Optimal conservatism and collective monetary policymaking under uncertainty*

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Abstract

We study how the optimal degree of conservatism relates to decision-making procedures in a Monetary Policy Committee (MPC). In our framework, central bank conservatism is required to attenuate the volatility of monetary decisions generated by the presence of uncertainty about the committee members' output objective. We show how this need for conservatism varies according to the number of MPC members, the MPC's composition as well as its decision rule. Moreover, we find that extra central bank conservatism is required when there is ambiguity about the MPC's true decision rule.

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1 Introduction

Over the past three decades, increasing attention has been given to the price stability objective in the debate about central bank design. It is now widely recognised that central bank conservatism (CBC) plays a crucial role in the achievement of this objective, albeit at the expense of higher output variability. The design of CBC providing an optimal trade-off between inflation and output stabilisation obviously depends on various factors, including for instance the structure of the economy, wage setting or fiscal policymaking.[1]

This paper investigates how the optimal choice of central bank conservatism relates to the collective nature of monetary policymaking. In the recent past, one has indeed observed a widespread shift of the responsibility of monetary policy from the single central banker to a Monetary Policy Committee (MPC).[2] Monetary policy committees can differ according to several aspects including their composition, their decision rules, the transparency of their decision making (whether they publish minutes and voting records), or the heterogeneities among their members (in terms of policy preferences and skills). The objective of this paper is to study how these aspects of the MPC influence the optimal choice of conservatism. This is done by means of a model of endogenous monetary policy delegation where the social planner chooses the MPC's degree of conservatism to minimise the society's loss function.

Hence, the paper provides a link between the literature about optimal design of central bank objectives and collective monetary policy-making. The

[1] Starting with Rogoff's (1985) seminal paper, a huge literature has explored the optimal type of the single central banker in terms of inflation aversion (see Siklos 2008 or Hayo and Hefeker 2010 for recent surveys).

[2] As Blinder (2004) notes, there are only four central banks where policy is formulated by a single governor: Canada, Malta, New Zealand, and Norway. For an overview of central bank boards around the world and their characteristics, see Berger and Nitsch (2011) and Lybek and Morris (2004).

latter has grown rapidly in recent years, focusing on different issues. Some contributions study the welfare consequences of different types of collective decision-making procedure in a monetary union, such as the relative weights that regional and common developments should receive. This is the case of Von Hagen and Süppel (1994), DeGrauwe (2000), Hefeker (2003), Matsen and Roisland (2005), Fatum (2006), Méon (2008) and Farvaque et al. (2009) who consider structural heterogeneities across union member countries as well as differences in their economic shocks. Another branch of this literature allows for the possibility that MPC members face some uncertainty when taking their decisions. Tillmann (2010), for instance, considers uncertainty about the model that best describes the economy, whereas Gerlach-Kristen (2006) assumes that policymakers are uncertain about the state of the economy. Focusing on the differences in skills among MPC members, Gerlach-Kristen (2008) demonstrates that consensus will be obtained more easily when the MPC is headed by a chairman who is more skilled than the other members. References that explicitly focus on heterogeneity in the members preferences about inflation and output and how this relates to their voting are Chappell et al. (2005), Harris et al. (2011), Göhlmann and Vaubel (2007), Besley et al. (2008), Montoro (2007) or Riboni and Ruge-Murcia (2008, 2010). In particular, Riboni and Ruge-Murcia (2008) study heterogeneity in policy preferences among committee members using individual voting records of the MPC of the Bank of England. Their results indicate that there are systematic differences in the MPC members' recommendations which can be explained by their career background and the nature of theirmembership (i.e. whether they are internal or external members).

However, most of this literature assumes that the policymakers' divergent preferences as well as the MPC's decision rule are perfectly known by thepublic.[3] This assumption seems justified when considering the case of a highly transparent central bank which publishes minutes and voting records – like the Bank of England, for instance – and where the decision-making mechanism has been clearly specified. However, in the case of a less transparent central bank, there may be some ambiguity about the policymakers' preferences and the MPC's decision procedure.[4] For the case of the European Central Bank (ECB), for instance, no such voting records are published. Thus, von Hagen and Brückner (2001), Riboni and Ruge-Garcia (2010) and Hayo and Méon (2011) aim to estimate its decision making rule empirically. While Riboni and Ruge-Garcia (2010) argue that it follows a consensus rule, Hayo and Méon (2011) conclude that the ECB seems to implement a GDP-weighted bargaining process.

In this paper, we explicitly take account of the ambiguity that may exist around the MPC's decision-making when examining the optimal choice of central bank conservatism. Two types of uncertainty are addressed. First, we consider ambiguity about the MPC members' preferences which could be explained by a lack of central bank *political transparency*.[5] As in Faust and Svensson (2001, 2002), Jensen (2002) andWestelius (2009), we assume that this uncertainty concerns the policymakers' output gap target. Secondly, we allow for uncertainty about the MPC's decision mechanism. That is, the public and the social planner do not know how divergent preferences of board members are aggregated. This uncertainty could be due to a lack of central bank *procedural transparency* in the sense that the central bank does not

[3]Important exceptions are the papers of Sibert (2003) and Mihov and Sibert(2006) who examine how the MPC structure is likely to affect the members' incentives to gain reputation for anti-inflation toughness.

[4]Hayo and Mazhar (2011) study the determinants of the degree of MPC transparency. They find that past inflation and the quality of institutional set up significantly influence MPC transparency.

[5]For a typology of the different aspects of central bank transparency, see Geraats (2002).

communicate how monetary policy decisions are taken. As a central result, it is shown that both types of uncertainty increase the need for conservatism.

Papers by Beetsma and Jensen (1998), Muscatelli (1999) and Hefeker and Zimmer (2009) examine the implications of uncertain preferences for the optimal degree of conservatism of a single central banker. Like we do, they demonstrate that some extra conservatism may be required in the presence of preference uncertainty because it helps to attenuate the higher volatility of monetary decisions. In addition, we show how this need depends on the collective decision-making procedure in the MPC. In particular, we find that the extra conservatism that is needed to compensate for preference uncertainty is declining in the number of MPC members. That is, larger and more politically transparent MPCs need less conservative members and could be more active. In other words, the lack of central bank transparency comes at the cost of less output stabilization because central bankers should be more conservative.

