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Designing the Optimal Conservativeness of the Central Bank

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Abstract

In this paper we propose a new measure of the degree of conservativeness of an independent central bank and we derive the optimal value from the social welfare perspective. We show that the mere appointment of an independent central bank is not enough to achieve lower inflation, which may explain the mixed results found between central bank independence and inflation in the empirical literature. Further, the optimal central bank should not be too conservative. For instance, we will show that in some circumstances it will be optimal that the central bank is less conservative than society in the Rogoff sense.

JEL classification: E58, E63.

Keywords: Central bank; Conservativeness; Independence.

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1. Introduction

In the second half of the 1980s and early 1990s, a series of influential articles (Rogoff, 1985; Alesina and Tabellini, 1987 and Debelle and Fischer, 1994, among others) postulated that an independent central bank with a priority for stabilizing inflation would achieve lower inflation. The ideas on central bank independence and conservativeness[1] spread very soon to the macroeconomic sphere: no fewer than 84 countries increased the formal autonomy of their central banks from the 1990s to 2008 (Rapaport et al., 2009). As Forder (2005) points out, so complete is the consensus on the desirability of central bank independence that it is possible to forget how quickly it emerged.

Surprisingly enough, however, the empirical studies that look at the relationship between central bank independence and inflation offer mixed results (see, among others, Klomp and De Haan (2010a, 2010b), Cukierman (2008) and Crowe and Meade (2007)).[2] Is it possible that we have gone too far too quickly?

A striking aspect of the widespread support for central bank independence is the lack of a thorough welfare analysis. An exception is Rogoff's (1985) model with only one policy, monetary policy. Rogoff proposed a measure of conservativeness: the weight placed on inflation stabilization relative to output stabilization by the central bank should be greater than society's. He showed that society could make itself better off by appointing a central banker who placed an additional weight on inflation rate stabilization. This additional weight must be positive and finite.

Given that monetary and fiscal policies are set in most industrial countries by two authorities that are (at least partly) independent and have different objectives, other studies extended the model to include a fiscal authority and fiscal policy. However, the welfare analysis of the models with two policies is not complete. For instance, Alesina and Tabellini (1987) showed that society's welfare would improve by appointing a central banker whose relative weights in the loss function were infinitesimally smaller than the ones of society, making the central bank slightly more conservative. Further, the preferences of society and the central bank tend to differ among studies. For instance, Alesina and Tabellini (1987) and Beetsma and Bovenberg (1997) consider society's and the authorities' preferences defined over inflation, output and public spending. Debelle and Fischer (1994), on the other hand, perform a welfare analysis assuming that both the central bank and society's losses do not depend on

[1] Conservativeness refers to the degree of central bank's inflation aversion, whereas independence refers to the extent to which the central bank determines monetary policy without political interference.

[2] For a recent survey, see Alesina and Stella (2010).

public spending.

In this article, we will introduce a new indicator of the conservativeness of the central bank with respect to the government and develop a global welfare analysis. We will show that when monetary policy is delegated to an independent central bank, the expected loss function for the society can be written in terms of the conservativeness indicator. Hence, from a normative point of view, if we are interested in designing a central bank that maximizes society's welfare,[3] we can reduce this choice to selecting its optimal degree of conservativeness. We show that there is a unique optimal value for this indicator from the society's point of view. Moreover, since we obtain an upper value of this indicator, we conclude that when we design a central bank we should not make it too conservative.

The rest of the paper is organized as follows. Section 2 outlines the model and presents the formal analysis. Concluding remarks are presented in Section 3 and proofs are gathered in the Appendix.

2. The optimal degree of conservativeness in a model with more than one policy

In this section we will study how conservative should an independent central bank be, from the society's welfare point of view, when there are two different instruments and policies. We will use a standard model such as Debelle and Fischer (1994) and Alesina and Tabellini (1987) to present the results.

Output is given by

$$x_t = \pi_t - \pi_t^e - \tau_t - w^* + \varepsilon_t, \tag{2.1}$$

where π_t and π_t^e are the actual and expected inflation rates, respectively. Moreover, τ_t represents taxes levied on output, w^* denotes the target real wage that workers seek to achieve, and ε_t is a productivity shock such that $\varepsilon_t \sim iid(0, \sigma_\varepsilon^2)$.

The government budget constraint is:

$$g_t = \tau_t + \pi_t, \tag{2.2}$$

where g_t denotes the ratio of public expenditures over output.[4] Note that public spending

[3] Or, in other words, if we are interested in what should the optimal weights be in the monetary authority's preferences.

