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Welfare Improving Coordination of Fiscal and Monetary Policy[1]

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Abstract

The paper considers a simple model in which monetary and fiscal policies are formally independent, but still interdependent - through their spillovers onto the macroeconomic targets to which they are not primarilly assigned. It shows that the average equilibrium levels of inflation, deficit, debt, and output depend on the two policies' (i) *potency* (elasticity of output with respect to the policy instruments); (ii) *ambition* (the level of their output target); and (iii) *conservatism* (inflation vs output volatility aversion). However, it is the *relative* degrees of these characteristics that matter, rather than the absolute degrees for each policy. Therefore, and as expected, coordination of monetary and fiscal policy is found to be superior to non-cooperative Nash behaviour for both policymakers. Interestingly though, it is coordination in terms of the policies' ambition, rather than conservatism, that is essential. That is a new result. Furthermore, ambition-coordination can be welfare improving even if the policymakers' objectives are idiosyncratic, and/or even their coordinated output targets differ from the socially optimal one.

Keywords: coordination, interaction, monetary policy, fiscal policy, central bank, government, inflation, deficit, debt.
JEL classification: E61, E63

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1. Introduction

Early work on the theory of economic policy stressed the importance of accounting for the interactions between fiscal and monetary policy. Tinbergen (1954) and Cooper (1969) showed us that there would be costs in missed targets, instability, and protracted imbalances if policy interaction was ignored. Yet most models that we use today treat fiscal (F) or monetary (M) policies as if they operated independently. This paper demonstrates the importance of those interactions, and what they imply for the optimal setting of each policy.

Unlike most of the post-Tinbergen interaction literature that examined the *direct interaction*,[3] this paper follows in the footsteps of Sargent and Wallace (1981) and Dixit and Lambertini (2003) by focusing on the *indirect interaction.* Specifically, we examine how M and F policies affect each other through spillovers onto the principle target of the other. As a matter of experimental control, we will separate the direct and indirect effects by assuming that the policymakers are fully *independent* (in a constitutional and political sense) and have perfect control over their instruments - the level of inflation for M, and the growth rate of nominal debt (size of deficit) for F. These assumptions are realistic in a world of independent central banks quite capable of achieving a certain level of inflation on average, even in the presence of shocks.

We use a parsimonious non-controversial model, a simple extension of Barro and Gordon (1983), in which both policymakers have the standard quadratic preferences over inflation and output. The advantages of such approach (over an explicitly micro-founded general equilibrium model) in terms of clearer exposition and intuition will become apparent as we proceed.[4] To further enhance the clarity we first focus on *long-run* macroeconomic outcomes (both levels and growth rates) that are the first order effects. The second order *short-run* stabilization consequences, which show up in the variability of the outcomes in the presence of shocks, are examined separately in Section 4.1.

The model incorporates, and shows the spillover effects of, three standard parameters for each policy. We define the policies' *potency* to be the elasticity of output with respect to the corresponding policy instrument. Next we define policy *ambition* to express the level of the output target relative to the natural rate. Finally, policy *conservatism* describes the degree of aversion to inflation volatility vis-à-vis output volatility.

Most of the papers' novel insights are due to the fact that it is the *relative* degrees of these characteristics which matter, not their absolute values. Because of that, many conventional results may be qualified or reversed by the other policymaker's influence. We find that, under some (but not all) circumstances: (i) A conservative central bank may increase rather than decrease inflation (unlike in Rogoff (1985)). (ii) An inflation bias may occur even if the central banker and/or the government are under-ambitious (aim at a below-natural output level); and conversely, a deflation bias may occur even if they are over-ambitious (aim at an above-natural output level). (iii) Similarly, an

[3] That is the ability of the government (fiscal policymaker) to directly affect monetary policy outcomes through the appointment of the central banker (Rogoff (1985)), optimal contract with the central banker (Walsh (1995)), overriding the central bank (Lohmann (1992)), or through a mixture of these (Hughes Hallett and Libich (2007a)).

[4] For a micro-founded approach see Woodford (2003) and the references therein.

election of a more ambitious government may lead to a greater rather than smaller deficit. (iv) Real debt may be increasing even if both policymakers are under-ambitious, and even if the government runs surpluses. The reverse can hold too: real debt may be decreasing even if both policymakers are over-ambitious, and even if the government runs deficits.

Many of the results reveal *observational equivalence* - an outcome may obtain under a range of (fundamentaly different) parameter values. For instance, and contrary to the Barro-Gordon literature, anti-inflation and fiscally sustainable policies may be time consistent and credible even if the respective policymaker is over-ambitious, and places greater weight on output than inflation. This implies that achieving low inflation targets and balanced budgets may *not* be a result of conservative and responsible policymaking. Conversely, failing to achieve these optimal outcomes may *not* be an indicator of idiosyncratic objectives or incompetent actions. In both cases it is the actions of the other policy which are disciplining the first, or restraining its outcomes.

All these findings suggest that policy coordination may be desirable, but that the important part is relative rather than absolute coordination in the language of Currie et al (1989). We examine this hypothesis explicitly by endogenizing all the policy preference parameters. Specifically, each policymaker is able to choose his ambition and conservatism. Interestingly, we find that it is coordination in terms of the policy ambition (targets) that is essential, and not in terms of conservatism (priorities). And these conclusions hold even if (and, in fact, especially when) the policymakers' objectives differ from the social optimum, and when their policy instruments differ in potency.[5]

Finally, we show that a second best alternative to ambition-coordination is to appoint an ultra-conservative central bank focused solely on inflation control. Interestingly, because of the policy interactions and unlike in Rogoff (1985), this does *not* increase the volatility of output in the presence of shocks to output.

The rest of the paper is structured as follows. Section 2 presents the basic model and its solution. Section 3 reports all the results in five subsections: the policy interdependence (Section 3.1), M policy outcomes (Section 3.2), F policy outcomes (Section 3.3), real output and real debt (Section 3.4), and the optimal coordination of the two policies under endogenous preferences (Section 3.5). Section 4 then considers robustness of the results by examining two further generalizations of the analysis. First, Section 4.1 studies the effect of shocks, both under information symmetry (in which case the public can, like the policymakers, observe the shocks in real time), and under information assymetry (when the public cannot observe the current period shock). Section 4.2 extends the supply function and allows for a deficit to have, even without the contribution of M policy, a contractionary effect. These extensions show that the results of the original version of the model are robust. Section 5 summarizes and concludes.

[5]Coordination helps when policies are used according to comparative advantage: Hughes Hallett (1986).

2. Model

2.1. **Setup.** The Lucas supply relationship summarizes the economy and is extended (relative to Barro and Gordon (1983)) to also include the effect of fiscal policy

$$x = \mu(\pi - \pi^e) + \rho g, \tag{1}$$

where x, π, π^e, and g denote the output gap, inflation, inflation expected by the public, and the growth rate of real debt respectively.[6] The parameters μ and ρ are positive and denote the *potency* of M and F policy respectively. We will throughout drop the time subscripts since our interest lies in the one shot game. Let us define the growth rate of real debt in the standard fashion

$$g = G - \pi, \tag{2}$$

where G is the growth rate of nominal debt (which can also be thought of as the size of the deficit, with $G = 0$ expressing a balanced budget). G and π are assumed to be the instruments of M and F policy, independently set and perfectly controlled.

