes.

³ Recent contributions to the large literature on inflation targeting include Walsh (2003) and Svensson (2002).
floating the exchange rate. These observations are consistent with the findings by Fry et al. (2000) that 61 (67) out of 94 central banks responding to a survey by the Bank of England regarded inflation (exchange rate) as either the main or a major objective during 1997-1998.

The issue to be addressed in this paper concerns the usefulness of exchange rate or inflation targeting compared to a linear inflation contract, given that central bank preference on the relative stabilization of inflation and output deviates randomly from that of government/society. When central bank preferences are uncertain, delegation implemented by inflation or exchange rate targeting may be superior to delegation implemented through an inflation contract. An exchange rate targeting regime is defined as the assignment by society to the central bank of specific foreign exchange rate, inflation and output targets, and designated weight on exchange rate stabilization. An inflation targeting regime is defined similarly.

Introduction of exchange rate or of inflation targeting comes at the price of stabilization bias of shocks to supply and terms of trade. However, the distortion generated by uncertainty about central bank preferences in stabilization bias in shocks to supply and terms of trade is less under targeting regimes than under a linear inflation contract combined with an optimal inflation target. If uncertainty about central bank preferences is large enough relative to other sources of uncertainty, then delegation through exchange rate or inflation targeting is preferred to delegation implemented through a linear inflation contract combined with an optimal inflation target.  

4 Calvo and Vegh (1993) argue that a high turnover of central bank governors is a major reason why developing countries opt for exchange rate stabilization policies.

5 It should be noted that an exchange rate targeting regime does not imply a fixed exchange rate regime unless the weight placed on exchange rate stabilization is infinite. Our setup follows Rogoff’s (1985) definition of intermediate targeting as design of incentives for the central bank to achieve a low rate of growth for a nominal variable.

6 On the other hand, if uncertainty about central bank preferences is relatively small, the outcome is closer to the situation in which there is no uncertainty about central bank preferences under which an inflation contract can replicate the commitment equilibrium while intermediate targeting cannot. Intermediate targeting of the growth in any nominal variable will introduce stabilization biases. These biases, however, may be dominated by stabilization
An increase in uncertainty of central bank preferences increases the weight attached to the exchange rate or the inflation targeting objective, and this decreases (increases) stabilization bias in productivity and terms of trade shocks (not) associated with uncertainty about central bank preferences. The benefits obtained by stabilization of shocks under exchange rate or inflation targeting are reduced with an increase in uncertainty of central bank preferences, but losses overall are capped by loss achieved under a fixed exchange rate (or a strict inflation target) whereas loss with a linear inflation contract increases continuously with an increase in uncertainty of central bank preferences. If supply is sensitive to the terms of trade stabilization of the exchange rate tends to stabilize output compared to linear inflation contract. An increase in inefficiency in the labor market increases the weight assigned to the exchange rate or inflation targeting objective, since rewards from eliminating inflation bias are greater.

It is found that appointment of a central banker from a more populist segment of the population, that is a banker who is likely to place more weight on the stabilization of output relative to inflation than does society overall, improves outcomes under exchange rate targeting and under a linear inflation contract combined with a Svensson (1997) optimal inflation target when there is uncertainty regarding central bank preferences. An optimal inflation target eliminates average inflation bias and an inflation contract eliminates stabilization bias introduced by uncertainty about central bank preferences (stochastic bias), but bias introduced by uncertainty about central bank preferences into stabilization of supply and terms of trade shocks is not eliminated. Appointment of a central banker with a populist bias tends to mitigate this cross stabilization bias.

The model is presented in Section 1. The optimal design for delegation with an intermediate exchange rate targeting regime is presented in Section 2. Optimal exchange rate targeting and optimal linear inflation contract combined with optimal inflation target delegation regimes are compared in Section 3. An inflation targeting regime is considered in Section 4. The effect of inflation–weight conservative or populist central bankers on results is considered in Section 5. Section 6 concludes.

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bias introduced by an inflation contract if the uncertainty about central bank preferences is large enough.
1. The Model

The model is the usual one-period credibility model. The government’s (and society’s) preferences are represented by:

\[ L_t = (1/2)\pi_t^2 + (\lambda/2)(y_t - y^*)^2, \]

where \( \pi_t \) is the rate of inflation, \( y_t \) is the log of output, \( y^* > 0 \) is the socially optimal level of output, and \( \lambda \) is the relative weight placed on output versus inflation stabilization by government/society.\(^7\) Output is measured relative to the natural level of output.

We will assume that supply depends on unexpected change in producer prices and in the terms of trade (the price of domestic output relative to price of imports). The supply of output relative to the natural rate is given by:

\[ y_t = \alpha(\pi_t - E_{t-1}\pi_t) - \phi(q_t - E_{t-1}q_t) + \xi_t, \quad \alpha > 0, \phi > 0, \]

where \( E_{t-1}\pi_t = \pi^*_t \) is the expected rate of inflation by the public, \( q_t \) is the terms of trade, \( E_{t-1}q_t = q^*_t \) is the expected terms of trade, and \( \xi_t \) is a productivity shock that is assumed to be independently and identically distributed with zero mean and finite variance, \( \sigma^2_{\xi} \).

