

Monetary Policy and Public Finances: Inflation Targets in a New Perspective

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This paper examines how the private sector, the monetary authority, and the fiscal authority interact and concludes that unrestricted central bank independence may not be an optimal way to collect seigniorage revenues or stabilize supply shocks. Moreover, the paper shows that the implementation of an optimal inflation target results in optimal shares of government finances—seigniorage, taxes, and the spending shortfall—from society’s point of view but still involves suboptimal stabilization. Even if price stability is the sole central bank objective, a positive inflation target has important implications for the government’s finances, as well as for stabilization. [JEL: E52, E62]

This paper examines the interplay between monetary and fiscal policies in an inflation-targeting framework. In this vein, the paper asks the following question: can an inflation target induce an independent central bank to provide the optimal rate of inflation, resulting in optimal seigniorage, taxes, public spending, and output? Does this also lead to optimal stabilization of aggregate supply shocks? The answer to the first question is yes, while the answer to the second is no, and the paper shows why.

These issues have been analyzed in various ways. First, a strand of literature has focused on the interaction between monetary policy and the private sector, and thus on the credibility/flexibility trade-off.¹ This approach, however, fails to take

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¹See, for example, Barro and Gordon (1983), Rogoff (1985), Lohmann (1992), and Alesina and Grilli (1992).

into account the impact of monetary policy on public finances. Second, other authors have employed a deterministic framework to explicitly model the interaction between monetary and fiscal policy. This approach has the weakness of disregarding the implications of aggregate supply shocks.² Finally, the inflation-target literature aims at resolving the time inconsistency problem of monetary policy but tends to overlook the fact that inflation targets could be used as a way of providing the optimal level of seigniorage (see, for example, Svensson, 1995). The aim here is to merge these ideas to derive implications for the optimal policy mix and the optimal policy response to a supply shock.³

The paper extends the work by Beetsma and Bovenberg (1997) by allowing for an aggregate supply shock and by investigating the merits of inflation targets for public finances when the government interacts with an independent central bank. Beetsma and Bovenberg (1997), following along the lines of Alesina and Tabellini (1987), stress the importance of public debt and assume a constant ratio of real base money holdings to nondistortionary output, that is, the inverse of velocity.⁴ Within this framework, they analyze the implications of alternative institutional arrangements—centralization versus decentralization, Nash versus Stackelberg—for society’s welfare. Whichever arrangement is preferable depends on society’s preferences for inflation, output, and public spending, as well as the structural parameters of the economy, such as real base money holdings and outstanding public debt.

This paper extends this analysis in several directions. First, it considers the link between monetary and fiscal policies in a stochastic model, that is, it includes an aggregate supply shock. Second, it provides intuition as to why it makes a difference whether the government faces a constrained optimization problem in which public spending is one of the arguments in the government’s objective function, or whether public expenditure is given as a residual by substituting the budget constraint into the policymakers’ objective functions. The implication of the constrained problem is that the central bank, when decentralizing its policies, does not automatically internalize the government’s budget constraint. Thus it does not make a difference whether the bank cares about public spending, which is in contrast to the existing literature (e.g., Alesina and Tabellini, 1987; and Debelle and Fischer, 1994).⁵ The paper then shows how an inflation target can bring society closer to the second-best equilibrium by serving as a substitute for the central bank’s disregard for the government’s budget constraint. The paper’s final extension is to analyze an “extreme” interpretation of the Maastricht proposal of price stability as the main objective of the European Central Bank (ECB) on a national

²See, for example, Tabellini (1986 and 1988), Alesina and Tabellini (1987), Jensen (1994), and Beetsma and Bovenberg (1997). Exceptions are Debelle and Fischer (1994), and Beetsma and Bovenberg (1999).

³A large body of literature has also focused on the seigniorage hypothesis as part of an optimal taxation problem. See, for example, Mankiw (1987), Fukuta and Shibata (1994), Froyen and Waud (1995), Gros and Vandille (1995), Evans and Amey (1996), and Click (1998). For an empirical investigation of developing countries, see Ashworth and Evans (1998).

⁴This parameter is assumed to be unity in the Alesina and Tabellini (1987) and Debelle and Fischer (1994) models.

⁵Except where the central bank would be “Stackelberg” leader with respect to the government.

basis. Again, a positive inflation target has interesting implications for smoothing the government's financing requirement over the sources of finance, as well as for stabilization.