The policymakers' one period utility function follows the convention in the literature and can, as Woodford (2003) has shown, be derived from microfoundations:[7]

$$u^i = -\beta^i(x - x_T^i)^2 - \pi^2, \tag{3}$$

where $i \in \{M, F\}$ is the set of players and the inflation target of both policies is set to zero. Further, $\beta^i > 0$ denotes the degree of policy *conservatism* (lower β^i values denoting greater conservatism, as in Rogoff (1985)). Finally, $x_T^i \in \mathbb{R}$ denotes the level of the output gap target, which we will refer to as the degree of *ambition.*

We will distinguish the policymakers according to three criteria. First, following Rogoff (1985) we will refer to $\beta^M < \beta^F$ and $\beta^M \geq \beta^F$ as the cases of *conservative* and *liberal* central banker respectively. Second, from the point of view of the natural rate hypothesis, we will refer to those with $x_T^i = 0$, $x_T^i > 0$, and $x_T^i < 0$ as *responsible*, *over-ambitious,* and *under-ambitious* respectively. Third, from a political economy viewpoint we will refer to the governments with $x_T^F = \bar{x}_T$ and $x_T^F \neq \bar{x}_T$ as *benevolent* and *idiosyncratic* respectively, where $\bar{x}_T \in \mathbb{R}$ is the level of the socially optimal output gap target (all variables referring to social welfare will be denoted by a bar).[8]

For simplicity, we will assume that F ambition is the only aspect in which the *social welfare function* $\bar{u}$ may differ from the government's own utility function u^F (ie $\bar{\beta} = \beta^F$). Further, it is assumed that the public, like the policymakers, has complete information and rational expectations. Finally, all parties can move every period. These

[6]Note that this specification ensures money neutrality. Section 4 considers some extensions to the supply curve, including shocks, and shows that are main findings are unchanged.

[7]The players can be thought of as discounting the future with δ_M and δ_F being their discount factors. But as we will be focusing on the one-shot game, discounting will not play any role in the analysis.

[8]Note that for generality we do not impose a specific value for $\bar{x}_T$. This setup nests four main cases of interest in which the government is: (i) benevolently over-ambitious, $x_T^F = \bar{x}_T > 0$, (ii) idiosyncratically over-ambitious, $0 < x_T^F \neq \bar{x}_T$, (iii) benevolently responsible, $x_T^F = \bar{x}_T = 0$, and (iv) idiosyncratically responsible, $x_T^F = 0 \neq \bar{x}_T$. The main reason for $x_T^F \neq \bar{x}_T$ identified in the literature has been the presence of various political economy features such as naïve voters; the desire to offset a central bank that is too conservative; or to overcome the effects of distortionary taxation or monopolistic competition which prevent markets clearing at full employment.

standard assumptions will enable us to focus on the policy interaction as there will be no reputational issues.[9]

2.2. **Solution.** Focusing on the one shot simultaneous move game we have, using (1)-(3) and rational expectations, the following reaction functions

$$\pi = \frac{\beta^M(\rho - \mu)(\rho G - x_T^M)}{1 + \beta^M \rho(\rho - \mu)} \text{ and } G = \frac{x_T^F}{\rho} + \pi. \tag{4}$$

Solving jointly yields the following equilibrium outcomes (denoted by a star throughout)

$$\pi^* = \beta^M(\rho - \mu)(x_T^F - x_T^M) \text{ and } G^* = \frac{x_T^F}{\rho} + \beta^M(\rho - \mu)(x_T^F - x_T^M), \text{ and} \tag{5}$$

$$g^* = \frac{x_T^F}{\rho} \text{ and } x^* = x_T^F, \tag{6}$$

where (5) reports the nominal variables (policy instruments) π and G and (6) reports the real variables g and x.

3. Results

This section reports results for our baseline model. For the sake of simplicity, we first derive results for four macroeconomic variables $\{\pi, G, g, x\}$ in terms of their *average* or equilibrium levels. Section 4 then introduces shocks and shows that our earlier propositions still hold in a stochastic environment.

3.1. **Monetary and Fiscal Policy Interdependence.** This section demonstrates that the two policies will typically be interrelated even if they are formally independent.

Proposition 1. *For almost all parameter values, (i) the equilibrium value of the M policy instrument is not only a function of M policy conservatism, ambition, and potency, but also of the ambition and potency of F policy; and (ii) the equilibrium value of the F policy instrument is not only a function of F policy ambition and potency, but also determined by the conservatism, ambition, and potency of M policy.*

Proof. Inspection of (5) reveals that both π^* and G^* are functions of $\beta^M, x_T^F, x_T^M, \rho$ and μ for all $\rho \neq \mu$ and $x_T^F \neq x_T^M$. □

The proposition implies that the other policy's setting generally matters; not just the policy values, but the characteristics that determine that policy stance. Graphically, Figure 1 shows that π^* depends on ρ (panel a) and G^* depends on μ (panel b). Figures 2b and 4a further show that G^* crucially depends on β^M and x_T^M respectively.

Proposition 2. *The inflation target and balanced budget are potentially time-inconsistent for almost all parameter values, including those in which the respective policymaker is responsible and/or conservative.*

[9]For the alternative cases in which (i) reputations matter, or (ii) the players' actions feature some rigidity and cannot be reconsidered every period (due to costly wage bargaining, information processing, and/or commitment), see Hughes Hallett and Libich (2007b) and Libich, Hughes Hallett, and Stehlík (2007) respectively.

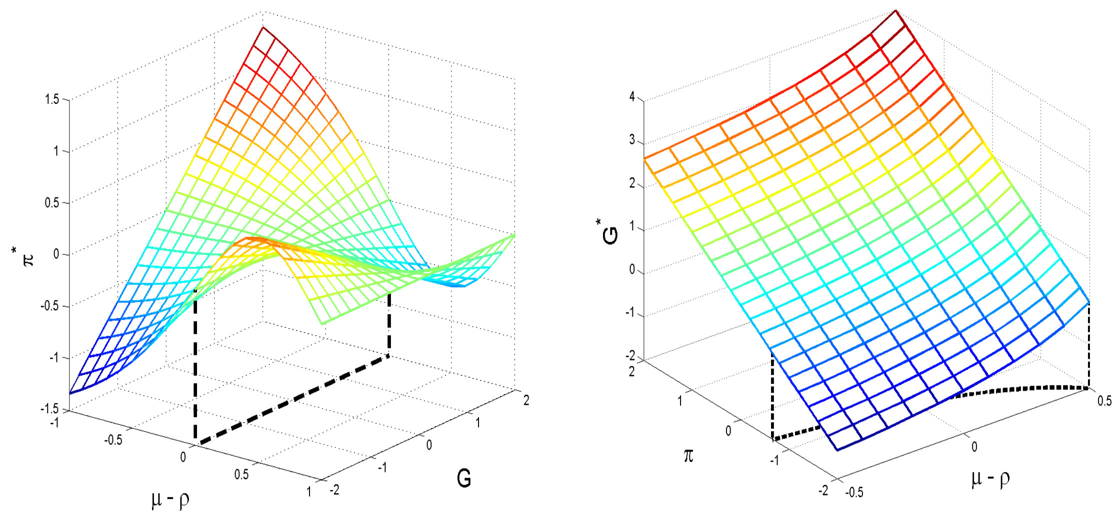

FIGURE 1. M and F policy reaction functions: Optimal inflation π^* (panel a) and deficit G^* (panel b) as functions of the setting of the other policy and their relative potency $\mu - \rho$; under $x_T^M = 0, x_T^F = 1, \beta^M = 1, \beta^F = 1, \mu = 1$.

Proof. It follows from (5) that $\pi^* \neq 0$ and $G^* \neq 0$ (unless $\rho = \mu$ or $x_T^F = x_T^M$ for the former and $\mu = \frac{\beta^M \rho^2 (x_T^F - x_T^M) - x_T^F}{\beta^M \rho (x_T^F - x_T^M)}$ for the latter). This means that the levels $\pi_t = 0$ and $G = 0$ are not the equilibrium choices of the respective policymaker and hence they may be time-inconsistent in the sense of Kydland and Prescott (1977). □

For an illustration see Figure 2. All values of π^* and G^*, except those indicated by the dashed lines, differ from zero, ie the optimal targets may prove time-inconsistent.