If \( \omega_t \) represents the change in the log of the domestic price of a unit of foreign currency and \( \pi^f \) is the foreign rate of inflation (assumed to be constant at zero), the change in the terms of trade is given by:

\[ q_t - q_{t-1} = \omega_t - \pi_t + \pi^f = \upsilon_t, \]

where \( \upsilon_t \) represents shocks to the terms of trade and is an independently and identically distributed random variable with zero mean and finite variance, \( \sigma^2_{\upsilon} \). A positive value for \( \upsilon_t \) indicates a positive shock to

\(^7\) We follow Clarida et al. (2002) in their model of the open economy and assume that domestic inflation rather than consumer price inflation appears in the loss function.
demand for foreign output relative to demand for domestic output and consequent increase in the rate of depreciation of the domestic currency.

As in standard models of credibility, the public’s expectation of inflation is formed (i.e., wage contracts are signed) without information on the supply and terms of trade shocks. The policy maker observes supply and terms of trade shocks before choosing the inflation rate (the policy variable).

It is assumed that government is unable to pre-commit to the optimal but time-inconsistent policy. Government faces the choice of delegating the conduct of monetary policy to an independent central bank with uncertain preferences or of pursuing a time-consistent discretionary policy. The solution under no delegation and discretion is given by:

\[ \pi_t = \lambda y^* - \lambda \frac{\xi_t - \phi \nu_t}{1 + \lambda}. \]  

(4)

Here, we have adopted for convenience, a normalization of \(\alpha = 1\). The first term on the right hand side of equation (4) represents average inflation bias associated with lack of credibility. The second term on the right hand side of equation (4) illustrates that positive shocks to supply are stabilized by lowering inflation (and reducing the increase in output), and positive shocks to terms of trade (that increase the price of imports and reduce output) are stabilized by increasing inflation (and reducing the reduction in output).

Expected loss under discretion to government is given by (substituting for \(\pi_t\) in equation (2), eliminating \(\pi_t\) and \(y_t\) in equation (1), and taking expectations):

\[ E(L^d) = (1/2)(1 + \lambda)((y^*)^2 + \lambda \frac{\sigma_z^2 + \phi^2 \sigma_\nu^2}{(1 + \lambda)^2}). \]  

(5)

Expected loss under no delegation and discretion is increasing in uncertainty and in the sensitivity of supply to changes in the terms of trade. The expected loss in equation (5) represents the upper bound for expected loss of different monetary policy regimes pursued by delegation of the conduct of monetary policy.

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8 Beetsma and Jensen (2003; footnote 7) show that any \(\alpha > 0\) can be accommodated by appropriate reformulation of the loss function.
If expected loss under delegation is larger than that given in equation (5) monetary policy will not be delegated.

It is assumed that the government can delegate the conduct of monetary policy to an independent central bank whose preferences on the relative stabilization of inflation and output deviate randomly from those of government/society. The outcome under an exchange rate targeting regime will be directly compared to that obtained from delegation by assignment of a linear inflation contract combined with an (Svensson (1997) type) optimal inflation target.

Delegation under an exchange rate targeting regime is implemented by the loss for the central bank given by:

\[
Z_i^X = \frac{1}{2}[(1-s_i)\pi_t^2 + (\lambda + s_i)(y_t - y^*)^2 + \psi(\omega_t - \omega^*)^2], \tag{6}
\]

where \(s_i\) is an independently and identically distributed random variable bounded between \(-\lambda\) and 1 with zero mean and variance \(\sigma_s^2\), \(\psi\) is the weight on the exchange rate objective and \(\omega^*\) is the target for the exchange rate. \(s_i\) is unobserved by the public and by government and changes every period. The parameters \(\psi\) and \(\omega^*\) will be chosen by the government.

Delegation under a linear inflation contract combined with an optimal inflation target is implemented by the loss for the central bank given by:

\[
Z_i^{\ell,\tau} = \frac{1}{2}[(1-s_i)(\pi_t - \pi^*)^2 + (\lambda + s_i)(y_t - y^*)^2 + \kappa \pi_t], \tag{7}
\]

where \(\kappa\) is the parameter on the linear inflation contract and \(\pi^*\) is the target set for the inflation rate to be chosen by government.

2. Delegation by Exchange Rate Targeting Regime

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The central bank minimizes the assigned loss function in equation (6) subject to equations (2) and (3). The first-order condition is given by:

\[
(1 - s_i)\pi_t + (\lambda + s_i)(y_t - y^*) + \psi(\omega_t - \omega^*) = 0. \tag{8}
\]

The rational expectations solution for inflation under an exchange rate target regime is given by:

\[
\pi_t = \pi^e - \frac{[\lambda s_t - (\lambda \phi - \psi) \nu_t]}{1 + \psi + \lambda} + \frac{(\pi^e + y^*)}{(1 + \psi + \lambda)} s_t - \frac{(\xi_t - \phi \nu_t)}{(1 + \psi + \lambda)} s_t, \tag{9}
\]

where \( \pi^e = \frac{\lambda y^* + \psi \omega^*}{1 + \psi} \).