[4] Expression (2.1) is derived from the optimization problem of a competitive firm using only one input (labour). Output is produced by labour (L), subject to a productivity shock ε_t: $X_t = L^\gamma e^{\varepsilon_t/2}$, where

will be financed by a distortionary tax (controlled by the fiscal authority) and/or by money creation (controlled by the authority responsible for monetary policy).[5]

The government will have the following loss function:

$$L_G = \frac{1}{2}\left(\pi_t^2 + \delta_G\left(x_t - x^*\right)^2 + \gamma_G(g_t - g^*)^2\right), \tag{2.3}$$

with δ_G, $\gamma_G > 0$. The government wishes to minimize the deviations of inflation, output and public spending from some targets.[6] This implies that policymakers are willing to tolerate some inflation and tax distortions in order to obtain certain levels of output and of public spending, x^* and g^*.

We will consider two cases: first, when monetary policy is controlled by the government, and second, when such policy is delegated to an independent authority (central bank). In both cases, the timing of events is as follows: expectations and thus, wages, are set first. Afterwards, the shock ε occurs. Finally, with no delegation, the government chooses both policies. In the case of delegation, the government and the central bank will choose their policies simultaneously.

2.1. No independence of monetary policy

When there is no delegation of monetary policy, the government chooses both fiscal policy (τ) and monetary policy (π). This case also contemplates the presence of a dependent central bank -i.e., with the same preferences as the government. The policies chosen are (where the superscript N indicates no delegation):

$$\begin{aligned}
\pi^N &= \frac{2\delta_G\gamma_G}{\delta_G + \gamma_G + 2\delta_G\gamma_G}A - \frac{2\delta_G\gamma_G}{\delta_G + \gamma_G + 4\delta_G\gamma_G}\varepsilon \text{ and} \\
\tau^N &= g^* - \frac{\left(2\gamma_G + 1\right)\delta_G}{\delta_G + \gamma_G + 2\delta_G\gamma_G}A + \frac{\left(2\gamma_G + 1\right)\delta_G}{\delta_G + \gamma_G + 4\delta_G\gamma_G}\varepsilon,
\end{aligned}$$

$\varepsilon_t \sim iid(0, \sigma_\varepsilon^2)$. Workers set the nominal wage (w in logs) to achieve a target real wage w^*: $w = w^* + p^e$. Distortionary taxes are levied on production. The representative firm maximizes profit, given by: $PL^\gamma e^{\varepsilon_t/2}(1-\tau) - WL$. Solving for the firm's optimization problem (assuming it can hire the labour it demands at the given nominal wage) and taking logs, yields the output supply: $x_t = \alpha\left(\pi_t - \pi_t^e - \tau_t - w^* + \ln\gamma\right) + \frac{\varepsilon_t}{2(1-\gamma)}$. For simplicity we set $\gamma = 0.5$, so that $\alpha = \frac{\gamma}{(1-\gamma)} = 1$, and, following Alesina and Tabellini (1987), we set $\ln\gamma = 0$, so the expression for output becomes (2.1). See Alesina and Tabellini (1987) and Debelle and Fischer (1994) for an explanation of how expression (2.2) is obtained.

[5] Following Beetsma et al. (1997), we also considered a model with $g_t = \tau_t + \kappa\pi_t$, where $\kappa \in [0, 1]$, to take into account the fact that seigniorage revenues in developed economies are small. The qualitative results were not altered. Further, the hypothesis that there is no public debt can alternatively be thought of as stating that in every period policymakers wish to raise the same constant amount of total revenues g^*, in the form of either taxes or money seigniorage (Alesina and Tabellini, 1987).

[6] For simplicity, we have normalized the inflation target at zero.

where $A = x^* + g^* + w^*$. Direct computations yield:

$$\begin{aligned} x^N - x^* &= -\frac{1}{2\delta_G}\pi^N \text{ and} \\ g^N - g^* &= -\frac{1}{2\gamma_G}\pi^N. \end{aligned}$$