Proposition 3. *Not only the magnitude, but also the direction of the central banker's best response to a budgetary outcome depends on the relative potency of the two policies. There exist circumstances under which the optimal response to a fiscal expansion (deficit) is:*
(i) M tightening (and this can be true even for an over-ambitious M),
(ii) M easing (and this can be true even for an under-ambitious or responsible M), or
(iii) no change in the stance of M policy.

Put differently, π can be a strategic substitute to G, a strategic complement to G, or independent of G.

Proof. Inspection of the reaction functions in (4) reveals that π^* is (i) decreasing in G iff $\rho \in (\max\{\mu - \frac{1}{\rho\beta^M}, 0\}, \mu)$, (ii) increasing in G iff $\rho \in (0, \mu - \frac{1}{\rho\beta^M}) \cup (\mu, \infty)$, and (iii) independent of G iff $\rho = \mu$. □

Figure 1 demonstrates these results graphically. It shows that, in panel b G^* is a monotone function of π, and that in panel a π^* is non-monotonic in G (the dashed line

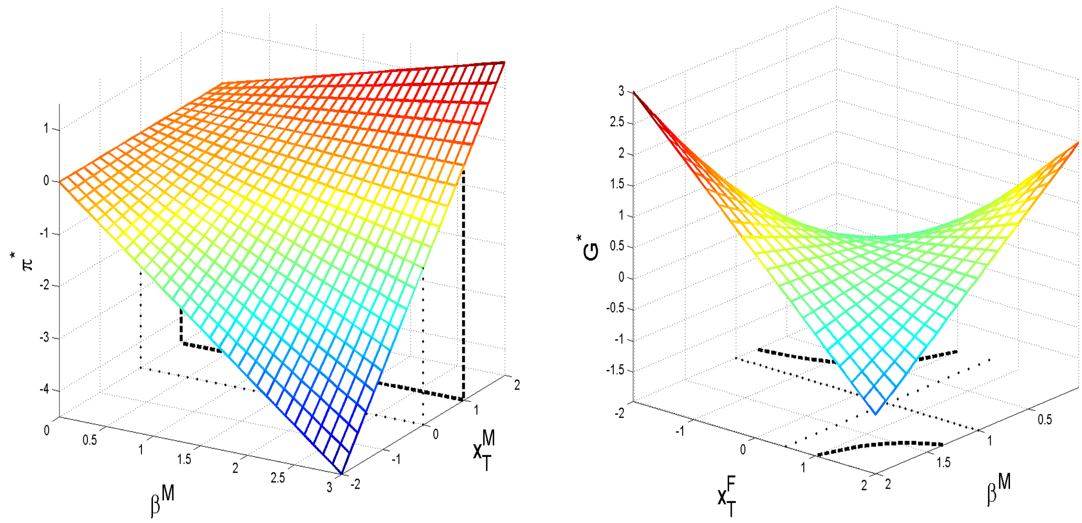

FIGURE 2. Nominal variables (policy instruments): Equilibrium inflation π^* (panel a) and deficit G^* (panel b) as functions of the output target values (x_T^M and x_T^F respectively) and M policy conservatism β^M; under $x_T^F = 1, \beta^F = 1, \mu = 1, \rho = 0.5$ in panel a, and $x_T^M = 0.5, \beta^F = 1, \mu = 2, \rho = 1$ in panel b.

indicates the threshold $\mu = \rho$ in which the direction changes). It should be stressed that the difference in optimal M responses is *not* due to business cycle fluctuations - to control for these we have made our baseline model deterministic. Instead, it is due to the *feedback effect* between M and F policy. Specifically, the level of inflation affects the optimal size of the deficit, which in turn affects the optimal level of inflation. Since the respective magnitudes of these effects may differ, the direction of the monetary responses (ie whether M counter-acts or accommodates) may vary too.

Also note that, in this setting, G is always a strategic substitute to π. That is to say G^* is increasing in π for all parameter values. In Section 4 it will be shown that, in the presence of shocks, this is not always the case.

3.2. **Monetary Policy Outcomes.** Next we examine the optimal setting and outcomes of the M policy instruments.

Proposition 4. *An inflation (deflation) bias can occur even if either one or both policymakers are under-ambitious (over-ambitious).*

Proof. It is claimed that parameter values exist under which $\pi^* > 0$ even if $x_T^M < 0$ and/or $x_T^F < 0$, and $\pi^* < 0$ even if $x_T^M > 0$ and/or $x_T^F > 0$. This can be seen in (5) - the former obtains under either $\rho > \mu$ and $x_T^F > x_T^M$, or $\rho < \mu$ and $x_T^F < x_T^M$; and the latter obtains under either $\rho > \mu$ and $x_T^F < x_T^M$, or $\rho < \mu$ and $x_T^F > x_T^M$. □

These results are graphically demonstrated in Figure 2a. In the interval between the two lines, $x_T^M \in (0, 1 = x_T^F)$, we have a deflation bias despite both policymakers being over-ambitious. This contrasts with the wide-spread view that high (low) inflation is necessarily due to the excessively high (low) output target of the central banker and/or the government.

The following two propositions show that the conventional wisdom of the Barro-Gordon literature - that M policy conservatism and ambition have a monotone effect on the level of inflation - to also possibly be reversed as a result of M and F interactions.

Proposition 5. *The inflation target may be time-consistent and credible even if M is over-ambitious and/or liberal.*

Proof. The proposition claims that we may obtain $\pi^* = 0$ even if $x_T^M > 0$ and/or $\beta^M \geq \beta^F$. From (5) it follows that this will be the case iff $\mu = \rho$ or $x_T^M = x_T^F$. □

For an illustration see Figure 2a. The dashed line shows the sole time-consistent value of π^*, which obtains at an over-ambitious value $x_T^M = x_T^F = 1$ and for all β^M.

Remark 1. *Proposition 5 shows that achieving the inflation target is not sufficient for us to conclude that the central bank is responsible and/or conservative - even in the absence of shocks.*

Intuitively, since different combinations of parameter values provide the right incentives to deliver the inflation target, it may be impossible to infer the type of the central banker - in contrast to Backus and Driffill (1985). To give one example, if M and F policy are equally potent, then neither M nor F policy preferences affect equilibrium inflation: under $\mu = \rho$ the level of π^* is independent of $\{\beta^M, \beta^F, x_T^M, x_T^F\}$. Similarly, if the policymakers are equally ambitious, the time-inconsistency problem is alleviated.

Proposition 6. *The direction (as well as the magnitude) of the effect of M policy conservatism on the level of inflation depends on 1) the relative degree of M and F policy ambition and 2) the relative potency of M and F policy. Specifically, a more conservative central banker will:*
(i) decrease inflation iff M policy is either more potent and less ambitious than F policy; or less potent and more ambitious than F policy,
(ii) increase inflation iff M policy is either both more potent and more ambitious than F policy; or both less potent and less ambitious than F policy,
(iii) not affect inflation iff M and F policy are equally potent and/or equally ambitious.

Proof. Equation (5) shows that (i) under $\mu > \rho \wedge x_T^M < x_T^F$ or $\mu < \rho \wedge x_T^M > x_T^F$ the value of π^* is increasing in β^M; (ii) under $\mu > \rho \wedge x_T^M > x_T^F$ or $\mu < \rho \wedge x_T^M < x_T^F$ the value of π^* is decreasing in β^M; and (iii) under $\mu = \rho \vee x_T^M = x_T^F$ the value of π^* is not a function of β^M. □

Figure 2a demonstrates these results graphically. For values $x_T^M > x_T^F = 1$, a greater value of β^M increases inflation, but for values $x_T^M < x_T^F = 1$ it reduces inflation, and for the $x_T^M = x_T^F = 1$ values it does not affect inflation.