If central bank preferences equaled those of society, i.e. \( s_i = 0 \), only the first two terms appear on the right hand side of equation (9). The first term indicates that the lower the rate of depreciation targeted and the greater the weight attached to the exchange rate objective the lower the expected rate of inflation. In the second term positive shocks to the terms of trade (that increase the cost of imports and reduce output) are stabilized by increasing the inflation rate (and reducing the reduction in output) if \( \lambda \phi > \psi \). The introduction of an exchange rate stabilization objective in the loss function (\( \psi > 0 \)) modifies the extent to which movements in output and inflation are stabilized by variation in the exchange rate.

If the central bank has a greater preference for stable output than society, i.e. \( s_i > 0 \), then, the third term on the right hand side of equation (9) indicates that the reaction in inflation to given shocks in supply and terms of trade is greater than before, so as to reduce variability in output. The fourth term on the right hand side of equation (9) captures the fact if the central bank weights inflation variability by less in the loss function (\( s_i > 0 \)) average inflation bias will be greater.

The government chooses the weight, \( \psi \), on the exchange rate objective and the target, \( \omega^* \), for the exchange rate objective, given the decision rule for the central bank in equation (9). However, government cannot observe \( s_i \) prior to delegation. Using \( \pi_t \) in equation (9) to obtain output in equation (2), substituting inflation and output into the society loss function given in equation (1), taking
expectations, and choosing $\omega^*$ and $\psi$ so as to minimize expected loss yields the following solutions for $\omega^*$ and expected inflation:

$$\omega^* = \frac{(1+\psi)\pi^e - \lambda \psi^*}{\psi} < 0, \quad \pi^e = -\frac{(1+\lambda)\psi^* \sigma_s^2}{(1+\lambda+\psi)^2 + (1+\lambda)\sigma_s^2} < 0. \quad (10)$$

The target rate of depreciation is negative and will depend upon uncertainty regarding central bank preferences. Expected inflation is also negative. The solution for $\psi$ that minimizes expected loss can be shown to be positive. Expected loss is minimized for $\psi$ satisfying the following condition:

$$\psi = \frac{\lambda^2 \psi^2 + \phi^2 \sigma^2_{\xi}}{(1+\lambda + \lambda \phi^2 \sigma^2_{\upsilon})}.$$

Let the left and right hand sides of equation (11) be expressed as $G(\psi)$ and $H(\psi)$, respectively. $G(\psi)$ is a straight line with slope $1/(\chi \sigma_s^2)$ and intercept $-1$. With regard to $H(\psi)$ we have:

$$H(0) > 0, \quad H'(\psi) > 0, \quad \lim_{\psi \to \infty} H(\psi) = \frac{(\psi^*)^2}{(\sigma_s^2 + \phi^2 \sigma_{\upsilon}^2)} > H(0) > 0. \quad (12)$$

We note that $H''(\psi) < 0$ for $\psi > [\sigma_s \sqrt{(1+\lambda) - (1+\lambda)}] = \psi$, $H''(\psi) > 0$ for $\psi < \psi$, and $H''(\psi) = 0$ for $\psi = \psi$. The functions $G(\psi)$ and $H(\psi)$, drawn for $\sigma_s^2 \leq 1 + \lambda$, are shown in Figure 1 intersecting at $\psi^* > 0$, the optimal value for weight to be attached to the exchange rate objective. We will assume that $\sigma_s^2 \leq 1 + \lambda$ in what follows.\(^{10}\)

\(^{10}\) The assumption that $\sigma_s^2 \leq 1 + \lambda$ is very likely to hold. For example, if the probability density function ($f(s)$) of $s$ is bi-rectangular with $f(s) = (1/\lambda(1+\lambda))$, $-\lambda \leq s \leq 0$ and $f(s) = (\lambda/(1+\lambda))$, $0 < s \leq 1$, the mean of $s$ is zero as required and $\sigma_s^2 = \lambda / 3$. We note that if $\sigma_s^2 \leq 1 + \lambda$ then $H(0) \geq (1/2) \lim_{\psi \to \infty} H(\psi)$.\)
Examination of equation (11) reveals proportionate increases in uncertainty of shocks to supply and the terms of trade shift the function $H(\psi)$ down ($G(\psi)$ is unaffected since $\chi$ is unchanged) and reduce $\tilde{\psi}$, since the value of stabilization of shocks rather than pursuing the exchange rate objective is now increased for a given value of $\sigma^2_s$. A rise in the variance of shocks to the terms of trade, $\sigma^2_\nu$, and a simultaneous reduction in the variance of supply shocks, $\sigma^2_\xi$, that leaves $\sigma^2_\xi + \phi^2 \sigma^2_\psi$ unchanged, lowers $\chi$ and results in less weight being assigned to the exchange rate objective.

