# Optimal In°ation Targets, In°ation Contracts and Political Cycles

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Abstract

It has been widely accepted that politically induced variance can be generated when the wage contract is written before an election. In this paper, we show that in°ation contracts and in°ation targets can eliminate both the in°ation bias and politically induced variance, if electoral uncertainty is merely due to di®erent preferences. In contrast to the independent central bank that is based on cooperation between competing parties prior to the election, as suggested by Alesina and Gatti (1995), the contract and the target can be delegated by the winning party after the election. Concern for reputation can lead to the convergence of the in°ation targets assigned by di®erent parties. We also consider the case where uncertainty is caused not only by di®erent preferences, but also by di®erent desired rates in°ation. We show that it is quite possible to reduce in°ation but increase the variances of in°ation and output by adopting the in°ation target regime.

Keywords: central bank independence, in°ation contract, in°ation target, and electoral uncertainty.

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# 1 Introduction

It has been widely accepted that uncertainty about electoral outcomes has significant effects on the consequences of monetary policy. One way to model this is to set up a two-party system, where the two competing parties have different preferences over inflation and output, as suggested by Alesina (1987) and Alesina and Gatti (1995). The political uncertainty is one of the factors that induces variance of inflation and output. A number of studies have therefore focused on how to eliminate this politically induced variance (Alesina and Gatti (1995) and Waller and Walsh (1996)).

An independent conservative central bank based on the idea of Rogoff (1995) is able to reduce the inflation bias and the variance of inflation, but on the other hand, increases the variance of output. Furthermore, if this central bank is either independent of influences from the parties or is agreed to by the parties prior to the election, politically induced variance can be eliminated as well. The net consequence of this fully independent conservative central bank is a reduction of inflation and its variance, but not necessarily an increase of the output variability, as suggested by Alesina and Gatti(1995).

A weakness of this kind of institutional setting is that the inflation bias can only be partly reduced. This is consistent with the general institutional weakness of Rogoff conservative central bank. The inflation contract (Walsh (1995) and Persson and Tabellini (1993)) and the inflation target (Svensson (1997)) have been suggested as new forms of the instrument independent central bank in order to remove the inflation bias. One advantage of inflation contracts and inflation targets is that both are able to eliminate the inflation bias created by the policy under discretion without generating a higher output variability when economic distortion is the nominal wage rigidity, as indicated by Svensson (1997). Despite awareness of the importance of inflation contracts and inflation targets, to our knowledge, there is no theoretical study on how the inflation contract and the inflation target work in an environment with political uncertainty. Furthermore, some empirical studies show that the variance of inflation and the variance of output have increased rather than decreased in countries that have adopted the inflation target as a means to reduce inflation (Iscan and Xu (1997) and Debelle (1997)). It is worth investigating the possible source of increased variance. The aim of this paper is, therefore, to address these issues.

We first follow Alesina and Gatti (1995) in introducing the political uncertainty that is due to different preferences in a two-party system. Then we focus on the effects of inflation contracts and inflation targets in this system. The main conclusion is that the inflation bias generated by discretionary policy and politically induced variance can be completely removed if the inflation contract or the inflation target is set according to the equilibrium condition. In contrast to the fully independent central bank suggested by Alesina and Gatti (1995), which is agreed to by both parties and should be appointed prior to the election, the instrument independent central bank, operating either with the inflation contract or with the inflation target, can be nominated by the winning party after the election. However, fluctuation still remains in the economy since the two parties would assign the inflation target with different values, resulting in different equilibria. We further study how the repeated game could result in a policy convergence in terms of a reduction of the difference between the targets preferred by the two parties. We also consider the case where uncertainty is caused not only by the different preferences, but also by different desired rates of inflation. We find that it is quite possible to reduce the inflation but increase the variance of inflation and the variance of output by adopting an inflation target regime when the difference with regard to the desired rate of inflation is large.

# 2 Electoral Uncertainty due to Different Preferences

## 2.1 The Model and the Equilibrium under Commitment

Following Alesina and Gatti (1995), here we model how to measure the political (electoral) uncertainty due only to different preferences. A more general case will be considered in section 5.

The output is determined by aggregate supply as follows:

$$y = \pi - \pi^e + \varepsilon; \tag{1}$$

where $\pi$ is the inflation, $\pi^e$ is the expected inflation based on the information available in the previous period, and $\varepsilon$ is the supply shock which is i.i.d. normal distribution with zero mean and variance $\sigma_\varepsilon$: The natural level of the expected output is normalized at zero.

There are two competing parties, D and R, in the economy. The only difference between these two parties is their preferences with respect to inflation and output. Thus their objective functions are

$$L^D = \frac{1}{2}(\pi - \pi^*)^2 + \frac{\lambda^D}{2}(y - y^*)^2; \tag{2}$$

and

$$L^R = \frac{1}{2}(\pi - \pi^*)^2 + \frac{\lambda^R}{2}(y - y^*)^2: \tag{3}$$

where $\pi^*$ and $y^*$ are positive constants and represent the socially desired rate of inflation and output level, respectively. $\pi^*$ and $y^*$ are the same across the parties. A positive $y^*$ indicates an overambitious output target that would lead to the inflation bias under a discretionary policy regime. A positive $\pi^*$ is not necessarily required by the system. We make this assumption here simply to ensure that the inflation target will be non-negative. The difference between the two parties' objective functions is due solely to different parameters of the preference regarding inflation and output, $\lambda$: Following Alesina and Gatti (1995), we suppose that $0 < \lambda^R < \lambda^D$: Thus party R cares more about inflation stabilization relative to output stabilization than party D.

We first consider the case where the monetary policy is implemented under a commitment policy regime. We also disregard the electoral uncertainty. The timing of events in each period is as follows. The election is carried out at the beginning of each period. The winning party then delegates the monetary policy with a policy rule to a central bank. Next the wage contract is written based on the result of the election and the policy rule. After the supply shock $\varepsilon$ is realized, the monetary policy $\pi$ is chosen by the central bank.

If party D wins, the expected inflation would be

$$\bar{\pi}^{De} = E(\bar{\pi}^D); \tag{4}$$

where $\bar{\pi}$ indicates that the inflation is chosen under commitment regime without electoral uncertainty. By minimizing (2) and considering the condition (4), we obtain the inflation:

$$\bar{\pi}^D = \pi^* - \frac{\lambda^D}{1 + \lambda^D}\varepsilon; \tag{5}$$

and the output:

$$\bar{y}^D = \frac{1}{1 + \lambda^D}\varepsilon: \tag{6}$$

An analogous argument holds for party $R$:

$$\bar{\pi}^{Re} = E(\bar{\pi}^R); \tag{7}$$

$$\bar{\pi}^R = \pi^* - \frac{\lambda^R}{1+\lambda^R}\varepsilon; \tag{8}$$

and

$$\bar{y}^R = \frac{1}{1+\lambda^R}\varepsilon. \tag{9}$$

Therefore, the mean of inflation is

$$E(\bar{\pi}) = \pi^*; \tag{10}$$

and the variance of inflation is

$$\mathrm{var}(\bar{\pi}) = [P(\frac{\lambda^D}{1+\lambda^D})^2 + (1-P)(\frac{\lambda^R}{1+\lambda^R})^2]\sigma_\varepsilon^2; \tag{11}$$

where the constant $P$ is the probability of party $D$ winning the election; and hence the constant $1-P$ is the probability of party $R$ winning the election. The mean and the variance of output are

$$E(y) = 0; \tag{12}$$

and

$$\mathrm{var}(\bar{y}) = [\frac{P}{(1+\lambda^D)^2} + \frac{1-P}{(1+\lambda^R)^2}]\sigma_\varepsilon^2; \tag{13}$$

respectively.

## 2.2 Electoral Uncertainty and the Discretionary Monetary Policy Regime

We now consider the case where political uncertainty is introduced into the economy. The timing of events in each period is changed as follows. The wage contract is written at the beginning of the period. Next, the election is carried out. The winning party then delegates the monetary policy to a central bank with its own objective function. After that the supply shock $\varepsilon$ is realized. Finally, the monetary policy $\pi$ is chosen by the central bank. The length of each period coincides with the length of a wage contract and with a term of office. Since each period is identical and there is no state variable, the optimal choice can be simplified as a single period choice if we rule out the reputation effect that will be considered in section 4.