We also find that the optimal degree of conservatism varies according to the MPC's decision rule. We consider alternative decision-making procedures: the "single central banker case" – which we refer to as the benchmark case – "averaging" and "voting". The latter assumes that the MPC's individual monetary decisions correspond to the median member's decision, whereas the averaging procedure implements the mean of the MPC members' decision. We show that the voting rule systematically requires a higher degree of CBC than the averaging rule. In a more general case, where the MPC's decisions are based on a combination of these stylised decision rules, we determine the optimal decision power-sharing in the MPC that minimises the need forconservatism. We find that it depends on the degree of preference uncertainty as well as on the size of the different decision bodies in the MPC.

When considering the case of uncertainty about the MPC's decision mechanism, we refer to the "robust delegation" concept developed by Tillmann (2009b).[6] More formally, we assume that the social planner is unable to define any probability distribution over the set of possible decision rules. To hedge against this uncertainty, he adopts a minmax strategy which consists in selecting the level of conservatism so as to minimise the maximum welfare loss that could occur due to uncertainty about the MPC's decision rule. In other words, the robustness-concerned planner chooses the degree of conservatism that is robust to the worst-case decision mechanism. This leads him to overestimate the volatility of monetary decisions and thereby to choose a high degree of conservatism. It finally appears that the lack of transparency about the MPC's decision mechanism creates some extra need for conservatism. We obtain a similar conclusion when using a Bayesian approach to uncertainty about the MPC decision process.

The remainder of the paper is structured as follows. Section 2 describes the model of the economy whereas section 3 presents monetary policy decisions in the MPC. After presenting the single central banker case as a benchmark, we examine monetary policy under alternative decision-making procedures. Section 4 analyses the optimal choice of conservatism in a MPC, depending on whether the committee's decision mechanism has been clearly specified or not. Finally, section 5 summarises our results and concludes.

[6] A series of papers has used the "robust control" approach to determine the optimal monetary policy when the central bank faces some model uncertainty. For recent contributions to the robust control literature in general, see for instance Hansen and Sargent (2005, 2008) or Tillmann (2009a). However, closer to our analysis is Tillmann (2009b) where the "robust control" approach is adapted to determine the optimal degree of monetary conservatism under uncertainty about the persistence of the cost-push process. More recently, Sorge (2013) studied the optimal choice of conservatism of a robustness-concerned social planner under uncertainty about the central banker's preferences.

2 The model

Our basic set up is a simple New-Keynesian model (see, for instance, Clarida et al., 1999 or Woodford, 2003) that is extended to allow for uncertainty about the policymakers' preferences. The development of inflation is derived under the assumption of 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:

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

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 is 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 $0 \leq \rho < 1$:

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

The social planner 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 social planner's relative concern with price stability. We refer to (3) as the social planner or the society's loss function.

Monetary decisions are taken by a Monetary Policy Committee (MPC) composed of n members indexed by i ($i = 1, ..., n$). Like the social planner, monetary policymakers seek price stability and output gap stabilisation. Preferences of MPC member i are summarised as follows:

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

where λ_{CB} denotes the MPC's degree of conservatism and ϵ_t^i member i's stochastic output gap target, with $E(\epsilon_t^i) = 0$ and $V(\epsilon_t^i) = \sigma_\epsilon^2$.[7] The key feature of our model is that each individual policymaker's output gap target is not perfectly known by the social planner and the public. This idea is captured by the presence of the random variable ϵ_t^i. According to the statistical properties of this preference shock, the policymakers' output gap target coincides on average with the social planner's one but 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 policymakers' output gap target.

This kind of preference uncertainty can be interpreted in several ways. The preference shock ϵ^i may represent idiosyncratic central banker preferences that are not fully known by the social planner either because the policymakers do not clearly reveal them or because of a high turnoverrate. These idiosyncrasies can for instance stem from the policymakers career background – as suggested by Riboni and Ruge-Murcia (2008) and Farvaque et al. (2011) – or the nature of their membership in the MPC (whether they are internal or external members). In the case of amonetary union where the MPC of a common central bank is composed of national representatives, these idiosyncrasies might reflect the member countries' heterogeneous economic situation. An alternative explanation would be the one proposed by Westelius (2009),

[7] We assume that the preference shocks ϵ_t^i are independent of the cost-push shock e_t, so that $E_t\left(\epsilon_t^i e_t\right) = 0$.

suggesting that the policymakers' uncertain output gap target reflects their measurement errors of the potential output level.[8]

The timing of events within the model is as follows. The first stage relates to the monetary regime design where the social planner chooses the policymakers' common degree of conservatism λ_{CB}. In the second stage, monetary policy is implemented and economic outcomes are realized. The game is solved by backward induction.

3 Monetary policymaking in the MPC

This section presents different decisions rules that can be adopted by a central bank. We first consider some stylised decision rules such as the single policymaker case, the averaging rule and the majority rule. We then turn to the more general case where monetary policy is the result of a combination of these decision rules.

3.1 Stylised decision rules

The single policymaker case

Within the MPC, monetary policy can be set according to different decision procedures. We first investigate the simplest case where one of the policymakers (MPC member i) takes decisions for the whole MPC. We hence assume that he is influential enough to impose his own judgement and preferences so that he has complete discretion in deciding monetary policy. This can be due for instance to his leader position in the committee or his high

[8] Orphanides and van Norden (2002) show that estimation errors of the output gap are highly persistent over time. In our analysis, however, the policymakers' preference shock ϵ_t^i is i.i.d. and thus transitory. For studies where this shock has a persistent component, see Faust and Svensson (2001, 2002) or Westelius (2009).

experience and skills.

Under this decision mechanism, monetary policy results from the minimisation of loss function (4) subject to the Phillips curve (1) taking inflation expectations as given. The resulting first order condition can be written:

$$x_t^{CBi} = \epsilon_t^i - \alpha\lambda_{CB}\pi_t \tag{5}$$

where superscript CBi refers to the single central banker i's monetary decision.