The effect of an increase in uncertainty regarding the preferences of the central bank raises the penalty (the weight on the exchange rate stabilization objective) and is given by (from equation (11)):

$$\frac{\partial \tilde{\psi}}{\partial \sigma^2_s} (G'(\tilde{\psi}) - H'(\tilde{\psi})) = \frac{(1 + \lambda + \tilde{\psi})^2}{(1 + \lambda + \tilde{\psi})^2 + (1 + \lambda)\sigma^2_s} [\frac{H(\tilde{\psi})}{\sigma^2_s} + \frac{1}{\sigma^2_s}] > 0 \quad (13)$$

On the left hand side of equation (13), $G'(\tilde{\psi}) - H'(\tilde{\psi}) > 0$. This is illustrated at the intersection of $G(\psi)$ and $H(\psi)$ at $\tilde{\psi}$ in Figure 1. The right hand side of equation (13) is positive for $\sigma^2_s \leq 1 + \lambda$. Thus, in line with intuition, a rise in $\sigma^2_s$ raises the optimal value of the penalty $\tilde{\psi}$, since discretionary stabilization bias associated with uncertain central bank preferences is increased relative to the bias introduced by stabilization of the exchange rate.

In order to directly compare expected loss under an exchange rate regime with expected loss under a linear inflation contract and inflation target regime a special case under the former regime will be considered.\textsuperscript{11} A sub-optimal policy will result in expected losses for society that will be greater than those incurred with the optimal policy, but will provide a basis for comparison with outcomes achieved under delegation to a central bank via a linear inflation contract and inflation target.

\textsuperscript{11} An explicit solution for $\tilde{\psi}$ is possible if $y^* = 0$. From equation (12), if $y^* = 0$, $\tilde{\psi} = \chi \sigma^2_s$. 

9
We will pre-set \( \bar{\omega}^* = -\lambda y^*/\psi \) (less than the optimal value of \( \omega^* \) in equation (11)) and choose the value of \( \psi \) that minimizes expected loss to society given this constraint.\(^{12}\) A bar over symbols will indicate optimization subject to the restriction \( \bar{\omega}^* = -\lambda y^*/\psi \). Given this constraint, the optimal value of \( \psi \) is given by:

\[
\bar{\psi} = \frac{(1 + \lambda)(\sigma_\xi^2 + \phi^2 \sigma_\nu^2)}{\left(\lambda^2 \sigma_\xi^2 + (1 + \lambda + \lambda \phi)^2 \sigma_\nu^2\right)} \cdot \left[1 + \frac{(y^*)^2}{(\sigma_\xi^2 + \phi^2 \sigma_\nu^2)}\right] \sigma_\xi^2 = \chi \Phi \sigma_\xi^2, \quad (14)
\]

where \( \Phi = \left[1 + \frac{(y^*)^2}{(\sigma_\xi^2 + \phi^2 \sigma_\nu^2)}\right] > 1 \).

Equation (14) indicates that an increase in uncertainty of central bank preferences increases the penalty weight \( \bar{\psi} \) attached to the exchange rate objective. An increase in inefficiency in the labor market increases the weight assigned to the exchange rate objective, since rewards from eliminating inflation bias are greater. Given \( \bar{\psi} = \chi \Phi \sigma_\xi^2 \), the targeted rate of depreciation becomes \( \bar{\omega}^* = -\lambda y^*/(\chi \Phi \sigma_\xi^2) \), and an increase in uncertainty regarding central bank preferences increases (makes less negative) the rate of depreciation that is targeted. Expected inflation remains unchanged at zero.

Under an exchange rate regime with \( \bar{\omega}^* = -\lambda y^*/(\chi \Phi \sigma_\xi^2) \) and \( \bar{\psi} = \chi \Phi \sigma_\xi^2 \) the expected loss to society can be expressed as (following substitution for \( \pi_t \) given in equation (9) and substitution of the corresponding level of output from equation (2) in equation (1) and taking expectations):

\[
EZ^X(\bar{\psi}, \bar{\omega}) = (1/2)\left\{\lambda(y^*)^2 + [\lambda \sigma_\xi^2 + (1 + \lambda + \phi^2) \sigma_\nu^2]\right\} - \frac{(1 + \lambda)[\sigma_\xi^2 + \phi^2 \sigma_\nu^2]}{2\chi(1 + \lambda + \chi \Phi \sigma_\xi^2)}. \quad (15)
\]

Expected loss to society in equation (15) is greater than expected loss if an optimal penalty is imposed \( (EZ^X(\bar{\psi}, \bar{\omega})) \). The first term on the right hand side of equation (15) represents expected loss that would occur under a strict fixed exchange rate regime.\(^{13}\) If exchange rate depreciation is kept equal to zero,

\[^{12}\text{Examination of equation (11) shows that setting } \omega^* = -\lambda y^*/\psi \text{ will result in elimination of average inflation bias.}\]

\[^{13}\text{A fixed exchange rate could be conducted directly by government or by delegation with a very large penalty being}\]
i.e. \( \omega_t = 0 \), by setting \( \pi_t = -\nu_t \) and completely offsetting shocks to the terms of trade, average inflation bias is eliminated, but stabilization bias is introduced into both supply and terms of trade shocks.