Since the wage contract is written before the election, the expected inflation embodies an electoral uncertainty:

$$\pi^e = PE(\pi^D) + (1 - P)E(\pi^R). \tag{14}$$

After the realization of the supply shock $\varepsilon$, the central bank appointed by the winning party chooses the policy $\pi$ by minimizing the loss function of the incumbent party. This leads to two possible outcomes. The rates inflation chosen by the two parties, if in office, are

$$\pi^D = \pi^* + \frac{\lambda^D(1+\lambda^R)}{1+\lambda^D(1-P)+\lambda^R P}y^* - \frac{\lambda^D}{1+\lambda^D}\varepsilon; \tag{15}$$

and

$$\pi^R = \pi^* + \frac{\lambda^R(1+\lambda^D)}{1+\lambda^D(1-P)+\lambda^R P}y^* - \frac{\lambda^R}{1+\lambda^R}\varepsilon. \tag{16}$$

The expected inflation becomes

$$\pi^e = \pi^* + \frac{\lambda^R(1+\lambda^D)+P(\lambda^D-\lambda^R)}{1+\lambda^D(1-P)+\lambda^R P}y^*. \tag{17}$$

The second term in (17) is the inflation bias, which is a monotonic function of the probability $P$. When $P = 0$, i.e., party R wins the election all the time, the inflation bias would reduce to $\lambda^R y^*$. We define this as the inflation bias associated solely with party R. On the other hand, if $P = 1$, i.e., party D always wins the election, the inflation bias would reduce to $\lambda^D y^*$. This is the inflation bias associated solely with party D. In general, when $0 < P < 1$, the following condition of the inflation bias is fulfilled, namely, $\lambda^R y^* < \frac{\lambda^R(1+\lambda^D)+P(\lambda^D-\lambda^R)}{1+\lambda^D(1-P)+\lambda^R P}y^* < \lambda^D y^*$. This indicates that the inflation bias lies between the two inflation biases associated exclusively with party D and party R. In fact, the inflation bias is a mixture of the standard inflation bias and the politically induced one. The decomposition is however of minor importance, since we expect the inflation target to be able to remove both of them. It can also be shown that the inflation bias increases with $(\lambda^D - \lambda^R)$. In other words, the inflation bias tends to be larger or its politically induced component becomes dominant if the difference between the two parties increases.

The outputs associated with the different parties' policies then become

$$y^D = \frac{(1-P)(\lambda^D-\lambda^R)}{1+\lambda^D(1-P)+\lambda^R P}y^* + \frac{1}{1+\lambda^D}\varepsilon; \tag{18}$$

and

$$y^R = -\frac{P(\theta^D - \theta^R)}{1 + \theta^D(1 - P) + \theta^R P} y^* + \frac{1}{1 + \theta^R}\varepsilon. \tag{19}$$

As a matter of fact, in each period, the economy may be characterized by one of the two equilibria, $(\pi^D; y^D)$ and $(\pi^R, y^R)$, i.e., the economy could end up with one of these equilibria. As described by (15) (16), (18) and (19), no matter which equilibrium is realized, the realized inflation and output are affected by the probability $P$. Therefore, the electoral uncertainty would have an impact on the consequence of the equilibria resulting from the election of the different parties.

Alesina and Gatti (1995) measure the electoral uncertainty by using the first and second moment of the expected inflation and output. The mean of inflation coincides with the inflation expectation, $E(\pi) = \pi^e$; which is given by (17). The variance of inflation is then

$$Var(\pi) = \frac{P(1 - P)(\theta^D - \theta^R)^2}{[1 + \theta^D(1 - P) + \theta^R P]^2} y^{*2} + [P(\frac{\theta^D}{1 + \theta^D})^2 + (1 - P)(\frac{\theta^R}{1 + \theta^R})^2]\sigma_\varepsilon^2. \tag{20}$$

The variance of inflation (20) can be decomposed into two parts: one is the politically induced variance, which increases with $(\theta^D - \theta^R)$, and the other is the standard (expected) variance of inflation.

The mean of output can be calculated from (18) and (19):

$$E(y) = 0. \tag{21}$$

Therefore, as in the single-party model, there is no systematic gain in output under the discretionary policy regime. The variance of output is

$$Var(y) = \frac{P(1 - P)(\theta^D - \theta^R)^2}{[1 + \theta^D(1 - P) + \theta^R P]^2} y^{*2} + [\frac{P}{(1 + \theta^D)^2} + \frac{(1 - P)}{(1 + \theta^R)^2}]\sigma_\varepsilon^2. \tag{22}$$

Like the variance of inflation, the first part of the variance of output in (22) is the politically induced variance, and the second part is the standard (expected) variance of output.

Thus, by using the first and second moment of inflation and output, we can measure the electoral uncertainty. If a designation of the monetary institution is taken into account, besides the inflation bias, the issue of how to remove/reduce the politically induced variance has to be considered as well.

Alesina and Gatti (1995) have suggested that, in the framework of Rogoff (1985), if the two parties could agree with each other before the election on the establishment of an independent central bank with a conservativeness $\hat{\lambda}$; which is smaller than both preferences $\lambda^D$ and $\lambda^R$, the economy could be improved to an equilibrium:

$$E(\hat{\pi}) = \pi^* + \hat{\lambda} y^*; \qquad E(\hat{y}) = 0;$$
$$var(\hat{\pi}) = \left(\frac{\hat{\lambda}}{1+\hat{\lambda}}\right)^2 \sigma_\varepsilon^2; \tag{23}$$
$$var(\hat{y}) = \frac{1}{(1+\hat{\lambda})^2}\sigma_\varepsilon^2;$$

where the inflation bias has been reduced and the politically induced parts of both the variance of inflation and the variance of output have been removed. It is natural to ask why the two parties should respect the predetermined agreement when they are in a position to choose the policy. If there is no blind commitment restricting the policy decision, such a fully independent central bank has to rely on the cooperation between the two parties prior to the election. In a one-shot game, such cooperation is incredible. This is because the winning party can always find a reason to implement the monetary policy according to its own loss function. In a repeated game, concern for reputation can probably lead to full cooperation. However, this requires the probability $P$ fulfills a certain condition and the discount rate $\beta$ is large enough.

Moreover, this institutional setting is based on the idea of Rogoff conservative central bank, which is not optimal since it can not remove the inflation bias completely. In the following section, we consider the case in which the winning party delegates an objective function together with either an inflation contract or an inflation target to the central bank after the election. We study how the inflation contract and the inflation target regimes are able to eliminate both the inflation bias and the politically induced variance.

# 3 Inflation Contract and Inflation Target Regimes

In contrast to the fully independent central bank based on cooperation between competing parties before the election, as suggested by Alesina and Gatti (1995), a central bank with either an inflation contract or an inflation target is instrument independent. Either an inflation contract or an inflation target is delegated together with the objective function by the winning party to the central bank after the election but before the realization of the shock $\varepsilon$. The timing of the events is not changed in other respects. First of all, the expected inflation is determined and the wage contract is written accordingly. Next, the election is carried out. The winning party then delegates the monetary policy, including an objective function, either with an inflation contract $f$, or an inflation target $\pi^B$. Finally, the supply shock $\varepsilon$ is realized, and the policy $\pi$ is chosen. We first consider the inflation contract regime.

## 3.1 Inflation Contracts

Walsh (1995) and Persson and Tabellini (1993) have suggested that if the society can add an extra cost, the inflation contract, to the central bank's loss function, the inflation bias can be removed without causing higher output variability. The inflation contract $f \cdot (\pi - \pi^*)$; where $f$ is a constant, is proportional to the deviation of inflation from the desired level, suggesting that extra weight is put on the inflation deviation. Now we shall investigate how the inflation contract works in an economy with the two-party system.