Hence, $E\left(\pi^N\right) = \frac{2\delta_G\gamma_G}{\delta_G+\gamma_G+2\delta_G\gamma_G}A > 0$, $E(x^N - x^*) = -\frac{1}{2\delta_G}E\left(\pi^N\right) < 0$ and $E\left(g^N - g^*\right) = -\frac{1}{2\gamma_G}E\left(\pi^N\right) < 0$. Notice that the higher the need to finance public spending (higher g^*), the higher the real wage target (higher w^*) and the higher the target for output (higher x^*), the further away are inflation, output and public spending from their targets. Moreover,

$$\begin{aligned} Var(\pi^N) &= \left(\frac{2\delta_G\gamma_G}{\delta_G+\gamma_G+4\delta_G\gamma_G}\right)^2\sigma_\varepsilon^2, \\ Var(x^N) &= \left(\frac{1}{2\delta_G}\right)^2 Var(\pi^N) \text{ and} \\ Var\left(g^N - g^*\right) &= \left(\frac{1}{2\gamma_G}\right)^2 Var(\pi^N). \end{aligned}$$

2.2. Delegation of monetary policy to an independent authority

In this case the government will delegate the implementation of monetary policy to an independent central bank or monetary authority with different preferences. We will follow Berger et al. (2001) and assume (full) independence of the central bank, implied by $\chi = 1$ in the following expression:

$$M = \chi L_{CB} + (1-\chi)L_G,$$

where M, L_{CB} and L_G represent monetary policy, the loss function of the central bank and the loss function of the government, respectively. We will assume a general loss function for the independent central bank or monetary authority:

$$L_{CB} = \frac{1}{2}\left(\pi_t^2 + \delta_{CB}\left(x_t - x^*\right)^2 + \gamma_{CB}(g_t - g^*)^2\right), \tag{2.4}$$

where $\delta_{CB} > 0$ and $\gamma_{CB} \geq 0$.[7] Notice that some authors have assumed $\gamma_{CB} = 0$. From the social point of view, should the central bank care about public spending? By adopting a more general loss function, we will be able to answer to this question.

[7] Even though both authorities are assumed to have the same goals, we allow them to differ in the relative weights attributed to output and public expenditures with respect to inflation.

The policy instrument chosen by the central bank will be π. The government will minimize its loss function (2.3) by setting τ. The policies chosen in this case will be (where superscript D indicates delegation):

$$\begin{aligned}
\pi^D &= \frac{\delta_{CB}\gamma_G + \gamma_{CB}\delta_G}{\gamma_G + \delta_G + \delta_{CB}\gamma_G + \gamma_{CB}\delta_G} A - \frac{\delta_{CB}\gamma_G + \gamma_{CB}\delta_G}{\gamma_G + \delta_G + 2\delta_{CB}\gamma_G + 2\gamma_{CB}\delta_G} \varepsilon \text{ and} \\
\tau^D &= g^* - \frac{\delta_G + \delta_{CB}\gamma_G + \gamma_{CB}\delta_G}{\gamma_G + \delta_G + \delta_{CB}\gamma_G + \gamma_{CB}\delta_G} A + \frac{\delta_G + \delta_{CB}\gamma_G + \gamma_{CB}\delta_G}{\gamma_G + \delta_G + 2\delta_{CB}\gamma_G + 2\gamma_{CB}\delta_G} \varepsilon.
\end{aligned}$$

Direct computations yield:

$$\begin{aligned}
x^D - x^* &= -\frac{\gamma_G}{\delta_{CB}\gamma_G + \gamma_{CB}\delta_G} \pi^D \text{ and} \\
g^D - g^* &= -\frac{\delta_G}{\delta_{CB}\gamma_G + \gamma_{CB}\delta_G} \pi^D.
\end{aligned}$$

Thus, $E\left(\pi^D\right) = \frac{\delta_{CB}\gamma_G + \gamma_{CB}\delta_G}{\gamma_G + \delta_G + \delta_{CB}\gamma_G + \gamma_{CB}\delta_G} A > 0$, $E(x^D - x^*) = -\frac{\gamma_G}{\delta_{CB}\gamma_G + \gamma_{CB}\delta_G} E\left(\pi^D\right) < 0$ and

$E\left(g^D - g^*\right) = -\frac{\delta_G}{\delta_{CB}\gamma_G + \gamma_{CB}\delta_G} E\left(\pi^D\right) < 0$. Moreover,

$$\begin{aligned}
Var(\pi^D) &= \left(\frac{\delta_{CB}\gamma_G + \gamma_{CB}\delta_G}{\gamma_G + \delta_G + 2\left(\delta_{CB}\gamma_G + \gamma_{CB}\delta_G\right)}\right)^2 \sigma_\varepsilon^2, \\
Var(x^D - x^*) &= \left(\frac{\gamma_G}{\delta_{CB}\gamma_G + \gamma_{CB}\delta_G}\right)^2 Var(\pi^D) \text{ and} \\
Var\left(g^D - g^*\right) &= \left(\frac{\delta_G}{\delta_{CB}\gamma_G + \gamma_{CB}\delta_G}\right)^2 Var(\pi^D).
\end{aligned}$$

