Can a Conservative Governor Conduct an Accommodative Monetary Policy?

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I - INTRODUCTION

The movement towards Central Bank independance in various European countries was largely justified by Rogoff’s theory of conservative Central Bankers (cf. European Commission (1990)). According to this theory, a Central Banker who takes more care of price stability than society will choose between decreasing the inflation bias, derived from a lack of credibility and weakening the capability to limit output fluctuations caused by a large supply shock. As it is the result of a trade off, this solution is too stable and such a framework is not appropriate to understand changes in the Central Banker behaviour. Particularly, a conservative Central Banker can never accept periods of high inflation.

Lohman (1992) explains inflation peaks in spite of the appointment of an independent monetary authority with the introduction of an escape clause. In usual circumstances, the Central Banker behaves like a conservative banker; but if a large shock occurs, he will adopt a discretionary policy which allows him to face up to the shock and keeps him from being fired. But, in this model the Central Banker adjusts his monetary policy even if he is sure to be fired, when for instance a very large negative shock hits the labour market. This result is non-intuitive because in such a case, it would be preferable for the Central Banker to minimize his first period cost function.

In this paper, a model which avoids this feature of Lohman’s model is proposed. To allow for inflation peaks in the model, we assume that the Central Banker is not appointed at vitam aeternam. For example, a Central Bank status law modification is possible. If the monetary policy conducted by the Central Banker ex post leads to a level of unemployment that is considered too high by the government (and alters its opportunity to be reelected), the Central Banker will be fired and a less conservative governor appointed. To prevent this, the Central Banker will adjust his policy, even if he is only interested in price stability. But, contrary to Lohman’s model, if a large shock occurs, he will choose not to conduct an accommodative monetary policy because he is aware that he will not be able to prevent his dismissal anyway.

The second part of this paper briefly recalls Rogoff’s theory and its main limits. As this theory can not explain the existence of inflation peaks, an alternative model proposed by Lohman is then presented. A third part is devoted to the presentation of the hypotheses of the model we propose. Then the main results of our work as well as numerical simulations are exposed in the fourth and fifth parts. To conclude, a sixth part describes some directions along which the model could be improved.
II - A CONSERVATIVE GOVERNOR CAN CONDUCT AN ACCOMMODATIVE POLICY IN SPECIAL CIRCUMSTANCES.

There is now a voluminous literature dealing with credibility and Central Banks’ independence. It originates in Kydland-Prescott (1977) seminal paper which first illustrates and shows the importance of time inconsistency and in Barro-Gordon (1983a) which applies this result to monetary policy. According to these authors, a government who aims at keeping inflation under control and at reaching an unemployment rate below the equilibrium level can only conduct an inflationist policy. In the absence of uncertainty a monetary policy based on a rule will lead to a larger welfare than a discretionary one. Conversely, when supply shocks hit the economy, respecting a fixed and known rule prevents the government from conducting an accommodative policy and thus limiting fluctuations on the labour market.

Rogoff (1985) found an original solution to the dilemma between credibility and flexibility. It consists in delegating the monetary power to a third agent, the Central Bank, which cares more about inflation than society. Appointing such a conservative governor affects the formation of inflation expectations and can decrease the inflation bias without reducing his ability to conduct a policy adapted to the shock. Rogoff’s solution is the result of a trade off between these two objectives.

However, this theory can be criticized in different ways. Mac Callum (1996), for instance, underlines that the conservative governor solution does not solve the time-inconsistency problem but only transfers it to an other level. Indeed, if a government is not credible enough to lead a satisfactory monetary policy, how could the delegation of power he gives to the Central Bank be credible ? The possibility that the government breaks his promise and becomes the monetary policy decision-maker can not be excluded. In spite of the relevance of this criticism, it will not be dealt with in this paper.

