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# Fiscal and monetary interaction under monetary policy uncertainty\*

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## Abstract

Despite the increasing number of studies on monetary policy uncertainty, its role on the strategic interaction between fiscal and monetary policies has not been fully explored. Our paper aims to fill this gap by evaluating the consequences produced by multiplicative uncertainty in such a context.

**J.E.L. Classification:** E61, E63.

**Keywords:** Monetary-fiscal policy interactions, parameter uncertainty, symbiosis.

## 1. Introduction

Nowadays one of the most important challenges for policymakers, in particular monetary authorities, is how to deal with uncertainty (Lane, 2003). In a public speech, Alan Greenspan (2003) observed that “uncertainty is not just an important feature of the monetary policy landscape; it is the defining characteristic of that landscape.” Central bankers face in fact a tremendous uncertainty about the state of the economy, its true structure and the impact policy actions have on the economy as “uncertainty – about the state of the economy, the economy’s structure, and the inferences that the public will draw from policy actions or economic developments – is a pervasive feature of monetary policy making,” in the words of another Fed Chairman, Ben Bernanke (2007).<sup>1</sup> Bernanke’s speech also emphasizes that uncertainty may assume different forms. These can be summarized in model, parameter and data uncertainty.<sup>2</sup>

Many studies have recently revised the robustness of the optimal monetary policy prescriptions in the face of uncertainty. Among them some have attempted to highlight the importance of multiplicative or parameter uncertainty, i.e., when policymakers are uncertain about the structural parameters of the economy.<sup>3</sup> The interest on this kind of uncertainty is however old. About forty years ago, Brainard (1967) showed that multiplicative uncertainty affects policymakers’ behavior and makes them more cautious, in the sense that they react less sharply to disturbances. By

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<sup>1</sup> Similar citations can be found in the public speeches of many other central bankers and in monetary authorities’ operative meetings – e.g., “as a consequence of greater uncertainty – the second feature resulting from global economic integration – monetary policy formulation and implementation is more challenging, complex and demanding” (Solans, member of the executive board of the ECB, 2000) or “participants noted the considerable uncertainty surrounding estimates of the output and unemployment gaps and the extent of their effects on prices.” (FOMC minutes, June 23-24, 2009).

<sup>2</sup> See Dennis (2005) for a clear definition of this taxonomy.

<sup>3</sup> See Estrella and Mishkin (1999), Hansen and Sargent (2004), Onatski and Williams (2003), Peersman and Smets (1999), Svensson (1999), Rudebusch (2001, 2002), Giannoni (2002), Söderström (2002), Lawler (2002), Schellekens (2002), Walsh (2003), Castelnuovo and Surico (2004), Orphanides and Williams (2005), Gurkaynak *et al.* (2005).

considering a linear quadratic context, Brainard (1968) shows that caution may be optimal because, in the presence of random multipliers, policy itself injects uncertainty into the economy. Aggressive policy moves which might otherwise (under certainty or certainty equivalence)<sup>4</sup> offset disturbances, excess inflation, for example, can trigger further uncertainty via policy changes. Thus, when policymakers are unsure of the impact of their policy it would be preferable for them to adjust policy more cautiously and gradually; this is in summary Brainard's conservatism principle.<sup>5</sup>

Despite the increasing number of studies, the role of uncertainty in strategic contexts, in particular in the interactions between fiscal and monetary policies, has not been fully explored, although its empirical relevance has been emphasized.<sup>6</sup> Our paper tackles this issue by focusing on the effects of model uncertainty on the strategic interaction between fiscal and monetary authorities. Our aim is to evaluate the consequences produced by multiplicative uncertainty in a class of policy games recently developed by Dixit and Lambertini (2001, 2003a, 2003b) – D&L from now onward. We test under parameter uncertainty some of D&L's prescriptions.

