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Central Bank Independence and Conservatism under Uncertainty: Substitutes or Complements?

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Abstract

The paper examines the optimal combination of central bank independence and conservatism in the presence of uncertain central bank preferences. We develop a model of endogenous monetary policy delegation in which government chooses the central bank's degree of independence and conservatism so as to minimise society's loss function. We find that the optimal combination between independence and conservatism is not necessarily characterised by substitutability. When uncertainty about the central bank's preferences is high, independence and conservatism can become complements. In this case, giving more independence to the central bank increases the need for conservatism.

JEL-Code: E520, E580.

Keywords: central bank independence, conservatism, transparency.

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1. Introduction

In the debate about the optimal institutional design of central banks, independence and conservatism are usually considered to be the most important ingredients for a stable and successful monetary policy. Building on Rogoff (1985), it is argued that delegating monetary policy to an independent and conservative central bank will improve its credibility and deliver, on average, a lower and less variable rate of inflation, albeit at the price of higher output variability.[1] In the literature about monetary policy delegation, however, most papers treat central bank independence and conservatism as a joint variable. Both institutional features are usually modelled by a unique parameter representing the relative weight attributed to inflation stabilisation in the central bank's objective function. Yet, independence and conservatism (henceforth, respectively CBI and CBC) are two different concepts: Independence refers to the central bank's ability to determine monetary policy without facing pressures from the government, while conservatism refers to the fact that the central bank assigns a higher relative weight to inflation control than society and the governement do. In this paper, we explicitly distinguish between CBI and CBC in order to examine the optimal combination between those monetary regime features. This is done by means of a model of endogenous monetary policy delegation where the government (the principal) chooses the central bank (agent)'s degree of independence and conservatism so as to minimise the society's loss function.

Up to now only few papers have allowed for a formal distinction between CBI and CBC.[2] An important first study is the paper by Eijffinger and Hoeberichts (1998). Using a Barro-Gordon type model, they introduce an explicit parameter for independence in a monetary policy model with a con-

[1] The literature relating to the discussion about the design of monetary institutions is much too broad to be completely referenced here. It includes seminal contributions by, for instance, Kydland and Prescott (1977), Barro and Gordon (1983), Rogoff (1985), Alesina and Tabellini (1987), Cukierman (1992), Walsh (1995) and Svensson (1997), Cukierman and Lippi (1999). Recent surveys include Berger et al. (2001), Siklos (2008), Laurens et al. (2009), and Hayo and Hefeker (2010).

[2] In the empirical literature, most papers construct indices of central bank characteristics that combine information on the legal independence with information on the inflation aversion of the central bank (see, for example, Cukierman, Webb and Neyapti (1992) or Alesina and Summers (1993)). Notable exceptions are the papers by de Haan and Kooi (1997), Berger and Woitek (2005) and, more recently, Berlemann and Hielscher (2010) that propose separate indices for independence and conservatism.

servative central banker. The central bank is assumed to face pressures from the government when setting its monetary decisions. This idea is captured by the fact that the loss function that effectively governs monetary policy is a weighted average of the central bank's loss function and the government's loss function. CBI is then defined as the strength of the central bank in negotiations with the government about monetary policy. Within this framework, they show that there exists a continuum of combinations of CBI and CBC that may be socially optimal. More important, these optimal combinations reveal the existence of a trade-off between independence and conservatism. This implies that if, for some reason, the government decides to reduce the central bank's independence, it is optimal for society that the central bank adopts a more conservative attitude.[3]

More recently, Eijffinger and Hoeberichts (2008) have shown that the trade-off between CBI and CBC also holds within a New Keynesian framework. Hughes Hallett and Weymark (2005) and Weymark (2007) examine the optimal combination of CBI and CBC in a model with strategic interaction between monetary and fiscal authorities, while Lippi (2000) studies how the optimal degrees of independence and of conservatism are related to social preferences (as represented by the median voter preferences). A common result of these papers is that they identify independence and conservatism as potential substitutes, suggesting that it is possible to compensate a lack of independence by appointing a more conservative central banker.

In this paper, we add another dimension to the analysis of the optimal combination of CBI and CBC by introducing uncertainty about the central bank's preference parameters. The assumption is that the government and the private sector do not perfectly know the central bank's preferences. The current debate about central bank transparency and communication suggests that the degree of predictability of central bank behavior will have a significant influence on the performance of monetary policy. Such an uncertainty plays a crucial role in practice and could therefore have important consequences for the design of monetary institutions.[4] The objective of this paper is to highlight the implications of this uncertainty for the optimal combi-

[3]Although the level of independence is usually determined by law, the central bank has some degree of freedom in choosing the degree of conservatism.

[4]Goldberg and Klein (2010) show that the initial years of the European monetary union where characterised by a significant degree of uncertainty about the ECB's preferences. Berger et al. (2009) show that there still seems to be uncertainty about the ECB's policy reactions in parts of the common monetary area.

nation of independence and conservatism. More precisely, the question is whether independence and conservatism remain substitutes when considering the possibility that the central bank's preferences and thus its policy decisions may not be fully predictable.

To formalise the interference of the government in a conservative central bank's decisions, we use a New Keynesian framework which is extended to allow for uncertainty about the central bank's preferences. The source of this monetary uncertainty varies across studies. Cukierman and Meltzer (1986), for instance, consider uncertainty about the relative weight that the central bank puts on the output gap compared to inflation. Geraats (2005), alternatively, allows for shifts in the central bank's inflation target. As in Faust and Svensson (2001, 2002), Jensen (2002) and more recently Westelius (2009), we assume that there is some uncertainty about the central bank's output gap target. This uncertainty could be explained by a lack of central bank transparency, i.e. the fact that central banks are somewhat reluctant to disclose information about their policy objectives.[5] An alternative explanation would be the one proposed by Westelius (2009), suggesting that the central bank's uncertain output gap target reflects its measurement errors of the potential output level. This explanation seems particularly relevant when considering the case of a central bank - like the European Central Bank (ECB)- that operates in a monetary union formed by countries with heterogenous economic structures.

