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Discussion Paper Series 2002.09

December 2002

* The authors thank Nissan Liviatan, Amit Friedman and Yoav Friedmann for their useful suggestions

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Roni Frish and Nir Klein

Abstract

This paper compares a strict inflation target regime and a conservative central bank regime in order to determine the monetary regime appropriate for a disinflation process. The analysis shows that in a two-period model, in which policymakers face given first period inflationary expectations, a strict inflation target could be preferred to the appointment of a conservative central banker who acts in a discretionary manner. The result differs from that of Roggof (1985), who assumed rational expectations and concluded that a conservative central banker is always preferred. The disadvantage of the conservative central banker derived from its tendency to accelerate the disinflation process compared to the desired rate from the social welfare point of view.

[1]The authors thank Nissan Liviatan, Amit Friedman and Yoav Friedmann for their useful suggestions.

1. Introduction

It is well known that when policymakers conduct a monetary policy with no commitment (discretion), the rate of inflation tends to rise above the socially optimal level [Kydland and Prescott (1977), Barro and Gordon (1983)]. This problem arises since policymakers face a tradeoff between employment and inflation, which exists only after nominal wage contracts have been set. Hence the policymakers' optimal inflation is different before and after that event (time inconsistency). Under rational expectations the time inconsistency leads to "inflationary bias", which is high inflation, but not surprisingly high; as a result the rate of employment would not exceed its natural level.

There are two main approaches to reducing the inflationary bias. The first one is a commitment to a strict inflation target (IT) before inflationary expectations are embodied into wage contracts; while the second approach is to appoint a conservative central bank governor (CCB) who is more concerned about price stability than society as a whole. Unlike the strict inflation target, a conservative CB determines its optimal monetary policy by discretion. This paper analyzes the government's problem in determining the appropriate regime between the alternatives above. In particular, the paper examines the costs of each regime in a disinflation process.

In the first alternative, the government, which has a prior reputation for commitment, determines a strict inflation target for each period. This regime enables the government to eliminate the inflationary bias but not to offset supply shocks. The ability to eliminate the inflationary bias depends, of course, on the initial reputation of the policymaker. This relationship between the policymaker's reputation and her preferred policy is compatible with the findings of Cukierman and Liviatan (1991) who presented a two-period model of incomplete information regarding the policymaker's type. The policymakers differ in their ability to commit to their promises (inflation targets) such that the dependable type is truly committed to the inflation target she announces, while the undependable chooses her policy according to what is expedient ex-post. They found that under incomplete information, the dependable type partially accommodates her policy according to inflationary expectations in order to prevent deep recession.[2] Their conclusions are in contrast to Vickers (1986) who found that in a framework in which the policymakers differ in their inflation aversion, the more inflation averse type underinflates in order to separate herself.

The inflation target regime, in this paper, differs from that of Cukierman and Liviatan (1991) in two main aspects. First, we use quadratic loss function and supply shocks which policymakers observe after they announce the inflation target but before they choose their actual inflation. Thus, the weak policymaker, who is motivated to stabilize output, is tempted to offset extreme fluctuations. Second, we treat inflationary expectations in the first period as exogenous in order to examine the cost of the disinflation process from the policymaker's point of view. One can interpret this assumption as an unpredictable change in the monetary regime. Therefore, the new policymaker faces given expectations, which have been embodied in the wage contracts. In addition, the use of the same exogenous expectations in both alternatives enables us to obtain a fair play comparison.

The second alternative for conducting monetary policy is to delegate authority to a conservative central banker, whose degree of conservatism is determined by the government at the beginning of the first period. This alternative is related to Rogoff (1985b), who was the first to analyze the issue of the optimal preferences of the central banker explicitly. By assuming that the welfare loss function is quadratic in both inflation and employment, the optimal degree of conservatism involves trading off some inflation volatility and inflation bias. On the one hand, a liberal central banker moderates output fluctuations by offsetting more supply shocks than does a conservative CB. On the other hand, this type of CB creates a higher inflationary bias than a conservative CB. Rogoff concluded that the optimal solution is that the government should appoint a central banker who places greater relative weight on the inflation objective than does society as a whole. In addition, Rogoff also noted that a conservative CB who cares only about inflation is not the optimal, since it does not offset any supply shocks

[2] Cukierman (2000) used Cukierman and Liviatan (1991) framework in order to show that under incomplete information, both policymakers choose more conservative policy plans; the dependable – in order to reveal herself, and the weak type – in order to improve her reputation.

fluctuations, and will obtain the same result as an IT regime with full reputation – zero inflation for any shock realization. Implicitly, one can infer from Rogoff's conclusions that the government will always prefer to appoint a conservative central banker rather than conduct an inflation target regime.

This paper differs from Rogoff's in two aspects. First, in the sequence of events and the number of periods: while the sequence of events in the second period is identical to that in Rogoff's model, the first period is different because nominal wage contracts have been signed prior to the government's decision. Under this assumption, the government takes inflationary expectations as given and chooses a more liberal CB to avoid a deep recession in the first period. The second aspect in which our work differs from Rogoff's is the assumption of incomplete information regarding the government's ability to maintain CB independence (unlike Rogoff, who assumes full reputation). As in Lohmann (1992), we assume that a weak government might override the CB policy for extreme supply shocks realization, but unlike her model we also assume a dependable type which is truly committed to maintaining CB independence. Another important difference between the two models is that in our model the cost of the government's overriding the CB is in terms of reputation lost, while in Lohmann's model it is a fixed cost that the government determines before it observes the supply shock realization.

The main conclusion of our work is that when the policymaker faces given expectations and cannot affect them, an inflation target regime could be preferred to a conservative CB[3]. In this case, appointing a conservative CB will lead to a sharp reduction in the inflation rate and to deep recession in the first period. Such recessions, which derive from an unexpected disinflation process, are often called sacrificed ratio. The higher the CB conservatism, the higher the gap between the actual sacrificed ratio and the desired one (from a social welfare point of view).

[3] We used partial reputation as a general case, since the dis-inflation process is characterized with a lack of credibility regarding the policymaker. As this work shows, the main result holds in both partial and full reputation.

From the comparative statics we found that IT regime is preferred when supply shock fluctuations are relatively low, while a conservative Central Bank is superior when supply shock fluctuations are relatively high. Unlike the variance effect, the rate of time preference has an ambiguous influence on the preferred regime. In very high and very low rates of time preference a CCB is superior even for very low supply shock fluctuations, while in the other cases, where the government cares about both the present and the future, a CCB could be inferior for low supply shock fluctuations. The impact of first period inflationary expectations is straightforward – the higher the first period inflationary expectations, the lower the IT loss relative to the loss in a CCB regime. In addition, an increase in the first period prior reputation, leads to IT advantage, because in this regime a prior reputation has a stronger effect on the second period inflationary expectations.

The paper is organized as follows. Section 2.1 describes the optimal policy under an inflation target regime. Section 2.2 characterizes the policy of a conservative CB and examines the optimal degree of conservatism chosen by the government. Section 3 compares CCB and IT regimes and analyzes the parameters that affect the government choice for both full and partial reputation cases. This is followed by concluding remarks.

2. The model

In this two-period model, the government would like to minimize its welfare loss. The government welfare loss function for each period can be presented as follows:

(1) $$V_t = \frac{1}{2}[(y_t - y_n) - k]^2 + \frac{1}{2}\pi_t^2, \qquad k > 0.$$

The loss function is quadratic and consists of two arguments, which are equal in their weights. The first argument reflects the desire to expand employment above the natural rate (y_n) by the positive parameter k (inflation bias motive), and the second argument reflects inflation aversion. The aim is to minimize both output and inflation fluctuations - inflation around zero, and output around y_n+k.

Aggregate output is given by a Lucas-type aggregate supply function of the form

(2) $$y_t = y_n + (\pi_t - \pi_t^e) + e_t, \qquad e \sim U(0, \sigma^2),$$

where π_t denotes actual inflation in period t, and π_t^e denotes inflationary expectations for the same period. The parameter – e - represents supply shocks, which are assumed to have a uniform distribution and zero mean.[4]

Eq. (2) can be motivated as arising from the presence of one-period nominal wage contracts, which are set at the beginning of each period according to the public's expectations regarding the rate of inflation. If actual inflation exceeds the expected rates, real wages will be eroded, and firms will expand employment. If actual inflation is lower than the rate expected, realized real wages will exceed the level expected and employment will be reduced.

