JEL classification: E42, E58, E63, H30
Keywords: dynamic inconsistency, fiscal and monetary policy interaction, independent fiscal council

Fiscal Councils and Economic Volatility*

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Abstract

We evaluate proposals for an independent fiscal authority put forward as a solution to excessive public spending. Our main conclusion is that shifting the responsibility to set broad measures of fiscal policy from the hands of the government to an independent fiscal council is not necessarily welfare improving. We show that the change is welfare improving if the ability of policymakers to assess the state of the economy does not change. However, if this institutional change involves a considerable decrease of capacity of the new agency to recognize economic shocks, citizens' welfare can decrease as a result. This is especially significant in times of increased economic volatility such as during the recent global financial crisis. Faced with the ambiguous theoretical result, we try to gain deeper insight by calibrating our simple model.

1. Introduction

The global financial crisis affected the fiscal positions of many countries. The main channels were not only direct government involvement in saving the banking system, but also a fall in tax revenues due to the economic slowdown and increased costs of long-term debt. As a result, budget deficits and the level of government debt are increasing. Especially in the EU, some countries such as Greece started to feel the consequences of the badly run fiscal policy of the past as the level of debt and the expected fiscal deficit reached values that could bring the given country almost to the point of sovereign bankruptcy. Given that most of the EU countries employ a common monetary policy (euro area), serious fiscal problems of one of the euro area's members could possibly endanger the stability of the common currency, the euro.

As a reaction to deteriorating fiscal positions that revealed the imprudent fiscal policy of the past, policymakers started once again to discuss the agenda of how to set up a fiscal framework that would prevent accumulation of deficits, especially in good times. One can remember that this discussion was already undertaken by academics and policymakers in the EU in the late 1990s and early 2000s together with the establishment and reform of the EU's Stability and Growth Pact. The debate at that time emphasized that while a rule-based fiscal policy that includes

* Financial support from the Czech Science Foundation (GACR 402/08/0501 and GACR 403/10/1235) and from the Grant Agency of Charles University (project GA UK No. 564612) is greatly appreciated. We wish to thank several anonymous referees for their helpful comments. The findings, interpretations and conclusions in this paper are entirely those of the authors and do not represent the views of any of the below-mentioned institutions.

deficit or debt limits is desirable, it is difficult to safeguard compliance with the rules if fiscal policy remains in the hands of elected policymakers. Some authors (Poterba, 1996; Strauch and von Hagen, 1999; European Commission, 2003) argued for fiscal policy to be taken from the hands of elected governments and to be vested in the hands of an independent institution. Such an independent institution would set broad measures of fiscal policy such as budget deficits and public debt. Looming fiscal problems in the EU during 2009–2010 that again spurred a decline in economic output due to the global financial crisis led policymakers in the EU to put once more on the agenda the possible role of independent fiscal councils.[1] The Treaty on Stability, Coordination and Governance in the Economic and Monetary Union (also known as the Fiscal Compact) came into force in January 2013. The treaty is an intergovernmental agreement of 25 EU member states[2] and it aims to strengthen fiscal discipline in the EU, including the call for setting up national fiscal councils.

From a political economy perspective, crisis periods provide a window of opportunity to change macroeconomic policy frameworks. The experience of Asian countries after the 1997 financial crisis shows that the hard landing the East Asian countries experienced compelled them to implement better macroeconomic and financial policies oriented towards economic and financial stability so that during the recent global financial crisis of 2007–2009 they stayed relatively resilient. However, establishing new institutions and policies such as an independent fiscal council while still in a period of increased economic volatility may also bring some risks (Saint-Paul, 2002).

Proposals for independent fiscal councils stem from the same logic, which led to the establishment of an institution comprising independent monetary authorities, i.e. vesting a broad aggregate of fiscal policy in the hands of an independent institution. This newly established authority would be responsible for independent monitoring of fiscal policy. The fiscal council would also set a binding limit on the size of public debt or the budget deficit, while democratically elected governments would decide about the composition of public spending and revenues. The argument is that the independent fiscal authority would not be subject to the short-sighted behavior of elected governments, which leads to spending bias. Also, by focusing solely on the debt or deficit, the independent fiscal authority would not be subject to the public tragedy of the commons.

In this paper we argue that setting up an independent fiscal council is a wealth-improving measure under the condition that the institution is able to properly identify shocks (i.e., with at least broadly the same or higher probability than the government, the initial fiscal authority). We construct a microeconomic model of macroeconomic policymaking that always involves two players (government versus central bank or fiscal council versus central bank) that are uncertain about the actions of the other policymaker. We investigate the claim for an independent fiscal authority from the point of view of citizens who prefer an optimal and stable economic environment. We show that in a period of higher economic volatility the failure of the fiscal council to recognize shocks has a significant negative effect on the final welfare, which can even outweigh the positive effects of getting rid of

[1] See Council of the EU (2010).

[2] Of the total 27 at the time, excluding the United Kingdom and the Czech Republic.

the politically motivated fiscal deficit bias. We calibrate the model in order to be able to quantify the effects in empirical terms. We are able to show that an ill-designed fiscal authority with virtually zero ability to recognize shocks and to optimally react to them that would be established in turbulent times can decrease the general welfare by roughly 20%.

The paper is structured as follows: Section 2 relates our work to the existing literature. Section 3 introduces the model, derives its equilibrium and discusses the welfare measure. Section 4 contains our calibration exercise. Section 5 concludes the paper. Derivation of the model equilibrium is relegated to *Appendix A1*.

2. Relation to Literature

Our work is related to several strands of literature. Most importantly, we investigate the claim of several authors who call for the designation of an independent fiscal authority as a means of preventing excessive public spending and budget deficits run by elected governments (see the survey in Debrun, Hauner and Kumar, 2009, for a detailed overview of the topic). In this respect, von Hagen and Harden (1994) and Eichengreen, Hausmann and von Hagen (1999) call for a "National Debt Board" and "National Fiscal Council", respectively. Both institutions would be independent, apolitical institutions that would set the maximum allowable increase of government debt in each year, a limit to which a proposed public budget would have to comply. In a similar spirit, Wyplosz (2005) calls for a "Fiscal Policy Committee" that would set the maximum allowable budget deficit. Von Hagen (2003) then proposes a "European Stability Council" as an institution that would focus on changes in public debt.[3]

The logic of all of these proposals is to mimic independent central banks on the fiscal side. A newly established council would have a mandate to set a binding limit on the size of public debt or the budget deficit, while democratically elected governments would decide about the composition of public spending and revenues. The independent fiscal authority would address the political failure, which is considered to be the source of fiscal indiscipline (Wyplosz, 2008). In particular, the council would not suffer from the short-sighted behavior of elected governments that leads to spending bias. Furthermore, having a clearly defined objective, the independent fiscal authority would not be subject to the public tragedy of the commons that is due to the fact that the costs of public spending (deadweight loss of taxation) are not borne by agents who decide the size and composition of public spending.[4]

All of the authors mentioned above argue that the proposed independent fiscal authority has the potential to improve the problematic conduct of fiscal policy. While that is certainly correct, we feel it is a partial equilibrium argument. What consequences, if any, would result with respect to monetary policy? What would be

[3] For proposals intended to solve the problem of excessive public spending and deficits that do not require fiscal policy to be (partly) taken over from the government, see Boonstra (2005), Saraceno and Monperrus-Veroni (2004) and von Hagen and Harden (1995).

[4] In the literature, this proposal is also referred to as the "hard fiscal policy council" (Wyplosz, 2008) or "independent fiscal authority" (Debrun et al., 2009). This concept is in contrast to the "soft" institutional setup where a newly established fiscal authority does not receive any mandate or authority over policy but rather works as an advisory body or provides inputs to the government. For a detailed discussion, see Wyplosz (2008), Debrun et al. (2009) and Calmfors and Wren-Lewis (2011).

the relation between the independent fiscal authority and the monetary policymaker? What are the consequences for economic agents and can this proposed institutional change be evaluated based on some welfare measure? Those are the questions we try to address in this paper. In order to do so, we set up a model that can be regarded as belonging to the Kydland and Prescott (1977) dynamic inconsistency tradition. In spirit, our model is similar to the Barro and Gordon (1983) model. Differently from most of the work Barro and Gordon (1983) initiated, our model explicitly allows for fiscal policy and is thus more suited for an investigation of the questions we ask. Rather than surveying the whole strand of literature that followed Barro and Gordon (1983) (see chapters 4–6 in Drazen, 2000, and chapters 15–17 in Persson and Tabellini, 2000), we discuss three papers which are closely related to ours in that they explicitly deal with fiscal policy.