A series of papers has investigated the reaction of the public (the private sector and the government) to uncertainty in monetary policy.[6] Sorensen (1991) and Grüner et al. (2009), for instance, consider the wage setters' reaction to uncertain central bank preferences, whereas Hefeker and Zimmer (2009) study the influence of monetary uncertainty on fiscal policies. The focus in this paper, however, is more normative. Closest in spirit to our analysis are papers by Beetsma and Jensen (1998) and Muscatelli (1999) that examine the implications of uncertain central bank preferences for the optimal design of monetary institutions. They demonstrate in particular that high conservatism may be desirable in the presence of monetary uncertainty

[5] See, for instance, Mishkin (2004) and Cukierman (2002, 2009).

[6] Again, there is a broad literature on the general issue of monetary uncertainty, too large to be fully referenced here. Important contributions are the papers by Brainard (1967) and Cukierman and Meltzer (1986), for instance. Recent surveys include Blinder et al. (2008), Crowe and Meade (2008), Geraats (2009), and Dincer and Eichengreen (2010).

as it helps to reduce the volatility of central bank decisions. These studies however only consider the extreme case of full central bank independence.

In this paper, we provide new insights into the workings of delegation arrangements for monetary policy. In particular, we show that when uncertainty about the central bank's output gap target is high, a positive correlation may emerge between the optimal degrees of central bank independence and conservatism. This result implies, in particular, that rendering the central bank more independent increases the need for conservatism. Intuitively, this happens because when more autonomy is delegated to a central bank whose output gap objective is highly uncertain, society faces the risk of a potential increase in the volatility of monetary decisions . To avoid excessive variability of macroeconomic outcomes, it is then in the interest of society to select a central banker who focuses on the inflation objective, which is clearly defined. By taking into account the uncertainty surrounding the central bank's preferences, our analysis finally qualifies the result of substitutability between CBI and CBC, indicating that these parameters may become complements when monetary uncertainty is high.

The remainder of the paper is organised as follows. The next section describes our formal framework. The optimal arrangement between CBI and CBC is examined in section 3, and concluding remarks are offered in section 4.

2. The New Keynesian framework with monetary uncertainty

This section presents a simple version of a New-Keynesian model (see, for instance, Clarida et al., 1999 or Woodford, 2003). The development of inflation is derived under the assumption of a monopolistic competition where optimizing firms adjust their prices in a staggered, overlapping way. The aggregate supply curve is thus represented by a forward-looking Phillips curve which takes the form:

$$\pi_t = \alpha x_t + \beta E_t \pi_{t+1} + e_t \tag{1}$$

where π_t is the inflation rate; x_t is the output gap defined as output relative to its equilibrium level under flexible prices (normalized to zero), and $E_t\pi_{t+1}$ is the expected future inflation rate (with E_t denoting the expectations operator). The discount factor is denoted by β and the sensitivity of inflation to the output gap is measured by α. The larger the value of α, the greater is the firms' ability to adjust their prices in response to changes in the current output gap. Finally, e_t represents a cost push shock which exhibits some degree of persistence measured by the coefficient $0 \leq \rho < 1$:

$$e_t = \rho e_{t-1} + \mu_t \text{ with } \mu_t \sim N(0,1) \tag{2}$$

The government aims to minimise a loss function defined over inflation and the output gap:

$$L_t^G = \lambda^G \pi_t^2 + x_t^2 \tag{3}$$

where λ^G measures the government's relative concern with price stability. Since the government is elected, it can reasonably be assumed that it shares the society's objectives. We therefore refer to (3) as the society's loss function as well.

Like the government, the central bank (CB) seeks price stability and output gap stabilisation. Its preferences are summarised as follows:

$$L_t^{CB} = \lambda^{CB} \pi_t^2 + (x_t - \epsilon_t)^2 \tag{4}$$

where λ^{CB} denotes the degree of central bank inflation aversion and ϵ_t denotes the central bank's stochastic output gap target, with $E(\epsilon_t) = 0$ and $V(\epsilon_t) = \sigma_\epsilon^2$.[7] The key feature of our model is that the central bank's output gap target is not fully known by government and society at the moment monetary policy is decided. This idea is captured by the presence of the random variable ϵ_t. We hence assume that society appoints a central banker with an output gap target that coincides on average with its own (and the government's) output gap target but where there is still some uncertainty around it which is measured by σ_ϵ^2. The larger is σ_ϵ^2, the higher is the uncertainty surrounding the central bank's output gap target.

Faust and Svensson (2001, 2002) and Jensen (2002) interpret the stochastic portion of the central bank's preferences as arising from the way the structure of the central bank aggregates heterogeneous societal preferences. Shifts in the central bank's output gap target could for instance result from changes in the composition of the policymaking board. Westelius (2009) suggests an alternative explanation by assuming that the central bank's stochastic output gap target reflects measurement errors of potential output. This explanation

[7]Note that in our analysis the central bank's preference shock ϵ_t is only transitory. For a study where this shock has a persistent component, see for instance Faust and Svensson (2001, 2002) and Westelius (2009). Moreover, we assume that the preference shock ϵ_t is independent of the cost-push shock e_t, so that $E_t(\epsilon_t e_t) = 0$.

is particularly relevant in the case of a common central bank that sets policy in a monetary union formed by countries with heterogeneous economic structures. Measurement errors of the monetary union-wide potential output can for instance arise from the central bank's difficulty to appreciate the individual member countries' effort in implementing labour market reforms or productivity-enhancing expenditures on infrastructure, education etc. We follow Westelius (2009)'s explanation in the remainder of the paper.[8]

In our analysis, we allow for the possibility of the government to interfere in monetary policymaking. The central bank is not fully independent in the way it sets monetary policy so that the loss function that effectively determines monetary policy is a weighted average of both authorities' loss function:

$$L_t^P = \gamma L_t^{CB} + (1-\gamma) L_t^G = \left(\lambda^G + \gamma\phi\right)\pi_t^2 + \gamma\left(x_t - \epsilon_t\right)^2 + (1-\gamma) x_t^2 \quad (5)$$

where $0 \leq \gamma \leq 1$ denotes the strength of the central bank in the negotiations with the government or its political independence; $\phi = \lambda^{CB} - \lambda^G$ measures the level of central bank conservatism. In what follows, we derive the optimal ϕ. It should be stressed that this optimal degree of central bank conservatism is a relative measure as it denotes the (positive) difference between the central bank's inflation aversion and that of the government (or society).[9] Hence, the central bank may for instance be highly averse to inflation (high λ^{CB}) without being conservative ($\phi = 0$). This is the case when the government or society is highly inflation averse as well. Moreover, as can be seen from (5), the monetary policymakers's expected output gap target is set to zero, indicating that there is no desire to reach an overoptimistic output level and thus no inflationary bias exists. Conservatism thus only impacts on the degree of shock stabilization but does not affect average inflation.