Rogoff’s theory is, moreover, not entirely empirically confirmed. Indeed, as the theory foretells, a decreasing relation between the degree of conservatism, as measured by an independence index (cf. Cukierman (1992)) and inflation seems to exist (cf. Grilli-Masciandaro-Tabellini (1991), Alesina-Summers (1993)) and there is no connection at all between independence and average growth (cf. Grilli-Masciandaro-Tabellini (1991), Alesina-Summers (1993), Cukierman-Kalaitzidakis-Summers-Webb (1993)). However, the expected positive relation between independence and the variability of growth can not be exhibited (cf. Cukierman-Kalaitzidakis-Summers-Webb (1993), Crosby (1996), Alesina-Gatt (1995)). On the one hand, it can be said that appointing a conservative governor would be a free lunch ; so one must find an other theory which fits these empirical results. But, on the other hand, because of the simplicity of the independence indexes used (cf. Eiffinger - Schaling (1993)), the data may not be taken to reject the theory.
The third criticism is more of our concern. As Rogoff’s theory is the result of a trade off between decreasing the inflation bias and limiting output fluctuations, it is characterised by stability and can not explain the occurrence of inflation peaks when a conservative governor is appointed (cf. Canzoneri (1985)).

Reputational models (cf. Backus-Driffill (1985), Barro-Gordon (1986)) allow for the existence of inflation bias. Indeed, if the net profit of cheating is larger than the cost of the loss of credibility during the next years, the government will lead an inflationist policy. However, this kind of model encounters at least two difficulties. First, they are based on very simplistic hypotheses concerning the private agents’ beliefs and are very sensitive to a minor change in these beliefs. Second, the probability of the occurrence of an inflationist peak increases in these models when the end of the governor’s mandate is close and not when a large shock hits the economy.

To explain why a bout of inflation may occur in spite of the presence of a conservative governor, Lohman (1992) introduces an escape clause in Rogoff’s seminal model (see also Flood Isard (1988)). When monetary power is delegated to a Central Bank, the government suffers a positive but finite cost if he breaks his commitment and takes the power of decision in his hands again. In this model, the government can implement a monetary policy which is nonlinear with respect to shocks: in extreme cases, for instance an oil shock, a war or a stock-exchange crisis, the monetary authority will conduct a more accommodative policy in order to avoid being fired.

This result is highly dependent on the specification of the objectives of the monetary authority. It is supposed that the Central Banker first aims at not being fired and then at minimizing a cost function. That implicitly means the Central Bank does not care about the future and what will happen in case of firing. Implementing a static game is then sufficient but it leads to a non intuitive effect : the Central Bank always leads an accommodative policy, even if a very large negative shock occurs. Indeed, in this case, the Central Bank may be forced to accept a very high level of inflation to limit the costs on the labour market. This choice is not very convincing if the Central Banker dislikes inflation and knows that he will be fired anyway.

The model described here avoids this unrealistic effect. The main difference concerns the objective function of the Central Bank, which is supposed to take into account the sum of the cost over the whole period. A dynamic model is thus considered in which being fired or not is not an aim in its own but has a consequence on the cost suffered in the future. To model it the characteristics of the new Central Banker, that is to say the one who replaces the governor fired on the first period, must be introduced.
III - Hypotheses of the model

The model proposed is, for the main part, based on the traditional hypotheses of the Barro-Gordon or Rogoff models. It is however different because it assumes there are social pressures in the country that force a conservative governor to take heed of the labour market situation as in Lohman, but differs from Lohman in that it is a dynamic model.

1 - The traditional hypotheses

The economy is composed of three agents: the private agent, the government and the Central Banker.

The employment is given by a Lucas supply curve

\( n = \bar{n} - \frac{1}{\eta}(\pi^e - \pi) + \varepsilon \)

where \( \bar{n} \) is the level of equilibrium employment, \( n \) the level of effective employment, \( \pi^e \) is the anticipated inflation, \( \pi \) the effective inflation and \( \varepsilon \) a supply shock, which is supposed to be independent and identically distributed, with a zero mean and a variance of \( \sigma^2 \). Small letters denote logarithms. To improve the situation on the labour market, the monetary authority can only resort to unanticipated inflation. A negative supply shock implies a decrease in the level of employment.

As is usual in this literature, the government tries to minimize a cost function, which describes a trade off between the costs and the benefits of inflation. More precisely, the government\(^1\) wants to minimize a function of both the difference between the level of the effective employment and the level of socially desired employment (\( \bar{n} \)) and the difference between the effective inflation rate and the socially desired one (\( \bar{\pi} \)). The private agent’s employment target is lower than the government’s which expresses the presence of distortions on the labour market (\( \bar{n} > \bar{\pi} \)).

The government can delegate his decision power to a Central Bank whose tastes concerning inflation can be different from his own. This Central Bank has total control of its objectives and directly chooses the inflation rate, by fixing the interest rate or a monetary aggregate.