According to this optimality condition, monetary policy positively depends on ϵ_t^i, the decision-maker's stochastic output gap target. A positive realisation of ϵ_t^i for example – which means either that the policymaker overestimates the economy's output potential or that he has an over-ambitious output gap target – induces him to implement an expansive monetary policy and thereby leads to an expansion of the economy.

The averaging rule

Under the averaging rule, it is assumed that before deciding about monetary policy, MPC members agree on a common preference shock $\bar{\epsilon}_t$ that corresponds to the average of individual preference shocks: $\epsilon_t^{AR} = \sum_{i=1}^{n} \epsilon_t^i/n$, where superscript AR denotes the averaging rule.

Hence, the loss function that governs the decisions of the MPC under the averaging rule can be described as follows:

$$L_t^{AR} = \lambda_{CB}\pi_t^2 + (x_t - \epsilon_t^{AR})^2 \tag{6}$$

Minimising loss function (6) under the constraint of equation (1) and taking inflation expectations as given yields the following optimal reaction function:

$$x_t^{AR} = \epsilon_t^{AR} - \alpha\lambda_{CB}\pi_t \tag{7}$$

An alternative to aggregating the arguments in the MPC's loss function would be to aggregate the MPC members' individual loss functions ($L_t^{AR} = \sum_{i=1}^{n} L_t^{CB,i}/n$) or to take the average of the individual optimal decisions ($x_t^{AR} = \sum_{i=1}^{n} x_t^{CBi}/n$). Matsen and Roisland (2005) refer to the former decision mechanism as the "Benthamite rule" and to the latter as the "consensus rule". In our model, both rules lead to a similar result as the one given by equation (7). This is because we consider only one kind of asymmetry among MPC members here, namely asymmetric preference shocks.

The majority rule

We finally examine the case where the monetary policy committee resorts to majority voting. To formalize this decision mechanism, we assume that all MPC members have equal voting power. Then, the median voter theorem applies and the implemented monetary policy corresponds to the median policymaker's optimal decision which is given by:

$$x_t^{MR} = \text{median}[x_t^1, ..., x_t^n] = \epsilon_t^{MR} - \alpha\lambda_{CB}\pi_t \tag{8}$$

where MR refers to the majority rule and $\epsilon_t^{MR} = \text{median}[\epsilon_t^1, ..., \epsilon_t^n]$.

3.2 The general case

In practice, the MPC may not necessarily use one of the stylized decision rules described above. It may rather resort to a combination of these rules. Indeed, the MPC may be composed of internal members – like the chairman or members of the executive board – and external members – like academic experts or local central bank representatives in the case of a federal central bank ; monetary policy decisions may thus have elements from all the decision rules considered above. In this case, the MPC's loss function can be described by:

$$
\begin{aligned}
L_t^{GEN} &= p\left[\lambda_{CB}\pi_t^2 + (x_t - \epsilon_t^{chair})^2\right] \qquad (9)\\
&\quad + (1-p)\left\{q\left[\lambda_{CB}\pi_t^2 + (x_t - \epsilon_t^{ARc})^2\right] + (1-q)\left[\lambda_{CB}\pi_t^2 + (x_t - \epsilon_t^{MRc})^2\right]\right\}\\
&= \lambda_{CB}\pi_t^2 + p\,(x_t - \epsilon_t^{chair})^2 + (1-p)\left[q(x_t - \epsilon_t^{ARc})^2 + (1-q)\,(x_t - \epsilon_t^{MRc})^2\right]
\end{aligned}
$$

where $\epsilon_t^{ARc} = \sum_b^{n_b} \frac{\epsilon_t^b}{n_b}$ and $\epsilon_t^{MRc} = \text{median}[\epsilon_t^1, ...\epsilon_t^{n_{ext}}]$; GEN refers to the general case. Parameter p ($p \in [0,1]$) can be seen as the chairman's relative decision power whereas $(1-p)$ describes the council's relative share in the MPC. Hence, we here assume that the MPC decisions consist in a weighted combination of the chairman's decisions and the decisions of a council. The chairman is indexed by *chair* and his preference shocks are described by ϵ^{chair}, with $E(\epsilon_t^{chair}) = 0$ and $V(\epsilon_t^{chair}) = \sigma^2_{\epsilon^{chair}}$. In addition, we consider a council that is composed of a board of internal members, indexed by b ($b = 1, ..., n_b$), and external members – academic experts or regional representatives in the case of a federal central bank –, indexed by ext ($i = 1, ..., n_{ext}$).[9] Preference shocks of each *individual* board member are defined by ϵ_t^b, with $E(\epsilon_t^b) = 0$ and $V(\epsilon_t^b) = \sigma_b^2$, whereas the preference shocks of the council's *individual* external member are described by ϵ_t^{ext}, with $E(\epsilon_t^{ext}) = 0$ and $V(\epsilon_t^{ext}) = \sigma^2_{ext}$. We assume that external members have to resort to voting whereas board members can easily share a common view and thus reach decisions by consensus (which in our framework is captured by the averaging rule). Parameter

[9]Obviously, $n_b + n_{ext} = n$ so that the MPC is formed by $n+1$ members.

q ($q \in [0,1]$) represents the board's relative share in the council.[10]

Minimising expression (9) with respect to x_t^{GEN}, we obtain the MPC's reaction function which can be written as a weighted combination of expressions (5), (7) and (8):

$$\begin{aligned} x_t^{GEN} &= \left\{p\ \epsilon_t^{chair} + (1-p)[q\epsilon_t^{ARc} + (1-q)\epsilon_t^{MRc}]\right\} - \alpha\lambda_{CB}\pi_t \qquad (10) \\ &= \epsilon_t^{GEN} - \alpha\lambda_{CB}\pi_t \end{aligned}$$

4 Optimal delegation in the MPC

In this section, we examine the choice of the optimal degree of central bank conservatism λ_{CB}^* in a MPC. To do so, we consider a model of endogenous delegation where the social planner selects the policymakers' common degree of conservatism λ_{CB} to minimise the expected social loss. This latter depends on the equilibrium output gap and inflation rate observed under the alternative decision rules. By combining the Phillips curve (1) with the optimal monetary policy rules given by expressions (5), (7), (8) and (10), we obtain respectively:

$$x_t^j = \frac{1}{\alpha^2\lambda_{CB}+1}\ \epsilon_t^j - \frac{\alpha\lambda_{CB}}{\alpha^2\lambda_{CB}+1-\beta\rho}\ e_t \qquad (11)$$

$$\pi_t^j = \frac{\alpha}{\alpha^2\lambda_{CB}+1}\ \epsilon_t^j + \frac{1}{\alpha^2\lambda_{CB}+1-\beta\rho}\ e_t \qquad (12)$$

where $j = CBi, AR, MR$ or GEN.