Inserting Eq. (2) into Eq. (1) yields:

(3) $$V_t = \frac{1}{2}\left[\pi_t - \pi_t^e + e - k\right]^2 + \frac{1}{2}\pi_t^2 \ .$$

The government, which faces given inflationary expectations, has to decide between two alternatives. The first is to conduct a strict inflation targets regime, while the second is to appoint a conservative CB governor. In the first case, the government determines inflation

[4]We denote the upper and the lower boundaries of the uniform distribution as e_H and (-)e_H respectively; from the variance formula of the uniform distribution we obtain the following equality: $e_H = \sqrt{3\sigma^2}$.

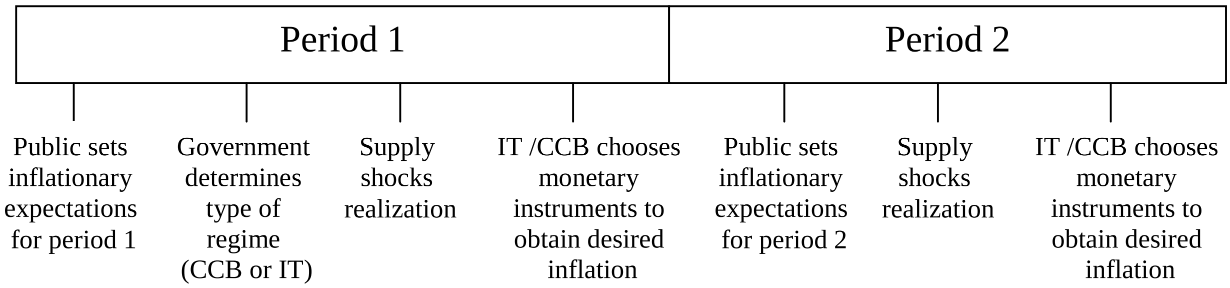
targets for both periods and the central bank has to carry them out. In the second case, the government chooses a Central Bank type from an infinite number of options, which differ from one another only by the weight they attribute to output relative to the inflation objective. The appointed governor will determine inflation for both periods according to her preferences.

There are two types of governments. The first type is the dependable type (D), which is truly committed to the declared policy, while the second type – the opportunistic or the weak type (W) - is not. In particular, in an inflation target regime a dependent government is truly committed to the inflation target, while in a conservative CB regime, the dependable type is committed to maintaining CB independence; hence the D type enables the CB to act according to its conservative preferences. In contrast to the dependable type, the opportunistic government is not truly committed to either an inflation target or to CB independence; therefore it chooses inflation according to what is expedient ex post. The public is unsure about the government type but has a prior reputation (P_1) that it is dependable. The prior reputation is updated after the first period realizations, and the posterior P_2 is used to form the second-period inflationary expectations.

Timing of events

As illustrated in Figure 1, the government chooses the monetary regime after inflationary expectations have been set. If an IT regime is chosen, the government has to announce an inflation target for the first period, which the CB has to achieve (for any supply shock magnitude). In the second period, the government announces an inflation target before the expectations are formed; hence the announcement could affect them (according to policymaker reputation). If a conservative CB has been chosen, the degree of its conservatism would be determined for both periods. This regime conducts its policy by discretion; hence the optimal inflation would be picked after the supply shocks are observed.

Figure 1: Timing of events in each period



2.1 Inflation Target Regime

The first case deals with a strict inflation target regime. In this regime, the government declares an inflation target (T) for each period. There are two types of government: the "Dependable"(D) type, which is truly committed to the declared inflation target, and the "Weak" (W) type, which chooses inflation according to what is expedient ex post.

2.1.1 Equilibrium in the second period

A weak government always announces the same inflation target as its dependable counterpart would have, otherwise it would reveal its nature at the beginning of this period. Since the weak type is not really committed to the target, and since this is the last period, it chooses its optimal inflation $\pi_{w,2}$ by minimizing the second period loss function [Eq. (3)]. This yields

(4) $$\frac{\partial V_2}{\partial \pi_2} = 0 \Rightarrow \pi^*_{w,2} = \frac{1}{2}(\pi^e_2 + k - e).$$

The inflation expectations, which in the second period embodied nominal wage contracts, will be the weighted average of the declared inflation target (T_2) and expected rate of inflation under the weak type.

(5) $$\pi^e_2 = p_2 T_2 + (1 - p_2)\frac{1}{2}(\pi^e_2 + k);$$

(5') $$\pi^e_2 = \frac{2T_2 p_2}{1 + p_2} + \frac{1 - p_2}{1 + p_2}k \quad .$$

The dependable government chooses the optimal target by minimizing the loss function [Eq. (3)] subject to the process of expectation formation in Eq. (5) and the dependability constraint $\pi_{d,2} = T_2$:

(6) $$\frac{\partial E(V)_2}{\partial \pi_{d,2}} = 0 \Rightarrow \pi^*_{d,2} = T^*_2 = \frac{1-p_2}{1+p_2^2} k .$$

Note that when the D type has full reputation (P_2=1), the inflation target falls to zero; in this case the inflation target eliminates the inflationary bias completely, but it does not offset the fluctuations in output resulting from the supply shocks.

Using the equilibrium strategies of each type [Eq. (4) - Eq. (6)], one can calculate the expected values of the second period loss function for both the weak and the dependable policymakers:

(7) $$E(V_{w,2}) = \left[\frac{k^2}{(1+p_2^2)^2} + \frac{1}{4}\sigma^2 \right];$$

(8) $$E(V_{d,2}) = \left[\frac{k^2}{(1+p_2^2)} + \frac{1}{2}\sigma^2 \right].$$

As can be seen, the higher the reputation in the second period (P_2), the higher the welfare of both policymakers.

2.1.2 Equilibrium in the first period

In the first period a **weak government** must take into account both the temporal and inter-temporal considerations. If it mimics [No Separation equilibrium (NS)] the dependable type by picking the inflation target, it will gain reputation in the second period; while a deviation from it in order to implement its myopic strategy [Separation equilibrium (S)] will expose its real type and reduce its second period welfare. The weak type picks its strategy after observing the supply shock. In case of a deviation from the inflation target, her myopic solution is -

(9) $$\pi_{w,1}(S) = \frac{1}{2}(\pi_1^e + k - e).$$

The expected value of both periods' loss function, which derived from the myopic strategy, is

(10) $$E[V_w(S)] = \frac{1}{4}(\pi_1^e + k - e)^2 + \delta(k^2 + \frac{1}{4}\sigma^2) ,$$

where δ is the discount factor. The expected value of both periods' loss function, which derived from obtaining the inflation target, is

(11) $$E[V_w(NS)] = \frac{1}{2}(T_1 - \pi_1^e + e - k)^2 + \frac{1}{2}T_1^2 + \delta\left[\frac{1}{(1+p_2^2)^2}k^2 + \frac{1}{4}\sigma^2\right].$$

From Eq. (10) and Eq. (11), we can infer the cases, which derive the pure strategies:

If $$\sqrt{1 - \frac{1}{\delta k^2}\left[T_1 - \frac{1}{2}(\pi_1^e + k - e)\right]^2} < \frac{1}{2},$$

a weak government will always choose to deviate from inflation target (separate equilibrium), hence by observing the inflation rate that is identical to the inflation target, the public can infer that the government is dependable [$P_2(\pi_1 = T_1) = 1$].

If $$\frac{1}{(1+p_1^2)} < \sqrt{1 - \frac{1}{\delta k^2}\left[T_1 - \frac{1}{2}(\pi_1^e + k - e)\right]^2},$$

a weak government will always choose to achieve the inflation target (pooling equilibrium), hence the public will not gain any new information regarding the government type even if it picks the inflation target [$P_2(\pi_1 = T_1) = P_1$].