We suppose that the inflation contract is delegated by the winning party after the election in each period. The new objective function for the central bank can be expressed as either

$$L^{DB} = \frac{1}{2}(\pi - \pi^*)^2 + \frac{\lambda^D}{2}(y - y^*)^2 + f^D \cdot (\pi - \pi^*); \tag{24}$$

or

$$L^{RB} = \frac{1}{2}(\pi - \pi^*)^2 + \frac{\lambda^R}{2}(y - y^*)^2 + f^R \cdot (\pi - \pi^*): \tag{25}$$

The first order conditions obtained for minimizing (24) and (25) are

$$\frac{\partial L^{DB}}{\partial \pi} \equiv \bar{\pi}^D - \pi^* + \lambda^D(\bar{\pi}^D - \pi^e - y^* + \varepsilon) + f^D = 0;$$

and

$$\frac{\partial L^{RB}}{\partial \pi} \equiv \bar{\pi}^R - \pi^* + \lambda^R(\bar{\pi}^R - \pi^e - y^* + \varepsilon) + f^R = 0;$$

respectively, where $\pi^e$ is given by (14). By taking expectations over the first order conditions, we can solve the expected inflations in the equilibria associated with the different parties:

$$E(\bar{\pi}^D) = \pi^* + \frac{\lambda^D(1 + \lambda^R)y^* - (1 + \lambda^R P)f^D - \lambda^D(1 - P)f^R}{1 + \lambda^D(1 - P) + \lambda^R P}; \tag{26}$$

and

$$E(\bar{\pi}^R) = \pi^* + \frac{\lambda^R(1 + \lambda^D)y^* - [1 + \lambda^D(1 - P)]f^R - \lambda^R P f^D}{1 + \lambda^D(1 - P) + \lambda^R P}: \tag{27}$$

Considering the fact that the monetary policy will be implemented according to the conditions $E(\hat{\pi}^D) = \pi^*$ and $E(\hat{\pi}^R) = \pi^*$, we obtain that

$$f^D = \lambda^D y^*; \tag{28}$$

and

$$f^R = \lambda^R y^*. \tag{29}$$

It is quite natural to have different contracts represented by different constants $f^D$ and $f^R$ assigned by the different parties. This is because an inflation bias with different values will result from different policies. As a matter of fact, the constants $f^D$ and $f^R$ are equal to the inflation biases in the absence of electoral uncertainty. The inflation contract regime can assure the general public that the expected inflation will be at the socially (as well as the individually) desired levels without being affected by the probability $P$:

$$\pi^e = \pi^*. \tag{30}$$

By substituting (28) (29) and (30) into the first order conditions, we obtain the inflation chosen by the winning party:

$$\hat{\pi}^D = \pi^* - \frac{\lambda^D}{1+\lambda^D}\varepsilon; \tag{31}$$

or

$$\hat{\pi}^R = \pi^* - \frac{\lambda^R}{1+\lambda^R}\varepsilon. \tag{32}$$

The output corresponding to the inflation policy can be expressed as

$$\hat{y}^D = \frac{1}{1+\lambda^D}\varepsilon; \tag{33}$$

or

$$\hat{y}^R = \frac{1}{1+\lambda^R}\varepsilon. \tag{34}$$

According to the expected inflation, the inflation bias has been completely removed:

$$E(\hat{\pi}) = \pi^e = \pi^*.$$

There is no change in the mean of output, which is the same as that in (21).

Under the inflation contract regime, the variance of inflation becomes

$$Var(\hat{\pi}) = \left[\frac{P(\lambda^D)^2}{(1+\lambda^D)^2} + \frac{(1-P)(\lambda^R)^2}{(1+\lambda^R)^2}\right]\sigma_\varepsilon^2. \tag{35}$$

By comparing (20) and (35), we reach the conclusion that politically induced variance has been eliminated from the variance of inflation. Furthermore, the variance of output is

$$Var(\hat{y}) = [\frac{P}{(1+\lambda^D)^2} + \frac{(1-P)}{(1+\lambda^R)^2}]\sigma_\varepsilon^2; \tag{36}$$

where the politically induced variance has also been completely eliminated. Hence, both the inflation bias and the politically induced variance can be eliminated by the inflation contract regime, no matter which is the incumbent party.

## 3.2 Optimal Inflation Targets

Next we consider the case of the inflation target. An inflation target regime implies that an explicit inflation target is assigned to the central bank by the winning party. Since the two parties would choose different rates of inflation, it is not an unreasonable assumption that the two parties would assign the inflation target with different values, either $\pi^{DB}$ or $\pi^{RB}$, if in office: Then, the new objective function for the central bank that would be delegated by the winning party can be expressed as[1]

$$L^{DB} = \frac{1}{2}(\pi - \pi^{DB})^2 + \frac{\lambda^D}{2}(y - y^*)^2; \tag{37}$$

or

$$L^{RB} = \frac{1}{2}(\pi - \pi^{RB})^2 + \frac{\lambda^R}{2}(y - y^*)^2: \tag{38}$$

The policy decision under discretion involves the setting of the inflation $\pi$ and its target $\pi^B$ by taking the expected inflation $\pi^e$ as given in order to minimize $L^{DB}$ or $L^{RB}$. The first order condition for the optimal decision is

$$\frac{\partial L^{DB}}{\partial \pi} \equiv \hat{\pi}^D - \pi^{DB} + \lambda^D(\hat{\pi}^D - \pi^e - y^* + \varepsilon) = 0;$$

or

$$\frac{\partial L^{RB}}{\partial \pi} \equiv \hat{\pi}^R - \pi^{RB} + \lambda^R(\hat{\pi}^R - \pi^e - y^* + \varepsilon) = 0;$$

where $\hat{\pi}$ represents an optimal inflation policy chosen by the winning party under the inflation target regime. By taking the expectation over the first order condition, we

[1] As a matter of fact, we implicitly suppose that the output targets $y^B$ of the two parties are the same and are always set as the socially desired output $y^*$.

obtain the expected optimal inflation policies:

$$E(\hat{\pi}^D) = \frac{\lambda^D(1+\lambda^R)y^* + \lambda^D(1-P)\pi^{RB} + (1+\lambda^R P)\pi^{DB}}{1+\lambda^D(1-P)+\lambda^R P}, \tag{39}$$

and

$$E(\hat{\pi}^R) = \frac{\lambda^R(1+\lambda^D)y^* + [1+\lambda^D(1-P)]\pi^{RB} + \lambda^R P \pi^{DB}}{1+\lambda^D(1-P)+\lambda^R P}. \tag{40}$$

Supposing that the optimal inflation target $\hat{\pi}^{DB}$ or $\hat{\pi}^{RB}$ is assigned according to the achievement of the socially desired level $\pi^*$, $E(\hat{\pi}^D) = \pi^*$ and $E(\hat{\pi}^R) = \pi^*$. There is no difference between the competing parties. The optimal value of the target can then be determined:

$$\hat{\pi}^{DB} = \pi^* - \lambda^D y^*, \tag{41}$$

or

$$\hat{\pi}^{RB} = \pi^* - \lambda^R y^*. \tag{42}$$

The inflation targets assigned by the two parties are different in the second terms of (41) and (42). The second term in (41) represents the inflation bias associated solely with party D, as described in the previous section. Thus the target assigned by party D, $\hat{\pi}^{DB}$, can be expressed as the socially desired level $\pi^*$ minus this inflation bias $\lambda^D y^*$. On the other hand, the inflation target assigned by party R, $\hat{\pi}^{RB}$, is the socially desired level $\pi^*$ minus the inflation bias associated solely with party R, $\lambda^R y^*$, as indicated in (42). Furthermore, both inflation targets, $\hat{\pi}^{DB}$ and $\hat{\pi}^{RB}$, are independent of the probability $P$. This is because the probability $P$ can only affect the monetary policy decision via the expectation of inflation $\pi^e$, since the winning party would only care about its own interests after the election.

The inflation target regime could have the same consequences as the inflation contract regime. Therefore, the inflation is the same as (31) or (32), and the output is the same as (33) or (34).

In general, the inflation target is imperfectly credible, since the target is less than the expected inflation $\pi^*$. The two competing parties will assign different targets to the central bank and the credibility of the target will therefore naturally differ. As indicated in (41) and (42), the inflation target assigned by party D, $\hat{\pi}^{DB}$, is distant from the expected inflation $\pi^*$, hence it is less credible. On the other hand, the target assigned by party R, which is more concerned about inflation (smaller $\lambda^R$), $\hat{\pi}^{RB}$, is closer to the expected inflation $\pi^*$, resulting in higher credibility. Moreover, the less credible inflation target $\hat{\pi}^{DB}$ is associated with a higher variance of inflation var($\hat{\pi}^{D}$); but a smaller variance of output var($\hat{y}^{D}$); as indicated in (31) and (32) as well as (33) and (34).