Arguably, while it is less likely that $x_T^M > x_T^F$ since M's ambition is commonly driven by F's ambition, the case of M policy being less potent than F policy, $\mu < \rho$, may be plausible and hence all three claims may obtain (unlike in the Barro-Gordon literature in which only claim (i) obtains)[10].

Intuitively, a low inflation policy may stimulate the economy better than a high inflation policy could have done given society's or the policymakers' preferences - by increasing the value of real debt and hence magnifying the expansionary effect of F policy better than any inflation surprise could.

Proposition 7. *The direction (as well as the magnitude) of the effect of M policy ambition on the level of inflation depends on the relative potency of M and F policy. But it does not depend on the degree of either M or F policy conservatism. Specifically, a more ambitious central banker will:*
(i) increase inflation iff M policy is more potent than F policy,
(ii) decrease inflation iff M policy is less potent than F policy,
(iii) not affect inflation iff M and F policy are equally potent.

Proof. Equation (5) shows that (i) under $\rho < \mu$ the level of π^* is increasing in x_T^M;(ii) under $\rho > \mu$ the level of π^* is decreasing in x_T^M; and (iii) under $\rho = \mu$ the level of π^* is not a function of x_T^M. □

It is important to consider why an under-ambitious or responsible M policymaker might find it optimal to inflate. It is because, by doing so, he attempts to decrease the real value of the debt in order to reduce the expansionary effect of the F policy and thus stabilize output closer to his target.

This result, like Proposition 4, alerts us to the fact that, in predicting macroeconomic outcomes, policy ambition has to be viewed in light of the other policy's ambition. Specifically, the effects of an over-ambitious M in the presence of an over-ambitious or under-ambitious fiscal policies may differ dramatically.

3.3. **Fiscal Policy Outcomes.** Let us now turn to examining the optimal outcomes of fiscal policy.

Proposition 8. *Nominal debt may be increasing (decreasing) - through persistent deficits (surpluses) - even if either one or both policymakers are under-ambitious (over-ambitious).*

Proof. It is stated that we can have $G^* > 0$ even if $x_T^F < 0$ and/or $x_T^M < 0$; and $G^* < 0$ even if $x_T^F > 0$ and/or $x_T^M > 0$. Rearranging of (5) shows that the latter obtains, inter alia, if

$$x_T^M < x_T^F \left(1 - \frac{1}{\rho\beta^M(\mu - \rho)}\right), \tag{7}$$

where $\mu > \rho$. But the former happens if the inequality in (7) is reversed. □

Figure 2b offers a demonstration of the proposition. Consider values $\beta^M > 1$. Then an under-ambitious F, $x_T^F < 0$, accumulates nominal debt, $G^* > 0$, whereas a sufficiently over-ambitious F (with x_T^F greater than the value shown by the dashed line which is implied by (7)) runs surpluses: $G^* < 0$.

[10]Note that the proposition qualifies the standard Barro-Gordon-Rogoff result by showing that, even under $\mu > \rho$, a conservative central banker may increase inflation.

The result of Proposition 8 is surprising - we commonly think of excessive spending and nominal debt accumulation as an outcome of policymakers with over-ambitious targets, and budget surpluses as those with under-ambitious or responsible targets.

Intuitively, an under-ambitious or responsible F policymaker may find it optimal to run deficits in an attempt to increase the real value of the debt and hence offset what they perceive to be the still too contractionary effect of M policy (note that $x_T^M < x_T^F$ in (7)). This strategy achieves output closer to their target.

Proposition 9. *The budget deficit and the growth rate of the nominal debt may be zero, even if F is over-ambitious and F policy is more potent than M policy.*

Proof. The proposition claims that we may obtain $G^* = 0$ even if $x_T^F > 0$ and $\rho > \mu$. From (5), it follows that this will be the case iff

$$\beta^M = \frac{x_T^F}{\rho(\rho - \mu)(x_T^M - x_T^F)}, \tag{8}$$

which completes the proof. □

The proposition can be seen in Figure 2b, in which the values of β^M from (8) are indicated by the dashed lines and they deliver $G^* = 0$ even if $x_T^F \neq 0$.

Remark 2. *Proposition 9 again shows that we cannot conclude that any government running balanced budgets or surpluses is responsible. This is because the central banker may indirectly (by altering the incentives faced by the F policymaker through changes made to M policy upon which the choice of F policy depends) 'discipline' an otherwise over-ambitious F policymaker.*

Three things should be noted. First, the disciplining central banker is not necessarily conservative - β^M in (8) may be greater or less than β^F. Second, the disciplining central banker is also not necessarily responsible - the x_T^M value in (8) may also be positive or negative. Third, the price for this discipline is a deflationary M policy.[11]

The following proposition however shows that under some circumstances, the central banker can, depending on the relative potency and ambition in the two policies, accentuate the ambition of the F policymaker and worsen the budgetary outcomes.

Proposition 10. *An appointment of a conservative and/or less ambitious central banker may increase, decrease, or have no effect on the size of the budget deficit and the growth rate of the nominal debt.*

Proof. It is claimed that G^* may be decreasing, increasing, or independent of β^M and/or x_T^M. In terms of β^M, equation (5) shows that this is indeed the case under $(\rho - \mu)(x_T^F - x_T^M) < 0$, $(\rho - \mu)(x_T^F - x_T^M) > 0$, and $(\rho - \mu)(x_T^F - x_T^M) = 0$ respectively. In terms of x_T^M, equation (5) reveals that this is the case under $\rho > \mu$, $\rho < \mu$, and $\rho = \mu$ respectively. □

[11] In Libich, Hughes Hallett, and Stehlík (2007) we allow the policymakers to explicitly commit to their actions (ie effectively equip them with an additional instrument), and show that in such cases M policy may discipline an over-ambitious F policy without compromising the inflation target. The paper contains a case study written by Dr Don Brash, the Governor of the Reserve Bank of New Zealand during 1988-2002, in which he shows that the adoption of the explicit inflation targeting framework by the Bank had a strong (and long-lasting) disciplining effect on fiscal policy in New Zealand.

These results are graphically demonstrated in Figure 2b. If $x_T^F = x_T^M = 0.5$ (shown by the dotted line), then the value of the deficit is independent of the type of the central banker β^M. However, if $x_T^F < x_T^M = 0.5$ and $x_T^F > x_T^M = 0.5$, a more conservative central banker (a lower value of β^M) leads to a higher/lower deficit G^* respectively.

This proposition is an analog of Propositions 6 and 7 in the realm of F policy. Intuitively, whether a conservative and responsible central banker improves or worsens the budgetary outcomes depends on what type of F opponent he is facing. The opponent type determines how strongly, and in which direction, the opponent is expected to react.

Proposition 11. *The election of a less ambitious government may decrease, increase, or have no effect on the size of the budget deficit and the growth rate of the nominal debt.*

Proof. It is claimed that G^* may be decreasing, increasing, or independent of x_T^F. Rearranging equation (5) reveals that this is indeed the case under $\mu < \bar{\mu}(\rho), \mu > \bar{\mu}(\rho)$, and $\mu = \bar{\mu}(\rho)$ respectively, where the threshold value $\bar{\mu}(\rho)$ is the following

$$\bar{\mu} = \rho + \frac{1}{\rho\beta^M} > \rho, \tag{9}$$

which completes the proof. □

Figure 2b illustrates the proposition. If $\beta^M = 1$ (shown by the dotted line implied by (9)), then the value of the deficit is independent of the type of the government's ambition x_T^F. However, under $\beta^M > 1$ and $\beta^M < 1$, a more ambitious government (higher value of x_T^F) leads to a lower/higher deficit G^* respectively. This implies that caution should be exercised in concluding that a less ambitious government will surely improve the country's fiscal position. But since the first case obtains over a larger parameter space (from the fact that $\bar{\mu} > \rho$ it follows that this parameter space includes values of $\rho > \mu, \rho < \mu$, as well as $\rho = \mu$), it might be argued that a less ambitious government leads to an improvement in fiscal discipline more often than not.