The first is Alesina and Tabellini (1987), who specify a model in which the central bank sets inflation and the fiscal authority sets taxes. Their model differs from ours in the objectives of both policymakers. Output, inflation and public expenditure enter a loss function of both policymakers, possibly with different weights. In our model, the central bank cares only about output and inflation, and the fiscal authority cares only about output and the public budget deficit. Their paper also differs in the questions asked. They investigate the welfare impact of commitment and the degree of the central bank's independence. We focus on the welfare impact of different institutional setups that differ in the identity of the fiscal policymaker. Furthermore, our model includes stochastic shocks impacting the economy and thus allowing the sharing of imperfect information between the policymakers.

The second closely related paper is that of Dixit and Lambertini (2003), who focus on the role of discretion and commitment in a model with fiscal and monetary authorities. They allow for two types of interaction of both players, one in which both authorities move simultaneously and the in which one of the authorities moves first. Their work differs from ours in that they focus on different questions. Furthermore, in their model the loss function of the fiscal authority is identical to the social welfare function. In our model, the fiscal authority has a loss function of its own.

The third closely related paper is that of Lambertini and Rovelli (2003), whose model again involves fiscal and monetary policy. They investigate the impact of the relative timing of decisions of both policymakers, allowing simultaneous or sequential decisions to be made. In their model, the government has a loss function equal to the social welfare function but the government can delegate fiscal policy-making to a non-independent institution it cannot fully control— bureaucracy— with a different loss function. Again, their model differs in the questions asked and in the loss functions that the different players possess.

All of the models mentioned above also differ in the details of the economy they specify but have in common, together with our model, two features. The first one is the positive effect of unexpected expansionary monetary policy on output. The second is the positive effect of expansionary fiscal policy (Dixit and Lambertini, 2003, subject to parameter constraints).[5, 6]

3. Model

We study a very simple model of the interaction of fiscal and monetary policy. We use basic insights of the dynamic inconsistency literature that has traditionally dealt with monetary policy and extend it to an environment that incorporates fiscal policy as well.

The model has three players: fiscal policymaker, monetary policymaker and the general public (government, central bank, citizens). There are three basic equations. The first one is an expectation-augmented Phillips equation in the form

$$y\left(I_\mu, I_\phi\right) = y^* + \alpha\left(\pi\left(I_\mu\right) - \pi^e\right) + \beta\left(d\left(I_\phi\right) - d^*\right) + \varepsilon \tag{1}$$

$y\left(I_\mu, I_\phi\right)$ is (log) deviation of output from its natural level y^*, $\pi\left(I_\mu\right)$ is inflation set by the monetary authority, π^e is inflation rationally expected by citizens based on the past behavior of the monetary authority, $d\left(I_\phi\right)$ is the budget deficit set by the fiscal authority and d^* is the optimal level of the budget deficit.

Both policies $\pi\left(I_\mu\right)$ and $d\left(I_\phi\right)$ and hence output $y\left(I_\mu, I_\phi\right)$ are dependent on information sets I_μ and I_ϕ of the policymakers. Those are explained in detail below.

Parameters α and β denote the effectiveness of monetary and fiscal policy, respectively, so it is natural to limit our attention to $(\alpha, \beta) \in [0,1]^2$. Shock ε is *i.i.d.* normal, zero-mean shock with constant variance σ^2, i.e. $\varepsilon \sim N\left(0, \sigma^2\right)$. It can be observed by policymakers and is not observed by the public.

Our choice of behavior of the economy warrants further comments. Note that the implicit assumption about monetary policy in (1) embodies the notion of long-term neutrality of money as well as the idea that only unexpected changes in monetary policy have an impact on output (Lucas, 1972). Any level of inflation chosen by the monetary authority will not influence the real side of the economy once the public's expectations incorporate this level of inflation. In a sense, what we are assuming is that the monetary authority possesses only a *nominal* instrument.

On the other hand, the assumption behind (1) concerning fiscal policy is that by choosing a certain level of the budget deficit, the fiscal authority has the power to

[5] There is another strand of literature related to our work that uses models with multiple fiscal authorities and a unique monetary authority (monetary union setup). We do not survey this literature here due to space constraints. Nevertheless, it can be divided into two strands. The first one deals with the effect of unification, see e.g., Beetsma and Bovenberg (1998) and Cooper and Kempf (2000). The second one deals with the question of whether coordination of national fiscal policies with each other and eventually also with monetary policy can be welfare improving. See, for example, Chari and Kehoe (2007) and the survey in Beetsma, Debrun and Klaassen (2001).

[6] There is a small but growing body of literature studying the repeated interaction of fiscal and monetary authorities under asynchronous timing of moves, something this literature interprets as varying degrees of commitment (Libich and Stehlik, 2010, 2012; Hughes Hallett, Libich and Stehlik, 2014). The uncertainty of one policymaker about the actions of the other, which is what we focus on in this paper, generally does not arise in these papers.

influence output without the need to be concerned about changes in the public's expectations. In other words, the fiscal authority can influence the *real* side of the economy. We think both assumptions capture an important aspect of the working of the economy and are quite realistic. What seems to be unrealistic is our assumption, made purely on convenience grounds, that both authorities can set their instruments perfectly, which is certainly not true in reality.[7]

One possible concern arises with our notion of the optimal budget deficit. In one interpretation, $d^* = 0$, which is relevant in a long-term context when the fiscal authority surely must keep its budget balanced on average in order not to become insolvent. However, we do not make such an assumption and let d^* take on any (reasonable) value, since in reality there might be prolonged periods when its optimal to have either a positive (e.g., expectation of the ageing of the population) or negative (e.g., debt-financed public investment in developing countries) budget balance.[8]

The second key equation is the government's loss function

$$\mathbb{G} = \mathbb{E}_{\phi}\left[\left(y\left(I_{\mu}, I_{\phi}\right) - \overline{y}_{\phi}\right)^2 + \phi\left(d\left(I_{\phi}\right) - d^*\right)^2\right] \tag{2}$$

and the third key equation is the central bank's loss function

$$\mathbb{M} = \mathbb{E}_{\mu}\left[\left(y\left(I_{\mu}, I_{\phi}\right) - \overline{y}_{\mu}\right)^2 + \mu\left(\pi\left(I_{\mu}\right) - \pi^*\right)^2\right] \tag{3}$$

where $\mathbb{E}_{\mu}(\cdot)$ and $\mathbb{E}_{\phi}(\cdot)$ denote the expectations of the central bank and the government, respectively. Parameter μ (ϕ) denotes the weight that the central bank (government) attaches to squared deviations of π (d) from its bliss level μ^* (d^*) relative to the squared deviation of y from $\overline{y}_{\mu}$ ($\overline{y}_{\phi}$). It is natural to assume $(\mu, \phi) \in \mathbb{R}_+^2$. Possible deviation of the level of output targeted by policymakers from the natural level is captured by parameter k_{μ} (k_{ϕ}) so that $\overline{y}_i - y^* = k_i$ where k_i represents any non-negative constant for $i \in \{\mu, \phi\}$.

Before any of the policymakers makes a decision about the policy, nature determines the size of the shock ε and whether the given policymaker observes it. The central bank observes the shock with probability p_{μ} and the government with probability p_{ϕ}.

Central bank's information set is denoted by I_{μ} and government's information set by I_{ϕ}. By abuse of notation, $I_{\mu} = 1$ if $\varepsilon \in I_{\mu}$, i.e. if the central bank observes the shock, and $I_{\mu} = 0$ if $\varepsilon \notin I_{\mu}$, i.e. if the central bank does not observe

[7] We believe that both assumptions about monetary and fiscal policy capture an important aspect of the working of economy; they are quite realistic and also in line with the standard macroeconomic literature (e.g., Romer, 2005).