The interaction between the government and the central bank can be described by the following sequence of events: In the first stage, the elected government determines the central bank's institutional design. More specifically, it chooses γ and ϕ so as to minimise its expected loss function (3). In

[8] More specifically, we assume that the central bank cannot directly observe $\hat{y}_t$, the economy's potential output, but it can estimate it. Let $\hat{y}_t^{CB}$ be the central bank's estimation of potential output so that $\hat{y}_t^{CB} = \hat{y}_t + \epsilon_t$. The central bank's measurement error of potential output is thus simply equal to: $\hat{y}_t^{CB} - \hat{y}_t = \epsilon_t$. Considering the expression of the output gap : $x_t = y_t - \hat{y}_t$, the central bank's objective to stabilise output around (the central bank's estimation of) its potential level can finally be written as: $y_t - \hat{y}_t^{CB} = x_t - \epsilon_t$.

[9] The distinction between the "conservatism" and the "inflation aversion" of the central bank also appears in Lippi (2000).

the second stage, monetary policy is implemented and economic outcomes (x_t, π_t) are realized. The game is solved by backward induction.

Under discretionary policy, the monetary authority minimizes its loss function (5) subject to the Phillips curve (1) taking inflation expectations as given. The respective first order condition can be written:

$$x_t = \gamma \epsilon_t - \alpha \left(\lambda^G + \gamma\phi\right) \pi_t \tag{6}$$

According to this optimality condition, the central bank responds to a rise in inflation by contracting demand which reflects a "leaning against the wind" policy. The strength of this response positively depends on both, α, the slope of the Phillips curve and, $\left(\lambda^G + \gamma\phi\right)$, the weight attached to inflation stabilisation in the objective function (5). Monetary policy is also positively affected by ϵ_t, the central bank's stochastic output gap target. A negative realisation of ϵ_t for example – which means that the central bank underestimates the economy's output potential – leads to a contraction of the economy. The influence of ϵ_t is amplified by the degree of independence γ, as independence allows the central bank to pursue its individual output gap target to a larger extent. This possibility is obviously not given when $\gamma = 0$. In this respect, independence matters for monetary policy even if the central bank has the same degree of inflation aversion as the government so that the degree of conservatism is nil (i.e. $\phi = \lambda^{CB} - \lambda^G = 0$).[10]

By combining the Phillips curve (1) with the optimal monetary policy rule (6), we obtain the following expressions for the equilibrium inflation and output gap (see Appendix A for details):

$$\pi_t = \frac{\alpha\gamma}{\alpha^2\left(\lambda^G + \gamma\phi\right) + 1}\,\epsilon_t + \frac{1}{\alpha^2\left(\lambda^G + \gamma\phi\right) + 1 - \beta\rho}\,e_t \tag{7}$$

$$x_t = \frac{\gamma}{\alpha^2\left(\lambda^G + \gamma\phi\right) + 1}\,\epsilon_t - \frac{\alpha\left(\lambda^G + \gamma\phi\right)}{\alpha^2\left(\lambda^G + \gamma\phi\right) + 1 - \beta\rho}\,e_t \tag{8}$$

It is clear from Eqs. (7) and (8) that the equilibrium inflation rate and output gap depend positively on the central bank's (stochastic) ouptut gap target ϵ_t. Indeed, if the central bank for instance overestimates the economy's output potential, its output gap target ϵ_t is positive. It is, therefore, induced to implement too an expansionary monetary policy which, in turn, results

[10]However when $\gamma = 0$, the degree of central bank conservatism does not matter for monetary policy. The central bank's preferences obviously do not influence policy in that case.

in inflationary pressure. Unsurprisingly, the strength of the impact of ϵ_t on x_t and π_t positively depends on γ, the central bank's ability to determine monetary policy independently.

The equilibrium expressions for output gap and inflation rate are also affected by e_t. A positive cost-push shock causes inflation to rise above its optimal level (which is set to zero, corresponding to price stability), inducing the central bank to contract demand. Moreover, it appears that an increase in the degree of the bank's conservatism ϕ – and thereby in the "effective" weight for inflation stabilisation $(\lambda^G + \gamma\phi)$ – reduces the impact of cost-push shocks on inflation whereas it amplifies the impact of these shocks on the output gap. We thus have the standard result that optimal conservatism trades off price stability and output gap stabilisation.

As is clear from expressions (7) and (8), the transmission of cost-push shocks e_t to the output gap and inflation rate is not affected by the central bank's preference shock ϵ_t. This is due to the fact that the preference shock concerns the central bank's targets and not the relative weight of its objectives.

It is also of interest to determine the volatility of macroeconomic outcomes and to study how this is affected by institutional parameters such as central bank conservatism and independence.[11] Determining the variance of the inflation rate and the output gap, we obtain respectively:[12]

$$V(\pi_t) = \frac{(\alpha\gamma)^2}{\left[\alpha^2\left(\lambda^G + \gamma\phi\right) + 1\right]^2}\,\sigma_\epsilon^2 + \frac{1}{\left[\alpha^2\left(\lambda^G + \gamma\phi\right) + 1 - \beta\rho\right]^2}\,\frac{1}{(1-\rho^2)} \quad (9)$$

$$V(x_t) = \frac{\gamma^2}{\left[\alpha^2\left(\lambda^G + \gamma\phi\right) + 1\right]^2}\,\sigma_\epsilon^2 + \frac{\alpha^2\left(\lambda^G + \gamma\phi\right)^2}{\left[\alpha^2\left(\lambda^G + \gamma\phi\right) + 1 - \beta\rho\right]^2}\,\frac{1}{(1-\rho^2)} \quad (10)$$

These expressions highlight the two sources of macroeconomic volatility in our model, that is: uncertainty about the central bank's output gap target – which is represented by the first term on the right hand side of expressions (9) and (10) – and cost push shocks – corresponding to the second term. Considering the impact of independence and conservatism on inflation and output variability yields the following results.