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\(^1\) The government is supposed to have the same objective function as society.
The timing of the game is the following:

- The government appoints a Central Banker (S) who becomes the monetary decision maker.
- Aware of the Central Banker’s preferences and of the main features of the economy, the private agents anticipate the inflation rate and negotiate their wages in nominal terms.
- A supply shock hits the economy.
- The Central Banker chooses monetary policy according to the magnitude of the shock.
- Depending on the \textit{ex post} situation on the labour market, the Central Banker is appointed again for the next period or fired and replaced by a less conservative one (W).

\section*{2 - Introduction of new hypotheses}

The model which is proposed here is very different from Rogoff’s. It is first assumed that the government delegates the monetary power to a Central Banker (S) whose only aim is to fight inflation. His objective function is

\begin{equation}
V_{BC} = \sum_{t=0}^{\infty} \delta^t E (\pi_t - \bar{\pi})^2
\end{equation}

with $0 \leq \delta \leq 1$ the discount rate, $\pi_t$ the effective inflation rate and $\bar{\pi}$ the socially desired inflation rate.

Delegating monetary policy to such a Central Banker is not optimal according to Rogoff’s theory, where the weight of the price objective should not be infinite to limit fluctuations on the labour market. It will be shown that an inflation bias can nevertheless appear even under this extreme hypothesis.

More importantly, it is supposed that social pressures exist in this economy: if \textit{ex post} the level of employment is below a certain threshold, demonstrations will occur and the government will have to fire the Central Banker if he wants to be reelected. To formalise this, it is assumed that the economy is characterized by a threshold level of employment $n^p$ so that if $n^p > n$, the Central Banker (S) will be fired and replaced by a new one whose preferences are different (W)$^2$. One can note that there is here a difference with Lohman’s model: in her model the government could break his commitment with a cost at the current period. Here on the contrary, the commitment can only be broken for the next period.

\footnote{\textsuperscript{2} As the weak governor will never be fired, a two period model might be used. Nonetheless, we use an infinite horizon model so as to rely on stationarity arguments.}
The « substitute » governor $W$ minimises the following cost function

\[ V = (\bar{n} - n)^2 + \beta(\pi - \bar{\pi})^2 \]

where $\beta$ is the weight given to the price stability objective and is usually called the degree of conservatism. Referring to Rogoff’s results, inflation expectations are given by

\[ \pi^e = \bar{\pi} + \frac{(\bar{n} - \pi)}{\beta\alpha} \quad \text{and} \quad \pi = \pi^e - \frac{1}{\alpha(\beta + \frac{1}{\alpha^2})} \epsilon \]  
(see Mourougane (1997) for more details).

The strong Central Banker’s cost when he is fired at the end of the first period\(^3\) is, under the previous hypotheses

\[ U^l = \frac{\delta}{1-\delta} \left[ \left( \frac{\bar{n} - \pi}{\beta\alpha} \right)^2 + \frac{\sigma_e^2}{\alpha^2(\beta + \frac{1}{\alpha^2})^2} \right]. \]

$U^l > 0$ and $U^l$ is a function of the exogenous parameters of the model. $U^l$ grows with the variance of the supply shock. Therefore, the larger the fluctuations are the more inflationary the monetary policy is in order to limit excessive costs on the labour market. Besides, the more governor $W$ is attached to price stability the lesser the cost suffered by governor $S$ in case of firing; such a result is rather intuitive since as the conservatism degree increases, the preferences of governor $W$ get closer to those of governor $S$. In the following, $U^l$ will be considered as fixed and known by all the agents of the economy.

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\(^3\) In the first period, the Central Banker $S$ chooses $\pi_t = \bar{\pi}$ then, for the periods to come, $\pi_t$ is fixed by the governor $W$. 

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IV - RESULTS

Let us show that under these hypotheses, there exists an interval of accommodation so that if the realisation of the supply shock belongs to this interval, the infinitely conservative governor will conduct an accommodative monetary policy. The possibility of the appearance of inflation peaks will imply the existence of an inflation bias in spite of the Central Banker’s preferences. The existence of the accommodative area is first studied assuming it has a certain shape. This hypothesis is then proved. The nature and the main property of the inflation bias are finally dealt with.