[8] Because of the static nature of our model, we can think of the actual or optimal level of the budget deficit as the actual or optimal level of public debt. In a dynamic framework, public debt becomes the accumulated budget deficit so that any systematic change affecting the budget deficit eventually translates into public debt.

the shock, and similarly for the government. The last piece of notation is $\varepsilon\left(I_\mu\right)$ with the meaning $\varepsilon\left(I_\mu=1\right)=\varepsilon$ and $\varepsilon\left(I_\mu=0\right)=0$.

Formally, the game we have just specified is a two-player simultaneous move game of imperfect information.[9] We look for the Bayesian Nash equilibrium of this game and for the remainder of the paper refer to it simply as equilibrium. Its key property is that the government minimizes its loss function (2) by choosing *d* subject to constraint represented by the economy equation (1) taking the behavior of the central bank and expected inflation as given. This similarly holds true for the central bank that sets π.

Solving the model amounts to finding expressions for $\pi\left(I_\mu\right)$, $d\left(I_\phi\right)$ and $y\left(I_\mu,I_\phi\right)$ which maximize the policymakers' expected utility given the constraint represented by the economy equation (1), provided that the behavior of the other policymaker and concurrence with citizens' expectations are correct. We relegate detailed derivation of the equilibrium to *Appendix A1,* in which we show that the equilibrium inflation can be expressed as

$$\begin{aligned}\pi\left(I_\mu=0\right)&=\pi^*+\frac{\alpha}{\mu}k_\mu-\frac{\alpha\beta^2}{\kappa}k_\phi\\ \pi\left(I_\mu=1\right)&=\pi^*+\frac{\alpha}{\mu}k_\mu-\frac{\alpha\beta^2}{\kappa}k_\phi-\frac{\alpha\phi+\alpha\beta^2\left(1-p_\phi\right)}{\lambda+\alpha^2\beta^2\left(1-p_\mu p_\phi\right)}\varepsilon\end{aligned}\tag{4}$$

with $\kappa=\beta^2\mu+\mu\phi$ and $\lambda=\alpha^2\phi+\beta^2\mu+\mu\phi$ or using the more compact notation

$$\pi\left(I_\mu\right)=\pi^*+\frac{\alpha}{\mu}k_\mu-\frac{\alpha\beta^2}{\kappa}k_\phi-\frac{\alpha\phi+\alpha\beta^2\left(1-p_\phi\right)}{\lambda+\alpha^2\beta^2\left(1-p_\mu p_\phi\right)}\varepsilon\left(I_\mu\right)\tag{5}$$

Similarly, the equilibrium deficit is given as

$$\begin{aligned}d\left(I_\phi=0\right)&=d^*+\frac{\beta\mu}{\kappa}k_\phi\\ d\left(I_\phi=1\right)&=d^*+\frac{\beta\mu}{\kappa}k_\phi-\frac{\beta\mu+\alpha^2\beta\left(1-p_\mu\right)}{\lambda+\alpha^2\beta^2\left(1-p_\mu p_\phi\right)}\varepsilon\end{aligned}\tag{6}$$

or using the more compact notation

$$d\left(I_\phi\right)=d^*+\frac{\beta\mu}{\kappa}k_\phi-\frac{\beta\mu+\alpha^2\beta\left(1-p_\mu\right)}{\lambda+\alpha^2\beta^2\left(1-p_\mu p_\phi\right)}\varepsilon\left(I_\phi\right)\tag{7}$$

[9] Studying a game with sequential moves is beyond the scope of this paper, but we suspect similar results would be obtained. What is key to our model is the uncertainty between the two policymakers regarding the information about the economic environment they hold. With sequential moves this uncertainty would be reduced but not eliminated and additional strategic incentives, such as signaling, would arise.

Finally, the equilibrium inflation and deficit can be used to calculate the output, which is given by

$$
\begin{aligned}
y\left(I_\mu = 1; I_\phi = 1\right) &= y^* + \frac{\beta^2 \mu}{\kappa} k_\phi + \frac{\mu\phi - \alpha^2\beta^2\left(1-p_\mu\right)\left(1-p_\phi\right)}{\lambda + \alpha^2\beta^2\left(1-p_\mu p_\phi\right)}\varepsilon \\
y\left(I_\mu = 1; I_\phi = 0\right) &= y^* + \frac{\beta^2 \mu}{\kappa} k_\phi + \frac{\mu\phi + \beta^2\mu + \alpha^2\beta^2 p_\phi\left(1-p_\mu\right)}{\lambda + \alpha^2\beta^2\left(1-p_\mu p_\phi\right)}\varepsilon \\
y\left(I_\mu = 0; I_\phi = 1\right) &= y^* + \frac{\beta^2 \mu}{\kappa} k_\phi + \frac{\mu\phi + \alpha^2\phi + \alpha^2\beta^2 p_\mu\left(1-p_\phi\right)}{\lambda + \alpha^2\beta^2\left(1-p_\mu p_\phi\right)}\varepsilon \\
y\left(I_\mu = 0; I_\phi = 0\right) &= y^* + \frac{\beta^2 \mu}{\kappa} k_\phi + \varepsilon
\end{aligned}
\tag{8}
$$

The equilibrium inflation given by (5), deficit given by (7) and output given by (8) can be used to calculate the variance of inflation, deficit and output. We assume that the central bank targets the natural level of output, i.e., $k_\mu = 0$. This reflects the current monetary policy framework in most countries based on the central bank's independence and (explicit or implicit) inflation targeting regime, which makes use of the observed "divine coincidence" (Blanchard, 2005) that stabilizing inflation is under some reasonable assumptions equivalent to stabilizing output around its natural level.

To evaluate welfare under the different institutional arrangements we use a welfare function of the form

$$
\mathbb{W}_i = -\left[\sum_v \left(\mathbb{E}\left(v - v^*\right)\right)^2 + \sum_v var(v)\right] \tag{9}
$$

for $v \in \{y, \pi, d\}$ and $i \in \{gv, fc\}$ where gv stands for the current setup in which the government sets the deficit and the central bank sets inflation and *fc* denotes the fiscal-council institutional setup. The welfare function embodies both citizens' preference for an economy to be close to its optimum and citizens' preference for a stable economic environment.[10]

From (5), (7) and (8) it is easy to confirm

$$
\begin{aligned}
\sum_v \left(\mathbb{E}\left(v - v^*\right)\right)^2 &= \psi_1 k_\phi^2 \\
\sum_v var(v) &= \psi_2 \sigma^2
\end{aligned}
\tag{10}
$$

Where $\psi_1 > 0$ and $\psi_2 > 0$.[11] To show the following results we will need some

[10] We assume that citizens weight these two incentives equally in $\mathbb{W}_i$. Careful reading of the proofs of the propositions we are about to state shows that this assumption is without loss of generality.

[11] Explicit expressions for ψ_1 and ψ_2 are stated in *Appendix A1* as equations (A30) and (A28). We do not include them in the main body of the paper for the sake of brevity.

additional notation. A vector of parameters capturing policy effectiveness and policy preferences is denoted by $\xi = (\alpha, \beta, \mu, \phi) \in [0,1]^2 \times \mathbb{R}_+^2 = \mathbb{Q}$. Furthermore, a vector of probabilities that the shock will be observed by the policymakers is denoted by $\mathbf{p} = \left(p_\mu, p_\phi\right) \in [0,1]^2 = \mathbb{P}$. Also, let X^O denote an interior of set X. To make dependence on the parameters explicit, ψ_1 is denoted by $\psi_1(\xi, \mathbf{p})$ and ψ_2 is donoted by $\psi_2(\xi, \mathbf{p})$. Then the welfare can be written as

$$\mathbb{W}\left(\xi, p, k_\phi, \sigma^2\right) = -\psi_1\left(\xi, \mathbf{p}\right) k_\phi^2 - \psi_2\left(\xi, \mathbf{p}\right) \sigma^2 \tag{11}$$

We assume that the institutional change from gv to fc does not change policy effectiveness or policy preferences regarding the trade-off between inflation or deficit and output. In other word we assume ξ is not affected by the institutional change. Furthermore, we assume the institutional change has no effect on the variance of economic shocks σ^2.

