

# Output contracts for central banks in a monetary union: a way out of the deflation bias

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## **Abstract**

This paper presents a new advantage of output contracts vs. inflation contracts not yet considered in previous literature [Beestma and Jensen (1999) and Røisland (2001)]. The analysis develops in the common agency framework used by Dixit and Jensen (2003), which models the political pressures that national governments (principals) in a monetary union exert on the common central bank (agent) through inflation contracts. In this context, we show that the deflation bias obtained in this last article can be avoided if one government designs an output-related contract and its counterpart does the same or, instead, offers an inflation contract.

*Keywords:* Central Banks, monetary union, common agency.

JEL: E52, E58

# 1 Introduction

The relationship in which several principals simultaneously try to influence the actions of an agent has been the cornerstone of the common agency theory pioneered by Bernheim and Winston (1986) and later applied to political economy issues by Grossman and Helpman (1994, 2001) and Dixit, Grossman and Helpman (1997). Recently, Dixit and Jensen (2003) have extended the common agency theory to cover situations that arises in many macroeconomic policy contexts where the expectations over the agent's action affect the principals's payoffs. They applied their theory to the institutional design of the common central bank (agent) in a monetary union with multiple principals (i. e., member governments) and a rational private sector. In this context, the contract metaphor proposed by Walsh (1995)<sup>1</sup> is used to model the political pressures that national governments exert on the common central bank<sup>2</sup>. In this common agency setting, Dixit and Jensen (2003) have concluded that, when principals non-cooperatively design inflation contracts which represent a cost to the principals, monetary policy has a deflation bias.

The aim of this paper is to propose a performance contract which, in the above context of a monetary union with common agency, avoids systematic deviations of inflation from the socially optimal level. We prove that such undesirable deviations will not take place if one government designs a contract which links performance to output and its counterpart does the same or, instead, offers an inflation contract.

The assumption that incentive schemes generate costs to the governments is crucial to understand these different outcomes. As will be explained in more detail below, in this setting, only when both contracts are linked to inflation, each principal will embark on a futile attempt to pass its share of the total incentive costs (paid to the agent) on to its counterpart. By contrast, no deflation (or inflation) bias can arise when at least one government offers an output contract. The reason is that average output cannot be influenced by the principals' behavior, since it equals the (exogenously given) natural level. In this sense, our paper shows a new advantage of output-related contracts (vs.

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<sup>1</sup> Walsh (1995) modelled the process of delegation to independent monetary authorities as a contract within a principal-agent framework. Bernanke (2004) has stated that, over the past 25 years, this paper has been one of the most influential ones in monetary policy.

<sup>2</sup>A similar common-agency setput arises in a single country where the national central bank is the agent. In this sense, Havrilesky (1993, p. 118), has pointed out that "interest groups place strong pressures on monetary policymaking, either directly or indirectly through politicians".

inflation contracts), not considered by previous literature which has shown that this type of central bank contract is an appropriate state-independent delegation when the output is persistent [Beestma and Jensen (1999) and Røisland (2001)].

The rest of the article is organized as follows. Section 2 presents the model. Section 3 is devoted to the results. Section 4 concludes.

## 2 The model

Our framework is based on the standard stochastic model widely used in the literature on credibility in monetary policy (see, for instance, Walsh [2003, chapter 8]). However, as in Dixit and Jensen (2003), we extend this setup to consider common agency in a monetary union. The world is made up of two countries ( $i = 1, 2$ ). The working of the economy is summarized by the following expressions:

$$y_i = \bar{y} + \alpha(\pi - \pi^e) - \varepsilon, \quad (1)$$

$$U_i^G = -[\beta\pi^2 + (y_i - y^*)^2] - \phi(A_i - b_i x_i), \quad (2)$$

$$U^{CB} = -\left[\sum_{i=1}^2(\beta\pi^2 + (y_i - y^*)^2)\right] + \xi \left[\sum_{i=1}^2(A_i + b_i x_i)\right], \quad (3)$$

where  $\alpha, \beta, \phi, \xi > 0$ ; and  $y^* > \bar{y}$ . Equation (1) shows that the economy possesses a Lucas supply function, so that the difference between output ( $y$ ) and the natural level ( $\bar{y}$ ) depends on the deviations of inflation ( $\pi$ ) from its expected value ( $\pi^e$ ) and on a supply shock ( $\varepsilon$ ) with zero mean and finite variance ( $\sigma_\varepsilon^2$ ). The private sector is rational, that is,  $\pi^e = E\{\pi\}$ , where  $E\{\cdot\}$  is the expectations operator.