3.4. **Real Variables.** This sections shows how the setting of the two policies determines the size of real debt and output.

Proposition 12. *Real debt may be increasing (decreasing) even if the nominal debt is decreasing (increasing); that is even if the government is running surpluses (deficits).*

Proof. The proposition argues that we may obtain $g^* > 0$ even under $G^* < 0$; and $g^* < 0$ even under $G^* > 0$. Inspection of (5) tells us that the former is true if (7) is satisfied together with $x_T^F > 0$, and the latter is true if the inequality is reversed and $x_T^F < 0$. □

A graphical demonstration can be found in Figure 3a. For some values of $\mu - \rho > 1$ (implied by (7)), we have $G < 0$ leading to $g^* > 0$ (see for example $\mu - \rho = 1.5$ and $G = -1$ leading to $g^* = 2$).

Since the price level may be moving in the opposite direction to the nominal debt in equation (5), meaning surpluses may be accompanied by positive inflation or deficits by deflation, the conventional positive correlation between the size of the deficit and real debt may be reversed.

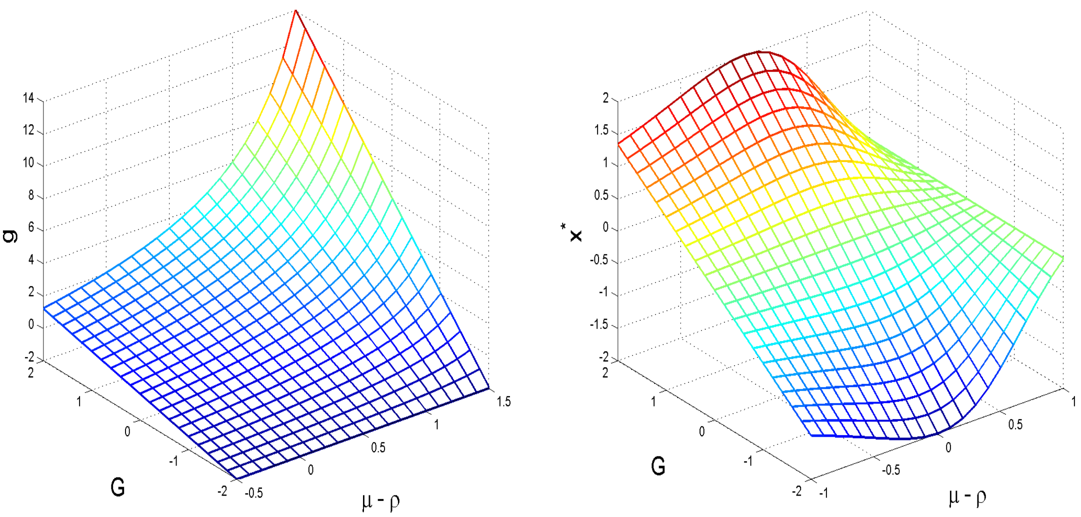

FIGURE 3. Real variables: Equilibrium real debt g^* (panel a) and real output x^* (panel b) as functions of the deficit G and the relative potency $\mu - \rho$; under $x_T^M = -1, x_T^F = 1, \beta^M = 1, \beta^F = 1, \rho = 0.5$ in panel a, and $x_T^M = 0, x_T^F = 1, \beta^M = 1, \beta^F = 1, \mu = 1$ in panel b.

Proposition 13. *Real output may be persistently below (above) the natural level, even if the government is running deficits (surpluses).*

Proof. It is stated that we can have $x^* < 0$ even if $G^* > 0$, and $x^* > 0$ even if $G^* < 0$. Inspection of (5) and (6) tells us that the latter is true if (7) is satisfied together with $x_T^F > 0$, and the former is true if the inequality in (7) is reversed and $x_T^F < 0$. □

These findings can be seen in Figure 3a, in which $g^* > 0$ and hence $x^* > 0$ may obtain under $G < 0$. Figure 3b further shows the non-monotonic effect of the combination of the budget deficit with the policies' potency.

Interestingly, these results (with a Keynesian flavour) obtain despite the fact that the supply function does not feature non-neutrality. Furthermore, the $x^* > 0$ case can be achieved by running surpluses, ie the government's intertemporal budget constraint is met. Nevertheless, since the central bank is running significant deflation, the price to pay is an accumulation of real debt and hence an accumulation of domestic or international imbalances.

Proposition 14. *Under almost all parameter values, the degrees of M policy conservatism and ambition affect the levels of the deficit and nominal debt, but do not affect the level of the real debt.*

Proof. Inspection of (4) reveals that for all $\mu \neq \rho$ the levels of π^* and G^* are functions of β^M and x_T^M. In contrast, (5) shows that g^* is not a function of these variables. □

This is in contrast to the conventional wisdom in which, in the absence of indirect policy interaction, central bank conservatism affects the size of real debt through inflation, but not the size of the deficit and nominal debt that is set independently by the government. In other words, the effect of β^M and x_T^M coming through M and F policy may cancel each other out.

Proposition 15. *Even if M policy is more potent than F policy, and even if it influences inflation and the size of the deficit (through its conservatism and/or ambition), it may have no effect on real output.*

Proof. Inspection of (6) shows that even if $\rho < \mu$ and π^* and G^* are functions of the monetary policy parameters β^M and x_T^M, x^* is not a function of these parameters. □

Note also that there is an asymmetry in the effect of the two policies; F policy has more effect on M policy than the other way round. This is because its impact is not dependent on surprising the public. While standard, this specification may appear too 'favourable' to what F policy can actually do. Section 4.2 therefore considers a case in which a deficit may actually have, even without the contribution of M policy, a contractionary rather than an expansionary effect.

The following two propositions further highlight the dichotomy between nominal and real variables.

Proposition 16. *Even if the relative potency of M and F policy only affects the nominal variables, π and G, and not the real variables, g and x, it still affects the utility of both policymakers and social welfare.*

Proof. If π^* is a function of μ and ρ (which (5) shows it to be for all values except $x_T^M = x_T^F$), then it follows from (3) the the players' and the society's utility will be affected, and this is regardless of whether μ and ρ affect g^* and x^*. □

Proposition 17. *(i) The degree of F policy conservatism affects no nominal or real variables in the model.*
(ii) The degree of F policy ambition affects all nominal and real variables in the model for almost all parameter values.

Proof. Inspection of (5) and (6) reveals that while π^*, G^*, g^* and x^* are all functions of x_T^F (with the exception of $\mu = \rho$ for π^*), none of them is a function of β^F. □

The first claim may seem surprising in light of Proposition 6 which showed that M policy conservatism affected the levels of the deficit and nominal debt for almost all parameter values. The second claim suggests that it is the target *level* of the F policy's output gap that plays a crucial role in determining the macroeconomic outcomes of both policies. In contrast to that, the relative weight that F places on the *deviations* from this target level does not have any importance. This suggests that x_T^F may be the variable with the greatest overall macroeconomic impact and the one to focus on. Unfortunately, while the determinants of the government's ambition have received a great deal of research attention (in the political business cycle literature), its effect on the outcomes of M policy has not been explored in any detail.