D&L's models are particularly attractive for our investigations as they consider both fiscal and monetary policies in a strategic but simplified New Keynesian framework and a non-linear structure for shocks on the basis of which the private sector forms its expectation. Hence they are appropriate to study policy interactions from our perspective.<sup>7</sup> In their models policymakers do however not face any uncertainty as they observe all the shocks. Under this assumption D&L (2003b) show that if fiscal and monetary authorities share identical output and inflation targets, but not necessary equal trade-offs between these objectives (symbiosis assumption), ideal output and inflation can be always achieved.<sup>8</sup> We instead assume that through some process of theorizing and data analysis, policymakers have arrived at a reference model of the economy. They want to use this model to set policy, but are concerned about uncertain deviations from it. In particular, similarly to Lawler (2006),<sup>9</sup> we assume uncertainty about the parameters of the monetary policy effectiveness: the central bank does not exactly know the value of some parameters but knows the distribution from which they were drawn.<sup>10</sup>

Our main findings are the following: D&L's symbiosis result no longer holds under unknown multiplicative shocks on monetary policy effects. Monetary uncertainty is not symmetric to the fiscal one, as the former may induce either more or less aggressive effects on the final outcomes according to the kind of existing interaction between the government and the central bank. Finally multiplicative uncertainty implies an endogenous Phillips relationship between inflation and output.

The rest of the paper is organized as follows. The next section describes our benchmark model when shocks are observed. In section 3 we study the effects of multiplicative uncertainty on monetary policy effectiveness by assuming that policymakers may be not perfectly informed about all the shocks. A final section concludes.

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<sup>4</sup> In this context, it is well known that additive shocks do not affect optimal policy.

<sup>5</sup> This principle has been challenged by some economists. Walsh (2003), e.g., shows that it does not obtain if the monetary authorities put no negligible weight on interest rate stabilization. In this case the central bank needs to act aggressively in order to neutralize the impact of demand shocks on output. See also Giuli (2010) for the case of Knightian uncertainty.

<sup>6</sup> See e.g. Lane (2003), De Grauwe and S negasb (2006) and references therein.

<sup>7</sup> However, note that the model does not explicitly include interest rates and public debt. Thus, it does not consider important channels of interaction, e.g., the possibility of fiscal dominance. See e.g. Bajo-Rubio *et al.* (2009).

<sup>8</sup> D&L (2001) also discuss the different results which obtain when symbiosis does not hold.

<sup>9</sup> Who, however, focuses on the interaction between the central bank and the private sector (unions) under monetary policy uncertainty.

<sup>10</sup> The empirical relevance of parameter uncertainty for monetary policy has been emphasized, among others, by Sack (1998), Sack and Wieland (1999), Batini *et al.* (1999), and Tetlow (2000).

## 2. The economic benchmark

We consider the extension of D&L (2003b)<sup>11</sup> to multiplicative uncertainty for policymakers developed in Di Bartolomeo *et al.* (2009), where the focus is only on fiscal policy uncertainty. The model is described by two elements: the policymakers' losses and the structure of the economy. We assume that policymakers play simultaneously (Nash equilibrium).

The policymakers' expected losses depend on deviations of inflation  $\pi$  and real output  $y$  from some common targets,  $\pi^*$  and  $y^*$  (i.e., the symbiosis assumption). Formally, government's ( $L_G$ ) and central bank's ( $L_B$ ) preferences are:

$$L_i = E \left[ \frac{1}{2} (\pi - \pi^*)^2 + \frac{\theta_i}{2} (y - y^*)^2 \right] \text{ for } i \in \{G, B\} \quad (1)$$

where  $E$  denotes the expectation operator;  $\theta_G$  and  $\theta_B$  are their marginal rates of substitution between inflation and real output deviations from the targets. We assume a conservative central banker (i.e.,  $\theta_B \leq \theta_G$ ) – see e.g. Rogoff (1985) and Lambertini (2004).