1 - Existence of the accommodative area

Some relations derived from the latter hypotheses and which are helpful to show the existence of the accommodative area are now presented.

Because of the constraint imposed on the labour market, the Central Bank will decide to conduct -or not- an accommodative policy according to the amplitude of the supply shock. It will be shown later that there exist two thresholds $\varepsilon_1 < 0$ and $\varepsilon_2$ such that if the supply shock is between these two thresholds, the Central Bank will conduct an accommodative monetary policy and accept inflation peaks (cf. Graph 1). Conversely, if the supply shock does not belong to this accommodative area, the Central Banker’s only objective will be to fight inflation. $\varepsilon_1$ and $\varepsilon_2$ verify:

- if $\varepsilon > \varepsilon_2$, the supply shock will be small in absolute value or positive. In this case, the level of effective employment will be larger than the threshold required without need of accommodation. When $\varepsilon = \varepsilon_2$, we have $\pi_i = \bar{\pi}$ and $n = n^p$.

- if $\varepsilon < \varepsilon_1 < 0$, the supply shock is too large. The Central Banker knows that reaching the threshold of employment required is not worthwhile and that he will be fired. So he will minimise his instantaneous cost and choose $\pi_i = \bar{\pi}$.

Finally, the Central Banker will decide not to conduct an accommodative monetary policy if the cost in case of firing is less than if he is reappointed. To make up its mind, he will solve the following program $\min_{\pi} \left\{ \text{Arg} \min (\pi - \bar{\pi})^2 + \delta EU^{S}_{1,\infty} \right\}$ where $EU^{S}_{1,\infty}$ is the cost actualised suffered by the Central Banker $S$ at period 1 of the game.
The employment equation (1) yields

\[ e_2 = \frac{1}{\alpha} (\pi^e - \bar{\pi}) + (n^p - \bar{\pi}). \]

When \[ e = e_1 \], the Central Banker will be indifferent between being fired or not. This implies that

\[ U^1 = (\alpha(n^p - \bar{\pi}) + \pi^e - \alpha e_1 - \bar{\pi})^2 + \delta EU_{1,\infty}^S. \]

In the following equation (9) the cost \[ EU_{1,\infty}^S \] is defined. The first integral refers to a case where the Central Banker only cares about price stability because the shock is too large; the Central Banker is fired at the end of the first period. In the second integral, the Central Banker leads an accommodative monetary policy in the first period and he is not replaced. In the third integral, the Central Banker’s only objective is to fight inflation because the shock is too small and the employment threshold is easily reached.

\[
EU_{1,\infty}^S = \int_{e_1}^{e_2} f(e) \left[ U^1 + \int_{e_1}^{e_2} f(e) \left[ (\alpha(n^p - \bar{\pi}) + \pi^e - \alpha e_1 - \bar{\pi})^2 + \delta EU_{2,\infty}^S \right] \right] \, de + \int_{e_1}^{e_2} f(e) \left[ (\bar{\pi} - \pi^e)^2 + \delta EU_{2,\infty}^S \right] \, de
\]

with \( f \) the probability density of \( e \) and \( \pi^e \) is the expectation formed by the private agent.

Using the employment equation (1) and assuming that \( e \) has a uniform distribution on \( [-k, k] \), \( k > 0 \), and given the stationarity of the cost (\( EU_{1,\infty}^S = EU_{2,\infty}^S \)), it is obtained (10)

\[
EU_{1,\infty}^S(1 - \delta \frac{k - e_1}{2k}) = U^1 \frac{e_1 + k}{2k} + \left[ \alpha(n^p - \bar{\pi}) + \pi^e - \bar{\pi} \right] \frac{e_2 - e_1}{2k} \left[ \frac{\alpha(n^p - \bar{\pi}) + \pi^e - \bar{\pi}}{2k} \left( \frac{e_2^3}{6k} - e_1^3 \right) \right]
\]

The private agents’ expectations are also a function of the distribution of the supply shocks.
The agents expect that \( \pi_{t+1} = \tilde{\pi} \) if the supply shock does not belong to the accommodative area. Otherwise, they anticipate an inflation rate compatible with \( n = n^p \). Under the hypothesis that \( \varepsilon \) follows an uniform distribution, the inflation expectations are given by

\[
\pi^e = \tilde{\pi} + \frac{\varepsilon_2 - \varepsilon_1}{2k - \varepsilon_2 + \varepsilon_1} n^p - \tilde{\pi} + \frac{\alpha(\varepsilon_2 + \varepsilon_1)(\varepsilon_2 + \varepsilon_1)}{2(2k - \varepsilon_2 + \varepsilon_1)}. \tag{12}
\]