In point of fact, it can easily be shown that the probability-independent equilibria, ($\hat{\pi}^{DB}$, $\hat{\pi}^{D}$, $\hat{y}^{D}$) and ($\hat{\pi}^{RB}$, $\hat{\pi}^{R}$, $\hat{y}^{R}$), are equivalent to the equilibria resulting from an economy where the wage contract is written upon the result of the election ($\bar{\pi}^{D}$, $\bar{y}^{D}$) and ($\bar{\pi}^{R}$, $\bar{y}^{R}$). Hence, the electoral uncertainty has been eliminated by the inflation target regime.

# 4 Convergence of Optimal Inflation Targets

Under the inflation contract and the inflation target regimes; the economy in each period can be described by two equilibrium states, ($\hat{\pi}^{DB}$, $\hat{\pi}^{D}$, $\hat{y}^{D}$) with probability $P$ and ($\hat{\pi}^{RB}$, $\hat{\pi}^{R}$, $\hat{y}^{R}$) with probability $1 - P$. Although the electoral uncertainty has been completely eliminated, fluctuations can still exist in the economy. For instance, the inflation target $\hat{\pi}^{B}$ would switch between $\hat{\pi}^{DB}$ and $\hat{\pi}^{RB}$: An institutional setting relying on cooperation between the two parties could help to reduce or even remove this kind of fluctuation. This institutional design is very similar to the fully independent central bank suggested by Alesina and Gatti (1995), but it has a different objective.

It would be misleading to measure the fluctuation by using the first and the second moments of the expected inflation and output, (30), (21), (35) and (36). This is because, even if the fluctuation is removed completely, there might be no change in the first moment, and it is difficult to detect a decreasing trend in the second moment. Therefore, following, among others, Alesina (1988), we use the convergence of economic variables to represent the reduction of fluctuation. We are particularly interested in the convergence of the inflation target $\hat{\pi}^{B}$, since this inflation target has been adopted in reality. The fluctuation of the target has significance for the credibility of monetary policy. The equilibrium with a policy convergence is a better one, since both parties could achieve lower losses.

So far we have regarded the preference parameters $\lambda^{D}$ and $\lambda^{R}$ as predetermined variables. In this section, we internalize the determination of the parameters $\hat{\lambda}^{D}$ and $\hat{\lambda}^{R}$; and investigate whether the cooperation could result in policy convergence.

If it is a one-shot game, and if there is no blind precommitment, cooperation between the two parties is not available. $(\theta^D, \theta^R)$ is the only Nash equilibrium. In other words, the preference parameters in the one-shot game equilibrium are always $\theta^D$ and $\theta^R$. Hence the time-consistent equilibrium for the inflation target is $(\hat{\pi}^{DB}, \hat{\pi}^{RB})$; where $\hat{\pi}^{DB}$ and $\hat{\pi}^{RB}$ are given by (41) and (42).

When the game can be repeated ad infinitum, the total expected loss functions for both parties can be expressed as

$$V^D(\hat{\theta}^D, \hat{\theta}^R) = \sum_{i=1}^{\infty} \beta^i L_i^D = \sum_{i=1}^{\infty} \beta^i [P L_i^D(\hat{\theta}^D) + (1 - P) L_i^D(\hat{\theta}^R)]; \tag{43}$$

and

$$V^R(\hat{\theta}^D, \hat{\theta}^R) = \sum_{i=1}^{\infty} \beta^i L_i^R = \sum_{i=1}^{\infty} \beta^i [P L_i^R(\hat{\theta}^D) + (1 - P) L_i^R(\hat{\theta}^R)]; \tag{44}$$

where $\beta$ is the discount rate and fulfills $0 < \beta < 1$. $L^D(\hat{\theta})$ in (43) is the indirect one-period expected loss function of party D with a shape of

$$L^D(\hat{\theta}) = \frac{1}{2} \frac{(\hat{\theta})^2 + \theta^D}{(1 + \hat{\theta})^2} \sigma_\varepsilon^2 + C^D; \tag{45}$$

where $\hat{\theta}$ is a control variable and $C^D$ is a constant with the value of $\frac{\theta^D y^{*2}}{2}$. $L^R(\hat{\theta})$ in (44) is the indirect one-period expected loss function for party R :

$$L^R(\hat{\theta}) = \frac{1}{2} \frac{(\hat{\theta})^2 + \theta^R}{(1 + \hat{\theta})^2} \sigma_\varepsilon^2 + C^R; \tag{46}$$

where $\hat{\theta}$ is a control variable and $C^R$ is a constant with the value of $\frac{\theta^R y^{*2}}{2}$. Thus, the expected total losses for both parties rely on the parameters $(\hat{\theta}^D, \hat{\theta}^R)$ chosen by the two parties simultaneously.

Even without blind precommitments, the economy can still reach better equilibria in an infinite-horizon game. In other words, if the two parties agree on the pair of parameters $(\hat{\theta}^{D*}, \hat{\theta}^{R*})$, where $\hat{\theta}^{D*} < \theta^D$ and $\hat{\theta}^{R*} > \theta^R$; the fluctuation could be moderated, and both parties could benefit from the cooperation. This can be stated as the individual rationality conditions[2]:

$$V^D(\hat{\theta}^{D*}, \hat{\theta}^{R*}) \leq V^D(\theta^D, \theta^R); \tag{47}$$

[2] It can easily be shown that all the other combinations of $(\hat{\theta}^{D*}, \hat{\theta}^{R*})$, such as $\hat{\theta}^{D*} > \theta^D$ and $\hat{\theta}^{R*} < \theta^R$; $\hat{\theta}^{D*} < \theta^D$ and $\hat{\theta}^{R*} < \theta^R$; and $\hat{\theta}^{D*} > \theta^D$ and $\hat{\theta}^{R*} > \theta^R$; are not Nash equilibria. In the first case, both parties' rationality conditions are simultaneously violated. In the other two cases, one individual party's rationality condition is violated.

and

$$V^R(\hat{\lambda}^{D*}, \hat{\lambda}^{R*}) \le V^R(\lambda^D, \lambda^R). \tag{48}$$

If cooperation on the pair of parameters $(\hat{\lambda}^{D*}, \hat{\lambda}^{R*})$ is sustainable, the subgame-perfect condition should be fulfilled. The subgame-perfect condition states that the "temptation" to deviate from the cooperation should not be greater than the "enforcement". The "temptation" and the "enforcement" are defined according to the punishment mechanism of the game. The "rules" of game are as follows. Both parties announce their preferred preference parameters before the election. If the elected party deviates from its "announced" parameter, the other party will not cooperate any more. In the coming periods, the equilibria would be the same as the one-shot equilibrium. The environment is therefore an infinite-horizon multi-stage game with observed actions that are continuous at infinity.

In the case of party D, the one-stage deviation principle can be expressed in terms of the one-period loss function $L^D$:

$$L^D(\hat{\lambda}^{D*}) - L^D(\lambda^D) \le \frac{\beta}{1-\beta}\{[PL^D(\lambda^D) + (1-P)L^D(\lambda^R)] - [PL^D(\hat{\lambda}^{D*}) + (1-P)L^D(\hat{\lambda}^{R*})]\}. \tag{49}$$

The left hand side of (49) is the gain from the deviation from the announced parameter $\hat{\lambda}^{D*}$ (temptation). Since $L^D(\hat{\lambda}^{D*})$ is always greater than $L^D(\lambda^D)$, there is always a motivation for party D to deviate. The right hand side of (49) represents the present value of total future costs of the deviation (enforcement). Hence condition (49) states that, if the cooperation parameter $\hat{\lambda}^{D*}$ is credible for party D, the cost should be larger than the gain. The analogous argument holds for party R:

$$L^R(\hat{\lambda}^{R*}) - L^R(\lambda^R) \le \frac{\beta}{1-\beta}\{[PL^R(\lambda^D) + (1-P)L^R(\lambda^R)] - [PL^R(\hat{\lambda}^{D*}) + (1-P)L^R(\hat{\lambda}^{R*})]\}. \tag{50}$$

It can be shown that there is at least one pair of parameters $(\hat{\lambda}^{D*}, \hat{\lambda}^{R*})$ that satisfies the conditions (47), (48), (49), and (50) for any given discount rate $\beta$. A detailed proof can be found in the Appendix. Both $\hat{\lambda}^{D*}$ and $\hat{\lambda}^{R*}$ are functions of the discount rate $\beta$. As indicated in the Appendix, following the increase of the discount rate $\beta$, $\hat{\lambda}^{D*}$ tends to decline, but $\hat{\lambda}^{R*}$ tends to increase. This indicates that the higher the discount rate $\beta$, the less the fluctuation. The underlying economic intuition is fairly clear. $\frac{\beta}{1-\beta}$ is an increased function of $\beta$; therefore, an increase of the discount rate $\beta$ would enhance the present value of the “enforcement” (the right hand sides of (49) and (50)), leading to greater potential for cooperation.