Result 1: *An increase in the degree of central bank conservatism*

[11]Note, from expression (3), that the expected social losses simply amount to the weighted sum of the variances of inflation and output, namely $E_t L_t^G = \lambda^G V(\pi_t) + V(x_t)$.

[12]The cost-push shock e_t is described by the AR(1) process: $e_t = \rho e_{t-1} + \mu_t$, with $0 \leq \rho < 1$ and $\mu_t \sim N(0,1)$. Hence, $E(e_t) = 0$ and $V(e_t) = E(e_t)^2 = \frac{V(\mu_t)}{1-\rho^2} = (1-\rho^2)^{-1}$.

(i) *reduces inflation variability,*

(ii) *may reduce output gap variability if the degree of monetary uncertainty* σ_ϵ^2 *is relatively high and the degree of cost-push shock persistence* ρ *relatively low.*

Proof (i) From expression (9), it is easy to see that: $\frac{\partial V(\pi_t)}{\partial \phi} < 0$.

(ii) Taking the derivative of (10) with respect to ϕ, we have $\frac{\partial V(x_t)}{\partial \phi} = 2\gamma\alpha^2 \left\{ \frac{-\sigma_\epsilon^2\gamma^2\left[\alpha^2\left(\lambda^G+\gamma\phi\right)+1-\beta\rho\right]^3+\frac{1}{(1-\rho^2)}\left[\alpha^2\left(\lambda^G+\gamma\phi\right)+1\right]^3\left(\lambda^G+\gamma\phi\right)}{[\alpha^2(\lambda^G+\gamma\phi)+1]^3[\alpha^2(\lambda^G+\gamma\phi)+1-\beta\rho]^3} \right\}$, which can become negative for sufficiently high values of σ_ϵ^2 and sufficiently low values of ρ.

The first part of result 1 is conventional in the literature initiated by Rogoff (1985). Central bank conservatism helps to attenuate inflation variability whatever the nature of the shocks affecting the inflation rate. The second part of result 1 is less standard: Conservatism might help to attenuate output gap volatility under certain conditions. To understand the intuition underlying this result we have to realize that central bank conservatism affects the output gap variance via two channels that operate in opposite directions. On one hand, the higher is the central bank's concern with price stability the lower is the macroeconomic volatility stemming from its output gap target. On the other hand, conservatism involves a trade-off between inflation and output gap variability due to cost-push shocks: a higher ϕ reduces inflation variability but at the expense of more output gap variability. The strength of the former effect positively depends on σ_ϵ^2, the uncertainty about the central bank's output gap target, whereas the strength of the latter effect is positively related to the variance of cost-push shocks and thereby to ρ, the persistence of these shocks.[13] Hence, when σ_ϵ^2 is relatively high and ρ is relatively low, the first mechanism dominates the second and the overall impact of conservatism on output gap varability is negative.

Result 2: *Granting greater independence to the central bank*

(i) *increases output gap volatility,*

(ii) *is likely to increase inflation variability if* ϕ*, the degree of conservatism, is relatively low and* σ_ϵ^2*, the uncertainty about the central bank's output gap target, is relatively high.*

[13] See footnote 12 for the expression of $V(e)$.

Proof (i) From expression (10), we can see that: $\frac{\partial V(x_t)}{\partial \gamma} > 0$.

(ii) Differentiating (9) with respect to γ and rearranging, we obtain: $\frac{\partial V(x_t)}{\partial \gamma} = 2\alpha^2 \left\{ \frac{\sigma_\epsilon^2 \gamma \left(\alpha^2 \lambda^G + 1\right)\left[\alpha^2\left(\lambda^G + \gamma\phi\right) + 1 - \beta\rho\right]^3 - \frac{\phi}{(1-\rho^2)}\left[\alpha^2\left(\lambda^G + \gamma\phi\right) + 1\right]^3}{\left[\alpha^2(\lambda^G + \gamma\phi) + 1\right]^3 \left[\alpha^2(\lambda^G + \gamma\phi) + 1 - \beta\rho\right]^3} \right\}$.

This expression becomes positive for relatively high values of σ_ϵ^2 and low values of ϕ. In particular, it is positive for $\phi = 0$.

The first part of result 2 is consistent with the discussions and the empirical results in the literature (see for instance, Cukierman and Lippi, 1999). In our analysis, higher central bank independence increases output gap volatility for two reasons. The first hinges on the fact that giving greater autonomy to a central banker whose preferences are not clearly defined exacerbates the uncertainty about monetary policy decisions. This in turn translates into higher macroeconomic volatility. The second reason only appears if the central bank is conservative ($\phi \neq 0$), i.e. more concerned about price stability than society and the governement. Higher independence then allows the central bank to better focus on inflation stabilisation at the cost, however, of less output gap stabilisation.

The second part of result 2 is novel. Central bank independence is likely to exacerbate inflation variability. Indeed, when the uncertainty about the central bank's output gap target σ_ϵ^2 is high, the macroeconomic volatility-increasing effect of independence may dominate its inflation stabilisation impact. This is the case if greater independence is given to a central bank with a relatively low degree of conservatism. In particular, if the central bank is not more concerned about price stability than the government ($\phi = 0$), higher central bank independence unambiguously leads to higher inflation volatility.

It is noteworthy in our analysis that when the uncertainty about the central bank's output gap target is high, independence and conservatism do not have the same effect on macroeconomic volatility: independence exacerbates the volatility generated by uncertain central bank preferences whereas conservatism helps to attenuate this kind of uncertainty. This result underlines the importance of disentangling CBI and CBC for a better understanding of the effects of monetary delegation arrangements in the presence of uncertainty about the central bank's output gap target.