Finally, a system with four equations (7,8,10,12) and four unknowns, \( \varepsilon_1, \varepsilon_2, \pi^e \) et \( EU^{1,\infty}_S \) is obtained. Instead of solving this system, which is long and not too useful, let us first write it in a more practical form in order to prove the existence of a solution. The sensitivity of this solution to the parameters of the model is then studied.

To make the calculations easier, let us denote

\[
\begin{align*}
A &= \varepsilon_1 + \varepsilon_2, \\
B &= \varepsilon_1 - \varepsilon_2.
\end{align*}
\]

Combining the equations (12) et (7), a simple relation can be found between \( A \) and \( B \):

\[
A = 2(n^p - \tilde{\pi}) + B + \frac{B^2}{2k}. \tag{13}
\]

Rewriting equation (10) with \( A \) and \( B \), and then replacing \( A \) by its expression in (13) it is found that \( B \) is the solution of the following fourth degree equation:

\[
\frac{2U^1k(1-\delta)}{\delta \alpha^2} = \left( \frac{2k}{\delta} - k + (n^p - \tilde{\pi}) \right) B + \frac{2}{3} B^3 + \frac{1}{4k} B^4. \tag{14}
\]

It is possible to solve this equation by transforming it into a third degree equation and then using the Cardano formula. However, the existence of a solution and the main properties of the model can be shown just by using equation (14) (cf. Appendix 1).
2 - Shape of the accommodative area

So far the shape of the accommodative area has been assumed. Indeed it has been suposed that an interval exists such that when the supply shock belongs to this interval, the Central Banker will conduct a looser monetary policy to reach the social level of employment threshold. If, on the contrary, the shock is out of the area, the Central Banker will only care about price stability. Let us now prove it.

Suppose that we are in the fourth step of the game. The private agents have already anticipated the inflation rate and a supply shock has hit the economy; knowing $\pi^e$ and $\epsilon$, the monetary authority must now choose the monetary policy.

Let us denote $\pi(n^p)$ the level of inflation compatible with the threshold of employment. Using the employment equation,

$$\pi(n^p) = \pi^e + \alpha (n^p - \pi - \epsilon).$$

If $\pi(n^p) < \bar{\pi}$, the governor is going to choose $\pi = \bar{\pi}$ and the level of employment will be ex post greater than $n^p$. The governor will thus not be fired.

If, on the contrary, $\pi(n^p) > \bar{\pi}$, the governor has the choice between deciding $\pi = \bar{\pi}$ and being fired or $\pi = \pi(n^p)$ and not being fired. Under the first alternative, he will suffer a welfare cost of $\delta U^l$ versus $(\bar{\pi} - \pi(n^p))^2 + \delta E_{1,\pi\pi}U$ under the second one. So he will decide to lead an accommodative monetary policy if

$$\pi^e - \frac{\bar{\pi}}{\alpha} + n^p - \pi - \frac{1}{\alpha} (\delta(U^l - EU_{1,\pi\pi}) \leq \pi^e - \bar{\pi} \leq \frac{1}{\alpha} n^p - \pi + \frac{1}{\alpha} (\delta(U^l - EU_{1,\pi\pi})).$$

Therefore, the accommodative area has the assumed shape.

3 - Existence of a positive inflation bias in spite of the appointment of an infinitely conservative governor

The existence of a positive inflation bias can be proven by using equations (4) and (5).

$$(15) \pi^e - \bar{\pi} = bias = \frac{\alpha B^2}{4k}.$$ 

This result is different from Rogoff’s. It shows that even the extreme hypothesis of the appointment of an infinitely conservative governor can not establish entirely the credibility of the monetary authority. The difference arises out of the possibility, which does not exist in Rogoff’s model, of the
replacement of the conservative governor S by a less independent one W, and above all of the private agents’ expectations of this replacement.

The inflation bias is, because of the hypotheses assumed, a quadratic function of the accommodative area.

4 - Sensitivity of the inflation bias

The sensitivity of the inflation bias, i.e. how this bias varies when one of the structural parameters of the economy changes is now studied.