The inflation targets affected by the policy convergence can be expressed as $\hat{\pi}^{BD*} = \pi^* - \hat{\lambda}^{D*} y^*$ and $\hat{\pi}^{BR*} = \pi^* - \hat{\lambda}^{R*} y^*$, respectively. A smaller parameter $\hat{\lambda}^{D*}$ (compared with $\hat{\lambda}^{D}$) would cause the inflation target $\hat{\pi}^{BD*}$ preferred by party D to move close to the socially preferred rate of inflation $\pi^*$, whereas the inflation target $\hat{\pi}^{BR*}$ assigned by party R would move away from the socially preferred rate of inflation $\pi^*$. The two targets would converge. As the discount rate $\beta$ increases, the targets would converge even more.

If the discount rate $\beta$ approaches to its upper level, 1, a common point $\hat{\lambda}^*$ can be accepted by both parties. The inflation targets would completely converge and become a single value:

$$\hat{\pi}^{B*} = \pi^* - \hat{\lambda}^* y^*; \tag{51}$$

and the economy would be improved to a fully cooperative equilibrium:

$$\begin{gathered} E(\hat{\pi}^*) = \pi^* \qquad E(\hat{y}^*) = 0; \\ \operatorname{var}(\hat{\pi}^*) = \left(\frac{\hat{\lambda}^*}{1+\hat{\lambda}^*}\right)^2 \sigma_\varepsilon^2; \\ \operatorname{var}(\hat{y}^*) = \frac{1}{(1+\hat{\lambda}^*)^2} \sigma_\varepsilon^2. \end{gathered} \tag{52}$$

This equilibrium differs from the equilibrium reached by the fully independent central bank (23) in terms of different values of $\hat{\lambda}^*$ and $\tilde{\lambda}$. As discussed by Alesina and Gatti (1995), $\tilde{\lambda}$ should be smaller than both parameters $\lambda^D$ and $\lambda^R$. However, the parameter under the inflation target regime $\hat{\lambda}^*$ is in between $\lambda^D$ and $\lambda^R$. The variance of inflation under the inflation target regime $\operatorname{var}(\hat{\pi}^*)$ would be larger than that under the Rogoff fully independent central bank $\operatorname{var}(\tilde{\pi})$, but the output variance under the inflation target regime $\operatorname{var}(\hat{y}^*)$ would be smaller than that under the Rogoff fully independent central bank $\operatorname{var}(\tilde{y})$.

# 5 Electoral Uncertainty with Different Desired Inflation Rates

Now we consider a more general case where the two parties have different desired rates inflation, $\pi^{*D}$ for party D and $\pi^{*R}$ for party R.[3] Since we have assumed that the party R is more concerned about inflation than output, we here assume that the inflation rate desired by party R; $\pi^{*R}$; is smaller than that by party D; $\pi^{*D}$: In order to avoid negative targets, we further assume that the desired inflation rates are all positive. By simply repeating the calculations performed in the previous sections, we can obtain the equilibria under different policy regimes.

## 5.1 Equilibrium under Commitment without Electoral Uncertainty

The equilibrium under commitment without electoral uncertainty can then be described by

$$\bar{\pi}^D = \pi^{*D} - \frac{\lambda^D}{1+\lambda^D}\varepsilon; \tag{53}$$

$$\bar{\pi}^R = \pi^{*R} - \frac{\lambda^R}{1+\lambda^R}\varepsilon; \tag{54}$$

$$E(\bar{\pi}) = P\pi^{*D} + (1-P)\pi^{*R}; \tag{55}$$

$$\mathrm{var}(\bar{\pi}) = P(1-P)(\pi^{*D} - \pi^{*R})^2 + [P(\frac{\lambda^D}{1+\lambda^D})^2 + (1-P)(\frac{\lambda^R}{1+\lambda^R})^2]\sigma_\varepsilon^2; \tag{56}$$

and

$$\bar{y}^D = \frac{1}{1+\lambda^D}\varepsilon; \tag{57}$$

$$\bar{y}^R = \frac{1}{1+\lambda^R}\varepsilon; \tag{58}$$

$$E(\bar{y}) = 0; \tag{59}$$

$$\mathrm{var}(\bar{y}) = [\frac{P}{(1+\lambda^D)^2} + \frac{1-P}{(1+\lambda^R)^2}]\sigma_\varepsilon^2: \tag{60}$$

There is a new term $P(1-P)(\pi^{*D} - \pi^{*R})^2$ in the variance of inflation. If the difference between the two parties with regard to the desired rate inflation is large, the variance of

[3] The restriction that the desired output level $y^*$ is the same across the parties can be relaxed as well. However, it can be shown that this only complicates the expressions without affecting the results.

inflation would be large as well. However, the difference would not have any effect on the variance of output.

## 5.2 Equilibrium under Discretion with Electoral Uncertainty

The equilibrium under discretion with electoral uncertainty becomes

$$\pi^D = \frac{(1+\theta^R P)\pi^{*D} + \theta^D(1-P)\pi^{*R}}{1+\theta^D(1-P)+\theta^R P} + \frac{\theta^D(1+\theta^R)}{1+\theta^D(1-P)+\theta^R P}y^* - \frac{\theta^D}{1+\theta^D}\varepsilon; \tag{61}$$

$$\pi^R = \frac{\theta^R P\pi^{*D} + [1+\theta^D(1-P)]\pi^{*R}}{1+\theta^D(1-P)+\theta^R P} + \frac{\theta^R(1+\theta^D)}{1+\theta^D(1-P)+\theta^R P}y^* - \frac{\theta^R}{1+\theta^R}\varepsilon; \tag{62}$$

$$E(\pi)(=\pi^e) = \frac{(1+\theta^R)P\pi^{*D}+(1+\theta^D)(1-P)\pi^{*R}}{1+\theta^D(1-P)+\theta^R P} + \frac{\theta^R(1+\theta^D)+P(\theta^D-\theta^R)}{1+\theta^D(1-P)+\theta^R P}y^*; \tag{63}$$

$$Var(\pi) = \frac{P(1-P)[(\pi^{*D}-\pi^{*R})+(\theta^D-\theta^R)y^*]^2}{[1+\theta^D(1-P)+\theta^R P]^2} + [P(\frac{\theta^D}{1+\theta^D})^2 + (1-P)(\frac{\theta^R}{1+\theta^R})^2]\sigma_\varepsilon^2; \tag{64}$$

and

$$y^D = \frac{(1-P)(\pi^{*D}-\pi^{*R})}{1+\theta^D(1-P)+\theta^R P} + \frac{(1-P)(\theta^D-\theta^R)}{1+\theta^D(1-P)+\theta^R P}y^* + \frac{1}{1+\theta^D}\varepsilon; \tag{65}$$

$$y^R = -\frac{P(\pi^{*D}-\pi^{*R})}{1+\theta^D(1-P)+\theta^R P} - \frac{P(\theta^D-\theta^R)}{1+\theta^D(1-P)+\theta^R P}y^* + \frac{1}{1+\theta^R}\varepsilon; \tag{66}$$

$$E(y) = PE(y^D) + (1-P)E(y^R) = 0; \tag{67}$$

$$Var(y) = \frac{P(1-P)[(\pi^{*D}-\pi^{*R})+(\theta^D-\theta^R)y^*]^2}{[1+\theta^D(1-P)+\theta^R P]^2} + [\frac{P}{(1+\theta^D)^2} + \frac{(1-P)}{(1+\theta^R)^2}]\sigma_\varepsilon^2: \tag{68}$$

The politically induced variance, $\frac{P(1-P)[(\pi^{*D}-\pi^{*R})+(\theta^D-\theta^R)y^*]^2}{[1+\theta^D(1-P)+\theta^R P]^2}$, appears in the variances of both inflation and output. One interesting feature is that this term could be smaller than under commitment without electoral uncertainty, $P(1-P)(\pi^{*D}-\pi^{*R})^2$; if the difference in the desired rate of inflation is dominant. In other words, under the discretionary regime with electoral uncertainty, the variance of output could be larger, but the variance of inflation could be smaller compared with the variances under the commitment regime.