The economy consists of a Lucas type supply equation and a simple demand equation:

$$y = \bar{y} + b(\pi - \pi^e) + ax \quad (2)$$

$$\pi = \varepsilon\pi_0 + \mu cx \quad (3)$$

where  $\pi^e$  is inflation expected by the private sector, and  $x$  and  $\pi_0$  are fiscal and monetary policy instruments. As usual, due to distortions in the good markets, the natural level of real output ( $\bar{y}$ ) is considered too low from a social point of view, i.e.  $y^* > \bar{y}$ . Real output can deviate from the natural level because of the supply effect of surprise inflation ( $\pi - \pi^e$ ) and of the direct effect of the fiscal instrument on real output which can be either positive, for Keynesian demand effects, or negative, for crowding out effects; the algebra of the model is however the same in the two cases. Both the fiscal and the monetary policy instruments affect the level of inflation (see equation (3)).<sup>12</sup> Without loss of generality for our scope, we assume  $b > 0$ ,  $c > 0$  and  $a > 0$ .<sup>13</sup>

Our benchmark is quite standard, apart from the fact that we introduce policy uncertainty by assuming that policymakers can be unable to fully know the effectiveness of their instruments. We in fact assume unobserved shocks to fiscal and monetary policy effectiveness, i.e.  $\mu \sim (1, \sigma_\mu^2)$  and  $\varepsilon \sim (1, \sigma_\varepsilon^2)$ .<sup>14</sup>

By minimizing the government's and the central bank's losses with respect to the fiscal and monetary instrument, respectively, subject to equations (2) and (3), we obtain the following first order conditions:

<sup>11</sup> We only consider the one-country version of D&L (2003b); however, our results can be easily extended to a monetary union (for a discussion, see Lambertini, 2004).

<sup>12</sup> This may be due to the fact that the central bank is, in practice, forced to accommodate fiscal expansion to some extent, or to a change in the equilibrium price of goods depending on the balance between the effects of fiscal policy on aggregate demand and on costs, produced by changes in tax distortions or in public investment. Thus  $c$  can be either positive or negative.

<sup>13</sup> See D&L (2003a, 2003b) for an extensive discussion about the model and its derivation.

<sup>14</sup> For similar specifications, see, among others, Letterie (1997), Pearce and Sobue (1997), Lawler (2002, 2006) and Schellekens (2002).

$$E\left[\mu c(\pi - \pi^*) + (a + \mu cb)\theta_G(y - y^*)\right] = 0 \quad (4)$$

$$E\left[\varepsilon(\pi - \pi^*) + \varepsilon b\theta_B(y - y^*)\right] = 0 \quad (5)$$

As shown by D&L (2003b), if the (multiplicative) shocks are perfectly observed by both policymakers, equations (4) and (5) imply that they always obtain their common targets  $(\pi^*, y^*)$ .<sup>15</sup> The framework, however, encompasses two different cases, even under perfect information (or on average if shocks are considered). As the common output target is larger than the natural output and fiscal policy is inflationary, the fiscal attempts to increase output above its natural value will always produce inflation. Thus, if the inflation target is zero (or small), the expansionary fiscal policy ( $x > 0$ ) must be supported by a restrictive monetary one ( $\pi_0 < 0$ ) in order to achieve the common targets. By contrast, if the common inflation target is particularly large ( $\pi^* > \frac{c}{a}(y^* - \bar{y})$ ), the expansionary fiscal policy will be supported by a monetary expansion.<sup>16</sup> We refer to the former case as the deflationary monetary regime and to the latter as the inflationary one. It is worth noticing that, in D&L's (2003b), monetary policy ( $\pi_0$ ) can be deflationary or inflationary, but inflation is always equal to  $\pi^*$ .

### 3. Shocks and symbiosis

Now we focus on the case of uncertainty on monetary policy effect, while fiscal policy is assumed to be known with certainty, i.e.,  $\mu = 1$  and  $\varepsilon \sim (1, \sigma_\varepsilon^2)$ .<sup>17</sup> The first order conditions (4) and (5) become:

$$E(y) - y^* = -\frac{c}{\theta_G(a + bc)}(E(\pi) - \pi^*) \quad (6)$$

$$E(\pi) - \pi^* = -\theta_B b(E(y) - y^*) - \sigma_\varepsilon^2 \pi_0(1 + \theta_B b^2) \quad (7)$$

since  $E(\varepsilon^2) = 1 + \sigma_\varepsilon^2$ .