With equation (14) it is possible to prove the following results (cf. Appendix 2 for more details):

- The greater the cost of being fired, the more the Central Banker is going to conduct an accommodative policy. The private agents, who know the cost $U^I$, will anticipate higher inflation.

- The bias is a decreasing function of the degree of conservatism of Central Banker W. This result is a direct consequence of the previous one because $U^I$ is a decreasing function of $\beta$. It is rather intuitive. The more the governor W will be independent the less the cost borne by the governor S will be important and so the less he will accommodate shocks.

- The higher $n^p$, that is if the employment requirements are strong, the more the governor will adapt his behaviour to satisfy them. The private agents thus will anticipate higher inflation.

- The inflation bias is an decreasing function of the discount rate. This result can be interpreted in terms of preference for the present. Intuitively, the more the governor S cares about the present, the less the temptation to conduct an accommodative monetary policy will be and thus the smaller the bias.

- The more often the economy will be hit by large shocks, the more the Central Banker will lead an accommodative policy to avoid being under the employment threshold. Thus, the private agents will form more inflationist expectations.

- It is not possible to anticipate how the inflation bias varies when the inflation elasticity to employment increases. The result indeed depends on the value of the various structural parameters of the model.
The previous results can be summed up in the following table:

<table>
<thead>
<tr>
<th>bias</th>
<th>$U^I$</th>
<th>$\sigma_x^2$</th>
<th>$\beta$</th>
<th>$n^p - \bar{p}$</th>
<th>$\delta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
V - NUMERICAL SIMULATIONS

To illustrate the previous results and to give a more precise information on the relation which links the inflation bias to the main parameters of the model, a numerical simulation has been implemented with the GAUSS software for the German case. To do it, a calibration of the model was necessary.

1 - The model’s calibration

The different values of the parameters used in the simulations are summed up in the following table.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$k$</td>
<td>0.35</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>1.4</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.67</td>
</tr>
<tr>
<td>$\bar{n} - \bar{n}$</td>
<td>0.02</td>
</tr>
<tr>
<td>$n^p - \bar{n}$</td>
<td>0.01</td>
</tr>
<tr>
<td>$\sigma^2$</td>
<td>0.04</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.97</td>
</tr>
</tbody>
</table>

The inflation elasticity to employment was chosen to be 0.7. This value seems reasonable for a Cobb-Douglas production function. The degree of conservatism was taken from the German political independence index constructed by Cukierman (1992) for the 80’s. In spite of the similarity and the relevance of the criticisms about the construction of these indexes (cf. Eiffinger et Schaling (1993), Mangano (1997)), their use can be justified in the present case because they all give the Bundesbank a high degree of independence (cf. Cukierman (1992), Grilli-Masciandaro-Tabellini (1991), Bade Parkin (1982)). The variance of the supply shock was calibrated with the variance of the German GDP (base 1 in 1980 in the OECD’s Economic Outlooks) from 1970 to 1996. The value of $\delta$ corresponds to a real short term interest rate of 300 base points which is the German average over the 1970 to 1996 period. The value of $k$ is compatible with the calibration of the variance of the shock.

The other parameters have been a priori fixed. However, the variables $k$, $n^p - \bar{\pi}$ and $\bar{n} - \bar{\pi}$ are linked and one must respect some constraints to calibrate them. As $\delta=0.97$, the model has a real solution if $k > \frac{-2}{1.12} (n^p - \bar{\pi})$. Besides, one must choose $n^p - \bar{\pi}$ and $\bar{n} - \bar{\pi}$ so that $n^p - \bar{\pi} < \bar{n} - \bar{\pi}$ to be sure that $n^p < \bar{n}$.
With this calibration it is possible to give a rough estimate of the inflation bias: 0.02. This figure is obtained by resolving the fourth degree equation (14). It depends largely on the value of \( \sigma_e \), \( \alpha \) and of \( k \) (cf. Table 2) and so one must not give it too much importance. Moreover, this evaluation relies on the extreme case when an infinite conservative governor is appointed and may be replaced by a governor as conservative as the Bundesbank in the 80’s.