## 5.3 Optimal Inflation Targets and Inflation Contracts

If the inflation target regime is introduced into the economy, the optimal inflation target can be determined:

$$\boldsymbol{\pi}^{DB} = \pi^{*D} + (1-P)\theta^D(\pi^{*D}-\pi^{*R}) - \theta^D y^*; \tag{69}$$

or

$$\boldsymbol{\pi}^{RB} = \pi^{*R} - P\theta^R(\pi^{*D}-\pi^{*R}) - \theta^R y^*: \tag{70}$$

Therefore the optimal inflation target depends on the difference in the desired rates of inflation.

An analogous argument holds for the optimal determined inflation contract:

$$f^D = \lambda^D y^* - \lambda^D (1 - P)(\pi^{*D} - \pi^{*R}), \tag{71}$$

or

$$f^R = \lambda^R y^* + \lambda^R P(\pi^{*D} - \pi^{*R}). \tag{72}$$

The equilibrium under both regimes can be expressed as

$$\hat{\pi}^D = \pi^{*D} - \frac{\lambda^D}{1 + \lambda^D}\varepsilon, \tag{73}$$

$$\hat{\pi}^R = \pi^{*R} - \frac{\lambda^R}{1 + \lambda^R}\varepsilon, \tag{74}$$

$$E(\hat{\pi})(= \hat{\pi}^e) = P\pi^{*D} + (1 - P)\pi^{*R}, \tag{75}$$

$$Var(\hat{\pi}) = P(1 - P)(\pi^{*D} - \pi^{*R})^2 + [\tfrac{P(\lambda^D)^2}{(1+\lambda^D)^2} + \tfrac{(1-P)(\lambda^R)^2}{(1+\lambda^R)^2}]\sigma_\varepsilon^2 , \tag{76}$$

and

$$\hat{y}^D = (1 - P)(\pi^{*D} - \pi^{*R}) + \frac{1}{1 + \lambda^D}\varepsilon, \tag{77}$$

$$\hat{y}^R = -P(\pi^{*D} - \pi^{*R}) + \frac{1}{1 + \lambda^R}\varepsilon, \tag{78}$$

$$E(\hat{y}) = PE(\hat{y}^D) + (1 - P)E(\hat{y}^R) = 0, \tag{79}$$

$$Var(\hat{y}) = P(1 - P)(\pi^{*D} - \pi^{*R})^2 + [\frac{P}{(1 + \lambda^D)^2} + \frac{(1 - P)}{(1 + \lambda^R)^2}]\sigma_\varepsilon^2. \tag{80}$$

The inflation target and the inflation contract can transfer, but not necessarily improve, the economy to the equilibrium under commitment without electoral uncertainty except for an extra term $P(1 - P)(\pi^{*D} - \pi^{*R})^2$ in the variance of output. Since the inflation targets and the inflation contracts are equivalent, we will focus in the discussion simply on an inflation target regime from now on.

## 5.4 Disinflation by Adopting an Inflation Target Regime

By comparing (63) and (75), we find that inflation is not necessarily to be reduced by adopting the an optimal inflation target regime. However, we are particularly interested in the situation where the inflation target can reduce inflation. Therefore we consider the case where

$$E(\hat{\pi}) - E(\pi) < 0. \tag{81}$$

This requires that the difference between the desired rates of inflation the two parties is not large:

$$\pi^{*D} - \pi^{*R} \leq \Psi y^*, \tag{82}$$

where $\Psi = \frac{\lambda^R(1+\lambda^D)+P(\lambda^D-\lambda^R)}{P(1-P)(\lambda^D-\lambda^R)} > 1$. In other words, if the difference $\pi^{*D} - \pi^{*R}$ is large enough, adopting an inflation target regime may not be a suitable strategy for reducing inflation. We also notice that $\frac{\partial \Psi}{\partial(\lambda^D-\lambda^R)} = -\frac{\lambda^{R2}+\lambda^D(1+\lambda^D-\lambda^R)}{P(1-P)(\lambda^D-\lambda^R)^2} < 0$. Thus, when the economy has a smaller difference in the preferences $(\lambda^D - \lambda^R)$, a larger difference with regard to the desired rate of inflation will be allowed. Since there is a convergence of preferences when the game is repeated[4], condition (82) could cover most situations of the economy in a framework of repeated game. In other words, the following result will hold for almost any value of the difference $\pi^{*D} - \pi^{*R}$, if we consider the game as a repeated one and the discount rate $\beta$ is fairly large.

In any case, if the condition (81) holds, inflation can be reduced by the inflation target. The question is then, what are the effects of the inflation targets adopted as a new monetary policy regime on the second moments of the inflation and the output. We observe that $var(\pi) = var(y)$ and $var(\hat{\pi}) = var(\hat{y})$, so we only consider the output. The gain or loss in the output variance can be calculated as follows:

$$var(\hat{y}) - var(y) = \frac{P(1-P)(-\Phi_1)\Phi_2}{[1+\lambda^D(1-P)+\lambda^R P]^2}, \tag{83}$$

where $\Phi_1 = (\lambda^D - \lambda^R)y^* - (\pi^{*D} - \pi^{*R})[\lambda^D(1-P) + \lambda^R P]$, and $\Phi_2 = (\lambda^D - \lambda^R)y^* + (\pi^{*D} - \pi^{*R})[2 + \lambda^D(1-P) + \lambda^R P]$. Thus the sign of $(var(\hat{y}) - var(y))$ depends on the sign of $-\Phi_1$. It can be identified that $-\Phi_1$ is a monotonically increased function of the difference in desired rates of inflation, namely, $\frac{\partial(-\Phi_1)}{\partial(\pi^{*D}-\pi^{*R})} > 0$. We here consider two extremes, where $\pi^{*D} = \pi^{*R}$, and where $(\pi^{*D} - \pi^{*R})$ takes its upper limit $\Psi y^*$ from condition (82). It

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[4] The convergence results obtained in the last section could apply in the case where the uncertainty is also due to the difference in the desired rates of inflation. This is because the choice of optimal convergence preferences is independent of the desired rates of inflation. The constant terms in the one-period expected loss functions become $\hat{\Phi}^D = \frac{\lambda^D[(1-P)(\pi^{*D}-\pi^{*R})-y^*]^2}{2}$ and $\hat{\Phi}^R = \frac{\lambda^R[P(\pi^{*D}-\pi^{*R})+y^*]^2}{2}$ under both the inflation target regime and the inflation contract regime.

can easily be shown that when $\pi^{*D} = \pi^{*R}$; var($\hat{y}$) < var(y). On the other hand, when $\pi^{*D} - \pi^{*R} = \alpha y^{*}$; var($\hat{y}$) > var(y). This result indicates that when the difference in the desired rates of inflation is dominant, the variances of inflation and output might increase once an inflation target regime is adopted.

Consequently, we show here a case of reduced inflation concurrently with increased variances of inflation and output. This result is in contrast to that found in an economy without different desired rates of inflation. Our theoretical finding here is consistent with some empirical results. Iscan and Xu (1997) show that the velocity of inflation in Canada has increased since Canada adopted an inflation target regime. Debelle (1997) demonstrates that the variability of output in countries that have adopted the inflation targets has increased, even though inflation has been reduced.

# 6 Discussion

It has been suggested that inflation contracts and inflation targets are to be able to eliminate the inflation bias (Walsh (1995), Persson and Tabellini (1993), and Svensson (1997)). The advantage of such regimes is that they remove the inflation bias without creating a higher variance of output, which can not be avoided under the institution of Rogoff conservative central bank (Rogoff (1985)). In this paper, we first study how inflation contracts and inflation targets work when there is electoral uncertainty caused by the parties' different preferences. We show that inflation contracts and inflation targets are able to eliminate both the inflation bias and the politically induced parts of the variance of inflation and the variance of output. Moreover, inflation contracts and inflation targets do not rely on cooperation between the two parties, which is however required by the fully independent central bank, as suggested by Alesina and Gatti (1995). Nevertheless, the inflation contract and the inflation target may not remove all the fluctuations in the economy. Cooperation could, at least, lead the economy to an equilibrium with policy convergence. If a fully cooperative equilibrium exists, the cooperation parameter $\lambda^{*}$ would lie in between the two individual preferences. This is in contrast to the fully independent central bank, for which the parameter $\tilde{\lambda}$ is smaller than both individual preferences. We further extend the simple setting by allowing differences in the desired rates of inflation to affect the economy. We find that the inflation target might possibly reduce inflation but create higher variances of inflation and output.