3. The optimal design of central bank institutions

We now turn to the choice of the optimal degrees of conservatism $\phi*$ and independence $\gamma*$ from the point of view of society. To do so, we consider a model of endogenous delegation where the government selects $\phi*$ and $\gamma*$ so as to minimise society's loss function. We assume that these regime parameters are defined before monetary policy decisions are taken which reflects the fact that the monetary regime is revised less frequently than policy decisions are taken.

Integrating the expressions for equilibrium output gap and inflation into Eq. (3) and taking expectations yields the following expected loss for government and society:

$$E_t L_t^G = \frac{\left(\lambda^G \alpha^2 + 1\right)\gamma^2}{\left[\alpha^2\left(\lambda^G + \gamma\phi\right) + 1\right]^2}\,\sigma_\epsilon^2 + \frac{\lambda^G + \alpha^2\left(\lambda^G + \gamma\phi\right)^2}{\left[\alpha^2\left(\lambda^G + \gamma\phi\right) + 1 - \beta\rho\right]^2} \cdot \frac{1}{(1-\rho^2)} \quad (11)$$

The first term is due to the inflation and output gap volatility arising from the uncertainty about the central bank's output gap target ($\sigma_\epsilon^2 > 0$). As we saw before, this term increases with γ, the bank's independence, and decreases with ϕ, its degree of conservatism. The second term corresponds to the volatility of output gap and inflation that is related to cost-push shocks.

3.1 Optimal conservatism

In this section, we first examine the optimal degree of conservatism for a given level of central bank independence, $\bar{\gamma}$.

Minimising the expected social loss with respect to ϕ, the degree of central bank conservatism, yields the following first order condition:

$$-\frac{\left(\lambda^G \alpha^2 + 1\right)\bar{\gamma}^2}{\left[\alpha^2\left(\lambda^G + \bar{\gamma}\phi\right) + 1\right]^3}\,\sigma_\epsilon^2 + \frac{\bar{\gamma}\phi\left(1-\beta\rho\right) - \lambda^G\beta\rho}{\left[\alpha^2\left(\lambda^G + \bar{\gamma}\phi\right) + 1 - \beta\rho\right]^3} \cdot \frac{1}{(1-\rho^2)} = 0 \quad (12)$$

The first term is always negative and reflects the fact that greater central bank conservatism ϕ reduces the volatility arising from the bank's uncertain output gap target. The second term can be positive or negative, depending in particular on the size of ϕ. This term highlights the trade-off between inflation and output gap stabilisation arising from the optimal choice of ϕ: a higher ϕ implies better inflation stabilisation but at the cost of less output gap stabilisation. Since the first term is negative, the optimal ϕ must be large enough for the second term to become positive. Accordingly, the optimal degree of central bank conservatism will be sufficiently high so that the marginal cost (less output gap stabilization) of an increase in ϕ outweighs its marginal gain (better inflation stabilization). Hence, in the presence of uncertainty about the central bank's preferences some extra conservatism is required.

Rewriting the first order condition (12), we have:

$$\phi = \frac{\bar{\gamma}\left(\lambda^G\alpha^2+1\right)\left(1-\rho^2\right)\left[\alpha^2\left(\lambda^G+\bar{\gamma}\phi\right)+1-\beta\rho\right]^3\sigma_\epsilon^2}{\left(1-\beta\rho\right)\left[\alpha^2\left(\lambda^G+\bar{\gamma}\phi\right)+1\right]^3}+\frac{\lambda^G\beta\rho}{\bar{\gamma}\left(1-\beta\rho\right)} \equiv f\left(\phi,\bar{\gamma}\right) \tag{13}$$

To find the optimal value of ϕ and to study its comparative static properties, we use a graphical method illustrated in Appendix B.[14] From this graphical analysis, we derive the following result.

Result 3: (i) *For a given level of central bank independence, the optimal degree of conservatism is positively related to σ_ϵ^2, the degree of uncertainty about the central bank's output gap target.*

(ii) *The optimal degree of conservatism increases with $\bar{\gamma}$, the given degree of central bank independence when σ_ϵ^2, the uncertainty about the central bank's output gap target, is relatively high and provided β and ρ are not too large.*

Proof (i) From expression (13), it is easy to see that $\frac{\partial f}{\partial \sigma_\epsilon^2} > 0$. Hence, a rise in σ_ϵ^2 causes an upward shift of function f and thereby raises ϕ^*.

(ii) Differentiating f with respect to $\bar{\gamma}$, we can write:

$$\frac{\partial f}{\partial \bar{\gamma}} = \frac{\sigma_\epsilon^2\left(\alpha^2\lambda^G+1\right)\left(1-\rho^2\right)B^2\left[AB+3\alpha^2\beta\rho\bar{\gamma}\phi\right]}{\left(1-\beta\rho\right)A^4} - \frac{\lambda^G\beta\rho}{\bar{\gamma}^2\left(1-\beta\rho\right)}$$

where $A = \alpha^2\left(\lambda^G+\gamma\phi\right)+1$ and $B = \alpha^2\left(\lambda^G+\gamma\phi\right)+1-\beta\rho$. This derivative becomes positive – implying a positive relation between ϕ^* and $\bar{\gamma}$ – for sufficiently high values of σ_ϵ^2 and provided that β and ρ are not too large.

According to the first part of result 3, in the presence of high uncertainty about the central bank's output gap target, it is optimal for society to select a policymaker who assigns a relatively large weight to his inflation target in order to limit the volatility of his decisions. As a consequence, central bankers whose output gap target is clearly defined can be allowed to be less conservative. A similar result has been found by Beetsma and Jensen

[14]See also Cukierman (1992) and Eijffinger and Hoeberichts (1998).

(1998).[15]

The second part of result 3 shows that, when the central bankers' output gap target is highly uncertain, giving them more autonomy increases the need for conservatism. To understand the intuition underlying this result, consider first the case without uncertainty. When $\sigma_\epsilon^2 = 0$, the optimal degree of central bank conservatism is $\phi^* = \frac{\lambda^G \beta\rho}{\bar{\gamma}(1-\beta\rho)}$. It is obvious from this expression that ϕ^* is inversely related to $\bar{\gamma}$, indicating that central bank independence has a negative impact on the optimal level of conservatism. Independence then helps to reduce the need for conservatism $\left(\frac{\partial f}{\partial \bar{\gamma}} < 0\right)$ as both monetary policy features have similar effects on the balance between inflation and output gap stabilisation.