The second term in equation (15) is negative and represents the benefits obtained by stabilization of shocks under a flexible exchange rate targeting regime not possible under a strict fixed exchange rate regime. An increase in \( \sigma_S^2 \) reduces the benefits of stabilization, increases expected loss under an exchange rate targeting regime, and increases the weight assigned to the exchange rate objective. For large values of \( \sigma_S^2 \), the very large penalty being imposed on deviations of the exchange rate from target will result de facto in a strict fixed exchange rate regime.

If the benefits of a strict fixed exchange rate exceed those from discretionary policy without delegation, i.e. if \( E(L_t^d) \) in equation (5) is greater than the first term in braces on the right hand side of equation (15) implying that:

\[
\Delta \equiv (y^*)^2 - (\lambda^2 \sigma_y^2 + (1 + \lambda \phi)^2 \sigma_\nu^2) / (1 + \lambda) > 0, \tag{16}
\]

then delegation to a central bank by an exchange rate targeting regime dominates not delegating without regard to the magnitude of uncertainty regarding central bank preferences. The condition in equation (16) implies that expected loss to society under the fixed exchange rate regime is less than under discretion without delegation if labor market inefficiency, captured by \( y^* \), is relatively big compared to \( \sigma_y^2 \) and \( \sigma_\nu^2 \), i.e. if the reduction in average inflation bias more than compensates for the stabilization biases introduced by fixed exchange rates compared to flexible exchange rates. In this case, delegation of monetary policy, through an exchange rate targeting regime, is always preferred to not delegating monetary policy.\(^{14}\)

Delegation may, however, be desirable even if the condition in (16) isn’t met. If \( \Delta < 0 \), delegation of an exchange rate target regime to a central bank with uncertain preference will still be desirable provided \( \sigma_S^2 \) is not too large, i.e. provided (from a direct comparison of equations (5) and (15)):

\(^{14}\) It is being assumed that the government lacks a pre-commitment technology.
\[ \Delta > - \frac{(1 + \lambda)(y^*)^2}{\chi\Phi\sigma_{\tilde{S}}^2}. \]  

(17)

3. Comparison with optimal linear inflation contract and optimal inflation target

Under an optimal linear inflation contract and optimal inflation target regime the government delegates the conduct of policy by assigning the loss function given in equation (7) and selects \( \kappa \) and \( \pi^* \). The decision rule for the central bank given the loss function in equation (7) is given by:

\[
\pi_t = (\pi^* + \lambda y^* - \kappa) - \frac{(\xi_t - \phi\nu_t)}{(1 + \lambda)}(\lambda + s_t) + \frac{(y^*(1 + \lambda) - \kappa)}{(1 + \lambda)}s_t.
\]

(18)

The government chooses \( \kappa \) and \( \pi^* \) knowing the decision rule for the central bank is of the form given in equation (20). Substituting \( \pi_t \) in equation (18) and the relevant level of output from equation (2) into the society loss function given in equation (1), taking expectations, and choosing \( \kappa \) and \( \pi^* \) so as to minimize expected loss yields the solutions \( \tilde{\kappa} = (1 + \lambda)y^* \) and \( \tilde{\pi}^* = y^* \).\(^{15}\) Expected loss for society under a contract and optimal inflation target regime is given by:

\[
EL^C(T)(\tilde{\kappa}, \tilde{\pi}^*) = (1/2)\lambda(y^*)^2 + \frac{(\sigma_{\xi}^2 + \phi^2\sigma_{\nu}^2)}{2(1 + \lambda)}(\lambda + \sigma_{\tilde{S}}^2).
\]

(19)

Expected loss in equation (19) is increasing in the variances of the supply and terms of trade shocks and in uncertainty about central bank preferences. However, whereas at large values of \( \sigma_{\tilde{S}}^2 \) expected loss under an exchange rate regime is capped at what it would be with a strict fixed exchange rate regime, under a contract and inflation target regime expected loss is increasing in \( \sigma_{\tilde{S}}^2 \).\(^{16}\) For \( \sigma_{\tilde{S}}^2 \) large

\(^{15}\) These solutions have been reported by Beetsma and Henrik (1998) and Muscatelli (1998) and others.

\(^{16}\) An optimal linear contract and optimal inflation target will only be preferable to not delegating monetary policy to a central bank for values of \( \sigma_{\tilde{S}}^2 < (1 + \lambda)(y^*)^2 / (\sigma_{\xi}^2 + \phi^2\sigma_{\nu}^2) \).
enough, an exchange rate targeting regime is preferable to delegation with assignment of an optimal linear inflation contract combined with an optimal inflation target.