**Table 2: rough estimate of the inflation bias according to the values of the parameters**

<table>
<thead>
<tr>
<th></th>
<th>( k = 1.6 )</th>
<th>( k = 0.35 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha = 1.4 )</td>
<td>0.08</td>
<td>0.02</td>
</tr>
<tr>
<td>( \alpha = 0.7 )</td>
<td>0.14</td>
<td>0.04</td>
</tr>
</tbody>
</table>

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2 - Some more results on the bias properties

In this part, we study how the inflation bias varies when one of model’s parameters increases and the other parameters are maintained fixed. The results are not fundamentally changed with another calibration (see for instance the results for another value of the variance of the shock in Annex 1).

In order to compute the inflation bias according to the value of \( n^p - \bar{\pi} \), it is assumed that the difference between \( n^p \) and \( \bar{\pi} \) is constant.

The numerical simulation of the model, simple as it is, allows us to find again the previous results of the sign of the main parameters’ influence on the inflation bias. However, some more information is supplied (cf. Graph 2). On the one hand, the inflation bias is almost a linear function of the shock variance and of the social pressure. On the other hand, it decreases very rapidly with the degree of conservatism of the weak governor.

For the values chosen for the different parameters, the bias is a decreasing function of \( \alpha \).
Graph 2: Results of the numerical simulation

1. Evolution of the inflation bias with the standard error of the shock
2. Evolution of the bias with the degree of conservatism
3. Evolution of the bias with delta
4. Evolution of the bias with npbbaru
5. Evolution of the bias with alpha
6. Evolution of the inflation bias with the cost
VI - CONCLUSIONS

As the replacement of a Central Banker is always possible, the presence of an infinitely conservative governor is not sufficient to avoid the existence of an inflation bias and of inflationist peaks when social pressures are too important. This bias is an increasing function of the variance of the supply shocks, of the cost suffered by the governor if he is replaced by a less conservative one and of the amplitude of the social pressure. It is conversely a decreasing function of the independence of the substitute governor and of the preference for the present of the first appointed governor.

The model developed here nonetheless suffers from various limits, mainly because of its simplicity. To improve the model, the private agents’ social pressure could be endogeneized so as to be for instance be a function of the previous rate of unemployment: if the agents face a high level of unemployment, they may be less demanding and accept lower increases in wages. Lastly, it could be interesting to weaken the hypothesis concerning the distribution of the supply shock and to obtain more general results.
APPENDIX 1 : EXISTENCE OF A SOLUTION

For simplicity, it is let : \( a_i = \frac{8k}{3}, \ b_i = 4k\left(\frac{2k}{\delta} - k + (n^p - \pi)\right), \ c_i = -\frac{8k^2U^1(1-\delta)}{\delta a^2} \).

Therefore equation (14) can be rewritten \( f(B) = B^4 + a_iB^3 + b_iB^2 + c_i = 0 \), \( a_i > 0, \ b_i > 0, \ c_i < 0 \).

It can be noted that, if a solution exists, it is negative because we have imposed \( \varepsilon_1 < \varepsilon_2 \).

So the study can be limited to \( \mathbb{R}^- \), where \( f \) exists, is continuous and derivable.

\[ \forall B \in \mathbb{R}^-, \quad f'(B) = B(4B^2 + 3a_iB + 2b_i) \]

As \( \delta < 1 \) and for \( k \) high enough, \( \Delta = 64^*[(1 - 2(\frac{2}{\delta} - 1))k^2 - 2k(n^p - \pi)] < 0 \), \( f^* \) has no real root than zero. \( f \) is continuous and decreasing on \( \mathbb{R}^- \); it is thus a bijection from \( \mathbb{R}^- \) to \( [c_1, +\infty[ \). As \( c_1 < 0 \), \( f \) has a unique root on \( \mathbb{R}^- \), called \( B^- \). Therefore, the model developed here has at least a real solution.
APPENDIX 2 : SENSITIVITY OF THE INFLATION BIAS

a - The bias is an increasing function of the cost endured by the Central Banker in case of layoff.

Equation (15) yields \( \frac{\partial \text{bias}}{\partial U^i} \bigg|_{B=B_0} = \frac{\alpha}{2k} B \frac{\partial h_i}{\partial U^i} \). Using equation (6) and noting that \( \frac{\partial a_i}{\partial U^i} = \frac{\partial h_i}{\partial U^i} = 0 \), it follows \( \frac{\partial B}{\partial U^i} (B(4B^2 + 3a_i B + 2h_i)) = -\frac{\partial c_1}{\partial U^i} \). But \( 4B^2 + 3a_i B + 2h_i > 0 \) and \( \frac{\partial c_1}{\partial U^i} = \frac{8k^2}{8\alpha^2} (1 - \delta) > 0 \).