2.3. The relative degree of central bank conservativeness

In the related literature the term "conservativeness" represents the degree of inflation aversion of an authority. For instance, Rogoff (1985), in a model with no fiscal policy, considered that the central bank was more conservative than society when $\delta_{CB} < \delta_G$ (assuming the fiscal authority incorporates the social preferences). Alesina and Tabellini (1987) considered a more conservative central bank when both δ_{CB} and γ_{CB} were lower than δ_G and γ_G, respectively. Thus, the degree of conservativeness of the central bank should be related to the number of instruments -and policies. The more realistic a model is, and thus, the more instruments and policies are included, the higher the number of parameters that measure how conservative an authority is. We will introduce a measure of the conservativeness of the central bank that takes into account this fact and encompasses both Rogoff's and Alesina and Tabellini's notions.

Definition 1. *The relative degree of conservativeness of the central bank with respect to the conservativeness of the government (c) is given by*

$$c = \frac{1}{\frac{\frac{\delta_{CB}}{\delta_G} + \frac{\gamma_{CB}}{\gamma_G}}{2}}.$$

Remark 1. *Note that this indicator is the inverse of the average of the relative weights of the central bank with respect to the weights of the government.*

To understand this indicator, let us consider some particular cases:

1) When both authorities have the same preferences, $\delta_{CB} = \delta_G$ and $\gamma_{CB} = \gamma_G$, then $c = 1$, i.e., the government and the central bank have the same degree of conservativeness;

2) If $\delta_{CB} \leq \delta_G$ and $\gamma_{CB} \leq \gamma_G$ and at least one of the previous inequalities is strict, then the central bank is more conservative than the government in the Alesina and Tabellini's sense. In this case, $c > 1$, i.e., the central bank is more conservative than the government;

3) If $\gamma_{CB} = \gamma_G$, then $c > 1$ is equivalent to $\delta_{CB} < \delta_G$, and in this case, the indicator of conservativeness we consider and the one proposed by Rogoff coincide.

If we compare the results provided above with and without delegation, we obtain the following result (see Appendix):

Proposition 1. *Delegation of monetary policy to an independent and "conservative enough" authority ($c > 1$) reduces the expected inflation, the expected output and the expected deviation of public spending. It also reduces the variance of inflation, but increases the variance of output and the variance of public spending.*

Having introduced another instrument (and policy) in the analysis delivers results that recover Rogoff's outcome but also results that digress from Rogoff's. Notice that $c > 1$ encompasses different combinations among the relative weights of the authorities preferences:

a) when the weight on public spending placed by the monetary authority and the government coincide ($\gamma_{CB} = \gamma_G$), we reproduce Rogoff's result: an independent central bank that places a lower weight on output stabilization than the fiscal authority ($\delta_{CB} < \delta_G$) delivers lower inflation but less output stabilization.

b) when the weight placed by the monetary authority on public spending is smaller than the weight of the fiscal authority ($\gamma_{CB} < \gamma_G$) or, when it does not enter the loss function of the monetary authority ($\gamma_{CB} = 0$), the condition $c > 1$ would then include instances where the central bank is less conservative than the fiscal authority in the Rogoff sense (i.e., for values of δ_{CB} such that $\delta_{CB} > \delta_G$).

Proposition 1 could be providing an explanation of the mixed results found between central bank independence and inflation in the empirical literature. The empirical evidence on the expected negative relationship between central bank independence (CBI) and inflation is, as pointed out in the survey of Alesina and Stella (2010), not clear-cut. The measurement of CBI has generally focused on a set of legal characteristics that relate to the central bank's independence from politicians (*de jure* CBI), or on *de facto* CBI, like the turnover of the central bank's governor. According to Proposition 1, delegation of monetary policy to an independent central bank per se is not enough to achieve lower inflation; it is also necessary that the central bank is "conservative enough" in the sense that $c > 1$. This is an important point that should be considered in the empirical assessment of the effects on inflation of delegating monetary policy to a central bank. The problem is, from a practical point of view, that the concept of conservativeness is hard to identify. However, as Berger et al. (2001) point out in their survey and we have demonstrated in Proposition 1, it is the combination of CBI and conservativeness that delivers lower inflation. Moreover, when taking into consideration more than one policy, what matters is the *relative degree* of conservativeness of the central bank.