On the other hand, the institutional change alters the output target of the fiscal policymaker. We assume that the gv institutional environment is characterized by $k_\phi > 0$ while the fc institutional environment is characterized by $k_\phi = 0$. This assumption is based on the idea that fiscal indiscipline stems from political failure (namely spending bias, public tragedy of the commons) and that the introduction of an independent fiscal council addresses this failure as discussed in the literature overview. The last thing the institutional change can affect is the ability of the policymakers to correctly observe the shocks. We assume that the probabilities of observing shocks by the policymakers under the gv institutional setup are $\mathbf{p} = \mathbf{p}^{gv}$ while under the fc institutional setup these are denoted by $\mathbf{p} = \mathbf{p}^{fc}$.

Substituting into the welfare function the gv institutional setup is characterized by $\mathbb{W}_{gv} = \mathbb{W}\left(\xi, \mathbf{p}^{gv}, \sigma^2, k_\phi\right)$ while the fc institutional setup is characterized by $\mathbb{W}_{fc} = \mathbb{W}\left(\xi, \mathbf{p}^{fc}, \sigma^2, 0\right)$. The institutional change increases welfare if $\mathbb{W}_{fc} - \mathbb{W}_{gv} > 0$. With this we can prove the following propositions.

Proposition 1: welfare improving institutional change

If the institutional change from gv to fc does not affect the policymakers' ability to observe shocks, then it is welfare improving.

Proof.

For $\mathbf{p}^{gv} = \mathbf{p}^{fc} = \mathbf{p}$ welfare under the two institutional arrangements is

$$\begin{aligned} \mathbb{W}_{gv}\left(\xi, \mathbf{p}, \sigma^2, k_\phi\right) &= -\psi_1(\xi, \mathbf{p}) k_\phi^2 - \psi_2(\xi, \mathbf{p}) \sigma^2 \\ \mathbb{W}_{fc}\left(\xi, \mathbf{p}, \sigma^2, 0\right) &= -\psi_2(\xi, \mathbf{p}) \sigma^2 \end{aligned} \tag{12}$$

with the difference being $\mathbb{W}_{fc} - \mathbb{W}_{gv} = \psi_1(\xi, \mathbf{p}) k_\phi^2 > 0$.

Intuitively in our model, the policymakers' ability to correctly observe shocks represents a cost of having two institutions participating in economic policymaking. If this ability is not affected by the institutional change, the only effect is removal of the fiscal policymaker's incentive to induce high output. As this incentive creates sub-optimally high output and a deficit on the one hand and sub-optimally low inflation on the other, removing it is welfare improving.

While the first result is positive, the second result we prove is negative.

Proposition 2: welfare reducing institutional change

For any generic $\xi \in \mathbb{Q}^O$, *any* $k_\phi \in \mathbb{R}_+$ *and any* $\mathbf{p}^{gv} \in \mathbb{P}^O$, *there exists* σ^2 *and vector of probabilities* $\mathbf{p}^{fc}$ *such that the institutional change from gv to fc is welfare reducing.*

Proof.

Fix generic ξ, k_ϕ and $\mathbf{p}^{gv}$. We want to show there exists $\left(\mathbf{p}^{fc}, \sigma^2\right)$ such that $\mathbb{W}\left(\xi, \mathbf{p}^{fc}, \sigma^2, 0\right) - \mathbb{W}\left(\xi, \mathbf{p}^{gv}, \sigma^2, k_\phi\right) < 0$. First note $\psi_2(\xi, \mathbf{p})$ is continuous and continuously differentiabfle in $\mathbf{p}$. Moreover

$$\frac{\partial \psi_2(\xi, \mathbf{p})}{\partial p_\mu} \neq 0 \qquad \frac{\partial \psi_2(\xi, \mathbf{p})}{\partial p_\phi} \neq 0 \tag{13}$$

for generic ξ. It follows that there exists $\mathbf{p}^{fc}$ in the neighborhood of $\mathbf{p}^{gv}$ such that $\psi_2\left(\xi, \mathbf{p}^{gv}\right) < \psi_2\left(\xi, \mathbf{p}^{fc}\right)$. Since $\mathbb{W}\left(\xi, \mathbf{p}^{fc}, \sigma^2, 0\right) - \mathbb{W}\left(\xi, \mathbf{p}^{gv}, \sigma^2, k_\phi\right) < 0$ rewrites as $k_\phi^2 \psi_1\left(\xi, \mathbf{p}^{gv}\right) < \sigma^2\left(\psi_2\left(\xi, \mathbf{p}^{fc}\right) - \psi_2\left(\xi, \mathbf{p}^{gv}\right)\right)$ where both sides of the inequality are positive, it follows that there exists σ^2 for which the institutional change is welfare reducing.

Intuitively, the result relies on the fact that we can always find a direction in which shock recognition capability induces a higher ψ_2 in the variance term of the welfare function. As this term multiplies σ^2 we can find high enough variance of economic shocks, which outweighs any benefit from $k_\phi = 0$.

The joint message of Propositions 1 and 2 is the ambiguous welfare effect of the institutional change from *gv* to *fc*. The first proposition shows that if the institutional change leaves the ability of the policymakers to assess the economic environment intact, then it has to be welfare improving. The second proposition shows that if this ability changes, we can always find cases where the institutional change is welfare reducing. In other words, the propositions show that any argument for an independent fiscal authority needs to trade off the benefit of the change, i.e. elimination of the deficit bias, with the cost of the change, i.e. a potential change in the interaction of monetary and fiscal policy. We stress that our claim is *not* that the institutional change from *gv* to *fc* is welfare reducing.

Instead, our work is intended to highlight the importance of other issues relevant for the establishment of independent fiscal councils. An important aspect of the institutional change from *gv* to *fc* is that the new setup must be accepted and promoted by the very same agents who are responsible for political failure (spending bias, public tragedy of the commons). In this respect, Wyplosz (2008) for instance argues that proposals for an independent fiscal council are (rightly) perceived as a threat to those interest groups that lie at the root of the spending bias.

To further support this argument, the political literature stresses that, unlike monetary policy, there is no clear consensus on optimal fiscal policy, which can adversely affect the issue of policy delegation. Alesina and Tabellini (2007) emphasize that successful delegation stands upon the widespread consensus about the goals of the fiscal council. According to Calmfors and Wren-Lewis (2011), if such a consensus is lacking, it argues against taking the decision over the debt or deficit away from an elected government. Apart from the complications with the definition of goals, Debrun et al. (2009) also discuss issues that stem from choosing the target and instruments of the independent fiscal authority. Finally, when proposing an institutional change, attention also needs to be paid to the quality of human[12], financial[13] and statistical[14] resources.

4. Calibration

To shed more light on the issue, we calibrated the model. We use $\alpha = 0.645$ from Mishkin (1983), $\beta = 0.552$ from Perotti (2002), $\mu = 2.$ from Taylor(1999) and $\phi = 1$, the last of which is set to capture the idea that, compared to monetary policymakers, fiscal policymakers are in general believed to be more concerned about output.[15]

To calibrate k_ϕ we do the following. First, we take our model and solve its version for the institutional setup when the government sets both monetary and fiscal policy. The resulting expected inflation is then subsequently subtracted from the expected inflation in the model where the government sets deficits and the central bank sets inflation. The resulting difference is a function of ξ and k_ϕ only. We set k_ϕ so that the term is equal to 0.7, which is the difference between 3.8 and 3.1, both

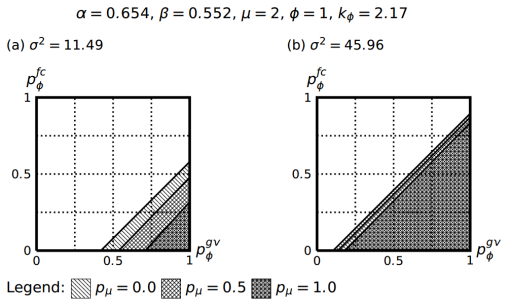
[12] Wyplosz (2008) emphasizes that in order for the new institution to perform well its decision-makers must be experts chosen for their competence in fiscal policy and budgetary planning. Their independence must be guaranteed by long terms in office analogous to the case of central bankers.

[13] Calmfors and Wren-Lewis (2011) argue that independence could be jeopardized if the council is not provided with sufficient resources but has instead to draw on the resources of the government or ministry of finance.

[14] Merola and Perez (2013) analyze the role of private information possessed by the government on the performance of fiscal forecasts prepared by independent agencies.