Thus \( \text{sign}(\frac{\partial B}{\partial U^i}) = \text{sign}(B) \). Besides \( B_0 < 0 \) and finally \( \frac{\partial B}{\partial U^i} < 0 \) and \( \frac{\partial \text{bias}}{\partial U^i} > 0 \).

b - The more vigorous the social pressures, the bigger the bias.

To simplify, let us note \( N = n^p - \bar{n} \).

Reasoning in the same way as was done in the study of the sensitivity of the bias to the cost in case of firing, we get \( \frac{\partial B}{\partial N} = \frac{4k[-B^2 + \frac{4k}{B\alpha^2} (\bar{n} - \bar{n})]}{B(4B^2 + 3a_i B + 2h_i)} \). Assuming that \( k \) is high enough, \( B^2 < + \frac{4k}{B\alpha^2} (\bar{n} - \bar{n}) \) and \( \frac{\partial B}{\partial N} < 0 \). Thus\(^4 \frac{\partial \text{bias}}{\partial N} > 0 \).

c - The more the governor cares about the present situation, the smaller the bias.

Noting \( \frac{\partial c_1}{\partial \delta} = 0 \), (14) implies \( \frac{\partial B}{\partial \delta} B(4B^2 + 3a_i B + 2h_i) + \frac{\partial h_i}{\partial \delta} B^2 = 0 \). As \( \frac{\partial h_i}{\partial \delta} = -\frac{8k^2}{8\alpha^2} < 0 \), \( 4B^2 + 3a_i B + 2h_i > 0 \) in the neighbourhood of the solution and \( B_0 < 0 \). Therefore, \( \frac{\partial B}{\partial \delta} < 0 \) and \( \frac{\partial \text{bias}}{\partial \delta} > 0 \).

d - The bias is an increasing function of the variance of the supply shock.

It is not a direct consequence of the previous result concerning the cost endured by Central Banker because \( \delta \) is also a function of \( \sigma^2 \).

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\(^4\) This result is obtained under the hypothesis that \( n^p - \bar{n} \) is constant.
Using the definition of the bias, we have \( \frac{\partial \text{bias}}{\partial \sigma^2_x} \bigg|_{B=B_c} = \frac{\alpha}{4k} \left[ 2B \left( \frac{\partial B}{\partial \sigma^2_x} \right)^2 - \frac{B^2}{k} \right]. \) But with equation (14)

\[
\frac{\partial B}{\partial \sigma^2_x} B(4B^2 + 3a_k B + 2b_h) = \frac{\partial a_k}{\partial \sigma^2_x} - \frac{\partial h}{\partial \sigma^2_x} B^2 - \frac{\partial k}{\partial \sigma^2_x}.
\]

Recalling that \( \frac{\partial k}{\partial \sigma^2_x} = \frac{3}{2\sqrt{3\sigma^2_x}} \), we have

\[
\frac{\partial \text{bias}}{\partial \sigma^2_x} \bigg|_{B=B_c} = -\frac{4B^2}{k} \left( \frac{8}{\sqrt{3\sigma^2_x}} + \frac{3a_k}{k} \right) B^3 - \left( \frac{2}{k} (\frac{2}{\delta} - 1) \right) \frac{24k}{\sqrt{3\sigma^2_x}} B^2 + \frac{12(1-\delta)kU}{\delta \alpha^2 \sigma^2_x} - \frac{16k^2}{\alpha^4 (\beta + \frac{1}{\rho})^2}.
\]

Thus, for \( k \) high enough, \( \frac{\partial \text{bias}}{\partial \sigma^2_x} \bigg|_{B=B_c} > 0 \).
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ANNEX 1: OTHER RESULTS OF THE NUMERICAL SIMULATION OF THE MODEL

*Calibration*: $k = 1.6$, $\alpha = 1.4$, $\beta = 0.67$, $\bar{\pi} - \bar{\pi} = 0.02$, $n^p - \bar{\pi} = 0.01$, $\sigma_\epsilon^2 = 0.81$, $\delta = 0.97$