The following case derives mixed strategies:

$$\frac{1}{(1+p_1^2)} > \sqrt{1 - \frac{1}{\delta k^2}\left[T_1 - \frac{1}{2}(\pi_1^e + k - e)\right]^2} > \frac{1}{2}.$$

Instead of choosing either T_1 or the myopic solution, a weak government may randomize between them. Let q_1 and $1-q_1$ be the probabilities assigned to T_1 and the myopic solution respectively. Since this strategy is common knowledge, by observing $\pi_1 = T_1$ the public remains unsure about the policymaker identity, and it updates its probability that the policymaker is dependable by means of Bayes' formula:

(12) $$P_2(\pi_1 = T_1) = \frac{p_1}{p_1 + (1-p_1)q_1}.$$

The weak government randomizes between T_1 and the myopic solution only if $P_2 = f(q_1)$ equalizes the utility between the separate and the pooling strategies:

(13) $$\sqrt{1-\frac{1}{\delta k^2}\left[T_1-\frac{1}{2}(\pi_1^e+k-e)\right]^2}=\frac{1}{(1+p_2^2)}=1-\frac{p_1^2}{[p_1+(1-p_1)q_1]^2+p_1^2}.$$

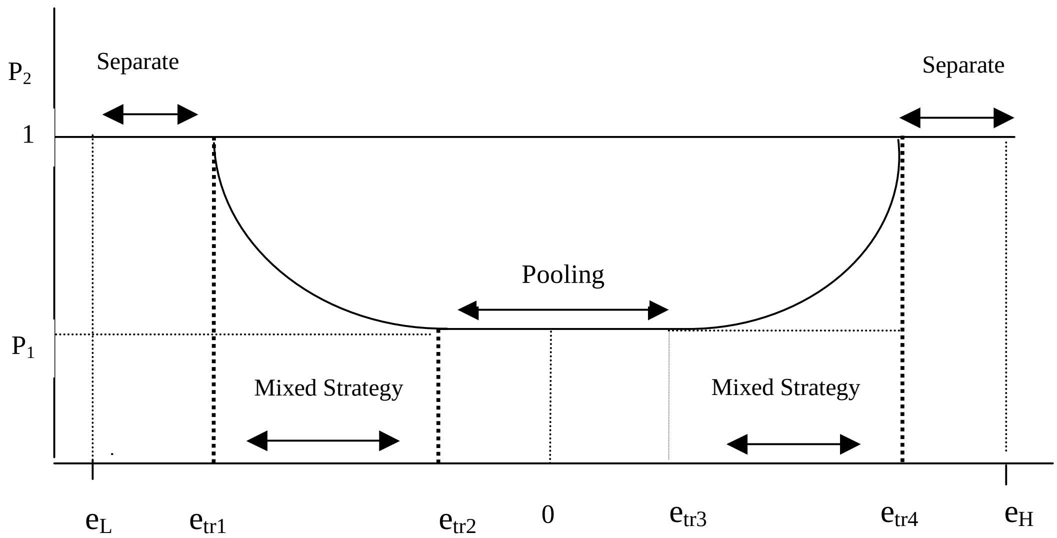
Eq. (13), describes the relation between the inflation target, the realization of supply shock and the second period reputation in the mixed strategy case. From this equation one can notice that the higher the distance between the inflation target and the myopic solution, the greater is the second period reputation.

To sum up, the reputation of the dependable type in the second period (P_2) is equal to 1 in the case of separate equilibrium, P_1 in the case of pooling equilibrium, and between P_1 and 1 in the case of mixed strategies equilibrium:

$$E(P_2)=1\cdot pr(Separate)+P_1\cdot pr(pooling)+f(q_1)\cdot\int f(q_1)dq_1 .$$

The supply shocks thresholds, which determines the probability of separate, non-separate and mixed strategy equilibrium for a given inflation target are described in appendix 1.A and presented in Figure 2 below.

Figure 2: The reputation updating process for any realization of supply shocks



The dependable government chooses a first-period inflation target in order to minimize its expected loss function in both periods; taking into account the dependability constraint $\pi_{d,1}=T_1$. Using Eq. (8), the expected value of the loss function from both periods could be written as follows:

(14) $$E(V)=\frac{1}{2}(T_1-\pi_1^e-k)^2+\frac{\sigma^2}{2}+\frac{T_1^2}{2}+\delta k^2E\left(\frac{1}{1+p_2^2}\right)+\frac{\delta}{2}\sigma^2.$$

By minimizing Eq. (14) with respect to T_1, one can obtain the optimal inflation target announced by the dependable type:

(15) $$\frac{\partial E(V)}{\partial T_1}=2T_1-\pi_1^e-k+\delta k^2\cdot\frac{\partial(1+p_2^2)^{-1}}{\partial T_1}=0 \;\Rightarrow\; T_1=\frac{1}{2}(\pi_1^e+k).$$

Since we assume uniform supply shock distribution, the government could not increase the probability of separation by changing the inflation target. On the one hand, if the government chooses a lower target, it will increase the probability of separation in the case of extreme negative shocks, but on the other hand, it will reduce the probability of separation for extreme positive shocks. Consequently, the total probability of separation would not change; i.e., the derivative of second-period reputation with respect to first-period inflation target will be equal to zero.

By inserting Eq. (15) into Eq. (14) one can obtain the expected loss of the dependable government:

(16) $$E(V)=\frac{1}{4}(\pi_1^e+k)^2+\frac{(1+\delta)\sigma^2}{2}+\delta k^2E\left(\frac{1}{1+p_2^2}\right).$$

Eq. (16) demonstrates the opposite effect of the supply shock variance on the expected loss of the dependable type. On the one hand, as the variance increases, the damage from output fluctuations increases, since the IT regime does not offset the supply shocks. On the other hand, a high variance increases the expected reputation, since the probability of separate equilibrium increases (the explicit solution for the second period expected reputation is described in Appendix 1.c). As expected, welfare decreases as the first-period inflationary expectations and the inflation bias motive (k) increase. In addition, since the expected reputation for the second period is increasing with prior reputation, the higher the latter, the lower its expected loss.

2.2 Independent central banker

The second case deals with the appointment of a conservative CB governor. The government chooses its optimal governor in terms of conservatism, i.e., the weight she gives employment relative to inflation. The potential governor's loss function for each period can be describe as follows:

(17) $$L_t = \frac{\theta}{2}\left[\pi_t - \pi_t^e + e - k\right]^2 + \frac{1}{2}\pi_t^2 , \qquad 0 < \theta \;\; ; \quad k > 0 .$$

As one can see, the loss function of the CB governor consists of the same arguments as the government welfare function, but it differs only in the weight of employment relative to that of inflation (θ). The parameter θ measures the degree of CB conservatism. A liberal governor is more concerned with employment (i.e. θ is relatively large), while conservative refers to a central banker who is more concerned with inflation (i.e. θ is relatively small).

As stated above, the public is unsure about the policymaker's type (Weak or Dependable). While the dependable type always maintains the central bank's independence, the weak type could override the CB and implement its preferred inflation. As in the case of IT, the choice of whether to override the CB or not is done after the supply shocks have occurred. On the one hand, if the weak type overrides the CB, she would reveal her type and loose her prior reputation. On the other hand, by mimicking the dependable type, the weak policymaker could maintain or even increase her prior reputation (as described below, this would depend on the supply shock magnitude). This game is related to Lohmann (1992) who also analyzed the appointment of a conservative central banker who could be overridden by the government. Unlike her work, the CB does not take into consideration the threat of being overridden, and thus the CB always acts according to its preferences. In addition, in the current paper the cost of overridden is not determined by the government, but is reflected by the loss of reputation.

Two steps are involved in achieving the optimal central banker's solution. The first step is to solve the optimal inflation rate for both periods for any type of central banker (θ). Then, by inserting the optimal inflation rate in the government welfare loss function and minimizing it with respect to θ, one can obtain the optimal conservatism of the CB (from the government point of view).