Unsurprisingly, the equilibrium output gap and inflation rate depend on the central bankers' stochastic output gap targets and thus on the way these

[10] Parameter q can also be seen as a binary number where a value of 1 (0) implies that council members resort to averaging (voting). Another interpretation of q would be that it represents the probability that the council reaches a consensus ; $(1-q)$ being the probability that the council fails to reach a consensus, in which case, it has to resort to voting. Obviously, with both interpretations of q, no distinction is made between board and external members within the council so that $n_b = n_{ext} = n$ and $\epsilon_t^b = \epsilon_t^{ext}$.

are aggregated through the MPC decision procedure. Moreover, as expressions (11) and (12) reveal, the transmission of cost-push shocks e_t to the output gap and inflation rate is not affected by these preference shocks ϵ_t^j. This is explained by the fact that the preference shocks concern the policymakers' targets and not the relative weight they give to their objectives.

Integrating expressions (11) and (12) into Eq. (3) and taking expectations yields the following expected social loss:

$$E_t L_j^G = \frac{\lambda_G \alpha^2 + 1}{\left(\alpha^2 \lambda_{CB} + 1\right)^2} V(\epsilon_t^j) + \frac{\lambda_G + \alpha^2 \left(\lambda^{CB}\right)^2}{\left(\alpha^2 \lambda_{CB} + 1 - \beta\rho\right)^2} \cdot \frac{1}{(1 - \rho^2)} \tag{13}$$

The first term of Eq. (13) is due to the inflation and output gap volatility arising from the uncertainty about the policymakers' output gap target. The second term corresponds to the macroeconomic volatility related to cost-push shocks.

Next, our objective is to investigate the optimal delegation implications of collective monetary policymaking. In particular, we want to study how the optimal degree of conservatism is influenced by the design of the MPC in terms of its size, its decision rule, and in terms of its transparency about the decision structure – i.e. the MPC's disclosure of its decision structure (p and q). In the general case, we hence distinguish between two cases depending on whether the MPC's decision structure is clearly specified or not.

In the following subsection, we first investigate the optimal degree of conservatism when the MPC adopts some stylised decision rules before, in the next subsection, turning to the general case.

4.1 Optimal delegation under stylised decision rules

To determine the optimal degree of conservatism λ_{CB}^{*}, we minimise the expected social loss (13) with respect to λ_{CB} and obtain the following first order condition:

$$-\frac{\lambda_G \alpha^2 + 1}{(\alpha^2 \lambda_{CB*} + 1)^3} V(\epsilon_t^j) + \frac{\lambda_{CB*}(1-\beta\rho) - \lambda_G}{(\alpha^2 \lambda_{CB*} + 1 - \beta\rho)^3} \cdot \frac{1}{(1-\rho^2)} = 0 \qquad (14)$$

The first term in (14) is always negative. This reflects the fact that greater conservatism reduces the volatility arising from the policymakers' uncertain output gap target. The second term can be positive or negative and increases with the size of λ_{CB*}. This term highlights the trade-off between inflation and output gap stabilisation arising from the optimal choice of λ_{CB}: a higher λ_{CB} implies better inflation stabilisation but at the cost of less output gap stabilisation. Since the first term is negative, the optimal λ_{CB} must be large enough for the second term to become positive. Hence, in the presence of uncertainty about the policymakers' true preferences some extra conservatism is required, depending on the decision procedure that has been adopted in the MPC. Moreover, the larger is the preference uncertainty, the higher is the level of optimal conservatism and the lower is output gap stabilisation.

Rewriting the first order condition (14), we have:

$$\lambda_{CB*} = \frac{(\lambda_G \alpha^2 + 1)(1-\rho^2)(\alpha^2 \lambda_{CB*} + 1 - \beta\rho)^3 \ V(\epsilon_t^j)}{(1-\beta\rho)(\alpha^2 \lambda_{CB*} + 1)^3} + \frac{\lambda_G}{(1-\beta\rho)} \equiv f(\lambda_{CB*}) \qquad (15)$$

As can be seen from this expression, the need for conservatism (i.e. the fact that $\lambda_{CB*} > \lambda_G$) at this stage of our analysis stems from the presence of both, shock persistence ρ and uncertainty about the policymakers' preferences $V(\epsilon_t^j)$. To determine the optimal degree of central bank conservatism λ_{CB*}, we use a graphical method.

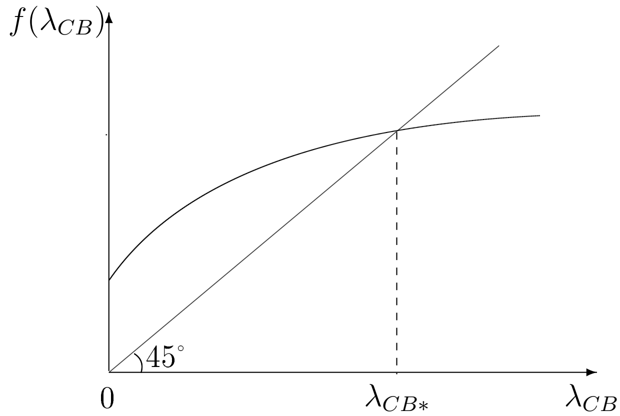

Figure 1: Determination of the optimal degree of conservatism

Figure 1 represents function $f(\lambda_{CB})$ on the right hand side of Eq. (15).[11] The left-hand side of Eq. (15) is a 45° line through the origin. The intersection point between the 45° line and function f curve gives the optimal degree of central bank conservatism λ_{CB*}^j. From this graphical analysis, we derive the following result:

Result 1: *When there is uncertainty about the policymakers' true preferences,*

i) the MPC should always be more conservative than society, even if cost push shocks are not persistent,

ii) the single policymaker case leads to the highest need for conservatism,

iii) the need for conservatism decreases with the number of MPC members,

[11] Studying the properties of this function, we observe that: $\frac{\partial f(\lambda_{CB})}{\partial \lambda_{CB}} = \frac{3\alpha^2\beta\rho\left(\lambda_G\alpha^2+1\right)\left(1-\rho^2\right)\left(\alpha^2\lambda^{CB}+1-\beta\rho\right)^2 V(\epsilon_t^j)}{(1-\beta\rho)(\alpha^2\lambda_{CB}+1)^4} > 0$. Hence, $f(\lambda_{CB})$ is monotonically increasing in λ_{CB}. Moreover, $\frac{\partial^2 f(\lambda_{CB})}{\partial^2 \lambda_{CB}} = \frac{-6\alpha^4\beta\rho\left(\lambda_G\alpha^2+1\right)\left(1-\rho^2\right)\left(\alpha^2\lambda^{CB}+1-\beta\rho\right)\left(\alpha^2\lambda^{CB}+1-2\beta\rho\right)V(\epsilon_t^j)}{(1-\beta\rho)(\alpha^2\lambda_{CB}+1)^5}$ becomes negative – implying that $f(\lambda_{CB})$ is concave – for sufficiently low values of β and ρ and/or sufficiently large values of λ_{CB} and α.

iv) averaging requires less conservatism than voting.

Proof: See appendix.

To understand the intuition underlying this result, we must have in mind that when the central bankers' preferences are not fully known by the public, extra conservatism is required to attenuate the subsequent macroeconomic volatility.[12] Accordingly, in the presence of this uncertainty, thecentral bank should always be more conservative than society, independent of whether cost push shocks are persistent or not. This result extends earlier findings of Tillmann (2009b) where the need for conservatism hinges on the persistence of cost push shocks.

Result 1 provides further precision by showing how the macroeconomic volatility generated by uncertain central banker preferences depends on the structure of the MPC, the number of members and the adopted decision procedure. More specifically, we find that the single policymaker case yields the highest variance of inflation and the output gap, followed by majority rule, while the averaging rule leads to the lowest macroeconomic volatility. This is due to the fact that the decisions of a committee areless volatile than the decisions of a single policymaker. And the larger the committee, the lower this volatility.[13] The large size of the committee helps indeed to weaken extreme positions of individual members. Furthermore, while the decisions of the committee's median member can never be extreme decisions (as it may be the case with a single decision-maker), they are however more volatile

[12]This effect also appears in earlier studies about the implications of uncertain central bank preferences for the optimal design of monetary institutions (see Beetsma and Jensen, 1999, Muscatelli, 1999, and Hefeker and Zimmer, 2009).

[13]This result implies that the optimal size of the committee is infinite. Incorporating additional effects like efficiency or decision costs would obviously restrict the optimal committee size (Berger 2006). This issue, however, is beyond the scope of our paper.

than the decisions of the average member. The majority rule therefore creates some extra volatility compared to the averaging rule and the smaller is the size of the committee, the higher is this extra volatility. Finally, as the macroeconomic volatility depends on the structure of the MPC, so does the resulting need for conservatism. Consequently, the latter is higher with a single central banker than with a committee and, in the case of collective monetary policymaking, resorting to majority voting requires a higher level of conservatism than resorting to averaging.

4.2 Optimal delegation in the general case

We next consider the general case where the MPC is composed of a chairman and a council of members, resorting to averaging and/or to voting.

The MPC's decision structure is known

We first turn to the case where the social planner knows the MPC's structure, i.e. the relative influence of the chairman (p) and the power-sharing among the council members (q). The analysis of the optimal degree of conservatism leads to the following result:

Result 2: *There exists an optimal decision structure* $p_{min} = \frac{q^2 \frac{\sigma_b^2}{n_b} + (1-q)^2 \frac{\Pi \sigma_{ext}^2}{2n_{ext}}}{\sigma_{chair}^2 + q^2 \frac{\sigma_b^2}{n_b} + (1-q)^2 \frac{\Pi \sigma_{ext}^2}{2n_{ext}}}$ *and* $q_{min} = \frac{\frac{\Pi \sigma_{ext}^2}{2n_{ext}}}{\frac{\sigma_b^2}{n_b} + \frac{\Pi \sigma_{ext}^2}{2n_{ext}}}$ *that minimises the expected social welfare loss as well as the optimal degree of conservatism.*

Proof See appendix.

As is obvious from result 2, the optimal weight for the chairman, p_{min}, is decreasing in the degree of uncertainty about his preferences σ^2_{chair}. The optimal weight p_{min} also depends on the council's parameters: p_{min} is decreasing in n, the number of council membersand increasing in σ^2_b and σ^2_{ext}, the degrees of uncertainty about the council members' (board and external members) preferences. This can be explained by the fact that the variance of the council's decisions falls with respect to its size n but increases in σ^2_b and σ^2_{ext}. Moreover, the lower the volatility of the council's decisions, the higher should be its decision power compared to the chairman. A similar analysis can be developed to explain why the board's optimal relative weight q_{min} is decreasing in the number of external members n_{ext} and increasing in the external members preference uncertainty σ^2_{ext}.

Moreover, as neither p_{min} nor q_{min} have extreme values (0 or 1), giving full monetary power to a single policymaker or a group of policymakers with similar preference uncertainty (σ^2) and/or who resort to a unique decision rule does not appear to be an optimal decision scheme. This result calls for some diversity within the MPC, in terms of preference uncertainty as well as in terms of decision rule. Hence, if society wants to attenuate the volatility of MPC decisions and thereby the need for conservatism, it is in its interest to allocate the decision power among different members who exhibit some heterogeneity in their degree of preference uncertainty σ^2 and/or who resort to different decision rules. Obviously, the allocation scheme should be based on the policymakers' level of preference uncertainty: the lower this latter, the higher should be their decision power within the committee.