[15] Mishkin (1983) comes from table 6.5 on p. 122 and captures the effect of unanticipated money growth on log GNP estimated from US data. Perotti (2002) comes from table 3 on p. 44 and captures the effect of a government spending increase equal in size to 1% of GDP on log GDP. We take quarterly effect and average over estimates for the US, UK, Germany, Canada and Australia. Finally, Taylor (1999) comes from table 7.1 on p. 330 (middle column) and is estimated based on US data. As the estimates imply that a monetary authority reacts twice as strongly to inflation compared to output, we set $\mu = 2$.

Figure 1



of which are average inflation rates under the corresponding institutional arrangements from Bordo and Schwartz (1999).[16] Note that this gives us $k_\phi = 2.17$.

Finally, to derive σ^2 we use $var(y) = 7.84$ from Basistha and Nelson (2007) along with other parameters in ξ.[17] One problem is that we need probabilities in $\mathbf{p}$ to evaluate $var(y)$. In order not to bias our results in a particular way, we maximize and minimize $var(y)$ for a fixed value of $\xi.$, which gives us two values of $\mathbf{p}$, $\mathbf{p}_{min}$ and $\mathbf{p}_{max}$, respectively. In the calibration exercise we then use an average of $\mathbf{p}_{min}$ and $\mathbf{p}_{max}$, which turns out to be [0.5, 0.5]. Overall this gives us $\sigma^2 = 11.49$.

Figure 1a shows the result of the calibration exercise. Assuming the probability that the central bank observes shocks does not change, the shaded area in the picture shows all combinations of p_ϕ before $\left(p_\phi^{gv}\right)$ and after $\left(p_\phi^{fc}\right)$ the institutional change under which this change is welfare reducing.

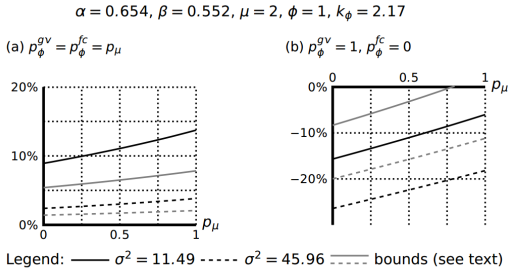
What *Figure 1a* shows is that the institutional change we study can be welfare reducing if the newly established fiscal authority has a considerably lower probability of assessing the state of the economy compared to the government, i.e. the fiscal authority before the change. The figure also shows that room for the institutional change to decrease welfare shrinks with an increase in the probability of the central bank observing economic shocks.

Our Proposition 2 suggests that an increase in the volatility of the economic environment decreases the potential for the institutional change towards the establishment of an independent fiscal council to be welfare improving. In order to confirm this intuition, we repeated the calibration exercise for the value of σ doubled with *Figure 1b* showing the result.

[16] The inflation of 3.8% is the average over the US, UK, Germany, France and Japan over the 1946–1970 period, i.e. before the recent wave of increases in central bank independence. The figure of 3.1% is the average for the same countries over the 1983–1995 period. We drop the intermediate period as inflation was influenced by different factors. All of the data come from Bordo and Schwartz, table 4.1 on page 205.

[17] Notice $var(y)$ can be interpreted as a variance of the output gap, since $var(y) = var(y–y^*)$. The value then comes from Basistha and Nelson (2007), table 2 on p. 505. We first calculate the average standard deviation of their proposed two measures of the output gap and square it.

Figure 2



Comparing the two pictures, the intuition turns out to be correct. The shaded region is considerably larger in *Figure 1b* compared to *Figure 1a*. It is also considerably closer to the main diagonal of the figure which, from Proposition 1, includes points for which the institutional change under consideration is welfare improving.

Finally, we were interested in the extent of potential welfare losses and gains that the change from a *gv* to *fc* institutional setup might produce. We evaluated the welfare difference stemming from the institutional change as a percentage of the pre-change welfare. *Figures 2a* and *2b* depict the resulting percentage change in the welfare as a function p_μ.

Figure 2a assumes a scenario in which the probability of the fiscal policymaker observing a shock does not change as a result of the institutional change and is equal to p_μ, i.e. $p_\phi^{gv} = p_\phi^{fc} = p_\mu$. From Proposition 1, we know that in this case the change from *gv* to *fc* has to be welfare improving. *Figure 2b* on the other hand assumes a scenario with the probability of the fiscal policymaker observing the shock before the institutional change being unity and after the institutional change being zero. We have picked this scenario as *Figure 1* suggests it is the worst case one.

The message of *Figures 2a* and *2b* is clear. Potential welfare loss produced by the institutional change is rather sizeable if it induces a large change in the ability of the fiscal policymaker to assess the state of the economy. For the extreme scenario we consider here, potential welfare loss is somewhere between 5% and 15% depending on the ability of the monetary policymaker to detect economic shocks, even for the low value of σ^2. On the other hand, the institutional change potentially produces welfare gains if it does not change the ability of the fiscal policymaker to assess the state of the economy. For the same low value of σ^2 the potential welfare gains lie somewhere between 10% and 15%.

Our simulation exercise naturally raises the question of robustness, mainly because of the diverse sources for the parameter values we use and because the parameter values constitute estimates with non-trivial variance. For this reason we have repeated the calculations underlying *Figures 2a* and *2b,* allowing the benchmark values of α, β, μ, ϕ and k_ϕ to vary by 10%, the usual significance level. Varying the values of these five parameters, for each value of p_μ we have calculated the largest and the smallest welfare change associated with the institutional change we study. The grey lines in *Figures 2a* and *2b* show the results and support our claim

that introduction of an independent fiscal council has the potential to bring sizeable welfare gains, but also losses.[18]

5. Conclusion

This paper evaluates the claim that conducting fiscal policy should be delegated to an independent institution in a dynamic microeconomic model that recognizes the fact that fiscal policy interacts with monetary policy. Once the interdependence between both policies is recognized and the volatility of the economic environment is taken into account, delegation of fiscal policy needs not be welfare improving.

Our model focused on two aspects of the proposed institutional change towards independent fiscal authority. The first aspect relates to the motivation of elected governments to run excessive public deficits, which would be eliminated by delegating some features of fiscal policy (mainly setting the deficit or debt levels) to an independent fiscal council. If this is the only change the institutional change induces, then it is unambiguously welfare improving.

The second aspect we focus on is the potential change in the interaction of the policymakers. In our model this is captured by a change in the nature of uncertainty between the policymakers regarding information they possess about the current state of the economy. Once the potential for change in the probability of recognizing shocks and the consequences for mutual interaction of both policymakers are recognized, the institutional change we consider needs not be welfare improving.

Given the ambiguous theoretical result, we calibrated the model to empirically estimated parameters. The calibration exercise leads to four main conclusions. First, an institutional change can be welfare reducing if the new independent fiscal policymaker is significantly less able to assess the state of the economy than the initial policymaker (i.e., the government or ministry of finance). Second, room for welfare reduction increases with the volatility of the economic environment. Third, potential welfare losses can be significant, reaching some 5% to 15% of welfare in calm times and roughly 20% to 25% in turbulent times for an extreme case scenario where the institutional change fully influences the probability that the policymaker will recognize a shock from perfect economic information from the government to zero information from the fiscal council. Fourth, potential welfare gains for the scenario where the institutional change does not change the capacity of the monetary and fiscal policymakers to observe economic shocks stemming from the introduction of an independent fiscal authority are in the 10% to 15% range in calm times and 2% to 5% range in turbulent times.

We interpret the results as follows. Generally, establishing an independent fiscal council is a desirable institutional change. However, if the probability that the new agency will recognize shocks to the economy is low, the institutional change will not necessarily be welfare improving. We further discuss specific circumstances under which this can be the case, emphasizing the role and incentives of the government in the creation process, nonexistent consensus on the objectives and instruments

[18] We plot only the relevant bounds, i.e. *Figure 2a* shows only the lower bound and *Figure 2b* shows only the upper bound.

of the fiscal councils, and the issue of the quality of human, financial and statistical resources. In this paper, we do not want to argue that introduction of an independent fiscal council is welfare reducing. Rather we attempt to show that the ability of the newly established institution to identify shocks is one of the important issues to take in account when setting it up. Furthermore, the negative effect of an ill-designed institution with low capacity to recognize shocks increases significantly in times of increased economic volatility such as during the recent global financial crisis. Given the fact that turbulent times (i.e. crisis periods) often open a window of opportunity for institutional reforms that would not be available in normal circumstances, the conclusion of the analysis should be taken into account when discussing institutional changes in the fiscal framework.