Debelle (1997) argues that most countries that have adopted an inflation target have experienced unsatisfactory monetary targeting or a fixed exchange rate. One of the main reasons for adopting an inflation target is to enhance the credibility of the monetary policy. The theoretical finding here indicates that the inflation target could be sufficiently powerful to reduce the inflation without causing higher output variability, if the political risk is caused by different preferences. However, if the political uncertainty is due to different desired rates of inflation, the inflation target would probably lead to higher output variability, even though inflation may still be reduced. In other words, some other means is needed to enhance the credibility of monetary policy. One way is to limit the individual parties' influence on the central bank's desired rate of inflation, i.e., to increase the independence of the central bank. Suppose that the central bank's desired inflation is $\pi^{*CB} = (1 - \theta)\pi^{*} + \theta\pi^{*P}$; where $\pi^{*P}$ is the desired rate of inflation delegated by the winning party with a value of either $\pi^{*D}$ or $\pi^{*R}$: If we normalize that $\pi^{*} = 0$ for simplicity, the politically induced variance has been reduced to $\theta P(1 - P)(\pi^{*D} - \pi^{*R})^2$ under both the inflation contract and the inflation target regimes.

Alternatively, a central bank with a multi-term central banker can be established. If it is only possible to delegate monetary policy to the newly appointed central banker, the political uncertainty can be completely removed in the period(s) of reappointment under both the inflation contract regime and the inflation target regime. In other words, from the viewpoint of monetary policy decisions, the probability $P$ is either 1 or 0 depending on the type of reappointed central banker in the period(s) of reappointment. One weakness of this kind of model is that the optimal term length is always infinite.

In order to avoid the infinite term length, Waller and Walsh (1996) have introduced persistent but infrequent shifts in the long-run socially desired rate of inflation in an economy associated with a random process of desired rate of inflation and with an infinite number of sectors. In their model, the central bank is the Rogoff conservative one, and its preference is partly reflected by that of the median voter (the government). They show that a central banker with a finite multi-term would be helpful in reducing the political uncertainty. Lin (1997) further extends the study to the inflation contract and the inflation target regimes and finds that all kinds of inflation contracts and inflation targets are able to remove the inflation bias. However, different regimes give different outcomes. The constant inflation target achieves the best outcome: it completely eliminates political uncertainty. The constant inflation contract has no effect on the political uncertainty. However, both regimes are less plausible, since the delegation should be based on the result of the election (the state of the shock). Rational agents would expect the inflation contract and the inflation target to be contingent on the desired inflation rate of the realized median voter. Therefore, the constant contract and the constant target regimes only reallocate the credibility problem rather than solving it. In any case, the optimal term lengths of the central bankers under both regimes are always one period. On the other hand, the state-contingent inflation contract and the state-contingent inflation target have the same economic consequence: the inflation bias is completely removed, but the effects of the political uncertainty increase, resulting in higher output variability. We conclude that, under both the state-contingent inflation contract and the state-contingent inflation target regimes, the multi-term central banker would be helpful in reducing the politically induced variability.

The setting is extremely simple in the present paper and can be further extended. The probabilities of individual parties winning the election are assumed to be constant in our study. However, as suggested by Alesina (1988), the probability could depend on the outcome of the policy. In other words, the economic outcome could increase or decrease the probability of the incumbent party being reelected. It is interesting to see how the electoral uncertainty affects the economic outcomes under the inflation contract and the inflation target regimes.

# Appendix:

## A Existence of Convergence Solution $(\hat{\lambda}^{R*}, \hat{\lambda}^{D*})$

In this appendix, we prove that there is always a convergence solution $\lambda^R < \hat{\lambda}^{R*} \leq \hat{\lambda}^{D*} < \lambda^D$ in an infinitely repeated game. The cooperation on $(\hat{\lambda}^R, \hat{\lambda}^D)$ is determined before the election in each period.

We first show that it is possible to have a pair of parameters $(\hat{\lambda}^R, \hat{\lambda}^D)$, where $\hat{\lambda}^R > \lambda^R$ and $\hat{\lambda}^D < \lambda^D$, which fulfills the individual rationality condition, i.e., it would result in reductions of both losses.

The total expected loss for party D can be expressed in terms of the indirect loss function:

$$V^D = \frac{1}{1-\beta}[PL^D(\widehat{\theta}^D) + (1-P)L^D(\widehat{\theta}^R)];$$

where $L^D(\widehat{\theta})$ is the one-period indirect expected loss function associated with party D with a shape of

$$L^D(\widehat{\theta}) = \frac{1}{2}\frac{(\widehat{\theta})^2 + \theta^D\sigma_\varepsilon^2}{(1+\widehat{\theta})^2} + C^D;$$

where $\widehat{\theta}$ is a control variable and the constant $C^D = \frac{\theta^{D\dagger *2}}{2}$. $L^D(\widehat{\theta})$ is an increased function of $\widehat{\theta}$ when $\widehat{\theta} > \theta^D$; but a decreased function of $\widehat{\theta}$ when $\widehat{\theta} < \theta^D$. If $\widehat{\theta} = \theta^D$, $\frac{\partial L^D(\widehat{\theta})}{\partial\widehat{\theta}} = 0$. Furthermore, when $\widehat{\theta} = \theta^D$, $\frac{\partial^2 L^D(\widehat{\theta})}{\partial\widehat{\theta}^2} = \frac{1}{(1+\theta^D)^3} > 0$. Therefore $L^D(\widehat{\theta})$ is a U-shape with a global minimum at the point of $\theta^D$.

The change of $V^D$ then follows

$$dV^D = \frac{1}{1-\beta}\left[\frac{P(\widehat{\theta}^D - \theta^D)}{(1+\widehat{\theta}^D)^3}d\widehat{\theta}^D + \frac{(1-P)(\widehat{\theta}^R - \theta^D)}{(1+\widehat{\theta}^R)^3}d\widehat{\theta}^R\right]. \tag{A1}$$

We only consider the case of $\widehat{\theta}^R > \theta^R$ and $\widehat{\theta}^D < \theta^D$. This is equivalent to $d\widehat{\theta}^D < 0$ and $d\widehat{\theta}^R > 0$. The net sign of $dV^D$ is unclear, since in the square brackets in (A1), the first term is positive but the second term is negative.

An analogous argument holds for party R. The expected loss function is

$$V^R = \frac{1}{1-\beta}[PL^R(\widehat{\theta}^D) + (1-P)L^R(\widehat{\theta}^R)];$$

where $L^R(\widehat{\theta})$ is the one-period indirect loss function associated with party R with a shape of

$$L^R(\widehat{\theta}) = \frac{1}{2}\frac{(\widehat{\theta})^2 + \theta^R\sigma_\varepsilon^2}{(1+\widehat{\theta})^2} + C^R;$$

where $\widehat{\theta}$ is a control variable and the constant $C^R = \frac{\theta^{R\dagger *2}}{2}$. $L^R(\widehat{\theta})$ is a U-shape as well: a decreased function when $\widehat{\theta} < \theta^R$; but an increased function when $\widehat{\theta} > \theta^R$. Furthermore, $\frac{\partial L^R(\widehat{\theta})}{\partial\widehat{\theta}} = 0$ and $\frac{\partial^2 L^R(\widehat{\theta})}{\partial\widehat{\theta}^2} = \frac{1}{(1+\theta^R)^3} > 0$, when $\widehat{\theta} = \theta^R$. Therefore when $\widehat{\theta} = \theta^R$, $L^R(\widehat{\theta})$ reaches the global minimum.

The change of $V^R$ then follows

$$dV^R = \frac{1}{1-\beta}\left[\frac{P(\widehat{\theta}^D - \theta^R)}{(1+\widehat{\theta}^D)^3}d\widehat{\theta}^D + \frac{(1-P)(\widehat{\theta}^R - \theta^R)}{(1+\widehat{\theta}^R)^3}d\widehat{\theta}^R\right]. \tag{A2}$$

In the square brackets in (A2), the first term is negative because $\widehat{\theta}^D - \theta^R > 0$; but the second term is positive because $\widehat{\theta}^R - \theta^R > 0$. The sign of (A2) is therefore unclear as well.