However, when there is some uncertainty about the central bank's output gap target, the impact of independence on the optimal degree of conservatism may be reversed. An increase in the degree of independence then has two countervailing effects on the need for conservatism. On one hand, it reinforces the weight the monetary authority places on inflation stabilisation and thereby helps to reduce the need for conservatism. This effect only exists when there is some persistence of the cost-push shock ($\rho > 0$). On the other hand, granting higher independence to a central bank whose preferences are highly uncertain exacerbates the volatility of its decisions. This in turn increases inflation and output gap variability and should therefore be compensated by greater conservatism. If the uncertainty surrounding central bank preferences is high and the persistence of cost-push shocks is not too important, the second effect is likely to dominate. Central bank independence then has a positive impact on the optimal degree of conservatism.

3.2 Optimal independence

We now consider the choice of the optimal degree of central bank independence for a given level of conservatism, $\bar{\phi}$.

Minimising the expected social loss function with respect to γ, the degree of central bank independence, we obtain the following first order condition:

$$\frac{\left(\lambda^G \alpha^2 + 1\right)^2 \gamma}{\left[\alpha^2\left(\lambda^G + \gamma\bar{\phi}\right) + 1\right]^3}\,\sigma_\epsilon^2 + \frac{\alpha^2\bar{\phi}\left[\bar{\phi}\gamma\left(1-\beta\rho\right) - \lambda^G\beta\rho\right]}{\left[\alpha^2\left(\lambda^G + \gamma\bar{\phi}\right) + 1 - \beta\rho\right]^3}\cdot\frac{1}{(1-\rho^2)} = 0 \quad (14)$$

[15] Beetsma and Jensen (1998) however consider uncertainty in the weight the central bank assigns to its inflation and ouptut objectives.

The first term is positive and highlights the fact that central bank independence aggravates macroeconomic volatility due to uncertain central bank preferences. The second term can be positive or negative, reflecting the trade-off between inflation and output gap stabilisation that arises from the optimal choice of γ: a higher γ implies better inflation stabilisation – provided $\bar{\phi} > 0$ – but at the cost of less output gap stabilisation. Since the first term is positive, the optimal γ must be sufficiently small for the second term to become negative. As a consequence, the central bank should be given less independence when there is some uncertainty about its preferences.

Rearranging condition (15), we have:

$$\gamma = \frac{\bar{\phi}\beta\rho\lambda^G\alpha^2 A^3}{\alpha^2\bar{\phi}^2 (1-\beta\rho) A^3 + \sigma_\epsilon^2 (1-\rho^2)(\alpha^2\lambda^G+1)^2 B^3} \equiv g(\gamma, \bar{\phi}) \qquad (15)$$

where $A = \alpha^2 (\lambda^G + \gamma\phi) + 1$ and $B = \alpha^2 (\lambda^G + \gamma\phi) + 1 - \beta\rho$.

It is easy to see from this expression that a government which is not concerned with price stability ($\lambda^G = 0$) has no reason to delegate monetary policy to an independent (and thus conservative) central banker.[16] The same result holds when there is no persistence of cost-push shocks ($\rho = 0$).

As before, we use a graphical method to determine the optimal degree of central bank independence, $\gamma*$, and its comparative static properties (see Appendix C). Our results are summarised as follows:

Result 4: (i) *For a given level of conservatism, the optimal degree of central bank independence decreases with respect to σ_ϵ^2, the degree of uncertainty about the central bank's output gap target.*
(ii) *The optimal degree of central bank independence increases with $\bar{\phi}$, the degree of central bank conservatism, when the latter is not too high and for relatively high levels of uncertainty about the central bank's output gap target, σ_ϵ^2.*

Proof (i) From expression (15), it is obvious that: $\frac{\partial g}{\partial \sigma_\epsilon^2} < 0$. This means that a rise in σ_ϵ^2 induces a downward shift of function g and thereby reduces γ^*.

(ii) To understand how $\bar{\phi}$ affects the optimal degree of central bank independence, we begin by rearranging expression (15) in the following way:

$$g(\gamma, \bar{\phi}) = \frac{\beta\rho\lambda^G\alpha^2}{\alpha^2\bar{\phi}(1-\beta\rho) + \sigma_\epsilon^2 (1-\rho^2)(\alpha^2\lambda^G+1)^2 \frac{B^3}{A^3\bar{\phi}}} \qquad (16)$$

[16]Indeed, $\gamma* = 0$ when $\lambda^G = 0$ (as well as $\phi* = 0$, according to Eq. (13)).

Differentiating expression (16) with respect to $\bar{\phi}$, we obtain:

$$\frac{\partial g}{\partial \bar{\phi}} = -\frac{\beta\rho\lambda^G\alpha^2}{D^2}\left\{\alpha^2\left(1-\beta\rho\right)+\frac{\sigma_\epsilon^2\left(1-\rho^2\right)\left(\alpha^2\lambda^G+1\right)^2 B^2}{A^4\bar{\phi}^2}\left[-AB+3\bar{\phi}\alpha^2\beta\rho\gamma\right]\right\}$$

where $D=\alpha^2\phi\left(1-\beta\rho\right)+\sigma_\epsilon^2\left(1-\rho^2\right)\left(\alpha^2\lambda^G+1\right)^2\frac{B^3}{A^3\phi}$.

The expression in square brackets is negative provided that $\bar{\phi}$ is not too large. The sign of the expression in curly brackets may then become negative as well for sufficiently high values of σ_ϵ^2. In this case, $\frac{\partial g}{\partial \bar{\phi}} > 0$, implying that $\gamma*$ is positively related to $\bar{\phi}$.