By solving equations (6) and (7) we obtain the optimal policy rules for the government and the central bank:<sup>18</sup>

$$x = -\frac{a(ac + bA_1)\theta_G}{A_1^2 + c^2 a^2 \theta_G} \pi_0 + \frac{abA_1\theta_G \pi^\varepsilon}{A_1^2 + c^2 a^2 \theta_G} + \frac{a\theta_G[ca\pi^* + (y^* - \bar{y})A_1]}{A_1^2 + a^2 c^2 \theta_G} \quad (8)$$

$$\pi_0 = -\frac{c + b(a + cb)\theta_B}{(1 + \sigma_\varepsilon^2)A_0} x + \frac{\theta_B b^2 \pi^\varepsilon}{(1 + \sigma_\varepsilon^2)A_0} + \frac{\pi^* + \theta_B b(y^* - \bar{y})}{(1 + \sigma_\varepsilon^2)A_0} \quad (9)$$

where  $A_0 = (1 + \theta_B b^2)$ ,  $A_1 = a(a + bc)\theta_G > A_2 = A_1 - abc\theta_B > 0$ .

<sup>15</sup> It is worth noticing that the introduction of unobserved additive shocks would not affect the optimal policies set under certainty (and thus average outcomes), because of the linear-quadratic nature of the game – certain equivalence would hold in this case. See Holly and Hughes Hallett (1989) for more details.

<sup>16</sup> See D&L's (2003a, 2003b) or Di Bartolomeo *et al.* (2009) for more details.

<sup>17</sup> Fiscal policy uncertainty has been studied in Di Bartolomeo *et al.* (2009).

<sup>18</sup> Equations (8) and (9) are the reaction functions given the private sector expectations, which are already formed when policymakers move. We determine expectations by backward induction.

The government supports expansionary policies to contrast the output gap or expected inflation and reacts to monetary policy by reducing the fiscal stance. The intuition is straightforward. If the economy is stabilized by the monetary authority, the government is more likely to be inactive, whereas greater distortions call for sharper fiscal activism. The central bank has a similar, but symmetric, behavior. Note that higher inflation expectations and wider gaps between natural and desired output ( $y^* - \bar{y}$ ) call for more aggressive policies.

Uncertainty makes the central bank reaction function flatter, meaning that the monetary authority is more cautious in reacting to the other variables and, therefore, in stabilizing the economy as result of Brainard's conservatism principle. By contrast, the reaction of the government does not depend on  $\sigma_\varepsilon^2$  as it is not affected by uncertainty.

By applying rational expectations to equations (8) and (9) and solving them, we obtain the following Nash equilibrium

$$x = \frac{A_0 \left( ac\pi^* - A_1 (y^* - \bar{y}) \right) \sigma_\varepsilon^2 - A_2 (y^* - \bar{y})}{a \left( A_0 \left( A_1 + c^2 \right) \sigma_\varepsilon^2 + A_2 \right)} \quad (10)$$

$$\pi_0 = \frac{A_2 \left[ \pi^* - \frac{c}{a} (y^* - \bar{y}) \right]}{A_0 \left( A_1 + c^2 \right) \sigma_\varepsilon^2 + A_2} \quad (11)$$

By using (10) and (11) into (2) and (3) we obtain the expected (or average) equilibrium values for output and inflation expressed as gaps from desired values (the superscript  $N$  denotes the Nash equilibrium):

$$E(y^N) - y^* = \frac{acA_0 \left[ \pi^* - \frac{c}{a} (y^* - \bar{y}) \right]}{A_0 \left( A_1 + c^2 \right) \sigma_\varepsilon^2 + A_2} \sigma_\varepsilon^2 \quad (12)$$

$$E(\pi^N) - \pi^* = - \frac{A_1 A_0 \left[ \pi^* - \frac{c}{a} (y^* - \bar{y}) \right]}{A_0 \left( A_1 + c^2 \right) \sigma_\varepsilon^2 + A_2} \sigma_\varepsilon^2 \quad (13)$$

Equations (12) and (13) emphasize the biases emerging from multiplicative uncertainty.<sup>19</sup> In D&L (2003a) they are both zero. Moreover, differently from D&L (2003a), the monetary regimes matter as they determine the sign of the biases. In the deflationary regime, monetary policy is not restrictive enough; a positive inflation bias and a negative output gap will thus be observed. Output is lower than the desired one as the cost of using the fiscal instrument is high because the central bank does not accommodate fiscal expansions. In the inflationary regime, the central bank continues not to accommodate fiscal expansions, but now through expansionary policies. Yet, monetary policy is not expansionary enough: a negative inflation bias and a positive output gap will then be observed.