The analysis is formulated as a game involving the private sector, the monetary authority, and the fiscal authority. The main results can be summarized as follows. A social planner, when in charge of monetary and fiscal policy, can achieve only a second-best equilibrium, as lump-sum taxes are ruled out.⁶ The social planner then has to use alternative sources of finance—distortionary taxes, seigniorage, and the shortfall of public expenditure from its desired target. The resulting second-best equilibrium involves optimal positive mean inflation. Therefore, depending on the tax base—that is, the size of real base money holdings—raising seigniorage revenues to some extent appears optimal, which is in contrast to the various zero inflation rules studied in the literature. Since discretionary policy-making is ruled out, the optimal positive inflation rate derives from optimal revenue considerations and not from a desire to raise output via surprise inflation. Aggregate supply shocks cause inflation, taxes, spending, and output to fluctuate (second best) optimally around their respective means.

The policy outcome under the assumption that a benevolent policymaker is in charge of monetary and fiscal policy serves as a benchmark case. Once policies are decentralized, that is, monetary policy is delegated to an independent but committed central bank, both financing and stabilization are distorted. Since the central bank does not optimize subject to the government's budget constraint and therefore ignores the social value of seigniorage, the entire financing requirement has to be met by the fiscal authority. The central bank does not provide any seigniorage revenues, either through budgetary considerations, or through a desire to boost output closer to its target through surprise inflation. Therefore, the fiscal authority has to rely to a greater extent on taxes—causing output to move further away from its desired target—and a larger expenditure gap. In terms of stabilization, inflation/seigniorage fluctuates less, while output and spending vary more. As a result, the social loss in this scenario is larger than under centralization. The way out of this dilemma is to impose a non-state-contingent inflation target on the central bank. The appealing feature of this target is that it provides the optimal level of expected seigniorage. This result highlights that any output effect in the targeting regime derives from lower taxation, since the amount of taxes necessary to finance a given financing requirement depends on the level of seigniorage provided by the central bank. The optimal inflation target is allowed to vary, depending on the base for the inflation tax. At the limit, where real base money holdings tend to zero, the seigniorage motive vanishes and the optimal inflation target becomes zero. In terms of society's loss, this solution—in which the central bank is independent but subject to an optimal inflation target—dominates the arrangement in which the independent central bank has no inflation target, but is still inferior to the centralized case. The last scenario is one in which controlling inflation is the sole objective of the central bank. While the model's inflation target ensures

⁶For an analysis with lump-sum taxes in the deterministic case, see Beetsma and Bovenberg (1997), and, in the stochastic case, Beddies (1997).

that the means of inflation/seigniorage, output taxes, and spending are at their second-best level, the central bank does not stabilize supply shocks at all, leaving the entire burden of smoothing the supply shock to the fiscal authority. Regarding the social loss, this solution is inferior to the centralized setting and the decentralized setting with the inflation target. Whether this extreme form of central bank independence is preferable to a central bank that cares about output but is not subject to an optimal inflation target depends on the significance of supply shocks.

The remainder of the paper is organized as follows. Section I sets up the basic model. Section II considers the social planner's problem as a benchmark case. Section III explores the decentralized setting and the implications of inflation targets. Section IV analyzes an "extreme" form of the Maastricht proposal for monetary policy—a framework in which the central bank only cares about inflation. Section V concludes the paper and gives some ideas of how to extend our model. The appendices provide derivations in support of our findings.

I. The Setup

The model has three players, namely, the private sector (represented by a trade union), the monetary authority (central bank), and the fiscal authority (government).⁷ The trade union seeks to minimize deviations of the real wage rate from a particular target. For convenience and without loss of generality, this real wage target is normalized to zero. Thus, trade unions set the log of the nominal wage rate equal to the expected price level, that is, $w = p^e$. To give the monetary and fiscal authorities an incentive to engage in surprise inflation, nominal wage contracts are assumed to be signed before the policies are selected. Our model is stochastic rather than deterministic, in contrast to Beetsma and Bovenberg (1997) and Alesina and Tabellini (1987). Thus, we allow for the possibility that the economy can be hit by shocks. Given these assumptions, normalized output, y , is given by⁸

$$y = \pi - \pi^e - \tau + \varepsilon, \quad (1)$$

where y is the log of real output; π and π^e denote the actual and expected rate of inflation, respectively; τ is the tax rate on output; and ε is an aggregate supply shock, distributed normally with zero mean and variance σ_ε^2 . From equation (1), it follows that in a rational expectations equilibrium, where $E_{t-1}(\pi_t) = \pi_t^e$, the long-run expected output level, denoted by the unconditional mean $E(y)$, is equal to $-\tau$. To achieve $E(y) = 0$, one has to remove the distortions arising from output taxation. The model also allows for nontax distortions, which are measured by $y^* > 0$.⁹ Note that y^* represents the first-best level of output in the absence of any distortion. Hence the first-best output level y^* can be achieved only by removing

⁷The basic model uses the framework of Beetsma and Bovenberg (1997). Also, see Beddies (1997).