We study a common agency with two principals (the governments) and one agent (the central bank). Expressions (2) and (3) are closely related. They represent the utility functions of, respectively, government  $i$  and the common central bank.<sup>3</sup> Their first terms (in brackets) express the corresponding player's concern over deviations of inflation and output from optimal levels, normalized to zero and  $y^*$ , respectively. In the case of the central bank, this concern arises since each government appoints one National representative to run the common monetary institution. The rest of both these equations shows that each national government tries to influence the conduct of the common monetary policy

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<sup>3</sup>These quadratic functions are standard in the literature on credibility in monetary policy. On the other hand, Woodford (2002) has shown that this type of objective functions build on microeconomic foundations, since they can be derived from a representative agent in a general equilibrium model.

by offering the central bank a performance contract. For principal  $i$ , the incentive scheme takes the form  $A_i - b_i x_i$ ; where  $x_i$  may be inflation,  $\pi$  [as in Dixit and Jensen (2003)] or the deviation of country  $i$ 's output from the natural level<sup>4</sup>,  $(y_i - \bar{y})$ .

Each government designs a performance contract, taking its counterpart's choice as given. Then, once expectations on (common) inflation are formed, the realization of the shock is observed by the central bank which, in turn, chooses the inflation rate. Parameters  $\phi$  and  $\xi$  need not coincide since they represent, respectively, the weight that governments and monetary authorities put on the incentive scheme relative to the social loss arising from deviations of inflation and output from optimum levels.

Finally, two points are worth emphasizing. First, as Walsh (1995) and Bernanke (2004) have stated, performance contracts are best treated as a metaphor. That is, incentives need not be interpreted strictly as pecuniary since central bankers take into account many others aspects of their job, including their professional reputations or the prestige of the institutions in which they serve. Second, as it is standard in the literature on central bank contracts, we assume that the principals are constrained to design incentive schemes which are not contingent on the realizations of the random shocks. The reason is that it is prohibitively costly to specify all possible contingencies in advance, let alone to enforce such a hypothetical kind of arrangement [see, for instance, Hart (1995)]. In our paper, incentives are not linked to the realizations of the shock but to either inflation or the deviation of country  $i$ 's output from the natural level.

### 3 The results

We explore the strategic interactions between the governments, the private sector and the central bank. We solve the game by backward induction. In the last stage, the central bank faces the following problem (plugging (1) into (3)):

$$Max_{\{\pi\}} - \left[ \sum_{i=1}^2 (\beta \pi^2 + (\bar{y} + \alpha(\pi - \pi^e) - \varepsilon - y^*)^2) \right] + \xi \left[ \sum_{i=1}^2 (A_i - b_i x_i) \right].$$

The solution yields the optimal response of the monetary authorities:

$$\pi = \frac{\alpha(y^* - \bar{y} + \varepsilon) + \alpha^2 \pi^e}{\beta + \alpha^2} - \frac{\xi(b_1 x'_1 + b_2 x'_2)}{4(\beta + \alpha^2)}, \quad (4)$$

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<sup>4</sup>Results do not change if we do not consider the deviations of output from the natural level but from any other reference value (e.g., the socially optimal level of output).

where  $x'_i = \frac{dx_i}{d\pi}$ . Therefore, taking expectations in (4) and solving for  $\pi^e$  one finds<sup>5</sup>:

$$\pi^e = \frac{\alpha(y^* - \bar{y})}{\beta} - \frac{\xi(b_1 E\{x'_1\} + b_2 E\{x'_2\})}{4\beta}. \quad (5)$$

Plugging this value for the expected inflation into equation (4) and solving for  $\pi$ , we obtain:

$$\pi = \frac{\alpha(y^* - \bar{y})}{\beta} + \frac{\alpha}{\alpha^2 + \beta}\varepsilon - \frac{\xi(b_1 E\{x'_1\} + b_2 E\{x'_2\})}{4\beta}. \quad (6)$$

Now, each government chooses its performance contract taking into account its counterpart's choice and the participation constraint of the agent. Formally, government  $i$  solves the following problem:

$$\begin{aligned} \underset{\{A_i, b_i\}}{Max} \quad & E\{U_i^G(A_i, b_1, b_2, x'_1, x'_2, E\{x'_1\}, E\{x'_2\}, \varepsilon, )\} \\ \text{s.t.} \quad & E\{U^{CB}(A_1, A_2, b_1, b_2, x'_1, x'_2, E\{x'_1\}, E\{x'_2\}, \varepsilon, )\} \geq u_0, \end{aligned}$$

where  $u_0$ , is some outside opportunity utility and the values of  $E\{U_i^G(A_i, b_1, b_2, x'_1, x'_2, E\{x'_1\}, E\{x'_2\}, \varepsilon, )\}$  and  $E\{U^{CB}(A_1, A_2, b_1, b_2, x'_1, x'_2, E\{x'_1\}, E\{x'_2\}, \varepsilon, )\}$  are obtained via the following sequence of computations: (i) substituting (1) into (2) and (3); (ii) plugging the values of  $\pi^e$  and  $\pi$  (appearing in equations (5) and (6)) into the resulting three expressions for  $U_i^G$  and  $U^{CB}$ ; and, finally, (iii) taking expectations.