2.2.1 Equilibrium in the second period

Since the second period is the last period, a weak government will always choose the optimal inflation ($\pi_{w,2}$) by overriding the conservative CB. The inflation rate, which minimize the government loss [Eq. (3)] is:

(18) $$\frac{\partial V_2}{\partial \pi_2} = 0 \Rightarrow \pi^*_{w,2} = \frac{1}{2}(\pi^e_2 + k - e).$$

The dependable government always maintains the CB independence, therefore the conservative CB chooses the optimal inflation by minimizing its loss function (according to its own degree of conservatism):

(19) $$\frac{\partial L_2}{\partial \pi_{d,2}} = 0 \Rightarrow \pi^*_{d,2} = \frac{\theta}{(1+\theta)}(\pi^e_2 + k - e).$$

As one can see, inflation increases with k and with inflation expectations. Note that the supply shocks are realized after the nominal wage contracts have been set, and before the conservative CB determined his favorite inflation. Thus, the conservative CB could moderate the output fluctuations using its policy instruments. As the degree of liberalism decreases (θ is smaller), both inflation bias and the reaction to the supply shocks are reduced.

Inflationary expectations, which are embodied in the second-period nominal wage contracts, will be weighted by the average of the inflation rate of both the dependable type and the weak type.

(20) $$\pi^e_2 = p_2 \pi^d_2 + (1-p_2)\pi^w_2 \;\; \Rightarrow \;\; \pi^e_2 = \frac{\theta(1+p_2)+(1-p_2)}{\theta(1-p_2)+(1+p_2)}k \;,$$

From Eq. (20) one can notice that the second-period expectations decrease with reputation. In the extreme case where reputation is full, expectations will be equal to θk, while when $p_2 = 0$, expectations will be equal to the inflation bias motive (k).

The expected values of the second-period loss function of both policymakers are:

(21) $$E(V_{w,2}) = \frac{(1+\theta)^2}{[(1+p_2)+\theta(1-p_2)]^2}k^2 + \frac{1}{4}\sigma^2 \quad ;$$

(22) $$E(V_{d,2}) = \frac{2(1+\theta^2)}{[(1+p_2)+\theta(1-p_2)]^2}k^2 + \frac{(1+\theta^2)}{2(1+\theta)^2}\sigma^2 .$$

Higher conservatism contributes to less damage from inflation, while it increases the loss from output fluctuations. As expected, the higher the reputation in the second period (P_2), the higher the welfare of both types.

2.2.2 Equilibrium in the first period

The Dependable type does not interfere in the central banker considerations; therefore the inflation rate is compatible with the preferences of the conservative CB. Minimizing Eq. (17) with respect to first period inflation yields:

(23) $$\frac{\partial E(L)}{\partial \pi_{d,1}} = 0 \Rightarrow \pi^*_{d,1} = \frac{\theta}{(1+\theta)}(\pi_1^e + k - e).$$

The weak government picks its first period strategy so as to minimize the expected loss in both periods. In choosing its myopic solution, the expected loss in both periods is

(24) $$E[V_w(S)] = \frac{1}{4}(\pi_1^e + k - e)^2 + \frac{\delta\sigma^2}{4} + \delta k^2 ,$$

while the expected value of both periods loss, which is derived from the mimic strategy, is

(25) $$E[V_w(NS)] = \frac{(1+\theta^2)}{2(1+\theta)^2}(\pi_1^e + k - e)^2 + \frac{\delta\sigma^2}{4} + \frac{(1+\theta)^2}{[(1+p_2)+\theta(1-p_2)]^2}\delta k^2 .$$

From Eq. (24) and Eq. (25), one can infer the cases, which yield the following pure strategies:

If $$\frac{1}{4}(\pi_1^e + k - e)^2 > \frac{(1+\theta)^2}{(1-\theta)^2}\left[1 - \frac{(1+\theta)^2}{4}\right]\delta k^2 \equiv A ,$$

a weak government will always prefer to override the CCB (separate equilibrium), hence by observing an inflation rate, which is compatible with the conservative preferences [Eq. (23)], the public can infer that the government is dependable $(p_2 = 1)$.

If $$\frac{1}{4}(\pi_1^e + k - e)^2 < \frac{(1+\theta)^2}{(1-\theta)^2}\left[1 - \frac{(1+\theta)^2}{[1+\theta+p_1(1-\theta)]^2}\right]\delta k^2 \equiv B,$$

a weak government will always prefer to mimic the dependable type (pooling equilibrium), hence by observing an inflation rate, which is compatible with the conservative preference, the public cannot gain any new information regarding the policymaker's type ($P_2 = P_1$).

In the remaining case, $[A > \frac{1}{4}(\pi_1^e + k - e)^2 > B]$, a weak policymaker is randomizing between the mimic and the non-mimic strategies. As in Eq. (12) (Bayes' formula), let $\hat{q}_1$ be the probability that the weak policymaker chooses to mimic the dependable type. This probability is common knowledge and it solves p_2 such that the following equality exists:

(26) $$(\pi_1^e + k - e)^2 = \frac{4(1+\theta)^2}{(1-\theta)^2}\left[1 - \frac{(1+\theta)^2}{[1+\theta+p_2(1-\theta)]^2}\right]\delta k^2 .$$

The following expression sums up the evolution of p_2:

$$E(P_2) = 1 \cdot pr(Separate) + P_1 \cdot pr(pooling) + f(q_1) \cdot \int f(q_1) dq_1 .$$

The supply shocks thresholds, which determines the probability of separate, non-separate and mixed strategy equilibrium are described in Appendix 1.b. Unlike Figure 2 these thresholds are symmetrically positioned around ($\pi_1^e + k$).

Turning to the second stage, the optimal degree of conservatism is derived from the expected loss of the dependable type in both periods. By inserting the D's type optimal inflation rate for the first period [Eq. (23)], and its expected loss of the second period [Eq. (22)], one can obtain:

(27) $$E(V_d) = \frac{(1+\theta^2)(\pi_1^e + k)^2}{2(1+\theta)^2} + \frac{\sigma^2(1+\delta)(1+\theta^2)}{2(1+\theta)^2} + E\left[\frac{2\delta k^2(1+\theta^2)}{[1+\theta+p_2(1-\theta)]^2}\right].$$

Since the government can choose any degree of CB conservatism, it will pick the optimal one (θ) according to its welfare loss function. Minimizing Eq. (27) with respect to θ, yields:

(28) $\frac{\partial E(V)}{\partial \theta}=0 \qquad \Rightarrow$

$$\frac{(\pi_1^e+k)^2+\sigma^2(1+\delta)}{\delta k^2}=\frac{(1+\theta)^3 4\left[\theta(1+p_2)-(1-p_2)-\frac{\partial p_2}{\partial \theta}(1-\theta)(1-2\theta^3)\right]}{(1-\theta)[\theta(1-p_2)+(1+p_2)]^3}.$$

2.2.3 The optimal degree of conservatism in the case of full reputation

When the prior reputation of the government is equal to one, the government does not have to signal the public its dependability trough strategic behavior (i.e., the derivative of p with respect to θ will be equal to zero), hence the optimal degree of conservatism could be expressed as

(28) $$\frac{\partial E(V)}{\partial \theta}=0 \rightarrow \frac{\theta(1+\theta)^3}{(1-\theta)}=\frac{(\pi_1^e+k)^2+\sigma^2}{\delta k^2}+\frac{\sigma^2}{k^2}.$$

As in Rogoff the optimal degree of CB conservatism is always higher than the government's, i.e. $\theta<1$. In addition, one can see that Rogoff's solution[5] yields a more conservative CB (smaller θ) than in this model solution [Eq. (28)]. The difference derives from the different sequence of events. In our model, the first-period expectations are exogenous (unlike in Rogoff who assumed rational expectations in both periods); hence, the government is tempted to choose a more liberal CB in order to raise the first-period inflation and reduce the cost of recession.