2.4. Welfare analysis: designing the optimal central bank

The question that follows is, then, how conservative should the independent central bank be from society's point of view. Rogoff (1985), in a model with only one policy, obtains that society can be better off if the central bank places a greater (but not infinitely greater) weight on inflation stabilization than society does. Alesina and Tabellini (1987) incorporate a second agent (the government) that controls fiscal policy and obtain that the welfare of the government would improve by delegating monetary policy to a slightly more conservative central bank. Debelle and Fischer (1994), in a model similar to Alesina and Tabellini's, consider a different welfare function for the society and obtain that the optimal value of δ_{CB} decreases with society's aversion to inflation, and increases with society's weight on output.

In order to study the optimal degree of conservativeness of the central bank, we will consider a general loss function for the society:

$$L_S = \frac{1}{2}\left(\pi_t^2 + \delta_S\left(x_t - x^*\right)^2 + \gamma_S(g_t - g^*)^2\right).$$

Taking expectations, under delegation, the expected loss for society is:

$$E\left[L_S^D\right] = \frac{1}{2}\left[\left(E\left(\pi^D\right)\right)^2 + Var\left(\pi^D\right)\right]\left(1 + \delta_S\left(\frac{\gamma_G}{\delta_{CB}\gamma_G + \gamma_{CB}\delta_G}\right)^2 + \gamma_S\left(\frac{\delta_G}{\delta_{CB}\gamma_G + \gamma_{CB}\delta_G}\right)^2\right),$$

which can be rewritten as a function of the relative degree of conservativeness of the central bank, c, as follows:

$$E\left[L_S^D\right] = \frac{1}{2}\left(\frac{1}{\left(\frac{\delta_G+\gamma_G}{\delta_G\gamma_G}\frac{c}{2}+1\right)^2}A^2 + \frac{1}{\left(\frac{\delta_G+\gamma_G}{\delta_G\gamma_G}\frac{c}{2}+2\right)^2}\sigma_\varepsilon^2\right)\left(1 + \delta_S\left(\frac{c}{2\delta_G}\right)^2 + \gamma_S\left(\frac{c}{2\gamma_G}\right)^2\right).$$

It is important to point out that the parameters δ_{CB} and γ_{CB} affect the society's welfare through c. Hence, the problem of finding the optimal relative weights, i.e. δ_{CB} and γ_{CB}, that maximize the society's welfare is reduced to determine the relative degree of conservativeness of the central bank. Formally,

$$\underset{c}{min} E\left[L_S^D\right].$$

Proposition 2: *There exists a unique value of c, denoted by c^*, that maximizes society's welfare. Moreover, $c^* \in (\beta, 2\beta)$* where $\beta = \frac{\delta_G\gamma_G(\delta_G+\gamma_G)}{\delta_S\gamma_G^2+\gamma_S\delta_G^2}$.[8]

Applying the Implicit Function Theorem we derive the following comparative statics results:

Corollary 3: $\frac{\partial c^*}{\partial \varkappa} < 0$ for $\varkappa = \delta_S$, γ_S and σ_ε^2, while $\frac{\partial c^*}{\partial \varkappa} > 0$ for $\varkappa = A$.

According to Corollary 3, the higher society's weights on output stabilization and public spending, the lower will be the optimal degree of conservativeness of the central bank. This is due to the fact that a more conservative central bank would increase the deviations of output and public spending from their targets, lowering welfare. Further, the higher the volatility of supply shocks, the lower is c^* and, thus, the less conservative the central bank should be in order to try to stabilize output. Finally, the higher the target level of output,

[8] Following on the comment of Footnote 5, when the government constraint is given by $g_t = \tau_t + \kappa\pi_t$, the optimal value of c^* belongs to the interval $\left(\beta, \frac{(k+1)}{k}\beta\right)$.

public spending or the real wage targeted by unions, the higher would be inflation and thus the more conservative the central bank would have to be.

Many articles consider that the fiscal authority incorporates the social preferences, as society would have chosen the government through elections, and thus, $\delta_S = \delta_G$ and $\gamma_S = \gamma_G$. In this case, we obtain the following corollary:

Corollary 4: *When the preferences of the government and society coincide, the optimal degree of conservativeness of the central bank satisfies that* $c^* \in (1, 2)$.

Therefore, in the optimal, the central bank is relatively more conservative than society (and the government). This is in line with the results of Rogoff (1985), Alesina and Tabellini (1987) and Beetsma et al. (1997).