Notice that the participation constraint must hold with equality since, otherwise, principal  $i$  would not be maximizing its expected utility. Namely, it could be better-off by lowering  $A_i$  (in such a "small" amount that the central bank still found it optimal to accept the contract). Therefore, from the usual first-order conditions of the Lagrangian function we obtain that principal  $i$ 's indifference curve must be tangent to the agent's, i.e., government  $i$ 's marginal rate of substitution between  $A_i$  and  $b_i$  equals the central bank's:

$$\left. \frac{\partial A_i}{\partial b_i} \right|_{E\{U_i^G\}=\overline{E\{U_i^G\}}} = \left. \frac{\partial A_i}{\partial b_i} \right|_{E\{U^{CB}\}=\overline{E\{U^{CB}\}}}, \quad i = 1, 2. \quad (7)$$

In the case considered by Dixit and Jensen (2003), where  $x_i = \pi$ , setting  $x'_1 = x'_2 = 1$  in (7) one finds that:

$$\frac{\alpha(y^* - \bar{y})(\xi + 2\phi)}{2\phi\beta} - \frac{\xi(\xi + 4\phi)b_i}{8\phi\beta} - \frac{\xi(\xi + 2\phi)b_j}{8\phi\beta} = -\frac{\xi(b_i + b_j)}{4\beta} \quad i, j = 1, 2; \quad i \neq j. \quad (8)$$

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<sup>5</sup>Notice that, since we know that  $x_i$  is  $\pi$  or  $y_i - \bar{y}$ , then  $x'_i$  is, respectively, 1 or  $\alpha$ . Therefore,  $\pi^e$  is not included in the right-hand side of (5).

Solving simultaneously the two equations implied by (8) one finds the Nash equilibrium in incentive schedules<sup>6</sup>:

$$b_i^{DJ} = \frac{2\alpha(y^* - \bar{y})(2\phi + \xi)}{\xi(\phi + \xi)}. \quad (9)$$

As a result, substituting the value of  $b_i$  (appearing in (9)) into (5) and bearing in mind that  $x'_1 = x'_2 = 1$ , we obtain that average inflation is negative, i.e.:

$$E(\pi^{DJ}) = -\frac{\alpha\phi(y^* - \bar{y})}{(\phi + \xi)\beta} < 0.$$

Namely, as highlighted by Dixit and Jensen (2003), if governments in the monetary union non-cooperatively offer the central bank inflation contracts, a deflation bias will be present. However, we consider a way out of the problem:

**Proposition:** *In a monetary union, no deflation nor inflation bias arises if the incentives of the central bank are linked to: (a) output in one government's contract and to inflation in its counterpart's; or (b) to output in both contracts.*

*Proof:*

(a) In this case  $x_1 = y_1 - \bar{y}$  and  $x_2 = \pi$ . Therefore, setting  $x'_1 = \alpha$  (because of (1)) and  $x'_2 = 1$  in (7) we have that:

$$\begin{aligned} \frac{2\alpha(\alpha^2\xi - 2\phi\beta)(y^* - \bar{y})}{2\phi\beta} - \frac{\alpha\xi^2 b_1}{8\phi\beta} - \frac{\alpha^2\xi^2 b_2}{8\phi\beta} &= \frac{\alpha^2\xi b_2}{4\beta} - \frac{2\alpha(\alpha^2 + \beta)(y^* - \bar{y})}{\beta}, \\ \frac{2\alpha^2(\xi + 2\phi)(y^* - \bar{y})}{2\phi\beta} - \frac{\xi(\xi + 4\phi)b_1}{8\phi\beta} - \frac{\alpha\xi(\xi + 2\phi)b_2}{8\phi\beta} &= -\frac{\xi b_1}{4\beta}. \end{aligned}$$

Therefore, solving for  $b_1$  and  $b_2$  yields:

$$b_1^{y\pi} = \frac{4(y^* - \bar{y})}{\xi}, \quad (10)$$

$$b_2^{y\pi} = 0. \quad (11)$$

Now, plugging this values of  $b_1$  and  $b_2$  (appearing in (10) and (11)) into (5) and setting  $x'_1 = \alpha$  and  $x'_2 = 1$  we have that average inflation is equal to zero, i.e.:

$$E(\pi^{y\pi}) = 0. \quad (12)$$

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<sup>6</sup>Note that since  $A_i$  does not appear in (8), it has a rather residual role, namely, to guarantee that the participation constraint holds with equality. It is straightforward to check that it is also the case in all the contracts considered below.