The MPC's decision structure is unknown

Until now, we have assumed that the social planner perfectly knows the MPC's decision procedure. Yet, central banks are not necessarily fully transparent about the way their monetary policy decisions are taken. When initially the decision procedure has not been clearly specified and/or if the central bank does not reveal monetary policy deliberations through the publication of minutes and voting records – as it is the case for the ECB – the MPC decision mechanism remains uncertain for the social planner (as well as the public in general).

We thus consider next the case where the social planner, when determining the optimal level of conservatism, is uncertain about the MPC's true decision procedure, in particular the relative weights of the chairman and council members (p and q). This does not mean, however, that the social planner is not informed about the composition of the MPC. It only means that he knows neither the decision power of the chairman and the coucnil, nor how the latter reaches decision – whether by averaging or by voting. He only knows that p and q both lie in an interval bounded by zero and unity. We also assume that he is unable to formulate, in the initial stage, any probability distribution of possible realizations of p and q. To address this uncertainty, he may want to determine a robust delegation scheme, i.e. to determine λ_{CB}^{*} so that it is robust against the worst possible scenario of policymaking in the MPC. This latter corresponds to the decision mechanism p, q that leads to the highest expected social loss.

More formally, to determine the optimal delegation parameter λ_{CB}^{*}, he adopts a min-max approach which consists in solving the following problem:

$$\min_{\lambda_{CB}} \left\{ \max_{p,q} EL_t^G \left[x_t(\epsilon^{UN}), \pi_t(\epsilon^{UN}) \right] \right\} \tag{16}$$

where $\epsilon_t^{UN} = p^{UN}\ \epsilon_t^{chair} + (1-p^{UN})[q^{UN}\epsilon_t^{ARc} + (1-q^{UN})\epsilon_t^{MRc}$; p^{UN} and q^{UN} define respectively the unknown chairman's decision power and the unknown board's decision power.

The equilibrium output gap and inflation when then MPC's decision structure is unknown are respectively described by:

$$x_t^{UN} = \frac{1}{\alpha^2\lambda_{CB}+1}\ \epsilon_t^{UN} - \frac{\alpha\lambda_{CB}}{\alpha^2\lambda_{CB}+1-\beta\rho}\ e_t \tag{17}$$

$$\pi_t^{UN} = \frac{\alpha}{\alpha^2\lambda_{CB}+1}\ \epsilon_t^{UN} + \frac{1}{\alpha^2\lambda_{CB}+1-\beta\rho}\ e_t \tag{18}$$

The analysis of problem (16)'s solution yields the followingresult:

Result 3: *The lack of transparency about the MPC's decision procedure leads the robustness-concerned social planner to overestimate the need for conservatism.*

Proof See appendix.

Hence, when the committee's decision procedure has not been clearly specified, the social planner voluntarily overestimates preference uncertainty and the resulting macroeconomic volatility. This obliges him to set an artificially high degree of conservatism. As a consequence, the lack of procedural transparency seems to create some extra need for conservatism. One could however argue that this result hinges on the robust min-max approach which leads the social planner to consider the worst-case scenario and thus to exaggerate the importance of the volatility of monetary decision. That is why we develop an alternative method to capture the idea of uncertainty in the MPC's decision structure by adopting a Bayesian approach.

Here, the social planner is assumed to have some information about the MPC decision procedure but is uncertain about it. This could, for instance, reflect the case where the MPC publicly announces its decision structure (p and q) but does not publish minutes so that these announcements can not be confirmed. Accordingly, we assume that the social planner is able to assign a prior on p and q which is however subject to white noise disturbances:

$$p = \bar{p} + \eta \quad \text{with } \eta \sim \aleph(0, \sigma_\eta^2) \tag{19}$$

$$q = \bar{q} + \mu \quad \text{with } \mu \sim \aleph(0, \sigma_\mu^2) \tag{20}$$

where σ_η^2 and σ_μ^2 respectively represent the degrees of uncertainty surrounding the chairman's and the board's relative decision power.

Under this specification, the expected social loss function writes:

$$E[L_t^G(\epsilon_t^{UNB})] = \frac{\lambda_G \alpha^2 + 1}{(\alpha^2 \lambda_{CB} + 1)^2} E(\epsilon_t^{UNB})^2 + \frac{\lambda_G + \alpha^2 \left(\lambda^{CB}\right)^2}{(1-\rho^2)\left(\alpha^2 \lambda_{CB} + 1 - \beta\rho\right)^2} \tag{21}$$

$$\begin{aligned} \text{where } E(\epsilon_t^{UNB})^2 &= E\left\{(\bar{p}+\eta)\,\epsilon_t^{chair} + (1-\bar{p}-\eta)[(\bar{q}+\mu)\,\epsilon_t^{ARc} + (1-\bar{q}-\mu)\epsilon_t^{MRc}]\right\}^2 \\ &= \left(\bar{p}^2 + \sigma_\eta^2\right)\sigma_{chair}^2 + \left[(1-\bar{p}^2) + \sigma_\eta^2\right]\left[\left(\bar{q}^2 + \sigma_\mu^2\right)\frac{\sigma_b^2}{n_b} + \left[(1-\bar{q}^2) + \sigma_\mu^2\right]\frac{\Pi\sigma_{ext}^2}{2n_{ext}}\right] \end{aligned}$$

According to this expression, the presence of uncertainty about the MPC's decision structure (σ_η^2 and σ_μ^2) exacerbates the volatility of monetary decisions and thereby induces the social planner to choose a higher level of conservatism than under certainty.

Both approaches (robust control and bayesian) to uncertainty about the MPC decision structure hence lead to the same conclusion, showing that a lack of procedural transparency induces the social planner to choose higher conservatism.

5 Concluding remarks

This paper provides insights into how optimal conservatism relates to the collective decision-making process in a MPC. We explicitly take account of two types of uncertainty that may characterise decision-making within a committee. More precisely, we assume that when choosing the optimal degree of CBC, the social planner is likely to face some uncertainty about the MPC members' heterogeneous preferences as well as about the MPC's decision-making procedure.