⁸This is standard in the literature. See, for example, Debelle and Fischer (1994) and Beddies (1997) for the case with shocks, and Beetsma and Bovenberg (1997) and Alesina and Tabellini (1987) for the case without shocks.

⁹This could be labor market union power and/or goods market monopoly power. See Beetsma and Bovenberg (1997), who consider those nontax distortions as an implicit tax on output.

both the tax and the nontax distortions. The natural way to achieve the first best and to remove these distortions would be to subsidize output by setting $y^* = -\tau$, whereby the negative tax represents the subsidy on output. This results in $E(y) = y^*$, which offsets the implicit tax on output caused by the nontax distortions.

The preferences of the society are specified in a social loss function defined over inflation, output, and public spending.¹⁰ The social loss function is given by

$$L_S = \frac{1}{2} \left[\xi_S \pi^2 + (y - y^*)^2 + \mu_S (g - g^*)^2 \right], \xi_S, \mu_S > 0, \quad (2)$$

where ξ_S is the weight that the society places on inflation and μ_S represents the weight that the society places on public spending, both relative to the output objective; π is the rate of inflation; y is the log of real output as defined in equation (1); y^* represents the first-best nondistortionary level of output; g is public spending; and g^* denotes the spending target. For simplicity, the target inflation rate is assumed to be zero.¹¹ The social loss (equation 2) is assumed to be an increasing function of the deviation from targets.

The loss functions of the fiscal and the monetary authority can be defined in a similar way:

$$L_F = \frac{1}{2} \left[\xi_F \pi^2 + (y - y^*)^2 + \mu_F (g - g^*)^2 \right], \xi_F, \mu_F > 0, \quad (3)$$

$$L_M = \frac{1}{2} \left[\xi_M \pi^2 + (y - y^*)^2 + \mu_M (g - g^*)^2 \right], \xi_M, \mu_M > 0. \quad (4)$$

The weights, corresponding to the respective targets in the social, the central bank's, and the government's loss function, may or may not differ.

Within this public finance framework, the government has to choose its policies subject to a budget constraint. This budget constraint in terms of shares of nondistortionary output is given by¹²

$$g + (1 + r)b + (1 + r + \pi^e - \pi)d = \tau + k\pi, \quad (5)$$

where g denotes government spending; b is the outstanding stock of indexed single-period government debt; and d represents the initial real value of nonindexed single-period debt. The right-hand side of equation (5) represents the sources of revenue. Thereby τ is the revenue from distortionary taxes and $k\pi$ is the revenue from seigniorage, with $k \geq 0$ as the constant ratio of real money holdings

¹⁰For an identical treatment of the social loss function, see, for example, Alesina and Tabellini (1987), Jensen (1994), Beetsma and Bovenberg (1997), and Beddies (1997).

¹¹Sections III and IV explore the situation where the central bank is allowed to have a positive inflation target.

¹²See Appendix I for details. In deriving this budget constraint, the paper follows Beetsma and Bovenberg (1997), but it does not analyze the case of unlimited access to lump-sum taxes. See Beddies (1997) on this issue considered within a stochastic model.

and nondistortionary output.¹³ The key assumption underlying this budget constraint is that all debt sold at the end of the previous period has to be repaid, while no new debt is issued in the present period. One can interpret this as a two-period game in which the sole focus is the last period. This assumption has the advantage of simplifying the algebra substantially. Hence the issue of the intertemporal allocation of tax distortions, inflation, and public spending is ignored. To ensure that there is a demand for government debt, the return on indexed debt must be at least as high as the real ex ante return on an outside investment opportunity, r . Regarding the nominal debt, investors set expected inflation as a markup on the real ex ante rate r ; thus, the nominal interest rate on nonindexed debt is $r + \pi^e$ (see, for example, Dornbusch, 1996). To ensure a clear separation between the government's sources of finance and the expenditures that have to be financed by these sources, that is, the government's financing requirement, the budget constraint (equation 5) is rewritten:¹⁴

$$F \equiv g^* + y^* + (1 + r)(b + d) = (\tau + y^*) + k\pi + (g^* - g) + (\pi - \pi^e)d. \quad (6)$$