(b) In this scenario,  $x_i = y_i - \bar{y}$ . Therefore, by a similar process as the one described in above: i) setting  $x'_1 = x'_2 = \alpha$  (from (1)) in (5); ii) solving for  $b_1$  and  $b_2$ ; iii) plugging them into (4) and bearing in mind, again, that  $x'_1 = x'_2 = \alpha$ , we obtain that no deflation nor inflation bias arises, i.e.  $E(\pi^{yy}) = 0$ . ■

We now explain the intuition why the deflation bias arises when both principals offer inflation contracts but this bias is eliminated when any or both of these two incentive schemes is replaced by an output contract. To begin with, consider the case where both contracts link incentives to inflation. In this setting, why the non-cooperative behavior of the governments brings the economy into deflation, even though both of them dislike it? In other words, why each principal has incentives to deviate from the scenario where the inflation bias is null and move into an equilibrium in which a deflation bias is present? The answer to this question lies with the governments' intent to save on incentive costs. Therefore, if, say, government 1 increased its penalization on inflation by a "small" amount, deflation would arise and, as a result, it would: (a) increase its expected stabilization loss of both inflation and output (first term in (2)); and (b) increase its expected incentive transfer (second term in (2)) by an amount  $\Delta T_1 > 0$ . However, the central bank: (i) would increase its expected stabilization loss (first term in (3)); but it will also increase not only the incentive reward received from government 1 (by the amount  $\Delta T_1 > 0$ ), but also the one provided by the other principal (by  $\Delta T_2 > 0$ ). Therefore, ignoring (a) and (i), since in terms of the envelope theorem they are only second order effects (because we depart from an optimal stabilization of output and inflation), the total increase in the incentive rewards received by the central bank would exceed the increase in the incentive cost borne by government 1 ( $\Delta T_1 + \Delta T_2 > \Delta T_1$ ). Since that would relax the central bank's participation constraint, government 1 could take advantage and decrease the fixed part of its contract,  $A_1$ , by an amount greater than  $\Delta T_1$  (approximately,  $\Delta T_1 + \Delta T_2$ ) so that the participation constraint held, again, with equality. To sum up, by increasing "a little" the penalization on inflation and readjusting the fixed part of its contract, the government could save on incentive costs. Applying an analogous reasoning, government 2 would also find it advantageous to deviate in the same direction from this ideal scenario with no deflation nor inflation bias.

It is worth noting that, the assumption that incentive schedules are costly to the principals is crucial for allowing for the possibility of a deflation bias arising when both contracts link incentives to inflation. The reason is that, when inflation contracts represent costs to both governments, each of them will try to save on them. How? As just discussed above, by manipulating its own incentive

scheme with the aim of shifting its share of the total incentive transfer (received by the central bank so that its participation constraint is satisfied) to its counterpart.

Notice that such competition between principals cannot take place when one of them, say government 1, offer an output contract (irrespective of whether the other principal designs an inflation or an output contract). The reason is that, in this scenario, government 2, by altering its penalization on inflation or output (and taking as given government 1's contract), can no longer affect government 1's incentive costs. Why? Because, government 1's incentive costs are now related to output whose expected value is invariant (and equal to the natural level). Hence, in this setting, principals will not be induced to attempt to pass its share of the total incentive costs (paid to the agent) on to its counterpart, avoiding the deflation bias present when both central bank's incentives are related to inflation.

## 4 Conclusions

Dixit and Jensen (2003) have extended the contracting approach to central banking to the case of a monetary union where there are multiple principals (the member governments). Their model takes account of the fact that even the European Central Bank's constitution cannot, in practice, fully isolate monetary authorities from political pressures. In their setting, incentive schemes offered by member governments to the common central bank model such pressures. In this context, they have concluded that when principals non-cooperatively design inflation contracts monetary policy in the union has a deflation bias. However, our paper has shown that this result depends crucially on the variable to which incentives are linked (i.e., inflation versus output). We have shown that such bias is eliminated if at least one government offer the common central bank an output-related contract. Therefore, the presence of this type of contract prevents the 'politicisation' of the monetary policy from causing a deflation bias.

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