APPENDIX

We now explicitly derive the equilibrium policies given in the main part of the paper. Restating the three main equations, we have the economy described by

$$y\left(I_\mu, I_\phi\right) = y^* + \alpha\left(\pi\left(I_\mu\right) - \pi^e\right) + \beta\left(d\left(I_\phi\right) - d^*\right) + \varepsilon \tag{A1}$$

the government's loss function

$$\mathbb{G} = \mathbb{E}_\phi\left[\left(y\left(I_\mu, I_\phi\right) - \overline{y}_\phi\right)^2 + \phi\left(d\left(I_\phi\right) - d^*\right)^2\right] \tag{A2}$$

and the central bank's loss function

$$\mathbb{M} = \mathbb{E}_\mu\left[\left(y\left(I_\mu, I_\phi\right) - \overline{y}_\mu\right)^2 + \mu\left(\pi\left(I_\mu\right) - \pi^*\right)^2\right] \tag{A3}$$

Differentiating and rearranging the loss functions of both policymakers gives two F.O.C.'s (it is easy to check that the S.O.C.'s are satisfied)

$$d\left(I_\phi\right) = d^* + \frac{\beta k_\phi - \alpha\beta\mathbb{E}_\phi\left[\pi\left(I_\mu\right) - \pi^e \mid I_\phi\right] - \beta\varepsilon\left(I_\phi\right)}{\beta^2 + \phi} \tag{A4}$$

$$\pi\left(I_\mu\right) = \frac{\alpha^2\pi^e + \mu\pi^* + \alpha k_\mu - \alpha\beta\mathbb{E}_\mu\left[d\left(I_\phi\right) - d^* \mid I_\mu\right] - \alpha\varepsilon\left(I_\mu\right)}{\alpha^2 + \mu} \tag{A5}$$

The expectations of both policymakers are given by

$$\mathbb{E}_\mu\left[d\left(I_\phi\right) - d^* \mid I_\mu\right] = \mathbb{E}_\mu\left[d\left(I_\phi = 1\right) - d^* \mid I_\mu\right] p_\phi + \mathbb{E}_\mu\left[d\left(I_\phi = 0\right) - d^* \mid I_\mu\right]\left(1 - p_\phi\right) \tag{A6}$$

$$\mathbb{E}_\phi\left[\pi\left(I_\mu\right) - \pi^e \mid I_\phi\right] = \mathbb{E}_\phi\left[\pi\left(I_\mu = 1\right) - \pi^e \mid I_\phi\right] p_\mu + \mathbb{E}_\phi\left[\pi\left(I_\mu = 0\right) - \pi^e \mid I_\phi\right]\left(1 - p_\mu\right) \tag{A7}$$

where, for example, (A6) reads as follows: the central bank forms its expectation about the difference between d and d^* as the difference $d - d^*$ when the government observes the shock, which happens with probability target p_Φ, plus the difference $d - d^*$ when the government does not observe the shock, which happens with probability 1 - p_Φ. The interpretation of (A7) is similar.

In order to derive (A6) and (A7), we need two sets of four expressions. One set for $\mathbb{E}_\mu\left[d\left(I_\phi\right) - d^* \mid I_\mu\right]$ and one set for $\mathbb{E}_\phi\left[\pi\left(I_\mu\right) - \pi^e \mid I_\phi\right]$, each for all possible combinations of $I_\phi \in \{0,1\}$ and $I_\mu \in \{0,1\}$. The following two paragraphs include the detailed derivation of each of these expressions.

To derive (A6), we use F.O.C.'s to get

$$\mathbb{E}_\mu\left[d\left(I_\phi = 1\right) - d^* \mid I_\mu = 1\right] = \frac{\beta k_\phi - \alpha\beta\mathbb{E}_\phi\left[\pi\left(I_\mu\right) - \pi^e \mid I_\phi = 1\right] - \beta\varepsilon}{\beta^2 + \phi}$$

for the case when the central bank observes the shock and assumes that the government also observed the shock since

$$\mathbb{E}_\mu\left\{\mathbb{E}_\phi\left[\pi\left(I_\mu\right) - \pi^e \mid I_\phi = 1\right] \mid I_\mu = 1\right\} = \mathbb{E}_\phi\left[\pi\left(I_\mu\right) - \pi^e \mid I_\phi = 1\right]$$

$$\mathbb{E}_\mu\left[\varepsilon\left(I_\phi = 1\right) \mid I_\mu = 1\right] = \varepsilon$$

For the case when the central bank does not observe the shock and assumes that the government did observe the shock, we get

$$\mathbb{E}_\mu\left[d\left(I_\phi = 1\right) - d^* \mid I_\mu = 0\right] = \frac{\beta k_\phi - \alpha\beta\mathbb{E}_\phi\left[\pi\left(I_\mu\right) - \pi^e \mid I_\phi = 0\right]}{\beta^2 + \phi}$$

since

$$\mathbb{E}_\mu\left\{\mathbb{E}_\phi\left[\pi\left(I_\mu\right) - \pi^e \mid I_\phi = 1\right] \mid I_\mu = 0\right\} = \mathbb{E}_\phi\left[\pi\left(I_\mu\right) - \pi^e \mid I_\phi = 0\right]$$

$$\mathbb{E}_\mu\left[\varepsilon\left(I_\phi = 1\right) \mid I_\mu = 0\right] = 0$$

For the case when the central bank does observe the shock and assumes that the government did not observe the shock, we get

$$\mathbb{E}_\mu\left[d\left(I_\phi = 0\right) - d^* \mid I_\mu = 1\right] = \frac{\beta k_\phi - \alpha\beta\mathbb{E}_\phi\left[\pi\left(I_\mu\right) - \pi^e \mid I_\phi = 0\right]}{\beta^2 + \phi}$$

since

$$\mathbb{E}_\mu\left\{\mathbb{E}_\phi\left[\pi\left(I_\mu\right) - \pi^e \mid I_\phi = 0\right] \mid I_\mu = 1\right\} = \mathbb{E}_\phi\left[\pi\left(I_\mu\right) - \pi^e \mid I_\phi = 0\right]$$

$$\mathbb{E}_\mu\left[\varepsilon\left(I_\phi = 0\right) \mid I_\mu = 1\right] = 0$$

For the case when the central bank does not observe the shock and assumes that the government also did not observe the shock, we get

$$\mathbb{E}_{\mu}\left[d\left(I_{\phi}=0\right)-d^{*} \mid I_{\mu}=0\right]=\frac{\beta k_{\phi}-\alpha\beta\mathbb{E}_{\phi}\left[\pi\left(I_{\mu}\right)-\pi^{e} \mid I_{\phi}=0\right]}{\beta^{2}+\phi}$$

since

$$\mathbb{E}_{\mu}\left\{\mathbb{E}_{\phi}\left[\pi\left(I_{\mu}\right)-\pi^{e} \mid I_{\phi}=0\right] \mid I_{\mu}=0\right\}=\mathbb{E}_{\phi}\left[\pi\left(I_{\mu}\right)-\pi^{e} \mid I_{\phi}=0\right]$$

$$\mathbb{E}_{\mu}\left[\varepsilon\left(I_{\phi}=0\right) \mid I_{\mu}=0\right]=0$$

To derive (A7), we use F.O.C.'s to get

$$\mathbb{E}_{\phi}\left[\pi\left(I_{\mu}=1\right)-\pi^{e} \mid I_{\phi}=1\right]=\frac{\mu\left(\pi^{*}-\pi^{e}\right)+\alpha k_{\mu}-\alpha\beta\mathbb{E}_{\mu}\left[d\left(I_{\phi}\right)-d^{*} \mid I_{\mu}=1\right]-\alpha\varepsilon}{\alpha^{2}+\mu}$$

for the case when the government observes the shock and assumes that the central bank also observed the shock since

$$\mathbb{E}_{\phi}\left\{\mathbb{E}_{\mu}\left[d\left(I_{\phi}\right)-d^{*} \mid I_{\mu}=1\right] \mid I_{\phi}=1\right\}=\mathbb{E}_{\mu}\left[d\left(I_{\phi}\right)-d^{*} \mid I_{\mu}=1\right]$$

$$\mathbb{E}_{\phi}\left[\varepsilon\left(I_{\mu}=1\right) \mid I_{\phi}=1\right]=\varepsilon$$