We are interested in finding the optimal relative weights of the central bank's preferences. By minimizing $\underset{c}{min} E\left[L_S^D\right]$ we are finding a relationship that the optimal values of δ_{CB} and γ_{CB} must satisfy. Therefore, with no loss of generality, as the relevant variable in the optimization problem of society's welfare is c, we can interpret that we have a degree of freedom when choosing the optimal values δ_{CB} and γ_{CB}. Consequently, we can suppose that $\gamma_{CB} = 0$, which corresponds to the case studied, among others, by Debelle and Fischer (1994). In this case, the following corollary applies:

Corollary 5: *If public spending is not included in the preferences of the central bank (*$\gamma_{CB} = 0$*) and the preferences of society and the government coincide, the optimal relative weight of output satisfies* $\delta_{CB} \in (\delta_G, 2\delta_G)$.

In this case, the central bank would be *less* conservative than the government and society in the Rogoff sense. However, we cannot conclude that in this case the central bank is less conservative, as $c > 1$. From a normative point of view, we could then justify that public spending does not need to be included in the loss function of the monetary authority, but the consequence of this is that the socially optimal value of δ_{CB} is then higher.

Further, the last two corollaries indicate that the optimal degree of conservativeness of the central bank might have been, in some cases, overstated. Notice that, when the government's and society's preferences coincide, the optimal degree of conservativeness of the central bank when there are two instruments of policy should be smaller than 2. This indicates that a central bank that is too conservative ($c > 2$) would not be optimal. In particular, if $\gamma_{CB} = 0$ and $\delta_{CB} < \delta_G$, which would be equivalent to Rogoff's model, then the central bank would be *too conservative*. Given that in the last decades a number of central banks have been made extremely inflation averse, the question arises from this analysis as to whether they are too conservative from the society's point of view.

In this sense, it is interesting to note that the possibility of accepting an ultra-conservative central bank might have become a reality for countries joining a monetary union like the case of the European Monetary Union (EMU) shows. The European Central Bank (ECB), the monetary authority of the EMU, was established as an ultra-conservative central bank, more independent than the Bundesbank was (see, among others, Wyplosz (1997) and De Haan (1997)). However, not all countries that decided to enter the monetary union might have had the same degree of inflation aversion. For instance, Scheve (2004) finds that Austria, Belgium, Finland, France, Greece, Italy, Ireland, the Netherlands, Portugal and Spain, for instance, have on average lower inflation aversion than Germany. The question that arises from the analysis presented here is whether the ECB has been too conservative from the social welfare perspective of some EMU member countries. Obviously, when joining a monetary union, a country might accept an ultra-conservative monetary authority as a trade off for other advantages that are not included in the model here and its overall welfare might not necessarily worsen. Nonetheless, the analysis carried out in this article questions the need for ultra-conservative central banks.

3. Conclusions

This article illustrates that, in the presence of more than one policy, inflation will be reduced when monetary policy is delegated to an independent authority that is also *relatively* conservative. Further, we also obtain a finite optimal degree of central bank conservativeness, which confirms Rogoff's (1985) conclusion that conservativeness should not be infinite. But, contrary to Rogoff´s results, we show that there may be instances where the optimal degree of conservativeness of the central bank is associated with a higher weight on output stabilization than the government -or than society, if the government represents society's preferences.

We have defined an indicator of the relative degree of conservativeness of the central bank, which is also useful to define the optimal relative weights in the preferences of the monetary authority from society's point of view. We have shown that, from a normative point of view, one can design a central bank that cares about public spending. Further, one could equally design a central bank that does not care about public spending, but then the optimal weight on output stabilization would have to be higher and thus the central bank would be less conservative in the Rogoff sense.