Eq. (28) also demonstrates the impact of the exogenous parameters on the optimal degree of conservatism. First, as in Rogoff's solution, a higher variance of supply shocks leads to a lower degree of CB conservatism. This choice results from the desire to offset the damage of extreme shock fluctuations. In addition, a higher k (inflation bias motive) leads to a higher degree of CB conservatism. Second, the higher is the first period inflationary expectations, the more liberal is the optimal CB. This choice stems from the government's will to avoid deep recession in the first period by reducing inflation gradually. Third, because the government has to choose the same degree of liberalism for both periods, it has to balance the desire to choose

[5] The optimal degree of conservatism according to Rogoff is: $\frac{\theta(1+\theta)^3}{(1-\theta)}=\frac{\sigma^2}{k^2}$.

a high degree of conservatism in the second period with its will to choose a liberal CB in the first period. Hence, higher discount factor (δ), which implies that the second period is more important, will induce the government to choose a more conservative CB (for a given σ^2 and k). A government that cares only about the second period (infinite future importance) will choose Rogoff's optimal conservative central banker.

2.2.4 The effect of partial reputation on the optimal degree of CB conservatism

The effect of partial reputation on the choice of the optimal degree of CB conservatism is not easily seen from Eq. (27). A-priori there are two effects which could have a contradicting impact. The first effect is straightforward: a low prior reputation leads to higher second-period inflationary expectations. Given the high expectations, the higher the degree of conservatism, the higher the recession. Therefore, the government would tend to accommodate by choosing a more liberal CB. The second effect runs through the inter-temporal considerations: the lower the prior reputation; the higher the incentive of the dependable policymaker to separate himself. This is done by choosing a more conservative CB, since the weak type would loose more from mimicking.[6] By using a numeric simulation we obtain that the first effect is the dominant; hence, an increase in the prior reputation leads to the choice of a more conservative CB (lower θ).

3. Inflation target regime versus conservative central bank

3.1 Full reputation

In this section we compare the value of the government loss in the two alternatives - a conservative CB regime and Inflation Targets regime - which are discussed in the previous two sections. First, we will examine the simple case were the policymaker has full reputation (P_1=1). In this case, the expected loss from the IT regime is [see Eq. (16)]:

(29) $$E\left[V\left(P_1=1\right)\right]=\frac{1}{4}(\pi_1^e+k)^2+\frac{\sigma^2}{2}(1+\delta)+\frac{1}{2}\delta k^2,$$

[6] However, there are few exceptions in which the second effect is eliminated even for a low prior reputation. For instance, if the dependable policymaker cannot separate herself (pooling equilibrium for any supply shock realization), a change in prior reputation will not lead to a change in the optimal degree of CB conservatism.

and the expected loss of CCB regime is [see Eq. (27)]

$$(30) \qquad E(V) = \frac{(1+\theta^2)}{2(1+\theta)^2}(\pi_1^e + k)^2 + \frac{(1+\theta^2)}{2(1+\theta)^2}\sigma^2(1+\delta) + \frac{\delta k^2(1+\theta^2)}{2},$$

where - $\frac{1}{4} < \frac{(1+\theta^2)}{2(1+\theta)^2} < \frac{1}{2}$.

The first argument in both equations reflects the loss of employment in first period. Since IT copes with inflationary expectations according the social welfare loss, while CCB does it according to its own preferences, the loss from a CCB regime is always higher than in an IT regime. The second argument in both equations reflects the damage from supply shocks fluctuations (in both periods), therefore, CCB, which partially offset those shocks, has a clear advantage over the IT regime. The third argument reflects the damage from inflationary bias in the second period. Since IT has full reputation, it declares a zero inflation target; hence the government's loss from this motive is always smaller than its loss from CCB.

3.1.1 Comparative statics – full reputation

The impact of the rate of time preference is ambivalent. If the government cares only about the future $(\delta \to \infty)$, it will choose a conservative CB (as in Rogoff 1985b); this optimal CCB will always be superior to an IT regime, since IT regime is equivalent to an infinity degree of conservatism $(\theta = 0)$, which according to Eq. (28) is not the optimal θ. If the government cares only about the present $(\delta \to 0)$, it will choose a central banker with the same preference as its own $(\theta = 1)$. This CB will always be superior to an inflation target regime since inflation bias under both regimes is the same, while a CB could eliminate supply shocks. In the remaining case where the government cares about both periods, a conservative CB could be inferior to a target regime, since the CCB's first-period inflation will be too low while the second-period inflation will be too high (see also Figures 3.A-5.A).

An increase in the other parameters (π_1^e, k, σ^2) damages both regimes; however, the magnitude of the damage is different in each regime. For instance, CCB deals better with supply shocks since it partially offsets them, while IT is committed to a strict target. On the other hand, IT deals better with the first-period inflationary expectations since it accommodates the target to the hostile expectations from the social point of view, while the CCB does it according to it own preferences. Therefore, (ex-ante) the recession in the first period is deeper in a CCB regime than in an IT regime. The impact of the inflationary motive (k) in the first period is the same as the first-period inflationary expectations [see Eq. (29) and Eq. (30)]; in addition IT deals better with the inflationary motive in the second period since (unlike a conservative CB) it eliminates completely the inflationary bias in this period.

Summing up the analysis above, one can infer that in disinflation where the first period's inflationary expectations are exogenous, an IT regime could be superior to a CCB regime. This result differs from that of Roggof who concluded that CCB is always preferred when there are rational expectations.

3.2 Simulation results - partial reputation

Since a-priori we cannot infer which regime is better, the determination of the superior alternative is based on computing numerically the equilibria for a sizeable range of parameter values. The use of numerical methods is necessary because the solution of CB's conservatism (θ) contains a third-order polynomial. In order to compute the indifference curves between the two regimes we solved for one parameter at a time the values that equalize the loss from the two regimes, while other exogenous parameters were held constant. For each simulation we used the same interval of supply shocks variance and the following parameters values as a benchmark - $\pi_1^e = 20, k = 10, p_1 = 0.5, \delta = 1$.

Figures 1.A-9.A illustrate the indifference curves between the two regimes. The upward lines in Figure 1.A describe the advantage of an inflation target regime from higher prior reputation (P_1), which offsets the disadvantage derived from high supply shocks variance, i.e., for a given σ^2, higher reputation than the level which is indicated by the indifference curve leads to an IT advantage and vice versa. The interpretation of this result is as follow: higher reputation leads to lower second-period inflationary expectations in both regimes, but its impact on IT inflationary expectations is stronger than to its impact on CCB. Since lower expectations leads to higher welfare, an increase in prior reputation (for both regimes) increases the IT advantage. By decreasing the first-period inflationary expectations, the indifference curve moves upward (to the striped line) and the zone in which the CCB is superior expands. This is due to the fact that IT has an advantage in avoiding deep recessions in the existence of hostile expectations, since it determines a different inflation target for each period (according to the social welfare loss). This pattern is reflected in Figures 1.A, 3.A and 7.A. As mentioned in the full reputation and as can be seen from Figures 2.A, 5.A and 9.A, higher inflationary bias motive (k) increase the IT advantage, and the zone in which IT is superior expands.

As discussed in the full reputation section and as can be seen from Figures 3.A – 5.A, the impact of the rate of time preference is ambivalent and as a result the indifference curves which presented in these figures have an inverse U-shaped pattern. When the government cares only about one period [$\delta \to \infty$ or $\delta \to 0$] CCB is always preferred, while when it cares about both periods, CCB could be inferior. This conclusion holds for both full and partial reputation.

4. Concluding remarks

In this paper we compare a strict inflation target regime and a conservative central bank regime. An important general lesson of the paper is that when the first-period inflationary expectations are exogenous, an IT regime could be superior to a conservative CB regime. This result differs from that of Roggof who assumed rational expectations and concluded that a conservative CB is always preferred. This main conclusion of the paper could justify the fact that several countries used IT regimes in order to reduce inflation.[7]

The CCB disadvantage in our model derives from the fact that appointing a conservative central banker is usually accompanied by some rigidity, i.e., the same central banker's preferences determine the monetary policy for more than one period, unlike inflation

[7] This includes seven countries: UK, Australia, Spain, Sweden, Finland, New Zealand, Canada and Israel. The latter three countries used a gradual decrease in inflation targets.

targets, in which the government can choose a different target for each period. Therefore, when the government delegates authority to a conservative CB, the central banker dictates the speed of the disinflation process according to her own preferences. In particular, a more conservative CB will accelerate the disinflation process and cause deep recession in the first period. The speed of the disinflation process leads to government welfare loss, which is in addition of the loss caused by the excess volatility of output (both losses are due to the excess CB conservatism relative to the government preferences).