We can summarize our main results in three propositions.

**Proposition 1.** Under multiplicative uncertainty, the symbiosis assumption no longer guarantees the achievement of ideal output and inflation when policy-makers attempt to achieve a level of output which is higher than the natural one, or target an inflation different from zero.

**Proof.** See equations (12) and (13).

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<sup>19</sup> It is worth noticing that the nature of these biases may change according to the transmission mechanisms of fiscal policy which is considered (i.e. the sign of  $a$  and  $c$ ). They never however disappear.

The result stemming from the above proposition derives from a coordination problem related to multiplicative uncertainty and the conflict between the policymakers that it implies. In the full information case, in fact, the common targets are always obtained (even if a cooperative solution is not considered) and there are no coordination problems. This occurs since there exists only one combination of policies that leads to those shared targets. By contrast, when we consider multiplicative uncertainty, outcomes are random and a conflict among policymakers emerges. Average outcomes are optimal for the fiscal authority that does not perceive any uncertainty, but they are suboptimal for the central bank as the costs of deviating from the optimal policy under certainty are now asymmetric. Thus achieving the common targets on average is no longer a common objective for the policymakers and a contrast among them arises. The conflict also implies that the Nash equilibrium is no longer efficient and coordination among policy-makers is needed.

Our result is rather general since it is robust with respect to different shock structures and to the order of moves (i.e., game timing).<sup>20</sup> In particular, the symbiosis assumption is not sufficient to guarantee the achievement of ideal outcomes for all the possible forms of multiplicative uncertainty (irrespective of parameter signs). The only exception is a shock on the semi-elasticity of the inflation surprise term (i.e., a shock on parameter  $b$  in equation (2)). In fact, even if policymakers observe all the shocks, they are not able to use inflation surprise in order to affect the average outcomes (in equilibrium expected inflation surprise is always zero as this policy is always anticipated by the private sector). Thus, if policymakers are able to achieve the common ideal outcomes in the D&L (2003)'s information set, they must be able to do so also if the effects of inflation surprise are subject to uncertainty. In other words, this shock does not prevent the policymakers' common ideal outcomes from being achieved on average as inflation surprise is not used to this aim.

Our results related to the monetary regimes and the monetary stance are summarized in the following proposition.

**Proposition 2.** Uncertainty leads to more (or less) expansionary monetary policies depending on the monetary regime that emerges under the perfect information (or the certainty equivalent) case. More in details, in the deflationary (inflationary) regime where expansionary fiscal policy must be supported by a restrictive (expansionary) monetary one, optimal monetary policy under multiplicative uncertainty is more (less) expansionary than in the certainty equivalent case.

**Proof.** Differentiate equation (11) with respect to  $\sigma_\varepsilon^2$ .

This result is apparently surprising as it is expected that multiplicative uncertainty should always lead to less aggressive policies. However, the result is just an application of Brainard's conservatism principle. In fact, if the inflation target is high ( $\pi^* > \frac{c}{a}(y^* - \bar{y})$ ), optimal monetary policy leads to the standard Barro & Gordon's inflationary equilibrium under perfect information. Therefore, uncertainty leads to the expected results of lower inflation by mitigating the expansionary monetary policy. By contrast, when  $\pi^* < \frac{c}{a}(y^* - \bar{y})$ , the full information equilibrium implies deflation. As a consequence, Brainard's conservative principle calls for more expansionary policy (i.e., less deflationary). Results are thus not surprising at all.

Proposition 2 stresses that the effects of multiplicative uncertainty on the policymakers' objectives depend not only on the sources of uncertainty, but also on the existing kind of interactions among them (i.e., the policy regime). In other words, in a single decision maker context, model parameterization only accounts for the strength, but not for the sign, of Brainard's moderation

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<sup>20</sup> For the sake of brevity, here robustness is only discussed in informal terms. Further analytical results are available upon request from the authors.



effect; in policy games it determines also the direction of such moderation as the “signs” of policies are endogenous and depend on the policy regime. This result qualifies the role of uncertainty in the debate on the subject matter.