3.5. **Optimal M and F Policy Coordination.** The above results suggest that the *relative* degrees of M and F policy conservatism, ambition, and potency may play a more important role in macroeconomic outcomes than their levels do individually.. In particular, they show that policymakers are often trying to offset the behaviour of the other policymaker which may lead to undesirable outcomes for both the policies and society. Therefore, two specific questions need to be addressed:

1) How conservative and ambitious should M and F policy be: what is the socially optimal institutional setting for these policies with respect to x_T^M, x_T^F, β^M and β^F?

2) Is this socially optimal scenario incentive compatible in a non-coordinated game in which the respective policymakers choose their policy parameters independently, or is policy coordination required? If so, is this only if the policymakers have idiosyncratic objectives or even if they are benevolent? Further, is it *'ambition-coordination'*, *'conservatism-coordination'*, or both, that can improve social welfare?

To examine these questions let us extend our game by endogenizing the four policy variables $\{x_T^M, x_T^F, \beta^M, \beta^F\}$. At the beginning of the game, in period $t = 0$, the corresponding policymakers choose simultaneously the values of their x_T^i and β^i (the timing is not crucial to the results obtained). Let us assume that all chosen $\{x_T^M, x_T^F, \beta^M, \beta^F\}$ can be observed by the opponent as well as the public before the (first period) simultaneous moves of π, π^e, and G are made.[12]

Proposition 18. *There exists infinitely many pure strategy Nash equilibria in the endogenous game, all such that* $\{x_T^{M*} = x_T^{F*} \in \mathbb{R}, \beta^{M*} \geq 0, \beta^{F*} \geq 0, \pi^*, G^*\}$. *They all yield the same, highest attainable utility to both policymakers, which is strictly greater than that of any non-Nash outcomes (pure or mixed). Since they all are some combination of* x_T^M *and* x_T^F*, ambition-coordination is optimal for both policymakers.*

Proof. It is shown in Appendix A that all pure strategy Nash equilibria are such that $x_T^{M*} = x_T^{F*} \in \mathbb{R}$, and π^* and G^* satisfy (5) - with any levels of β^M and β^F. In those Nash equilibria we therefore have $\pi^* = 0$ and $x^* = x_T^F$ from (6), and hence $u^i = 0, \forall \beta^i, \mu, \rho, i$ from (3), which is the unique maximum of $u^i, \forall i$. From the fact that (i) there exist an infinite number of pure strategy Nash equilibrium ambition levels, (ii) both policymakers are indifferent between them but prefer them to all non-Nash levels, and (iii) there exist no beliefs that would indicate any $x_T^i \in \mathbb{R}$ of the opponent to be more likely, it follows that the non-coordinated values of x_T^M and x_T^F will almost certainly differ from each other and therefore deviate from the pure strategy Nash equilibria (from a game theoretic perspective the most 'likely' non-coordinated outcome is the Nash equilibrium in mixed strategies). The fact that any $x_T^M \neq x_T^F$ is inefficient yielding $u^i < 0, \forall i$ completes the proof. □

Note that M and F policy ambition are *complements.* These results are demonstrated graphically in Figure 4b. It shows that the F policmaker's utility is maximized at the coordinated level $x_T^F = x_T^M = 1$. Figure 4a further discloses that the government's optimal size of the deficit (indicated by the dashed line) is a function of various factors

[12] Since we know that the optimal value of β^M may depend on the size of shocks (Rogoff (1985)), we will need to revisit this result in the next section where stochastic disturbances are introduced.

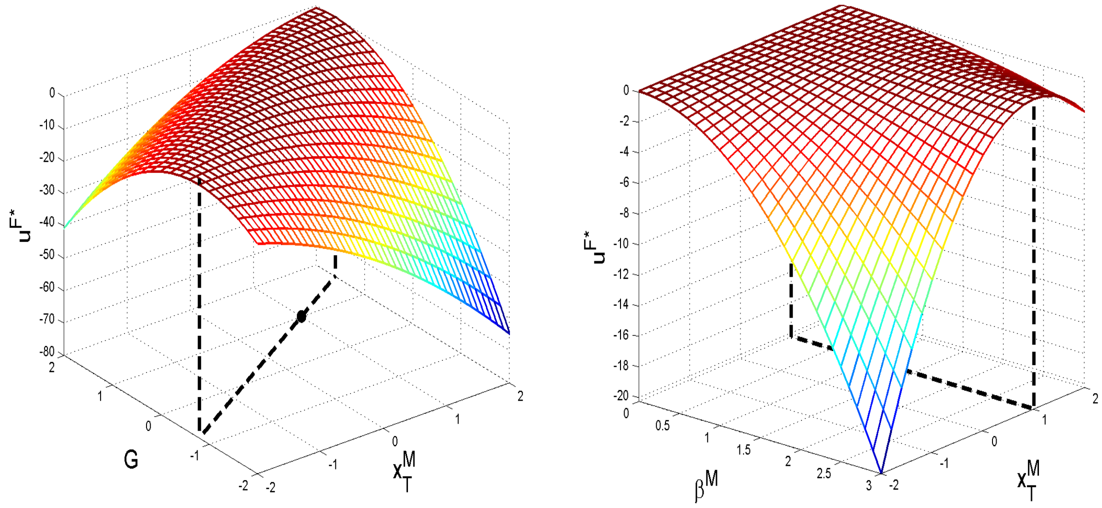

Figure 4. Equilibrium social welfare under benevolent F, $\bar{u}^* = u^{F*}$, as a function of M policy ambition x_T^M, and the deficit G (panel a) or M policy conservatism β^M (panel b); under $x_T^F = 1, \beta^M = 1, \mu = 1.5, \rho = 1$ in panel a, and $x_T^F = 1, \beta^F = 1, \mu = 1, \rho = 0.5$ in panel b.

including x_T^M (whereby the black dot agin shows the unique global maximum at $x_T^F = x_T^M = 1$).

Proposition 19. *There exists a unique socially optimal combination of the degrees of M and F policy ambition, $x_T^{M*} = x_T^{F*} = \bar{x}_T$. It belongs to the set of pure strategy Nash equilibria and is incentive compatible. Nevertheless,* ***ambition-coordination*** *may improve social welfare even if the policymakers are idiosyncratic, and coordinate on a certain combination of output targets other than the socially optimal one. In contrast,* ***conservatism-coordination*** *affects neither the utility of the individual policymakers, nor social welfare.*

Proof. See Appendix B. □

Figure 4b shows that social welfare $\bar{u}^*$ (assuming $\bar{x}_T = x_T^F$ for illustration) is maximized at the coordinated ambition level $x_T^F = x_T^M = 1$ indicated by the dashed line (this range corresponds to the black dot in Figure 4a). It is also apparent from the figure that the greater the difference $\left|x_T^F - x_T^M\right|$, the lower is social welfare.

Intuitively, coordination of M and F policy on the level of their output targets is desirable for both players as well as the society because a specific combination of x_T^M and x_T^F delivers the optimal inflation target, $\pi^* = 0$. Since M policy cannot affect the equilibrium level of average output (Proposition 15), this is the best long-run M policy setting. Thus ambition-coordination is socially optimal even if the policymakers are *not* benevolent and coordinate on an idiosyncratic output target.[13]

The case in which ambition-coordination is *not* socially optimal is one in which coordination moves the output target away from $\bar{x}_T$. This could be the case if the central bank's output target is pre-set at a level different from the socially optimal one, and the central bank has greater 'bargaining power' in the ambition-coordination process than a benevolent government (with $x_T^F = \bar{x}_T$).

While Proposition 18 shows that any value of β^M constitutes a Nash equilibrium, and Proposition 19 argues that there is no need for conservatism-coordination, it may still be the case that the value of β^M matters. Since the socially optimal β^M value may be affected by shocks, see eg Rogoff (1985), we will examine that case in the next section.

4. Extensions

This sections considers two generalizations of our baseline model and shows that all the above results carry over.