This paper also shows that the choice between the two regimes depends upon the parameters. The impact of each parameter on both regimes is as follow: The rate of time preference has an ambiguous influence on the preferred regime. In very high and very low rates of time preference a CCB is superior even for very low supply shocks fluctuations, while in the other cases, where the government cares about both the present and the future, CCB could be inferior for low supply shocks fluctuations.

Another important result is the effect of the prior reputation. An increase in the first period prior reputation gives the IT an advantage, since in this regime; a prior reputation has a stronger effect on the second-period inflationary expectations. In addition, an inflation target regime is preferred when supply shocks fluctuations are relatively low and when the first-period inflationary expectations and inflation bias motive (k) are relatively high.

The paper also examines the impact of the above parameters on the optimal degree of conservatism. As in Rogoff, an increase in the inflationary bias motive (k) and decrease the supply shock variance leads to a more conservative CB. In addition, in the two-period framework we found that higher first-period expectations, a lower discount factor and lower prior reputation lead to a more liberal CB.

Appendix 1:

The gradual learning process is as follows -

$$p_2 = \begin{cases} 1 & if \quad e < e_{tr1} \quad or \quad e > e_{tr4} \\ f(q_1) & if \quad e_{tr1} < e < e_{tr2} \quad or \quad e_{tr3} < e < e_{tr4} \\ p_1 & if \quad e_{tr2} < e < e_{tr3} \end{cases} .$$

A. The thresholds values in IT case are:

$$e_{tr1} \equiv \pi_1^e + k - 2T_1 - k\sqrt{3\delta} \ ; \qquad e_{tr4} \equiv \pi_1^e + k - 2T + k\sqrt{3\delta}$$

$$e_{tr2} \equiv \pi_1^e + k - 2T_1 - 2k\sqrt{\delta(1 - \frac{1}{(1+p_1^2)^2})} \ ; \ e_{tr3} \equiv \pi_1^e + k - 2T_1 + 2k\sqrt{\delta(1 - \frac{1}{(1+p_1^2)^2})}$$

B. The thresholds values in CCB case are:

$$e_{tr1} \equiv \pi_1^e + k - \frac{2(1+\theta)}{(1-\theta)} k \sqrt{\delta\left[1 - \frac{(1+\theta)^2}{4}\right]} \ ; \ e_{tr2} \equiv \pi_1^e + k - \frac{2(1+\theta)}{(1-\theta)} k \sqrt{\delta\left[1 - \frac{(1+\theta)^2}{[1+\theta+p_1(1-\theta)]^2}\right]}$$

$$e_{tr4} \equiv \pi_1^e + k + \frac{2(1+\theta)}{(1-\theta)} k \sqrt{\delta\left[1 - \frac{(1+\theta)^2}{4}\right]} \ ; \ e_{tr3} \equiv \pi_1^e + k + \frac{2(1+\theta)}{(1-\theta)} k \sqrt{\delta\left[1 - \frac{(1+\theta)^2}{[1+\theta+p_1(1-\theta)]^2}\right]}$$

C. The explicit solution for the second period expected reputation is:

$$E\left(\frac{1}{1+p_2^2}\right) = \left\{\left(\frac{1}{1+1}\right)\cdot\left(1 - \frac{e_{tr4} - e_{tr1}}{2e_H}\right) + \left(\frac{1}{1+p_1^2}\right)\frac{e_{tr3} - e_{tr2}}{2e_H} + \frac{1}{e_H}\int_{e_{tr1}}^{e_{tr2}} \sqrt{1 - \frac{1}{\delta k^2}\left[T_1 - 0.5(\pi_1^e + k - e)\right]^2}\, de\right\}$$

where e_H and e_L are the upper and the lower boundaries of the uniform distribution. By inserting the thresholds value in the equation above one can obtain:

$$E\left(\frac{1}{1+p_2^2}\right) = \frac{1}{2} + \frac{k\sqrt{\delta}}{\sqrt{3\sigma^2}}\left\{\frac{1}{(1+p_1^2)}\cdot\sqrt{(1 - \frac{1}{(1+p_1^2)^2}} - \frac{\sqrt{3}}{4} + sin^{-1}\frac{\sqrt{3}}{2} - sin^{-1}\sqrt{1 - \frac{1}{(1+p_1^2)^2}}\right\}.$$

D. The derivative of the second-period expected reputation with respect to the degree of conservatism:

$$\frac{\partial E(p_2)}{\partial \theta} = \frac{4k\sqrt{\delta}}{2e_H}\left\{\frac{2(p_1 U - V)}{(1-\theta)^2} + \frac{4(1+\theta)}{(1-\theta)^3}\left[sin^{-1} V - sin^{-1} U - V + U\right]\right\} ,$$

$$where \quad U = \sqrt{1 - \frac{(1+\theta)^2}{[\theta(1-p_1) + (1+p_1)]^2}} \quad ; \qquad V = \sqrt{1 - \frac{(1+\theta)^2}{4}} .$$