It order to directly compare costs under the flexible exchange rate regime and that of contracts equation (15) can be re-written as:

$$EZ^X(\overline{y}, \overline{w}) = \frac{(1/2)\lambda (y^*)^2 + (\sigma^2 + \phi^2 \sigma^2_v)}{2(1+\lambda)} [\lambda + \frac{(1+\lambda)\Phi}{(1+\lambda + \chi \Phi \sigma^2_S)]}. \quad (15')$$

We see from a comparison of (15') and (19) that $E(Z^X(\overline{y}, \overline{w})) < E(Z^{CT}(\overline{\kappa}, \overline{\pi}^*))$ if:

$$\Omega = \frac{(1+\lambda)\Phi}{(1+\lambda + \chi \Phi \sigma^2_S)} < 1, \quad (20)$$

or equivalently $\sigma^2_S > \overline{\sigma}^2_S = \frac{(1+\lambda)(\Phi - 1)}{\chi \Phi} [\lambda^2 \sigma^2_v + (1+\lambda(1+\phi))^2 \sigma^2_v)](y^*)^2$$

$$\frac{(\sigma^2 + \phi^2 \sigma^2_v)}{(\sigma^2 + \phi^2 \sigma^2_v)[(y^*)^2 + (\sigma^2 + \phi^2 \sigma^2_v)]}. \quad (20)$$

Condition (20) indicates that $\Omega < 1$ if $\sigma^2_S$ is large enough. Thus, an exchange rate targeting regime is superior to an optimal linear inflation contract combined with an optimal inflation target if uncertainty about central bank preferences is large enough relative to the variability in supply shocks and in shocks to the terms of trade. This follows since $\partial \overline{\sigma}^2_S / \partial \sigma^2 < 0$ and $\partial \overline{\sigma}^2_S / \partial \sigma^2 < 0$. If in addition $\Delta > 0$, delegation through an exchange rate targeting regime is superior to not delegating the conduct of policy to a central bank with uncertain preferences. In the event that $\Delta < 0$, it can be shown that there exists a range of values of $\sigma^2_S$ whereby delegation through an exchange rate targeting regime dominates delegating through a linear inflation contract combined with an optimal inflation target and not delegating provided $$(\lambda^2 \sigma^2_v + (1+\lambda(1+\phi))^2 \sigma^2_v) < (1+\lambda)[(\sigma^2_v + \phi^2 \sigma^2_v)] + (y^*)^2].$$

The reason why an exchange rate targeting regime does better with a rise in the variability of productivity shocks or shocks to the terms of trade relative to the variability in uncertainty regarding central bank preferences, is that although direct stabilization bias of productivity and terms of trade shocks under the exchange rate regime is larger than under the contract regime, the indirect stabilization bias in these shocks generated by uncertainty about central bank preferences is larger under the contract
regime than under the exchange rate regime. This can be illustrated by considering stabilization of the productivity shock. Optimal stabilization requires that response in $\pi_t$ to the productivity shock should be $-(\lambda/(1+\lambda))\xi_t$. The response under the exchange rate regime is $-[(\lambda + s_t)/(1+\lambda)]\xi_t$ and under the contract regime is $-[(\lambda + s_t)/(1+\lambda)]\xi_t$. The appearance of the incentive or penalty weight, $\overline{\psi}$, to stabilize the exchange rate, in the absence of $s_t$ introduces stabilization bias. However, when there is uncertainty regarding central bank preferences the additional stabilization bias is partially offset the greater is $\overline{\psi}$.

In comparison of the regimes the characteristics of $\Omega$ are critical in equation (20). It seems likely that $\Omega$ is decreasing in $\phi$, the sensitivity of supply to the terms of trade, with the implication that the more open the economy is to shocks to the terms of trade the more probable it is that $1<\Omega$. The effect of $\phi$ on $\Omega$ is given by:

$$\frac{\partial \Omega}{\partial \phi} = -\frac{2(1+\lambda)^2 \sigma_{u}^2}{(1+\lambda + \chi \Phi \sigma_{u}^2)^2} \left[ \frac{\phi(y^*)^2}{(\sigma_{u}^2 + \phi^2 \sigma_{y}^2)^2} + \frac{(1+\lambda)\Phi^2 \sigma_{y}^2 (\phi(1+\lambda + \lambda \phi)\sigma_{u}^2 - \lambda \sigma_{y}^2)}{(\lambda^2 \sigma_{y}^2 + (1+\lambda(1+\phi))^2 \sigma_{y}^2)^2} \right].$$  \hspace{1cm} (21)

A sufficient condition for $\partial \Omega / \partial \phi < 0$ is that $\phi(1+\lambda + \lambda \phi)\sigma_{u}^2 \geq \lambda \sigma_{y}^2$, or that variance of shocks to the terms of trade is relatively substantial compared to that of shocks to productivity. In this case, at a larger value of $\phi$ it is more likely that $\Omega<1$ and that stabilization of the exchange rate is a more attractive policy. If supply is sensitive to the terms of trade and shocks to the terms of trade are relatively substantial in comparison to productivity shocks, then stabilization of the exchange rate tends to stabilize output compared to the alternative contract and optimal inflation target regime.

4. Inflation targeting

The model reduces to a closed economy with inflation targeting if we eliminate shocks to the terms of trade by setting $\nu_t = 0$ (and $\sigma_{u}^2=0$, $\phi = 0$). This reduces the loss function assigned to the central bank in equation (6) under an exchange rate targeting regime into a loss function assigned to a central bank under an inflation targeting regime in a closed economy (from equation (3), $\omega_t = \pi_t$), where $\psi$ is now the weight assigned to
achievement of the inflation target objective and $\omega^*$ is now the inflation rate target.\textsuperscript{17} The loss function can be re-formulated so as to interpret $\psi$ as an increase in the weight on the inflation objective, possibly obtained by sampling from sectors of the population known to be more inflation-weight conservative than the general population. The presence of uncertainty concerning central bank preferences means that use of an inflation weight conservative need not be inferior to that of a linear inflation contract combined with an optimal inflation target.