4.1. Extension 1: Shocks.

Let us incorporate a supply shock by augmenting (1):

$$x = \mu(\pi - \pi^e) + \rho g + \varepsilon, \tag{10}$$

where ε is a shock with a zero mean. For simplicity, we will provide the solution for the case of an i.i.d shock with variance σ_ε^2, but it will be apparent that all our conclusions will hold for various data generating processes including persistent shocks. As elsewhere in the literature, we will assume that the policymakers can observe the shock in real time. Nevertheless as a robustness check, we will consider a case in which this is not true for the public.

Symmetric Information. In this case the public, like the policymakers, can observe the current shock before forming expectations. The equilibrium macroeconomic outcomes analogous to (5)-(6) become the following (all are denoted by ε in the superscript)

$$\pi^\varepsilon = \beta^M(\rho - \mu)(x_T^F - x_T^M) \text{ and } G^\varepsilon = \frac{x_T^F - \varepsilon}{\rho} + \pi^\varepsilon, \tag{11}$$

$$g^\varepsilon = \frac{x_T^F - \varepsilon}{\rho} \text{ and } x^\varepsilon = x_T^F. \tag{12}$$

Asymmetric Information. In this case the public, unlike the policymakers, cannot observe the current shock before forming expectations. The equilibrium macroeconomic outcomes analogous to (5)-(6) become the following (all are denoted by $\varepsilon\varepsilon$ in the superscript)

$$\pi^{\varepsilon\varepsilon} = \beta^M(\rho - \mu)(x_T^F - x_T^M) \text{ and } G^{\varepsilon\varepsilon} = \pi^{\varepsilon\varepsilon} - \frac{1 + \beta^M \rho(\rho - \mu)}{\rho\left[1 + \beta^M(\rho - \mu)^2\right]}\varepsilon, \tag{13}$$

[13] Economic theory identifies two main reasons for $x_T^F \neq \bar{x}_T$. First, the presence of naïve voters and other political economy features often seem to lead governments to be excessively ambitious (short termism). Second, since x_T^F is affected by various F policy settings that are legislated - eg health, welfare and pension schemes - there may be significant persistance in the value of x_T^F across subsequent governments.

$$g^{\varepsilon\varepsilon} = \frac{x_T^F}{\rho} - \frac{1+\beta^M \rho(\rho-\mu)}{\rho\left[1+\beta^M(\rho-\mu)^2\right]}\varepsilon \text{ and } x^{\varepsilon\varepsilon} = x_T^F. \tag{14}$$

Let us first revisit our results reported above in the presence of shocks.

Proposition 20. *The average levels of $\{\pi, G, g, x\}$ in both the symmetric and asymmetric cases are equivalent to those of our baseline deterministic model in Section 3. Therefore, interpreting all references to $\{\pi, G, g, x\}$ therein as average (long-run, trend) levels, Propositions 1-19 hold even in the presence of shocks.*

Proof. Comparison of (5)-(6) with (11)-(12) and (13)-(14) shows that the deterministic components of all four macroeconomic variables coincide across the three settings. □

The following propositions report some additional results implied by (11)-(14).

Proposition 21. *The stabilization (cyclical) outcomes of π and x are unaffected by neither policies' ambition, conservatism, nor potency, and this is regardless of the public's information about the shock, and even if both policies have optimally responded to the shock.*

Proof. The inspection of (11)-(14) shows that the stochastic ε components of π and x is not a function of $\{x_T^i, \beta^i, \mu, \rho\}$ in either the symmetric or asymmetric case. It is straightforward to check that both players' reaction functions include the shock.[14] □

This result, among others, calls the conventional conclusions of the Barro-Gordon model without F policy into question. In the conventional model, the central banker's private information necessarily leads to an improvement in stabilization as it may be exploited to surprise the public (see Cukierman and Meltzer (1986) and the subsequent literature). Here, by contrast, stabilization in the presence of fiscal policy is equivalent in the symmetric and asymmetric cases.

Let us now consider the optimal choice of β^M.

Proposition 22. *Even in the presence of shocks, and regardless of whether or not the public can observe them in real time, it is socially optimal to appoint an* ***ultra-conservative*** *central banker, $\beta^{M*} = 0$. Such extreme degree of conservatism is optimal (incentive compatible) not only for the central banker of any ambition, but also for a government of any type (including those that are over-ambitious and strongly dislike output variability). The welfare benefits of this appointment increase in the degree of ambition mis-coordination.*

[14]The F and M policy reaction functions are the following:

$$G^{\varepsilon} = \frac{x_T^F - \varepsilon}{\rho} + \pi \text{ and } G^{\varepsilon\varepsilon} = \frac{\left[1+\beta^M\rho(\rho-\mu)\right]\left[\pi(\rho-\mu)+x_T^F-\varepsilon\right] - \mu\beta^M(\rho-\mu)x_T^M}{\rho\left[1+\beta^M(\rho-\mu)^2\right]},$$

$$\pi^{\varepsilon} = \bar{\pi} - \frac{\beta^M(\mu-\rho)}{1+\beta^M\rho(\rho-\mu)}\varepsilon \text{ and } \pi^{\varepsilon\varepsilon} = \bar{\pi} - \frac{\beta^M(\mu-\rho)}{1+\beta^M(\rho-\mu)^2}\varepsilon,$$

where $\bar{\pi}_t = \frac{\beta^M(\mu-\rho)(x_T^M - \rho G_t)}{1+\beta^M\rho(\rho-\mu)}$. This also shows that, unlike in the deterministic and symmetric scenarios, under information asymmetry G may be a strategic complement to (or independent of) π.

Proof. Let us start claim (i) by noting that an ultra-conservative central banker, $\beta^M = 0$, ensures inflation on target for all three scenarios, in all periods, and for any degree of the policies' ambition and size of the shock. Formally, under $\beta^M = 0$ we have $\pi^* = \pi_t^\varepsilon = \pi_t^{\varepsilon\varepsilon} = 0, \forall t, x_T^i, i, \sigma_\varepsilon^2$ from (5), (11), and (13) respectively. Since the equilibrium levels of inflation and output in all three cases, $\{\pi^*, x^*, \pi_t^\varepsilon, x^\varepsilon, \pi_t^{\varepsilon\varepsilon}, x^\varepsilon\}$, are independent of the shock, this increases the utility of both policymakers $(\forall x_T^i, i, \beta^F, \sigma_\varepsilon^2)$ as it brings average inflation closer to the target without compromising the ability to stabilize outcomes or increasing the variability of inflation and output. Welfare benefits increase in the degree of ambition mis-coordination is implied by the fact that under $x_T^F \neq x_T^M$ we have $|\pi^*|$ increasing - and $\bar{u}$ decreasing - in the difference $\left|x_T^F - x_T^M\right|$. □

This result is graphically demonstrated in Figure 4b. It shows that $\bar{u}^*$ (assuming $\bar{x}_T = x_T^F$) is, for any x_T^F and x_T^M, maximized if $\beta^M = 0$. The optimality of $\beta^M = 0$ for all parties is natural in the deterministic case as there are no shocks to be stabilized. It is however somewhat surprising in the symmetric case, and even more so in the asymmetric case, in which the policymakers can exploit their private information about the shock. In both cases, this is because in the presence of two policy instruments the shocks can be stabilized more effectively than with M policy alone.

Let us now contrast the findings to those of Rogoff (1985) that does not include F policy. In his analysis (of the asymmetric case), it is socially optimal to appoint a conservative central banker, $\beta^{M*} < \beta^F$, but there are two qualifications, both of which are brought into question by our analysis. First, in Rogoff's framework the $\beta^{M*} < \beta^F$ result does not obtain under a responsible central banker (in which case $\beta^{M*} = \beta^F$). Second, in Rogoff's framework it is *not* optimal to appoint an ultra-conservative central banker, ie $\beta^{M*} > 0$. Contrast to this, our analysis shows that in the presence of F policy $\beta^{M*} < \beta^F$ may obtain even under $x_T^M = 0$, and that $\beta^{M*} > 0$ may not hold. Both of these qualifications are due to the fact that in our framework the danger of an inflation bias comes from not only M policy, but also F policy. Therefore, more stringent institutional measures may be required.