Appendix 2 - Figures

Figure 1.A - Indifference Curve - P

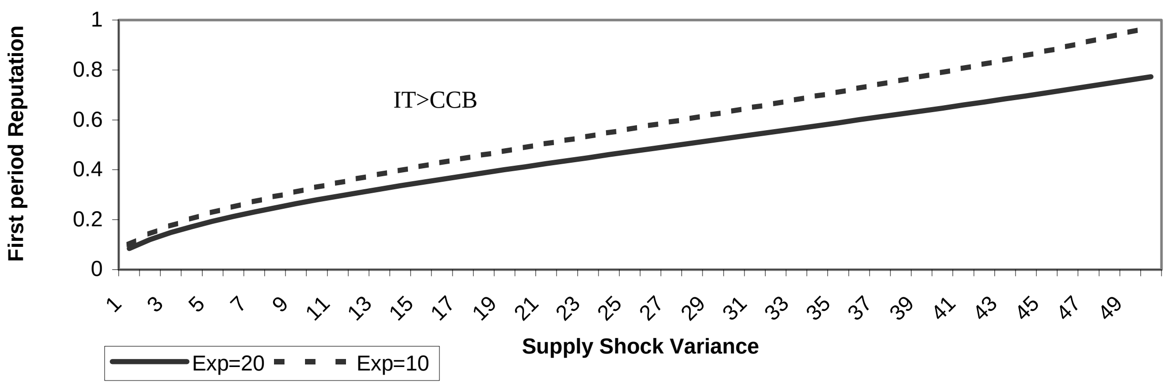


Figure 2.A - Indifference Curve - P

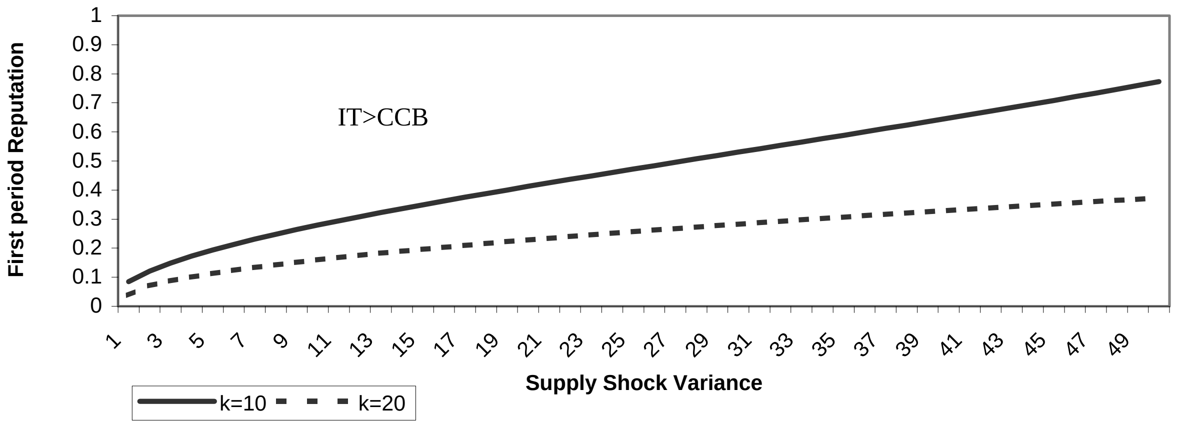
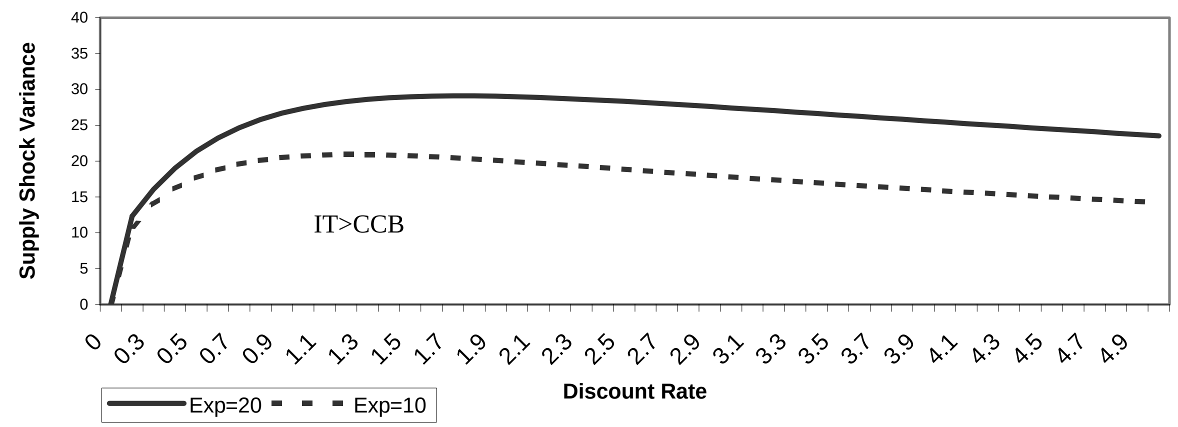


Figure 3.A - Indifference Curve - Delta



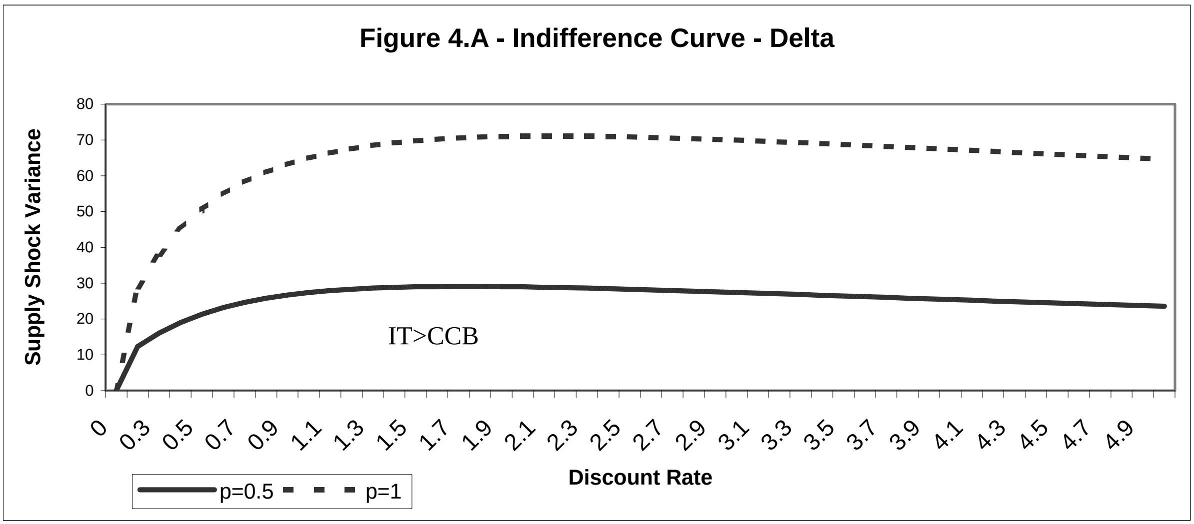


Figure 4.A - Indifference Curve - Delta
Supply Shock Variance
80
70
60
50
40
30
20
10
0
IT>CCB
0
0.3
0.5
0.7
0.9
1.1
1.3
1.5
1.7
1.9
2.1
2.3
2.5
2.7
2.9
3.1
3.3
3.5
3.7
3.9
4.1
4.3
4.5
4.7
4.9
Discount Rate
p=0.5
p=1

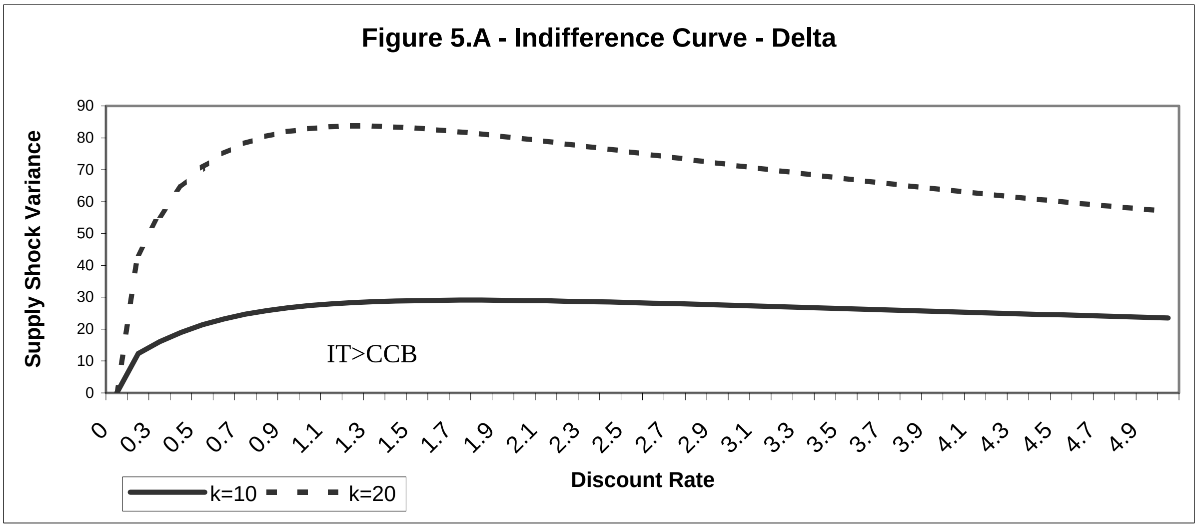


Figure 5.A - Indifference Curve - Delta
Supply Shock Variance
90
80
70
60
50
40
30
20
10
0
IT>CCB
0
0.3
0.5
0.7
0.9
1.1
1.3
1.5
1.7
1.9
2.1
2.3
2.5
2.7
2.9
3.1
3.3
3.5
3.7
3.9
4.1
4.3
4.5
4.7
4.9
Discount Rate
k=10
k=20