The intuition underlying part (i) of result 4 is obvious: it is in society's interest to limit the central bank's independence if the uncertainty surrounding the latter's decisions is high. Part (ii) of result 4 suggests a positive relationship between the optimal degree of independence and the degree of conservatism for high values of σ_ϵ^2 and low values of $\bar{\phi}$. Indeed, in this case – according to result 2 (ii) – a large degree of CBI may be associated with high inflation variablity that should be compensated by greater conservatism. Hence, society is less willing to hand over power to a central bank (low $\gamma*$) that places too much importance on its uncertain output gap objective (low ϕ).

3.3 The optimal combination of independence and conservatism

The combination of the first order conditions (Eqs. (13) and (15)) allows us to study the nature of the relation between the optimal degrees of CBI and CBC. We derive the following result:

Result 5: *Central bank independence and conservatism are likely to become strategic complements when the uncertainty concerning the central bank's output gap target, σ_ϵ^2, is high.*

Proof According to results 3 and 4, $\phi*$ is positively related to γ and $\gamma*$ is positively related to ϕ, for sufficiently high values of σ_ϵ^2.

When there is no uncertainty about the central bank's output gap target $\sigma_\epsilon^2 = 0$, independence and conservatism are strategic substitutes.[17] This

[17]When $\sigma_\epsilon^2 = 0$, the first order conditions (13) and (15) reduce to the following equation:

result is in the line with the findings of Lippi (2000), Hughes Hallett and Weymark (2005) and Weymark (2007). By allowing for some uncertainty in the central bank's preferences, however, our analysis extends their findings. It turns out that when there is great ambiguity about the central bank's output gap target, $\phi*$ and $\gamma*$ are positively correlated, suggesting that independence and conservatism should be treated as complements rather than substitutes.

4. Concluding remarks

This paper has examined the optimal arrangement between independence and conservatism in the presence of uncertainty about the central bank's output target. The main finding is that, in the presence of such uncertainty, the optimal arrangement between CBI and CBC is not necessarily characterised by substitutability. Instead, if the ambiguity about the central bank's output gap target is sufficiently high, CBI and CBC complement each other. This suggests that giving high (low) independence to the central bank is likely to increase (decrease) the need for conservatism in some situations. Intuitively, giving greater autonomy to a central bank whose preferences are uncertain exacerbates the volatility of monetary policy decisions. It may therefore become optimal for society to appoint a more conservative central banker in order to compensate for this additional volatility. One policy conclusion would therefore be that discussions about the appropriate combination of independence and conservatism should not overlook the issue of the central bank transparency and the degree of uncertainty about its policy targets.

An interesting possible application of our study could be in the context of the Economic and Monetary Union (EMU), where we have a common central bank which is at the same time very independent and very conservative, a combination that would be hard to rationalize if independence and conservatism are considered to be substitutes. Although the ECB's priority for price stability is clearly articulated for all to understand, there is greater ambiguity concerning its output objective when the inflation rate is low. Our analysis suggests that under such circumstances the ECB's degree of independence and conservatism are likely to be complements. To take the analysis one step further, one might argue that the ECB's high independence could be one additional reason for its relatively great conservatism. Besides being

$\phi* = \frac{\lambda\beta\rho}{\gamma*(1-\beta\rho)}$, clearly showing that there is subsitutability between $\phi*$ and $\gamma*$.

desired for historical or political considerations, this large degree of conservatism may be required due to the ECB's high independence. Indeed, the delegation of the monetary instrument to a supra-national authority whose output objective is not clearly defined creates additional uncertainty in the member states. Since the member states' national authorities are not allowed to interfere in the ECB's decisions, it is in their interest to make sure that priority will be given to the price stability objective – which is clearly defined – and therefore to select a highly conservative central banker to avoid excessive monetary uncertainty.

A Derivation of the equilibrium output gap and inflation rate

Inserting the optimality condition (6) into the New Keynesian Phillips curve and rearranging terms, we obtain:

$$x_t \left[\alpha^2 \left(\lambda^G + \gamma\phi\right) + 1\right] = \gamma\epsilon_t + \beta E_t x_{t+1} - \alpha \left(\lambda^G + \gamma\phi\right) e_t \tag{17}$$

Since the relevant state variables in (17) are ϵ_t and e_t, it is apparent that x_t will be of the form:

$$x_t = b_0\epsilon_t + b_1 e_t \tag{18}$$

Forwarding Eq. (18) and taking expectations with respect to the public's information set we get:

$$E_t x_{t+1} = b_1 \rho e_t \tag{19}$$

Substituting (19) into (17), we get:

$$x_t = \frac{\gamma\epsilon_t + \left[\beta b_1 \rho - \alpha\left(\lambda^G + \gamma\phi\right)\right] e_t}{\alpha^2 \left(\lambda^G + \gamma\phi\right) + 1} \tag{20}$$

Comparing (20) and (18), we can solve for the coefficients b_0 and b_1:

$$b_0 = \frac{\gamma}{\alpha^2 \left(\lambda^G + \gamma\phi\right) + 1} \tag{21}$$

$$b_1 = \frac{-\alpha\left(\lambda^G + \gamma\phi\right)}{\alpha^2 \left(\lambda^G + \gamma\phi\right) + 1 - \beta\rho} \tag{22}$$

The equilibrium output gap can then be written:

$$x_t = \frac{\gamma}{\alpha^2 \left(\lambda^G + \gamma\phi\right) + 1}\, \epsilon_t - \frac{\alpha\left(\lambda^G + \gamma\phi\right)}{\alpha^2 \left(\lambda^G + \gamma\phi\right) + 1 - \beta\rho}\, e_t \tag{23}$$

The equilibrium expression for inflation is derived by inserting (23) into the optimality condition (6) and rearranging:

$$\pi_t = \frac{\alpha\gamma}{\alpha^2 \left(\lambda^G + \gamma\phi\right) + 1}\, \epsilon_t + \frac{1}{\alpha^2 \left(\lambda^G + \gamma\phi\right) + 1 - \beta\rho}\, e_t \tag{24}$$