Remark 3. *The government has two substitute (but not mutually exclusive) ways of maximizing social welfare and ensuring credibility in the inflation target:*
1) appoint an ultra-conservative central banker, $\beta^M = 0$*, and/or*
2) coordinate with a central banker (of any β^M*) on their output targets (ambitions).*
Since option 2) may be perceived as conflicting with central bank independence, and harder to implement due to the difficulty of measuring a time varying natural rate of output,[15] *option 1) may be preferable.*

These findings seem to be consistent with the observed trends towards more independent and conservative M policy around the globe during the past three decades, and the emergence of explicit inflation targeting. Given that independent central bankers are commonly responsible, $x_T^M = 0$, it may be hard for the government to coordinate on an over-ambitious (and politically driven) output target. Therefore, the government is more likely to use the first option; appoint an ultra-conservative central banker, and

[15] See for example Orphanides (2001).

still pursue its over-ambitious output goals through F policy (Demertzis et al (2004)). The fact that the majority of industrial countries (i) achieve their inflation targets with some precision, and (ii) still run budget deficits on average, is consistent with this interpretation.

4.2. **Extension 2: Contractionary Deficits.** As the presence of the shock was shown not to alter our results, recall Proposition 20, let us revert to our deterministic environment. Extend the Lucas supply function as follows

$$x = \mu(\pi - \pi^e) + \rho g + \tau G, \tag{15}$$

where the parameter $\tau \in \mathbb{R}$ expresses the potency of *nominal-F* policy (as opposed to the potency of *real-F* policy ρ). This enables us to better consider (i) a contractionary as well as an expansionary effect of a budget deficit and (ii) an asymmetry in the effect of fiscal policy. The equilibrium macroeconomic outcomes analogous to (5)-(6) become the following (all are denoted by τ in the superscript)

$$\pi^\tau = \beta^M(\rho - \mu)(x_T^F - x_T^M) \text{ and } G^\tau = \frac{x_T^F + \rho\beta^M(\rho - \mu)(x_T^F - x_T^M)}{\rho + \tau} \text{ and} \tag{16}$$

$$g^\tau = \frac{x_T^F - \tau\beta^M(\rho - \mu)(x_T^F - x_T^M)}{\rho + \tau} \text{ and } x^\tau = x_T^F. \tag{17}$$

The following generalization is then implied.

Proposition 23. *The equilibrium inflation and output levels under the generalized supply function (15) are equivalent to those of the deterministic, symmetric, and asymmetric scenarios. Therefore, all results of Propositions 1-19 regarding π and x hold for all $\tau \in \mathbb{R}$.*

Proof. By inspection of (16)-(17). □

This shows that our main results are robust to the specification of F policy. Perhaps most surprisingly, the finding of Proposition 13 (about output persistently deviating from the natural rate) may still obtain. Specifically, an output level that is permanently above the natural rate, $x^\tau > 0$, can be achieved even under negative values of τ, that is even if an expansionary F policy (deficits) would have a contractionary effect. This is because in such cases the F policymaker would find it optimal to run surpluses, $G^\tau < 0$, that have a stimulatory effect on the economy.

5. Summary and Conclusions

The interactions between fiscal and monetary policies are both important and complex, even if we abstract from differences in the policies' timing or reputations. One of the reasons behind the complexity is that macroeconomic outcomes depend on the spillovers from each policy onto the targets to which they are not principally assigned.[16] And this is why, even if the policies are politically and consitutionally independent, they are inter-dependant - their optimal setting is a function of the other policy's setting.

[16]The received position is that the Central Bank should control inflation and be independent of outside forces (political pressures in particular), and that national fiscal policies should be left free to account for and address the remaining targets of economic policy.

Such inter-dependence implies a role for policy coordination, which the paper examines in detail. It finds, rather surprisingly, that while coordination in terms of policy ambition (targets) is crucial, coordination in terms of conservatism (priorities) is not. This is true even if the policymakers' objectives are idiosyncratic, and the coordinated output targets (as well as the resulting actual output level) differ from the socially optimal one.

The fact that there exist multiple policy settings that maximize the policymakers' utility, all equally preferred by both policymakers, implies a different kind of coordination to the one examined in the existing literature. We argue that optimal coordination may be more a matter of information exchanges between the policymakers (about the natural rate of output) than direct, competative and discretionary negotiations over the details of each policy choice.

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Appendix A. Proof of Proposition 18

Proof. Solving by backwards induction, the Nash equilibrium values of inflation and output are those derived in Section 3 under exogenous ambition and conservatism parameters. They were reported in (5)-(6). Moving backwards, substitute these into the players' utility functions and differentiate them with respect to the degree of M and F ambition respectively to obtain

$$\frac{\partial u^{M*}}{\partial x_T^M} = 2\beta^M(x_T^F - x_T^M) + 2\left[\beta^M(\rho-\mu)\right]^2(x_T^F - x_T^M),$$

$$\frac{\partial u^{F*}}{\partial x_T^F} = -2\left[\beta^M(\rho-\mu)\right]^2(x_T^F - x_T^M).$$

Setting equal to zero and rearranging implies that the non-coordinated Nash equilibria obtain for any $x_T^{M*} = x_T^{F*} \in \mathbb{R}$. For the rest of the proof see the main text. □

Appendix B. Proof of Proposition 19

Proof. Substitute the equilibrium values from (5) and (6) into the social welfare function (which is (3) with β^F and $\bar{x}_T$) and differentiate with respect to the degree of M and F ambition respectively to obtain

$$\frac{\partial \bar{u}^*}{\partial x_T^M} = 2\left[\beta^M(\rho-\mu)\right]^2(x_T^F - x_T^M),$$

$$\frac{\partial \bar{u}^*}{\partial x_T^F} = -2\beta^M(x_T^F - \bar{x}_T) - 2\left[\beta^M(\rho-\mu)\right]^2(x_T^F - x_T^M).$$

Setting equal to zero and rearranging implies that the unique social welfare maximum obtains under $\bar{x}_T^{M*} = \bar{x}_T^{F*} = \bar{x}_T$. As this is one of the pure strategy Nash equilibria reported in Proposition 18 and which deliver the highest attainable utility to both players, it is incentive compatible. Whether or not ambition-coordination improves social welfare when $x_T^{M*} = x_T^{F*} \neq \bar{x}_T$ will depend on the levels of x_T^i chosen in its presence and absence. The proof of Proposition 18 explained that there can be no unique outcome in the former case, and the same is true in the latter (even though the set of possible outcomes under ambition-coordination is smaller, it is still infinite). Nevertheless, it is obvious that there exist a range of circumstances under which ambition-coordination is a case in point. It improves social welfare even if the coordinated ambition levels do not coincide with the socially optimal one. For example, the case in which policymakers coordinate on an output target that would have been chosen by F even in the absence of ambition-coordination. It then follows from (6) that (i) the output outcome of ambition-coordination and non-coordination are equivalent, but (ii) the inflation outcomes differ, in that under ambition-coordination we have $\pi^* = 0$ and without ambition-coordination we have $\pi^* \neq 0$. The proof of Proposition of 18 then implies $\bar{u} = 0$ and $\bar{u} < 0$ respectively.

In terms of conservatism-coordination, its redundancy is implied by the fact that β^F does not affect any macroeconomic variables, see Proposition 17(i). Therefore, the combination of β^M and β^F plays no role either. □