An upper bound for expected loss to society of a conservative central banker with an inflation target can be obtained by taking $\bar{\omega}^* = -\lambda y^*/\psi$ and $\bar{\psi} = ((1 + \lambda)/\lambda^2) [1 + (y^*/\sigma_\xi)^2] \sigma_\xi^2$ (from equation (16)) to yield $\chi = (1 + \lambda)/\lambda^2$ and $\Phi = (1 + (y^*/\sigma_\xi)^2)$. The greater the volatility of supply shocks, the less weight attached to the inflation target objective and the smaller the inflation target. The reverse holds the greater the volatility of central bank preferences.

The expected loss will be less under an inflation target than the expected loss to society of using an optimal contract and optimal inflation target for the closed economy if:

$$\sigma_S^2 > \frac{\lambda^2 (y^*)^2}{\sigma_\xi^2 + (y^*)^2}.$$  \hspace{1cm} (22)

Equation (22) illustrates an observation made for the exchange rate regime. A rise in uncertainty about supply shocks reduces the critical value for uncertainty about central bank preferences at which an inflation targeting regime is preferred to a linear inflation contract combined with an optimal inflation target. The result follows because the additional stabilization bias of productivity shocks generated by uncertainty about central bank preferences is larger under the contract regime than under the exchange rate or inflation targeting regimes.

\textsuperscript{17} For the open economy, an inflation targeting regime would have expressed the third term on the right hand side in terms of consumer rather than producer price inflation. Fry et al. (2000) and Svensson (2000) note that countries express inflation targets in terms of consumer prices, sometimes exclusive of certain components such as some commodity prices or mortgage interest rates, but that no country targets only domestic inflation.
5. Role for Conservative or Populist Central Banker

We will now compare the expected loss under an exchange rate regime with from delegation with a linear inflation contract and optimal inflation target combined with an inflation-weight (Rogoff (1985) conservative or populist tending central banker. Muscatelli (1999) shows that if a central banker who is expected to be more conservative than the general population is appointed, then the outcome under delegation with either a linear inflation contract or an optimal inflation target can be improved upon. We follow Muscatelli (1999) in assuming that government can achieve appointment of either a conservative or populist leaning central banker by using information about where to best sample in the population for the central banker with the required bias.

It is interesting that a populist central banker can improve the solution in the case of a combined contract and optimal inflation target. It can be shown that if delegation is implemented by the loss function for the central bank, the central bank is selected from a different subgroup captured by the parameter \( z \), given by:

\[
Z^{C,T,z}_t = (1/2)[(1-s_t)(\pi_t - \pi^{*z})^2 + (\lambda + z + s_t)(y_t - y^*)^2 + \kappa^z\pi_t].
\] (23)

It can be shown that the parameter values selected by government (so as minimize society expected loss) for the linear inflation contract and the optimal inflation target are \( \kappa^z = (1 + \lambda + z)y^* \) and \( \pi^{*z} = y^* \), and optimal value of \( z = (1 + \lambda)\sigma^2_y \). The expected loss for society is given by (after eliminating \( \kappa^z \) and \( \pi^{*z} \)):

\[
EZ^{C,T,z} = (1/2)\lambda(y^*)^2 + \frac{(\sigma^2_y + \phi^2\sigma^2_s)}{2(1 + \lambda + z)^2}((\lambda + z)^2 + \lambda + \sigma^2_y(1 + \lambda)).
\] (24)

If \( z = 0 \), \( EZ^{C,T,z} \) reduces to \( EZ^{C,T} \) in equation (19). Substituting for \( z = (1 + \lambda)\sigma^2_y \) yields expected loss given by:

---

18 A “Rogoff” conservative central banker is defined as placing less weight on stabilization of output. A populist central banker is defined as placing more weight on stabilization of output.
Introduction of a populist central banker has effectively eliminated the implication that expected loss rises without limit as variability in uncertainty of central bank preferences increases. A comparison of equations (19) and (24') reveals that $EZ^{C,T,z} < EZ^{C,T}$.  