B Graphical analysis of the optimal ϕ

Figure 1 represents function $f(\phi, \bar{\gamma})$ on the right hand side of Eq. (13). Studying the properties of this function, we observe:

$$\frac{\partial f(\phi,\bar{\gamma})}{\partial\phi} = \frac{3\alpha^2\bar{\gamma}^2\beta\rho\sigma_\epsilon^2\left(\lambda^G\alpha^2 + 1\right)\left(1-\rho^2\right)\left[\alpha^2\left(\lambda^G + \bar{\gamma}\phi\right) + 1 - \beta\rho\right]^2}{\left(1-\beta\rho\right)\left[\alpha^2\left(\lambda^G + \bar{\gamma}\phi\right) + 1\right]^4} > 0 \tag{25}$$

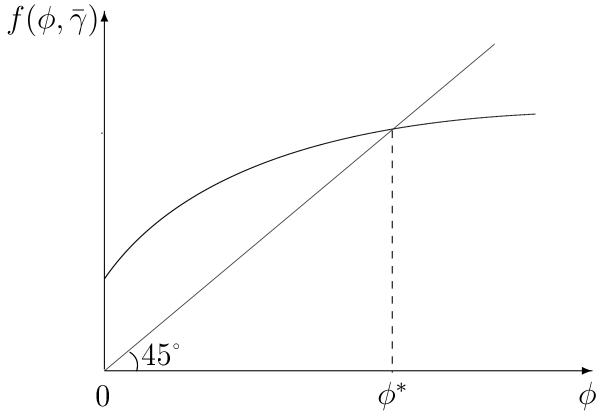

Figure 1: Determination of the optimal degree of CB conservatism

Hence, $f(\phi,\overline{\gamma})$ is monotonically increasing in ϕ.

$$\frac{\partial^2 f(\phi,\bar{\gamma})}{\partial^2\phi} = \frac{6\alpha^4\bar{\gamma}^3\beta\rho\sigma_\epsilon^2\left(\lambda^G\alpha^2+1\right)\left(1-\rho^2\right)\left[\alpha^2\left(\lambda^G+\bar{\gamma}\phi\right)+1-\beta\rho\right]}{\left(1-\beta\rho\right)\left[\alpha^2\left(\lambda^G+\bar{\gamma}\phi\right)+1\right]^5} \times \frac{\left[2\beta\rho-\alpha^2\left(\lambda^G+\bar{\gamma}\phi\right)-1\right]}{\left(1-\beta\rho\right)\left[\alpha^2\left(\lambda^G+\bar{\gamma}\phi\right)+1\right]^5} \quad (26)$$

This expression becomes negative – implying that $f(\phi,\overline{\gamma})$ is concave – for sufficiently low values of β and ρ and/or sufficiently large values of λ^G and $\bar{\gamma}\phi$.

The left-hand side of Eq. (13) is a 45° line through the origin. The intersection point between the 45° line and the function f curve gives the optimal degree of central bank conservatism ϕ^*.[18] The comparative static properties of ϕ^* can be derived from the partial derivatives of function f. If f shifts upward (downward), the intersection point shifts to the right, implying an increase (a decrease) in ϕ^*.

C Graphical analysis of the optimal γ

Figure 2 represents function $g(\gamma,\bar{\phi})$ on the right hand side of Eq. (15). A study of the properties of this function reveals that it is monotonically falling in γ. Differentiating function $g(\gamma,\bar{\phi})$ with respect to γ, we obtain:

$$\frac{\partial g(\gamma,\bar{\phi})}{\partial\gamma} = \frac{-3\alpha^4\sigma_\epsilon^2\lambda^G\phi^2\left(\beta\rho\right)^2\left(\lambda^G\alpha^2+1\right)^2\left(1-\rho^2\right)A^2B^2}{\left[\alpha^2\phi^2\left(1-\beta\rho\right)A^3+\sigma_\epsilon^2\left(1-\rho^2\right)\left(\alpha^2\lambda^G+1\right)^2B^3\right]^2} < 0 \quad (27)$$

[18]In fact, to find a unique positive value of ϕ^* it is sufficient that $\frac{\partial f(\phi,\bar{\gamma})}{\partial\phi} < 1$.

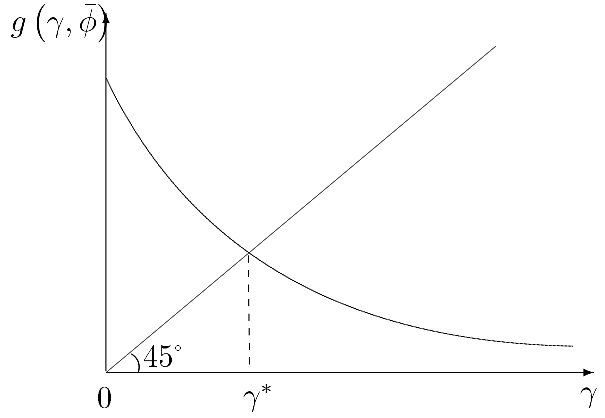

Figure 2: Determination of the optimal degree of CB independence

Moreover, we observe that:

$$\begin{aligned} \frac{\partial^2 g(\phi,\gamma)}{\partial^2 \gamma} &= \frac{6\alpha^6\sigma_\epsilon^2\lambda^G\phi^3(\beta\rho)^2\left(\lambda^G\alpha^2+1\right)^2(1-\rho^2)AB}{\left[\alpha^2\phi^2(1-\beta\rho)A^3+\sigma_\epsilon^2(1-\rho^2)(\alpha^2\lambda^G+1)^2B^3\right]^3} \\ &\times \left[\alpha^2\phi^2A^3(1-\beta\rho)(A-2\beta\rho)+\sigma_\epsilon^2\left(1-\rho^2\right)\left(\alpha^2\lambda^G+1\right)^2B^3(A+\beta\rho)\right] \end{aligned} \quad (28)$$

which is positive for sufficiently low values of ρ and β, implying that function $g(\gamma, \bar{\phi})$ is convex with respect to γ.

The left-hand side of Eq. (15) is represented by a 45° line through the origin. The optimal degree of central bank independence γ^* is thus given by the intersection between the 45° line and the function g curve. If g shifts upward (downward), the intersection point shifts to the right (left), implying an increase (decrease) in γ^*.

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