Within this framework, we first demonstrate that more preference uncertainty should be compensated through more conservatism. Indeed, preference uncertainty creates volatility of monetary decisions and higher conservatism helps to attenuate this effect at the price however of less output gap stabilisation. In addition, we show that this extra conservatism that is needed to compensate for preference uncertainty is declining in the number of MPC members. That is, larger and more transparent MPC need less conservative members. An application to the case of the ECB, which is one of the central banks with the largest MPCs, and arguably also one of the less transparent central banks, would hence suggest that reform efforts that aim to reduce the size of the MPC are not necessarily costless, even if they increase efficiency. The large size of the committee indeed helps to attenuate extreme positions of heterogeneous policymakers.

Also, we find that when the MPC members resort to voting, the need for conservatism is higher than when they resort to averaging. A more general decision-making process where MPC decisions are based on a combination ofthese stylised decision rules reveals that concentrating the full decision power in the hands of a single policymaker or a group of identical policymakers is not optimal. To minimise the volatility of monetary decisions and thereby the need for conservatism, room should be left for diversity within the committee, in terms of preference uncertainty and of decision rules.

Finally, we have allowed for a lack of procedural transparency which translates into some ambiguity about the specification of the MPC's decision rule. We have assumed that the social planner addresses this kind of uncertainty by following a robust delegation approach. This consists in choosing a level of conservatism which is robust to the worst possible decision mechanism that the MPC might adopt, i.e. to the decision mechanism that yields the highest welfare loss. We show that, in this context, the robustness-concerned social planner is induced to overestimate the volatility of monetary decisions and thereby to set a higher level of conservatism than under full procedural transparency. A similar conclusion is obtained when using a Bayesian approach where the social planner is able to formulate a probability distribution over the uncertain allocation of decision power.

Our findings eventually highlight the importance of taking into account the volatility that may arise from collective monetary policymaking for the optimal design of central bank conservatism. Yet, it should be kept in mind that our analysis only focuses on one dimension of the debate and one should thus be careful to draw immediate policy consequences from it. However, we feel that the interaction between collective monetary policymaking and other important issues – like central bank transparency and optimal monetary delegation – has been insufficiently researched. This paper makes a first step at filling this gap.

Appendix

Proof of Result 1:

From expression (15), it is easy to see that $\frac{\partial f}{\partial V(\epsilon_t^j)} > 0$. Hence, a rise in $V(\epsilon_t^j)$ causes an upward shift of the function f and thereby a shift to the right of the intersection point between the 45° line and the function f curve, implying an increase in λ_{CB*}.

As $\epsilon_t^{AR} = \sum_i^n \epsilon_t^i/n$, the aggregation process implies: $E(\epsilon_t^{AR}) = 0$ and $V(\epsilon_t^{AR}) = \sigma_\epsilon^2/n$. Further, since $\epsilon_t^{MR} = \text{median}[\epsilon_t^1, ..., \epsilon_t^n]$, we have $E(\epsilon_t^{MR}) = 0$ and $V(\epsilon_t^{MR}) = \frac{\Pi}{2n}\sigma_\epsilon^2$.[14]

i) It is obvious from (15) that $\lambda_{CB*} > \lambda_G$ even if $\rho = 0$.
ii) Since $V(\epsilon_t^{CBi}) = \sigma_\epsilon^2$, it follows that $V(\epsilon_t^{CBi}) > V(\epsilon_t^{MR})$ and $V(\epsilon_t^{CBi}) > V(\epsilon_t^{AR})$. Consequently, $\lambda_{CB*}^{CBi} > \lambda_{CB*}^{MR}$ and $\lambda_{CB*}^{CBi} > \lambda_{CB*}^{AR}$.
iii) Since $\frac{\partial V(\epsilon_t^{AR})}{\partial n} < 0$ and $\frac{\partial V(\epsilon_t^{MR})}{\partial n} < 0$, λ_{CB*}^{AR} and λ_{CB*}^{MR} depend negatively on n.
iv) Finally, as $V(\epsilon_t^{AR}) < V(\epsilon_t^{MR})$ we have $\lambda_{CB*}^{AR} < \lambda_{CB*}^{MR}$, according to the graphical analysis.

Proof of Result 2:

To demonstrate result 2, we begin by deriving $V(\epsilon_t^{GEN})$:

$$\begin{aligned} V(\epsilon_t^{GEN}) &= E\left\{p\ \epsilon_t^{chair} + (1-p)[q\epsilon_t^{ARc} + (1-q)\epsilon_t^{MRc}]\right\}^2 \\ &= p^2\sigma_{chair}^2 + (1-p)^2\left[q^2\frac{\sigma_b^2}{n_b} + (1-q)^2\frac{\Pi\sigma_{ext}^2}{2n_{ext}}\right] \end{aligned} \tag{22}$$

[14]Note that $\Pi = 3,14159...$ (as opposed to π_t) refers to the mathematical constant and not to inflation. See Méon (2008) and Farvaque et al. (2009) for a detailed explanation of the statistical properties of the median.

Differentiating this expression with respect to p yields:

$$\frac{\partial V(\epsilon_t^{GEN})}{\partial p} = 2p[\sigma_{chair}^2 + q^2\frac{\sigma_b^2}{n_b} + (1-q)^2\frac{\Pi\sigma_{ext}^2}{2n_{ext}}] - 2[q^2\frac{\sigma_b^2}{n_b} + (1-q)^2\frac{\Pi\sigma_{ext}^2}{2n_{ext}}] \quad (23)$$

This derivative is negative if $p < \frac{q^2\frac{\sigma_b^2}{n_b}+(1-q)^2\frac{\Pi\sigma_{ext}^2}{2n_{ext}}}{\sigma_{chair}^2+q^2\frac{\sigma_b^2}{n_b}+(1-q)^2\frac{\Pi\sigma_{ext}^2}{2n_{ext}}} = p_{\min}$ and becomes positive otherwise. Hence, $p_{\min}$ minimises $V(\epsilon_t^{GEN})$ and the optimal degree of conservatism λ_{CB*}^{GEN} as well.