Regarding the robustness of this result, differently from Proposition 1, our statement applies only to monetary policy uncertainty. In fact, as showed in Di Bartolomeo *et al.* (2009), in the same context, multiplicative uncertainty on fiscal policy always leads to policy attenuation in the use of the fiscal instrument and to more expansionary monetary policy.

Finally, regarding policy implications, uncertainty induces an equilibrium relationship between the objective variables which is described by the following proposition.

**Proposition 3.** Multiplicative uncertainty implies an endogenous relationship between the objective variables that resembles a Phillips curve menu, i.e. an increase in policy-makers’ desired output raises both output and inflation – and vice versa.

**Proof.** By cumbersome algebra, differentiating (12) and (13), it is easy to derive that the sign of  $\frac{\partial \pi}{\partial y^*}$  is always the same of  $\frac{\partial y}{\partial y^*}$ .

The above proposition asks for a qualification. In the realm of policy games, policies cannot be examined *ex ante* as they are endogenously determined from players’ preferences, information sets and interactions (i.e., model constraints);<sup>21</sup> thus a Phillips menu cannot be explicitly defined. It can be however described in terms of changes in policymakers’ preferences. Thus, we refer to a Phillips menu as the fact that *coeteris paribus* an increase in the common output target implies that output rises in equilibrium, as desired by the policymakers, but inflation increases too. The same can be said by considering a change in the common inflation target; e.g., to reduce the inflation target after an exogenous change in their preferences, policymakers must accept a cost in terms of output reduction.

The Phillips relationship derives from the fact that multiplicative uncertainty implies deviations from full-information optimal monetary policy which in turn depends on desired inflation and output. This relationship is peculiar of monetary policy uncertainty as it does not emerge in the case of fiscal policy. Multiplicative uncertainty on fiscal policy implies that expected output is given by a weighted average of  $y^*$  and  $\bar{y}$ , but it is not related to  $\pi^*$ . This occurs because, differently from monetary policy, under full information optimal fiscal policy does not depends on  $\pi^*$  (see Di Bartolomeo *et al.*, 2009).

#### 4. Conclusions

This paper has extended a well-known model of fiscal-monetary interactions to the case in which policymakers face uncertainty on the effects of their policies. A more general stochastic structure than the additive one implies that uncertainty may be no longer neutral (for average outcomes) and may lead to different results and policy implications from those stemming in the certain equivalence case.

Summarizing, our main findings are as follows. The D&L’s symbiosis result no longer holds under unknown multiplicative shocks on monetary policy effects. Monetary uncertainty and fiscal uncertainty are not symmetric, as only the former may induce both more and less aggressive effects on the final outcomes according to the kind of existing interaction between the government and the central bank.<sup>22</sup> Finally, multiplicative uncertainty implies an endogenous Phillips relationship

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<sup>21</sup> See, for a discussion, Acocella and Di Bartolomeo (2004).

<sup>22</sup> In the same context, fiscal uncertainty always implies more conservative fiscal policy and more expansionary

between inflation and output which does not emerge under fiscal uncertainty.

Two different regimes can emerge which imply different outcomes and properties. Our result can thus potentially explain the conflicting empirical evidence on the sign and magnitude of the effects of inflation uncertainty and economic activity.<sup>23</sup> Given the relevance of central bank's time-varying inflation targets to explain economic dynamics stressed by recent studies,<sup>24</sup> we emphasize that the effectiveness of monetary policy under uncertainty may be related to the time varying targeting policy and the fiscal stance, and that empirical evidence should take account of these factors in order to fully understand the real effect of inflation uncertainty.

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monetary policy.

<sup>23</sup> See e.g. Holland (1993), Davis and Kanago, (1996), Cunningham *et al.* (1997), Grier and Perry (2000), Elder (2004) and Caporale *et al.* (2009).

<sup>24</sup> See, among others, Ireland (2007), Stock and Watson (2007), Cogley and Sbordone (2008), Leigh (2008), Castelnuovo (2009) and Cogley *et al.* (2010).

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