Now we suppose that the changes in the expected loss functions are in the same path, i.e. $dV^D = dV^R$. So we have the following relationship from (A1) and (A2):

$$\frac{d\hat{\lambda}^D}{d\hat{\lambda}^R} = -\frac{(1-P)(1+\hat{\lambda}^D)^3}{P(1+\hat{\lambda}^R)^3}. \tag{A3}$$

By substituting (A3) into (A1) and (A2), we have

$$dV^D = dV^R = -\frac{(1-P)(\hat{\lambda}^D - \hat{\lambda}^R)}{2(1-\beta)} d\hat{\lambda}^R < 0. \tag{A4}$$

Therefore, if the changes of $\hat{\lambda}^D$ and $\hat{\lambda}^R$ fulfill condition (A3), the total expected loss functions for both parties can be reduced as far as $\hat{\lambda}^D > \hat{\lambda}^R$.

From the relationship (A3), we define that

$$\delta = \varphi\theta, \tag{A5}$$

where $\varphi = \frac{(1-P)(1+\lambda^D)^3}{P(1+\lambda^R)^3} > 0$. (A5) represents the relative changes of $\hat{\lambda}^D$ and $\hat{\lambda}^R$ in the neighborhood of $(\lambda^D, \lambda^R)$.

Secondly, we show that there is always a pair of parameters $(\hat{\lambda}^{D*}, \hat{\lambda}^{R*})$, which is able to improve the welfare, and, at the same time, fulfills the subgame perfection conditions (49) and (50). Those conditions can be rewritten as the following:

$$[1-\beta(1-P)]L^D(\hat{\lambda}^D) + \beta(1-P)L^D(\hat{\lambda}^R) \leq [1-\beta(1-P)]L^D(\lambda^D) + \beta(1-P)L^D(\lambda^R), \tag{A6}$$

and

$$\beta P L^R(\hat{\lambda}^D) + (1-\beta P)L^R(\hat{\lambda}^R) \leq \beta P L^R(\lambda^D) + (1-\beta P)L^R(\lambda^R). \tag{A7}$$

We define that

$$\Delta^D(\hat{\lambda}^D, \hat{\lambda}^R) = [1-\beta(1-P)]L^D(\hat{\lambda}^D) + \beta(1-P)L^D(\hat{\lambda}^R), \tag{A8}$$

and

$$\Delta^R(\hat{\lambda}^D, \hat{\lambda}^R) = \beta P L^R(\hat{\lambda}^D) + (1-\beta P)L^R(\hat{\lambda}^R). \tag{A9}$$

Therefore the subgame-perfect conditions can be expressed as $\Delta^D(\hat{\lambda}^D, \hat{\lambda}^R) \leq \Delta^D(\lambda^D, \lambda^R)$ and $\Delta^R(\hat{\lambda}^D, \hat{\lambda}^R) \leq \Delta^R(\lambda^D, \lambda^R)$.

We now show that there is always a pair of parameters $(\hat{\lambda}^{D*}, \hat{\lambda}^{R*})$ fulfilling the subgame-perfect conditions (A6) and (A7) for any discount rate $\beta$.

From (A8) and (A9) we have

$$d\Delta^D(\hat\lambda^D,\hat\lambda^R) = \frac{[1-\beta(1-P)](\hat\lambda^D-\lambda^D)}{(1+\hat\lambda^D)^3}d\hat\lambda^D + \frac{\beta(1-P)(\hat\lambda^R-\lambda^D)}{(1+\hat\lambda^R)^3}d\hat\lambda^R, \tag{A10}$$

$$d\Delta^R(\hat\lambda^D,\hat\lambda^R) = \frac{\beta P(\hat\lambda^D-\lambda^R)}{(1+\hat\lambda^D)^3}d\hat\lambda^D + \frac{(1-\beta P)(\hat\lambda^R-\lambda^R)}{(1+\hat\lambda^R)^3}d\hat\lambda^R. \tag{A11}$$

By substituting (A3) into both (A10) and (A11), we obtain that

$$d\Delta^D(\hat\lambda^D,\hat\lambda^R) = \frac{-[1-\beta(1-P)](\hat\lambda^D-\lambda^D)+\beta P(\hat\lambda^R-\lambda^D)}{P(1+\hat\lambda^R)^3}(1-P)d\hat\lambda^R, \tag{A12}$$

$$d\Delta^R(\hat\lambda^D,\hat\lambda^R) = \frac{-\beta(1-P)(\hat\lambda^D-\lambda^R)+(1-\beta P)(\hat\lambda^R-\lambda^R)}{(1+\hat\lambda^R)^3}d\hat\lambda^R. \tag{A13}$$

According (A5), we can rewrite (A12) and (A13) by defining that $\hat\lambda^D = \lambda^D-\delta$, and $\hat\lambda^R = \lambda^R+\frac{\delta}{\tau}$:

$$d\Delta^D(\delta) = \frac{[1-\beta(1-P)]\delta-\beta P[(\lambda^D-\lambda^R)-\frac{\delta}{\tau}]}{P(1+\hat\lambda^R)^3}(1-P)d\hat\lambda^R, \tag{A12'}$$

$$d\Delta^R(\delta) = \frac{-\beta(1-P)[(\lambda^D-\lambda^R)-\delta]+(1-\beta P)\frac{\delta}{\tau}}{(1+\hat\lambda^R)^3}d\hat\lambda^R. \tag{A13'}$$

In order to fulfill the subgame-perfect conditions, we need both $d\Delta^D(\delta) \le 0$ and $d\Delta^R(\delta) \le 0$. The negative numerators in (A12') and (A13') imply that

$$\delta \le \frac{\beta P(\lambda^D-\lambda^R)}{1-\beta(1-P)+\frac{\beta P}{\tau}}, \tag{A14}$$

and

$$\delta \le \frac{\beta(1-P)(\lambda^D-\lambda^R)}{\beta(1-P)+\frac{1-\beta P}{\tau}}. \tag{A15}$$

Therefore for any discount rate $\beta > 0$, a positive constant $\delta^*$ fulfilling conditions (A14) and (A15) can be found, and hence a constant $\theta^*$, which satisfies condition (A5). Furthermore, since $\hat\lambda^{D*} = \lambda^D-\delta^*$ and $\hat\lambda^{R*} = \lambda^R+\theta^*$, $d\Delta^D(\hat\lambda^{D*},\hat\lambda^{R*}) < 0$ and $d\Delta^R(\hat\lambda^{D*},\hat\lambda^{R*}) \le 0$. Hence, $\Delta^D(\hat\lambda^{D*},\hat\lambda^{R*}) \le \Delta^D(\lambda^D,\lambda^R)$ and $\Delta^R(\hat\lambda^{D*},\hat\lambda^{R*}) \le \Delta^R(\lambda^D,\lambda^R)$. Thus, $(\hat\lambda^{D*},\hat\lambda^{R*})$ is a subgame-perfect equilibrium and can lead to both parties simultaneously being better off (A4).

Finally, we carry out the comparative statics study. The right hand sides of (A14) and (A15) are the increased functions of the discount rate $\beta$:

$$\partial\frac{\beta P(\lambda^D-\lambda^R)}{1-\beta(1-P)+\frac{\beta P}{\tau}}/\partial\beta = \frac{P(\lambda^D-\lambda^R)}{[1-\beta(1-P)+\frac{\beta P}{\tau}]^2} > 0$$

for the right hand side of (A14), and

$$\partial\frac{\beta(1-P)(\lambda^D-\lambda^R)}{\beta(1-P)+\frac{1-\beta P}{\varphi}}\Big/\partial\beta=\frac{(1-P)(\lambda^D-\lambda^R)}{\varphi[\beta(1-P)+\frac{1-\beta P}{\varphi}]^2}>0$$

for the right hand side of (A15). Therefore we should have larger values of $\delta^*$ and $\theta^*$: This implies that the policy pair $\hat{\lambda}^{D*}$ and $\hat{\lambda}^{R*}$ would move close together, i.e., there is more chance of a policy convergence, resulting in smaller economic fluctuations.

When $\beta \to 1$; we know from (A14) and (A15) that $\delta \to \frac{\varphi}{1+\varphi}(\lambda^D-\lambda^R)$; and therefore $\theta \to \frac{1}{1+\varphi}(\lambda^D-\lambda^R)$: Hence $\delta+\theta \to (\lambda^D-\lambda^R)$: In other words, we have full convergence.

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