We then turn to the council and differentiate $V(\epsilon_t^{GEN})$ with respect to q. In doing this, we obtain :

$$\frac{\partial V(\epsilon_t^{GEN})}{\partial q} = 2q\frac{\sigma_b^2}{n_b} - 2(1-q)\frac{\Pi\sigma_{ext}^2}{2n_{ext}} \quad (24)$$

This derivative is negative for $q < q_{\min} = \frac{\frac{\Pi\sigma_{ext}^2}{2n_{ext}}}{\frac{\sigma_b^2}{n_b}+\frac{\Pi\sigma_{ext}^2}{2n_{ext}}}$ and positive otherwise. As a consequence, $p_{\min}$ minimises $V(\epsilon_t^{GEN})$ and thereby the optimal degree of conservatism λ_{CB*}^{GEN}.

Proof of Result 3:

To solve problem (16), the first stage is to identify the realizations of (p^{UN}, q^{UN}) that maximise the expected social loss:

$$\max_{p^{UN},q^{UN}} E[L_t^G(\epsilon_t^{UN})] = \max_{p^{UN},q^{UN}} \left\{ \frac{\lambda_G\alpha^2+1}{(\alpha^2\lambda_{CB}+1)^2}\ E(\epsilon_t^{UN})^2 + \frac{\lambda_G+\alpha^2\left(\lambda^{CB}\right)^2}{(1-\rho^2)\left(\alpha^2\lambda_{CB}+1-\beta\rho\right)^2} \right\} \quad (25)$$

$$\begin{aligned} \text{where } E(\epsilon_t^{UN})^2 &= E\left\{p^{UN}\ \epsilon_t^{chair} + (1-p^{UN})[q^{UN}\epsilon_t^{ARc} + (1-q^{UN})\epsilon_t^{MRc}]\right\}^2 \\ &= E\left(p^{UN}\right)^2\sigma_{chair}^2 + E(1-p^{UN})^2\left[\left(q^{UN}\right)^2\frac{\sigma_b^2}{n_b} + (1-q^{UN})^2\frac{\Pi\sigma_{ext}^2}{2n_{ext}}\right]. \end{aligned}$$

Note that $E[L_t^G(\epsilon_t^{UN})]$ only depends on p^{UN} and q^{UN} via $E(\epsilon_t^{UN})^2$. The social planner first determines the allocation of decision power within the council that maximises the expected social loss. Differentiating $E(\epsilon_t^{UN})^2$ with respect to q^{UN} yields

$$\frac{\partial E(\epsilon_t^{UN})^2}{\partial q^{UN}} = 2q^{UN}\frac{\sigma_b^2}{n_b} - 2(1-q^{UN})\frac{\Pi\sigma_{ext}^2}{2n_{ext}}.$$

As has already been demonstrated, for a given p, $E(\epsilon_t^{UN})^2$ attains its minimum for $q_{min} = \frac{\frac{\Pi\sigma_{ext}^2}{2n_{ext}}}{\frac{\sigma_b^2}{n_b}+\frac{\Pi\sigma_{ext}^2}{2n_{ext}}}$ and thus its maximum for extreme values of q in the interval $[0,1]$. We finally compare $E(\epsilon_t^{UN}|_{q=0})^2 = \frac{\Pi\sigma_{ext}^2}{2n_{ext}}$ with $E(\epsilon_t^{UN}|_{q=1})^2 = \frac{\sigma_b^2}{n_b}$ to show that if $\frac{\Pi\sigma_{ext}^2}{2n_{ext}} > (<)\frac{\sigma_b^2}{n_b}$, q_{max} – i.e. the value of q that maximises $E(\epsilon_t^{UN})^2$ and thus $E[L_t^G(\epsilon_t^{UN})]$ – is equal to 0 (1).

Once q_{max} has been determined, the social planner turns to p_{max}, the value of p that maximises $E(\epsilon_t^{UN})^2$ and thus $E[L_t^G(\epsilon_t^{UN})]$.

Taking the derivative of $E(\epsilon_t^{UN})^2$ with respect to p^{UN} yields

$$\frac{\partial E(\epsilon_t^{UN})^2}{\partial p^{UN}} = 2p^{UN}[\sigma_{chair}^2+q_{max}^2\frac{\sigma_b^2}{n_b}+(1-q_{max})^2\frac{\Pi\sigma_{ext}^2}{2n_{ext}}]-2[q_{max}^2\frac{\sigma_b^2}{n_b}+(1-q_{max})^2\frac{\Pi\sigma_{ext}^2}{2n_{ext}}] \quad (26)$$

For a given $q = q_{max}$, $E(\epsilon_t^{UN})^2$ has its minimum at $p_{min} = \frac{q^2\frac{\sigma_b^2}{n_b}+(1-q)^2\frac{\Pi\sigma_{ext}^2}{2n_{ext}}}{\sigma_{chair}^2+q^2\frac{\sigma_b^2}{n_b}+(1-q)^2\frac{\Pi\sigma_{ext}^2}{2n_{ext}}}$ and its maximum for extreme values of p in the interval $[0,1]$. We thus compare $E(\epsilon_t^{UN}|_{p=0})^2 = (q_{max})^2\,\frac{\sigma_b^2}{n_b} + (1-q_{max})^2\frac{\Pi\sigma_{ext}^2}{2n_{ext}}$ with $E(\epsilon_t^{UN}|_{p=1})^2 = \sigma_{chair}^2$.

If $(q_{max})^2\,\frac{\sigma_b^2}{n_b}+(1-q_{max})^2\frac{\Pi\sigma_{ext}^2}{2n_{ext}} > \sigma_{chair}^2$, then $p_{max} = 0$, otherwise $p_{max} = 1$. In both cases, $E(\epsilon_t^{UN})^2 = V(\epsilon_t^{UN}) > V(\epsilon_t^{GEN})$ – the latter being defined by (22) – which means that the optimal degree of conservatism, λ_{CB*}^{UN}, when the MPC's decision procedure is unknown is higher than λ_{CB*}^{GEN}, the one obtained under transparency about the decision procedure.

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