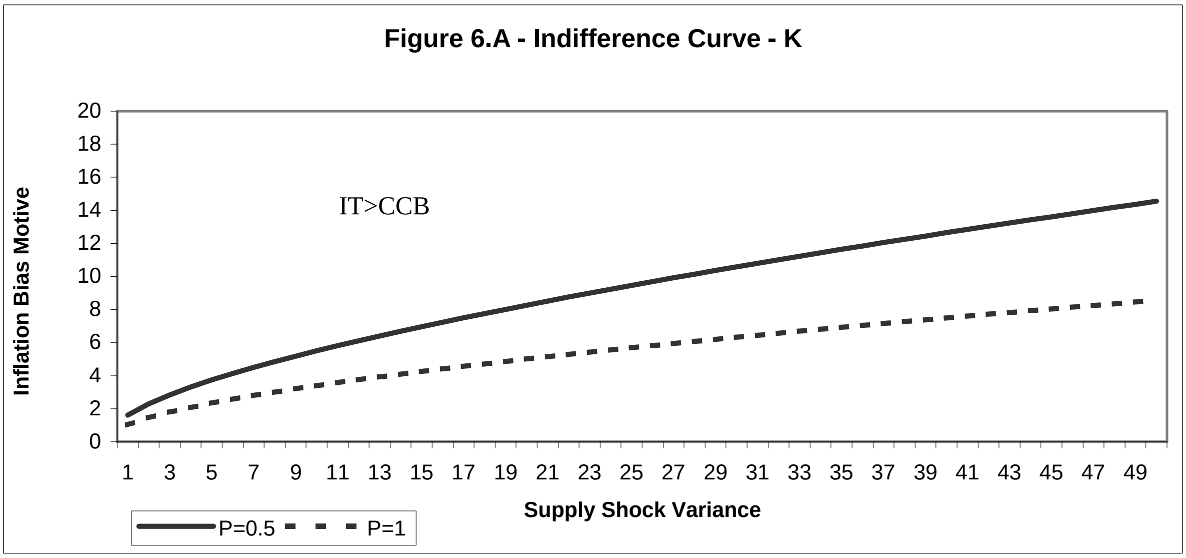


Figure 6.A - Indifference Curve - K
Inflation Bias Motive
20
18
16
14
12
10
8
6
4
2
0
IT>CCB
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
43
45
47
49
Supply Shock Variance
P=0.5
P=1

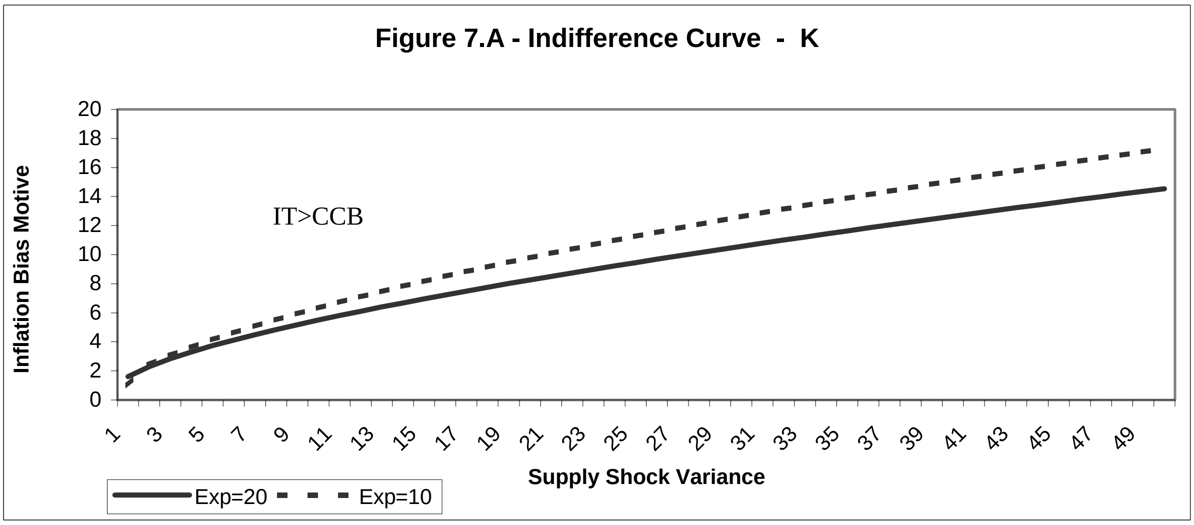


Figure 7.A - Indifference Curve - K
Inflation Bias Motive
IT>CCB
Supply Shock Variance
Exp=20
Exp=10

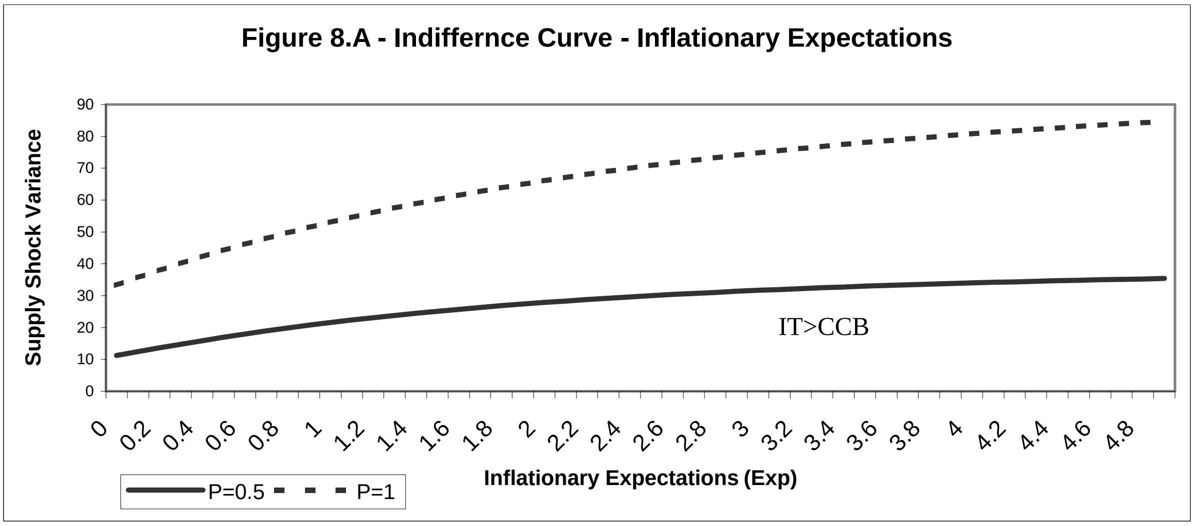


Figure 8.A - Indiffernce Curve - Inflationary Expectations
Supply Shock Variance
IT>CCB
Inflationary Expectations (Exp)
P=0.5
P=1

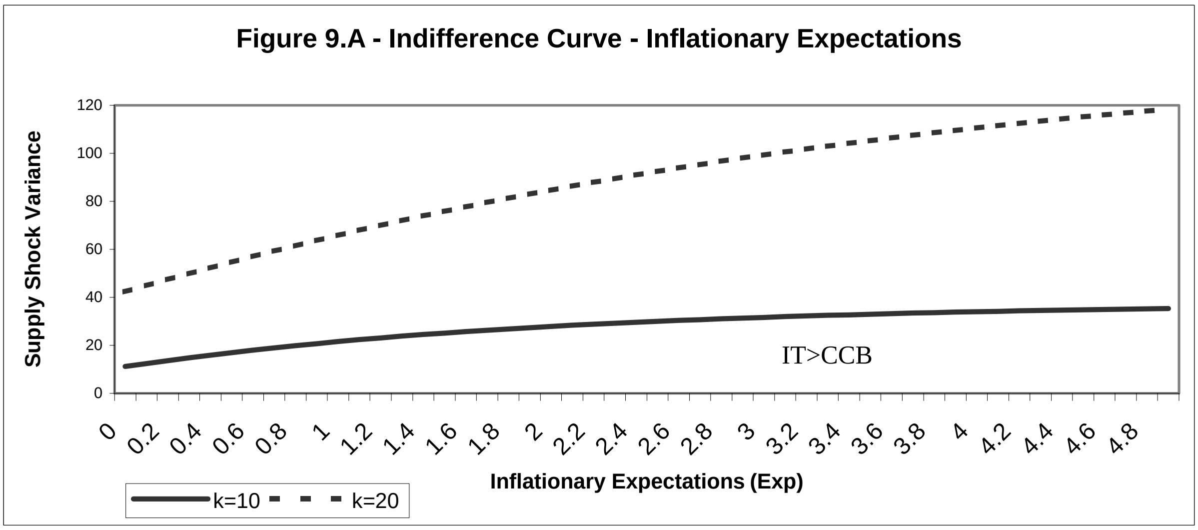


Figure 9.A - Indifference Curve - Inflationary Expectations
Supply Shock Variance
IT>CCB
Inflationary Expectations (Exp)
k=10
k=20

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