For the case when the government does not observe the shock and assumes that the central bank observed the shock, we get

$$\mathbb{E}_{\phi}\left[\pi\left(I_{\mu}=1\right)-\pi^{e} \mid I_{\phi}=0\right]=\frac{\mu\left(\pi^{*}-\pi^{e}\right)+\alpha k_{\mu}-\alpha\beta\mathbb{E}_{\mu}\left[d\left(I_{\phi}\right)-d^{*} \mid I_{\mu}=0\right]}{\alpha^{2}+\mu}$$

since

$$\mathbb{E}_{\phi}\left\{\mathbb{E}_{\mu}\left[d\left(I_{\phi}\right)-d^{*} \mid I_{\mu}=1\right] \mid I_{\phi}=0\right\}=\mathbb{E}_{\mu}\left[d\left(I_{\phi}\right)-d^{*} \mid I_{\mu}=0\right]$$

$$\mathbb{E}_{\phi}\left[\varepsilon\left(I_{\mu}=1\right) \mid I_{\phi}=0\right]=0$$

For the case when the government does observe the shock and assumes that the central bank did not observe the shock, we get

$$\mathbb{E}_{\phi}\left[\pi\left(I_{\mu}=0\right)-\pi^{e} \mid I_{\phi}=1\right]=\frac{\mu\left(\pi^{*}-\pi^{e}\right)+\alpha k_{\mu}-\alpha\beta\mathbb{E}_{\mu}\left[d\left(I_{\phi}\right)-d^{*} \mid I_{\mu}=0\right]}{\alpha^{2}+\mu}$$

since

$$\mathbb{E}_{\phi}\left\{\mathbb{E}_{\mu}\left[d\left(I_{\phi}\right)-d^{*}\right] \mid I_{\phi}=1\right\} \mid I_{\mu}=0=\mathbb{E}_{\mu}\left[d\left(I_{\phi}\right)-d^{*} \mid I_{\mu}=0\right]$$

$$\mathbb{E}_{\phi}\left[\varepsilon\left(I_{\mu}=0\right) \mid I_{\phi}=1\right]=0$$

For the case when the government does not observe the shock and assumes that the central bank also did not observe the shock, we get

$$\mathbb{E}_{\phi}\left[\pi\left(I_{\mu}=0\right)-\pi^{e}\mid I_{\phi}=0\right]=\frac{\mu\left(\pi^{*}-\pi^{e}\right)+\alpha k_{\mu}-\alpha\beta\mathbb{E}_{\mu}\left[d\left(I_{\phi}\right)-d^{*}\mid I_{\mu}=0\right]}{\alpha^{2}+\mu}$$

since

$$\mathbb{E}_{\phi}\left\{\mathbb{E}_{\mu}\left[d\left(I_{\phi}\right)-d^{*}\mid I_{\mu}=0\right]\mid I_{\phi}=0\right\}=\mathbb{E}_{\mu}\left[d\left(I_{\phi}\right)-d^{*}\mid I_{\mu}=0\right]$$

$$\mathbb{E}_{\phi}\left[\varepsilon\left(I_{\mu}=0\right)\mid I_{\phi}=0\right]=0$$

Substitution of the above expressions into (A6) gives

$$\begin{aligned}\mathbb{E}_{\mu}\left[d\left(I_{\phi}\right)-d^{*}\mid I_{\mu}=1\right]=&\frac{\beta k_{\phi}}{\beta^{2}+\phi}-\frac{\alpha\beta\mathbb{E}_{\phi}\left[\pi\left(I_{\mu}\right)-\pi^{e}\mid I_{\phi}=0\right]}{\beta^{2}+\phi}\left(1-p_{\phi}\right)-\\&-\frac{\alpha\beta\mathbb{E}_{\phi}\left[\pi\left(I_{\mu}\right)-\pi^{e}\mid I_{\phi}=1\right]+\beta\varepsilon}{\beta^{2}+\phi}p_{\phi}\end{aligned}\tag{A8}$$

$$\mathbb{E}_{\mu}\left[d\left(I_{\phi}\right)-d^{*}\mid I_{\mu}=0\right]=\frac{\beta k_{\phi}-\alpha\beta\mathbb{E}_{\phi}\left[\pi\left(I_{\mu}\right)-\pi^{e}\mid I_{\phi}=0\right]}{\beta^{2}+\phi}\tag{A9}$$

and substitution into (A7) gives

$$\begin{aligned}\mathbb{E}_{\phi}\left[\pi(I_{\mu})-\pi^{e}\mid I_{\phi}=1\right]=&\frac{\mu\left(\pi^{*}-\pi^{e}\right)+\alpha k_{\mu}}{\alpha^{2}+\mu}-\\&-\frac{\alpha\beta\mathbb{E}_{\mu}\left[d(I_{\phi})-d^{*}\mid I_{\mu}=0\right]}{\alpha^{2}+\mu}\left(1-p_{\mu}\right)-\\&-\frac{\alpha\beta\mathbb{E}_{\mu}\left[d(I_{\phi})-d^{*}\mid I_{\mu}=1\right]+\alpha\varepsilon}{\alpha^{2}+\mu}p_{\mu}\end{aligned}\tag{A10}$$

$$\mathbb{E}_{\phi}\left[\pi\left(I_{\mu}\right)-\pi^{e}\mid I_{\phi}=0\right]=\frac{\mu\left(\pi^{*}-\pi^{e}\right)+\alpha k_{\mu}}{\alpha^{2}+\mu}-\frac{\alpha\beta\mathbb{E}_{\phi}\left[\pi\left(I_{\mu}\right)-\pi^{e}\mid I_{\phi}=0\right]}{\beta^{2}+\phi}\tag{A11}$$

Note that expressions (A8), (A9), (A10) and (A11) constitute a system of four equations with four unknown terms involving $\mathbb{E}_{\mu}(\cdot)$ and $\mathbb{E}_{\phi}(\cdot)$ with the solution given by

$$\mathbb{E}_{\mu}\left[d\left(I_{\phi}\right)-d^{*} \mid I_{\mu}=1\right]=-\frac{\alpha\beta\mu\left(\pi^{*}-\pi^{e}\right)+\alpha^{2}\beta k_{\mu}-\beta\left(\alpha^{2}+\mu\right)k_{\phi}}{\lambda} - \frac{\beta\left[\alpha^{2}\left(1-p_{\mu}\right)+\mu\right]p_{\phi}\varepsilon}{\lambda+\alpha^{2}\beta^{2}\left(1-p_{\mu}p_{\phi}\right)} \tag{A12}$$

$$\mathbb{E}_{\mu}\left[d\left(I_{\phi}\right)-d^{*} \mid I_{\mu}=0\right]=-\frac{\alpha\beta\mu\left(\pi^{*}-\pi^{e}\right)+\alpha^{2}\beta k_{\mu}-\beta\left(\alpha^{2}+\mu\right)k_{\phi}}{\lambda} \tag{A13}$$

$$\mathbb{E}_{\phi}\left[\pi(I_{\mu})-\pi^{e} \mid I_{\phi}=1\right]=\frac{\left(\pi^{*}-\pi^{e}\right)\kappa+\alpha\left(\beta^{2}+\phi\right)k_{\mu}-\alpha\beta^{2}k_{\phi}}{\lambda}- - \frac{\alpha\left[\beta^{2}\left(1-p_{\phi}\right)+\phi\right]p_{\mu}\varepsilon}{\lambda+\alpha^{2}\beta^{2}\left(1-p_{\mu}p_{\phi}\right)} \tag{A14}$$

$$\mathbb{E}_{\phi}\left[\pi\left(I_{\mu}\right)-\pi^{e} \mid I_{\phi}=0\right]=\frac{\left(\pi^{*}-\pi^{e}\right)\kappa+\alpha\left(\beta^{2}+\phi\right)k_{\mu}-\alpha\beta^{2}k_{\phi}}{\lambda} \tag{A15}$$