Appendix

A. Proof of Proposition 1

Using the expression of c, direct computations yield

$$\begin{aligned}
E(\pi^D) - E(\pi^N) &= -\frac{2(\delta_G+\gamma_G)\delta_G\gamma_G(c-1)}{((\delta_G+\gamma_G)c+2\delta_G\gamma_G)(\delta_G+\gamma_G+2\delta_G\gamma_G)}A, \\
E(x^D-x^*) - E(x^N-x^*) &= -\frac{2\delta_G\gamma_G^2(c-1)}{((\delta_G+\gamma_G)c+2\delta_G\gamma_G)(\delta_G+\gamma_G+2\delta_G\gamma_G)}A, \\
E(g^D-g^*) - E(g^N-g^*) &= -\frac{2\delta_G^2\gamma_G(c-1)}{((\delta_G+\gamma_G)c+2\delta_G\gamma_G)(\delta_G+\gamma_G+2\delta_G\gamma_G)}A, \\
Var(\pi^D) - Var(\pi^N) &= -4\frac{((\delta_G+\gamma_G)(c+1)+8\delta_G\gamma_G)(\delta_G+\gamma_G)\delta_G^2\gamma_G^2(c-1)}{(c(\delta_G+\gamma_G)+4\delta_G\gamma_G)^2(\delta_G+\gamma_G+4\delta_G\gamma_G)^2}\sigma_\varepsilon^2, \\
Var(x^D-x^*) - Var(x^N-x^*) &= \frac{8(c(\delta_G+\gamma_G+2\delta_G\gamma_G)+2\delta_G\gamma_G)\delta_G\gamma_G^3(c-1)}{(c(\delta_G+\gamma_G)+4\delta_G\gamma_G)^2(\delta_G+\gamma_G+4\delta_G\gamma_G)^2}\sigma_\varepsilon^2 \text{ and} \\
Var(g^D-g^*) - Var(g^N-g^*) &= \frac{8(c(\delta_G+\gamma_G+2\delta_G\gamma_G)+2\delta_G\gamma_G)\delta_G^3\gamma_G(c-1)}{(c(\delta_G+\gamma_G)+4\delta_G\gamma_G)^2(\delta_G+\gamma_G+4\delta_G\gamma_G)^2}\sigma_\varepsilon^2.
\end{aligned}$$

Hence, if $c > 1$, then we obtain the desired results. ■.

B. Proof of Proposition 2

Let's minimize the expected value of the loss function for society:

$$\underset{c}{min} E\left[L_S^D\right]$$

The f.o.c. of this optimization problem is given by:

$$\begin{aligned}
\frac{\partial}{\partial c}E\left[L_S^D\right] &= 2\delta_G\gamma_G\left(\frac{c\left(\delta_S\gamma_G^2+\gamma_S\delta_G^2\right)-2\delta_G\gamma_G(\delta_G+\gamma_G)}{(c(\delta_G+\gamma_G)+2\delta_G\gamma_G)^3}A^2 + 2\frac{\left(c\left(\delta_S\gamma_G^2+\gamma_S\delta_G^2\right)-\delta_G\gamma_G(\delta_G+\gamma_G)\right)}{(c(\delta_G+\gamma_G)+4\delta_G\gamma_G)^3}\sigma_\varepsilon^2\right) \\
&= 0.
\end{aligned}$$

Note that if $c > \frac{2\delta_G\gamma_G(\gamma_G+\delta_G)}{\delta_S\gamma_G^2+\gamma_S\delta_G^2}$, $\frac{\partial}{\partial c}E\left[L_S^D\right] > 0$. Moreover, if $c < \frac{\delta_G\gamma_G(\gamma_G+\delta_G)}{\delta_S\gamma_G^2+\gamma_S\delta_G^2}$, $\frac{\partial}{\partial c}E\left[L_S^D\right] < 0$. Hence, we know that there exists a value of c belonging to the interval $\left(\frac{\delta_G\gamma_G(\gamma_G+\delta_G)}{\delta_S\gamma_G^2+\gamma_S\delta_G^2}, \frac{2\delta_G\gamma_G(\gamma_G+\delta_G)}{\delta_S\gamma_G^2+\gamma_S\delta_G^2}\right)$ that satisfies the f.o.c.

In relation to the s.o.c. note that

$$\frac{\partial^2}{\partial^2 c}E\left[L_S^D\right] = 4\delta_G\gamma_G\left(\begin{array}{c} \frac{\delta_G\gamma_G\left(3(\gamma_G+\delta_G)^2+\left(\delta_S\gamma_G^2+\gamma_S\delta_G^2\right)\right)-\left(\delta_S\gamma_G^2+\gamma_S\delta_G^2\right)(\gamma_G+\delta_G)c}{(c(\gamma_G+\delta_G)+2\gamma_G\delta_G)^4}A^2 \\ +\frac{\delta_G\gamma_G\left(3(\gamma_G+\delta_G)^2+4\left(\delta_S\gamma_G^2+\gamma_S\delta_G^2\right)\right)-2\left(\delta_S\gamma_G^2+\gamma_S\delta_G^2\right)(\gamma_G+\delta_G)c}{(c(\gamma_G+\delta_G)+4\gamma_G\delta_G)^4}\sigma_\varepsilon^2 \end{array}\right).$$