An optimal inflation target eliminates average inflation bias and an inflation contract eliminates stabilization bias introduced by uncertainty about central bank preferences, but bias introduced by uncertainty about central bank preferences into stabilization of supply and terms of trade shocks is not eliminated by these measures. This can be illustrated by re-writing the first order condition for the central bank $z \neq 0$:

$$
\pi^{C,T,z}_{t} = \left( \pi^{z} + (\lambda + z)y^{*} - \kappa^{z} \right) - \frac{(\xi_{t} - \phi\nu_{t})}{(1 + \lambda + z)}(\lambda + z + s_{t}) + \frac{(y^{*}(1 + \lambda + z) - \kappa^{z})}{(1 + \lambda + z)}s_{t}.
$$

Optimal values for $\kappa^{z}$ and $\pi^{z}$ eliminate the first and third terms on the right hand side of equation (25). Setting $z=(1+\lambda)\sigma^{2}_{z}$ results in bias, introduced by uncertainty about central bank preferences into stabilization of supply and terms of trade shocks, in the second term on the right hand side of equation (25) being mitigated by appointment of a populist central banker. Equation (25) becomes:

$$
\pi^{C,T,z}_{t} = -\frac{(\xi_{t} - \phi\nu_{t})}{(1 + \lambda)(1 + \sigma^{2}_{z})}(\lambda + s_{t} + (1 + \lambda)\sigma^{2}_{z}).
$$

Bias due to uncertainty about central bank preferences in stabilization of supply and terms of trade shocks is now reduced by the degree of uncertainty regarding central bank preferences, $(1 + \sigma^{2}_{z})$.  

Using a technique employed by Muscatelli (1999), it is possible to determine whether appointment of an inflation weight conservative or populist is appropriate when targeting the exchange rate, by delegating a loss function to the central bank given by:

$$
\bar{Z}^{x,z}_{t} = (1/2)[(1 - s_{t})\pi^{2} + (\lambda + z + s_{t})(y_{t} - y^{*})^{2} + \psi^{2} (\omega_{t} - \omega^{*})^{2}] .
$$

The solution for inflation under discretion for the central bank is given by:
\[
\pi_t = \pi^c - \frac{[\hat{\lambda} + z] \xi_t - ((\hat{\lambda} + z) \phi - \psi\hat{z}) \nu_t}{1 + \psi\hat{z} + \lambda + z} + \frac{(\pi^c + \psi^z)}{(1 + \psi\hat{z} + \lambda + z)} \xi_t - \frac{(\xi_t - \phi \nu_t)}{(1 + \psi\hat{z} + \lambda + z)} s_t,
\]  

(27)

\[
\pi^c = \frac{1 + \psi\hat{z} + \lambda + z}{1 + \psi\hat{z}} \omega^{\nu z}.
\]

If government imposes the constraint \(\omega^z = -(\hat{\lambda} + z) y^z / \psi\hat{z}\) equilibrium under a monetary policy rule such an exchange rate target can be improved by appointment of a populist central banker since:

\[
\frac{\partial Z^X}{\partial z} = -\frac{(1 + \lambda)^2}{(1 + \lambda + \chi \Phi \sigma_S^2)^2} \left[ \frac{(y^z)^2}{(\sigma_S^2 + \phi \sigma_S^2)^2} + \frac{(1 + \lambda)(1 + \lambda + 2 \lambda \phi) \sigma_S^2 \Phi^2 \sigma_S^2}{(\lambda^2 \sigma_S^2 + (1 + \lambda \phi)^2 \sigma_S^2)^2} \right] < 0.
\]  

(28)

6. Conclusion

Exchange rate targeting or inflation targeting is widely used intermediate monetary policy operating arrangements, despite their deficiency of introducing stabilization bias into shocks to productivity and terms of trade. Under certain circumstances, including absence of uncertainty regarding central bank preferences on the trade off between stabilizing income and inflation, these targeting regimes are dominated by the use of a linear inflation contract. In this paper we argue that exchange rate or inflation targeting could be superior to a linear inflation contract (combined with an optimal inflation target) when there is uncertainty regarding central bank preferences. Bias introduced by uncertainty about central bank preferences into stabilization of productivity and terms of trade shocks is larger under the contract regime than under the targeting regimes. This advantage increases as uncertainty about central bank preferences increases since the incentive/weight assigned to exchange rate or inflation targeting also increases, and it is this weight that deflates the stabilization bias created by introduction of uncertainty about central bank preferences. Expected losses with exchange rate and inflation targeting are capped by loss achieved under a fixed exchange rate and strict inflation targeting, respectively.

Appointment of a central banker drawn from a populist segment of the population improves outcomes under exchange rate targeting and under the contract/optimal inflation target regime when there is uncertainty about central bank preferences. With a combined contract/optimal inflation target regime,
inflation bias is eliminated except for bias introduced by uncertainty about central bank preferences into stabilization bias of shocks to productivity and terms of trade. Appointment of a populist central banker tends to mitigate this bias in stabilization of productivity and terms of trade shocks.
REFERENCES


Fig. 1. Optimal penalty $\tilde{\psi}$

$$G(\psi) = \frac{\psi}{\chi \sigma_s^2} - 1, \quad H(\psi) = \frac{(y^*)^2}{(\sigma_s^2 + \phi^2 \sigma_s^2 \mu^2)} \left[ \frac{(1 + \lambda + \psi)^2}{(1 + \lambda + \psi)^2 + (1 + \lambda)\sigma_s^2} \right]^2$$

$$\sigma_s^2 \leq 1 + \lambda, \quad H''(0) \leq 0, \quad \psi \geq 0, \quad \text{and} \quad H(0) \geq (1/2) \lim_{\psi \to \infty} H(\psi)$$