with $\kappa=\beta^{2}\mu+\mu\phi>0$ and $\lambda=\alpha^{2}\phi+\beta^{2}\mu+\phi\mu$.
Substituting (A12) and (A13) into the central bank's F.O.C. (A5) gives

$$\pi\left(I_{\mu}=0\right)=\frac{\alpha^{2}\phi\pi^{e}+\kappa\pi^{*}}{\lambda}+\frac{\alpha\left(\beta^{2}+\phi\right)k_{\mu}-\alpha\beta^{2}k_{\phi}}{\lambda} \tag{A16}$$

$$\pi\left(I_{\mu}=1\right)=\frac{\alpha^{2}\phi\pi^{e}+\kappa\pi^{*}}{\lambda}+\frac{\alpha\left(\beta^{2}+\phi\right)k_{\mu}-\alpha\beta^{2}k_{\phi}}{\lambda}-\frac{\alpha\left[\beta^{2}\left(1-p_{\phi}\right)+\phi\right]}{\lambda+\alpha^{2}\beta^{2}\left(1-p_{\mu}p_{\phi}\right)}\varepsilon \tag{A17}$$

for the central bank's optimal inflation depending on whether the central bank observed the shock (equation (A17) applies) or not (equation(A16) applies), which does not involve the expectations of the government. Equations (A16) and (A17) can be used to derive the inflation expected by citizens. Using

$$\pi^{e}=\mathbb{E}\left[\pi\left(I_{\mu}=1\right)\right]p_{\mu}+\mathbb{E}\left[\pi\left(I_{\mu}=0\right)\right]\left(1-p_{\mu}\right)$$

some algebra gives

$$\pi^{e}=\pi^{*}+\frac{\alpha k_{\mu}}{\mu}-\frac{\alpha\beta^{2}k_{\phi}}{\kappa} \tag{A18}$$

which substituted back into (A17) and (A16) gives the equilibrium inflation

$$\pi\left(I_\mu=0\right)=\pi^*+\frac{\alpha}{\mu}k_\mu-\frac{\alpha\beta^2}{\kappa}k_\phi$$
$$\pi\left(I_\mu=1\right)=\pi^*+\frac{\alpha}{\mu}k_\mu-\frac{\alpha\beta^2}{\kappa}k_\phi-\frac{\alpha\phi+\alpha\beta^2\left(1-p_\phi\right)}{\lambda+\alpha^2\beta^2\left(1-p_\mu p_\phi\right)}\varepsilon \tag{A19}$$

Using the equilibrium inflation to derive $\pi^*-\pi^e$, expressions (A14) and (A15) become

$$\mathbb{E}_\phi\left[\pi\left(I_\mu\right)-\pi^e\mid I_\phi=1\right]=-\frac{\alpha\left[\beta^2\left(1-p_\phi\right)+\phi\right]p_\mu\varepsilon}{\lambda+\alpha^2\beta^2\left(p_\mu p_\phi\right)} \tag{A20}$$

$$\mathbb{E}_\phi\left[\pi\left(I_\mu\right)-\pi^e\mid I_\phi=0\right]=0 \tag{A21}$$

which used in the government's F.O.C. (A4) gives expression for the equilibrium deficit

$$d\left(I_\phi=0\right)=d^*+\frac{\beta\mu}{\kappa}k_\phi$$
$$d\left(I_\phi=1\right)=d^*+\frac{\beta\mu}{\kappa}k_\phi-\frac{\beta\mu+\alpha^2\beta\left(1-p_\mu\right)}{\lambda+\alpha^2\beta^2\left(1-p_\mu p_\phi\right)}\varepsilon \tag{A22}$$

Finally, the equilibrium inflation and deficit can be used to calculate the output, which is given by

$$y\left(I_\mu=1;I_\phi=1\right)=y^*+\frac{\beta^2\mu}{\kappa}k_\phi+\frac{\mu\phi-\alpha^2\beta^2\left(1-p_\mu\right)\left(1-p_\phi\right)}{\lambda+\alpha^2\beta^2\left(1-p_\mu p_\phi\right)}\varepsilon$$
$$y\left(I_\mu=1;I_\phi=0\right)=y^*+\frac{\beta^2\mu}{\kappa}k_\phi+\frac{\mu\phi+\beta^2\mu+\alpha^2\beta^2p_\phi\left(1-p_\mu\right)}{\lambda+\alpha^2\beta^2\left(1-p_\mu p_\phi\right)}\varepsilon \tag{A23}$$
$$y\left(I_\mu=0;I_\phi=1\right)=y^*+\frac{\beta^2\mu}{\kappa}k_\phi+\frac{\mu\phi+\alpha^2\phi+\alpha^2\beta^2p_\mu\left(1-p_\phi\right)}{\lambda+\alpha^2\beta^2\left(1-p_\mu p_\phi\right)}\varepsilon$$
$$y\left(I_\mu=0;I_\phi=0\right)=y^*+\frac{\beta^2\mu}{\kappa}k_\phi+\varepsilon$$

The equilibrium inflation given by (A19), deficit given by (A22) and output given by (A23) can be used to calculate the variance of inflation, deficit and output. To calculate welfare, a few more results are useful. Denoting

$$\nu_1=\frac{\alpha\phi+\alpha\beta^2\left(1-p_\phi\right)}{\lambda+\alpha^2\beta^2\left(1-p_\mu p_\phi\right)}$$
$$\nu_2=\frac{\beta\mu+\alpha^2\beta\left(1-p_\mu\right)}{\lambda+\alpha^2\beta^2\left(1-p_\mu p_\phi\right)} \tag{A24}$$

variance of inflation and deficit can easily be shown to be

$$\begin{aligned} var(\pi) &= p_\mu \nu_1^2 \sigma^2 \\ var(d) &= p_\phi \nu_2^2 \sigma^2 \end{aligned} \tag{A25}$$

From the equation for the economy (A1) variance of output is

$$\begin{aligned} var(y) = \alpha^2 var(\pi) + \beta^2 var(d) + \sigma^2 + 2\alpha\beta cov(\pi, d) + \\ + 2\alpha cov(\pi, \varepsilon) + 2\beta cov(d, \varepsilon) \end{aligned} \tag{A26}$$

which after some algebra gives

$$var(y) = \left[p_\mu \left(1 - \alpha\nu_1\right)^2 + p_\phi \left(1 - \beta\nu_2\right)^2 + 1 - p_\mu - p_\phi + 2\alpha\beta p_\mu p_\phi \nu_1 \nu_2 \right] \sigma^2 \tag{A27}$$

$\psi_2(\xi, \mathbf{p})$ can thus be written as

$$\begin{aligned} \psi_2\left(\xi, \mathbf{p}\right) = p_\mu \nu_1^2 + p_\phi \nu_2^2 + \\ + \left[p_\mu \left(1 - \alpha\nu_1\right)^2 + p_\phi \left(1 - \beta\nu_2\right)^2 + 1 - p_\mu - p_\phi + 2\alpha\beta p_\mu p_\phi \nu_1 \nu_2 \right] \end{aligned} \tag{A28}$$

To calculate $\mathbb{E}\left(v - v^*\right)$ for $v \in \{y, \pi, d\}$, using equations (A23), (A19) and (A22) we have

$$\mathbb{E}\left(v - v^*\right) = \% \begin{cases} \dfrac{\beta^2 \mu}{\kappa} k_\phi & \text{if } v = y \\ \% \dfrac{\alpha}{\mu} k_\mu - \dfrac{\alpha\beta^2}{\kappa} k_\phi & \text{if } v = \pi \\ \% \dfrac{\beta\mu}{\kappa} k_\phi & \text{if } v = d \end{cases} \tag{A29}$$

so that $\psi_1\left(\xi, \mathbf{p}\right)$ can be written as

$$\psi_1\left(\xi, \mathbf{p}\right) = \left(\frac{\beta^2 \mu}{\kappa} k_\phi \right)^2 + \left(\frac{\alpha}{\mu} k_\mu - \frac{\alpha\beta^2}{\kappa} k_\phi \right)^2 + \left(\frac{\beta\mu}{\kappa} k_\phi \right)^2 \tag{A30}$$

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