In a value of c that satisfies the f.o.c., $A^2 = \frac{-2\frac{\left(c\left(\delta_S\gamma_G^2+\gamma_S\delta_G^2\right)-\delta_G\gamma_G(\gamma_G+\delta_G)\right)}{\left(c(\gamma_G+\delta_G)+4\gamma_G\delta_G\right)^3}}{\frac{c\left(\delta_S\gamma_G^2+\gamma_S\delta_G^2\right)-2\delta_G\gamma_G(\gamma_G+\delta_G)}{\left(c(\gamma_G+\delta_G)+2\gamma_G\delta_G\right)^3}}\sigma_\varepsilon^2$. Hence, in this case

$$\frac{\partial^2}{\partial^2 c}E\left[L_S^D\right] = \frac{4\left(\gamma_G+\delta_G\right)\sigma_\varepsilon^2\delta_G^2\gamma_G^2\left(\gamma_G^2\delta_S+\delta_G^2\gamma_S\right)p(c)}{\left(2\delta_G\gamma_G\left(\delta_G+\gamma_G\right)-c\left(\delta_S\gamma_G^2+\gamma_S\delta_G^2\right)\right)\left(c\left(\delta_G+\gamma_G\right)+4\gamma_G\delta_G\right)^4\left(c\left(\delta_G+\gamma_G\right)+2\delta_G\gamma_G\right)},$$

where

$$p(c) = 4\delta_G^2\gamma_G^2\left(2-3\frac{\left(\delta_G+\gamma_G\right)^2}{\left(\gamma_G^2\delta_S+\delta_G^2\gamma_S\right)}\right)+24\left(\delta_G+\gamma_G\right)\delta_G\gamma_G c+\left(\left(\delta_G+\gamma_G\right)^2-6\left(\gamma_G^2\delta_S+\delta_G^2\gamma_S\right)\right)c^2.$$

Direct computations yield that $p(c)$ is increasing in the interval $\left(\frac{\delta_G\gamma_G(\delta_G+\gamma_G)}{\delta_S\gamma_G^2+\gamma_S\delta_G^2}, \frac{2\delta_G\gamma_G(\delta_G+\gamma_G)}{\delta_S\gamma_G^2+\gamma_S\delta_G^2}\right)$ and $p(\frac{\delta_G\gamma_G(\delta_G+\gamma_G)}{\delta_S\gamma_G^2+\gamma_S\delta_G^2}) > 0$. Thus, it follows that in a value of c that satisfies the f.o.c. $\frac{\partial^2}{\partial^2 c}E\left[L_S^D\right] > 0$. This guarantees that the value c that solves the f.o.c. is unique and it is a minimum. ■

Proof of Corollary 3: Recall that c^* is the solution of a optimization problem. From the f.o.c., we know that c^* satisfies

$$F(c^*, \varkappa) = 0,$$

where

$$F(c,\varkappa) = \frac{c\left(\delta_S\gamma_G^2+\gamma_S^2\delta_G\right)-2\delta_G\gamma_G\left(\delta_G+\gamma_G\right)}{\left(c\left(\delta_G+\gamma_G\right)+2\delta_G\gamma_G\right)^3}A^2+2\frac{\left(c\left(\delta_S\gamma_G^2+\gamma_S\delta_G^2\right)-\delta_G\gamma_G\left(\delta_G+\gamma_G\right)\right)}{\left(c\left(\delta_G+\gamma_G\right)+4\delta_G\gamma_G\right)^3}\sigma_\varepsilon^2$$

and $\varkappa$ denotes a parameter. In addition, from the s.o.c., we know $\frac{\partial F}{\partial c}(c^*, \varkappa) > 0$. Applying the Implicit Function Theorem, we get

$$sign\left(\frac{\partial c^*}{\partial \varkappa}\right) = -sign\left(\frac{\partial F}{\partial \varkappa}(c^*, \varkappa)\right).$$

Direct computations yield $\frac{\partial F}{\partial \varkappa}(c^*, \varkappa) > 0$ for $\varkappa = \delta_S, \gamma_S$ and σ_ε^2, while $\frac{\partial F}{\partial \varkappa}(c^*, \varkappa) < 0$ for $\varkappa = A$. Hence, we have that $\frac{\partial c^*}{\partial \varkappa} < 0$ for $\varkappa = \delta_S, \gamma_S$ and σ_ε^2, while $\frac{\partial c^*}{\partial \varkappa} > 0$ for $\varkappa = A$. ■

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