The government has to finance the spending target; the output subsidy to (partly) offset the labor market distortions, y^* ; and the repayment and servicing costs of the indexed and the nominal debt. The right-hand side of equation (6) accounts for the source of finance: "revenues" from inflating away nominal debt, $(\pi - \pi^e)d$; revenues via the shortfall of public spending from its target ($g^* - g$); seigniorage revenues, $k\pi$; and, finally, revenues from explicit and implicit taxes on output, $(\tau + y^*)$.¹⁵ The paper assumes that the financing requirement does not exceed production. Finally, the private sector's expectations are assumed to be rational and hence satisfy (conditional on the information set available in the previous period, $t - 1$, that is, containing all information up to and including period $t - 1$) the following:

$$E_{t-1}(\pi_t) = \pi_t^e. \quad (7)$$

II. A Benevolent Policymaker

This section shall serve as a benchmark case for judging alternative outcomes in the decentralized policy setting. Suppose that a committed, benevolent policymaker is in charge of setting monetary and fiscal policies. She thus can take account of the private sector's expectations. The optimization problem is

¹³For simplicity, the potentially distortionary effects of the inflation tax on the demand for real money is not considered, thus k is not defined as a function of expected inflation. See, for example, Calvo and Leiderman (1992) and Calvo and Guidotti (1993) for models incorporating the money demand implications of the inflation tax, and Cagan (1956) in a hyperinflation framework.

¹⁴The spending and the output target on both sides in equation (5) are added and terms rearranged.

¹⁵Labor market distortions are measured by the deviation of the first-best output level, y^* , from the actual output level, y , in the absence of any tax distortions, where $E(y)$ would be zero.

characterized by minimizing the loss function (equation 2) subject to the budget constraint (equation 6), to the rational expectations constraint (equation 7) and to the supply function (equation 1). Hence, the Lagrangian is

$$L = \min_{\pi, \pi^e, \tau, g, \lambda, \delta} \frac{1}{2} \left[\xi_s \pi^2 + (\pi - \pi^e - \tau + \varepsilon - y^*)^2 + \mu_s (g - g^*)^2 \right] \quad (8)$$

$$+ \lambda \left[F - (\tau + y^*) - k\pi - (g^* - g) - (\pi - \pi^e)d \right] + \delta \left[E_{t-1}(\pi_t) - \pi_t^e \right],$$

where π , τ , and g are the instruments; λ is the Lagrange multiplier associated with the government's budget constraint; and δ is the Lagrange multiplier associated with the expectations constraint. Minimizing equation (8) with respect to π , π^e , τ , g , λ , and δ yields the following first-order conditions:

$$\xi_s \pi + (\pi - \pi^e - \tau + \varepsilon - y^*) + \lambda(-k-d) + E(\delta) = 0. \quad (9)$$

$$-(\pi - \pi^e - \tau + \varepsilon - y^*) + \lambda d - \delta = 0. \quad (10)$$

$$-(\pi - \pi^e - \tau + \varepsilon - y^*) - \lambda = 0. \quad (11)$$

$$\mu_s(g - g^*) + \lambda = 0. \quad (12)$$

$$F - (\tau + y^*) - k\pi - (g^* - g) - (\pi - \pi^e)d = 0. \quad (13)$$

$$E_{t-1}(\pi_t) - \pi_t^e = 0. \quad (14)$$

Combining equations (10), (11), and (12) with equation (13), taking rational expectations (note that $E_{t-1}(\pi_t) = \pi_t^e$; see equation 14) into account, and using equation (9), we obtain

$$E(\delta) = (F - k\pi^e) \left[\frac{\mu_s(1+d)}{1+\mu_s} \right] = F \frac{\mu_s \xi_s (1+d)}{\xi_s + \xi_s \mu_s + \mu_s k^2}, \quad (15)$$

where equation (15), the expectations of the Lagrange multiplier associated with the expectations constraint, is the (average) marginal cost of expected inflation. Thus, within this commitment framework, the policymaker understands that the benefit of higher inflation comes at the cost of higher average expected inflation. This cost is reflected in the right-hand side of equation (15). For example, a higher financing requirement, F , makes seigniorage more valuable but at the same time increases the marginal cost of expected inflation. At the optimum, costs and benefits have to be equal. Substituting equation (15) into equation (9), solving the above first-order conditions, and imposing rational expectations (equation 7), we obtain the following equilibrium policy outcomes for seigniorage/inflation, taxes, public spending, and output:

$$k\pi = \frac{k^2\mu_s F}{\xi_s + \xi_s\mu_s + \mu_s k^2} - \frac{\mu_s k(1+k+d)}{\xi_s + \xi_s\mu_s + \mu_s(1+k+d)^2} \varepsilon \quad (16)$$

$$\tau + y^* = \frac{\mu_s \xi_s F}{\xi_s + \xi_s\mu_s + \mu_s k^2} + \frac{\xi_s \mu_s [(k+d)(1+k+d)]}{\xi_s + \xi_s\mu_s + \mu_s(1+k+d)^2} \varepsilon \quad (17)$$

$$g^* - g = \frac{\xi_s F}{\xi_s + \xi_s\mu_s + \mu_s k^2} - \frac{\xi_s}{\xi_s + \xi_s\mu_s + \mu_s(1+k+d)^2} \varepsilon \quad (18)$$

$$y^* - y = \frac{\mu_s \xi_s F}{\xi_s + \xi_s\mu_s + \mu_s k^2} - \frac{\mu_s \xi_s}{\xi_s + \xi_s\mu_s + \mu_s(1+k+d)^2} \varepsilon. \quad (19)$$

Because the model abstracted from the unlimited access to lump-sum taxes, the above equilibrium is second best. In contrast to the literature dealing with policy games between the monetary authority and the private sector, the second-best optimal solution here involves optimal positive mean inflation. Depending on the size of k , taxing real base money holdings to some extent, in order to finance part of the public expenditures, appears to be optimal.¹⁶

By inspection of equations (16) through (19), one can verify that a higher government financing requirement raises the means of inflation and explicit taxes, while reducing the mean of public expenditure. Moreover, output moves farther away from its target, because of increased taxes, while the optimal relative variability between inflation, taxes, spending, and output is not affected. Hence, supply-side shocks are smoothed out over output and the three sources of finance, independent of the financing requirement. The social loss necessarily increases with a raise in the financing requirement, as all actual outcomes move farther away from their respective targets (see Appendix II on the social loss).

Societies with a lower k (that is, higher velocity) experience a lower optimal mean and a lower variance of seigniorage (see equation 16) because the taxable base is smaller. Thus, in these countries, seigniorage is of less importance than in countries where real base money holdings are higher and, hence, the base for the inflation tax is larger. When regarding output deviations (equation 19) and spending deviations (equation 18) from their respective targets, the opposite is true. Means and variances are higher if k is smaller. Not surprisingly, the mean of implicit and explicit taxes (equation 17) also increases when k becomes smaller, while its variance decreases.¹⁷ The consequence of reduced accessibility to

¹⁶In Andrabi (1997), seigniorage passively adjusts to the budget constraint as a residual tax, while this paper treats it as an instrument. However, his setup is purely decentralized.

¹⁷The effect on the tax variance stems from the reduced inflation variance, which is already putting pressure on output stabilization.

seigniorage is that the government's financing requirement has to be met by less spending and increased taxes, resulting in a larger gap between actual output and its nondistortionary target. The same argument applies to the task of stabilizing supply shocks. At the limit, where k tends to zero, it is no longer optimal to use seigniorage as a source of finance. Hence, inflation responds only to the supply shock to maintain the optimal relative variability among output, inflation, and the remaining financing sources. As a result, F needs to be financed entirely by implicit and explicit output taxes and by the shortfall of spending from its target.

If society views inflation as especially important and consequently increases the weight attached to inflation, ξ_S , it can reduce the mean of inflation as well as its variance. This "gain," however, comes at the cost of higher mean distortionary taxes and, hence, less output, and it also moves public spending away from its target. It further induces output and spending to be more variable, and thus transfers the burden of stabilizing shocks from inflation to output and spending. The impact of different inflation weights on the variance of distortionary taxes depends on the parameters but has a likely negative sign, if society cares sufficiently about spending as well.¹⁸

A higher weight on public spending, μ_S , decreases the gap between public spending and its target and reduces its variance. This implies that the means of seigniorage, output, and distortionary taxes have to increase to meet the financing requirement, because being more concerned about public spending diminishes its value as a financing source. The task of smoothing out the supply shock is increasingly transferred to inflation and output. The tax variance, however, is decreasing in the spending weight, μ_S , in order not to put additional pressure on output.

Higher nominal debt ratios undoubtedly increase the government's financing requirement. As a result, seigniorage/inflation is higher, distortionary taxes increase, and output as well as public expenditures move farther away from their respective targets. The fact that the supply shock is positively related to output and thus to taxation implies that debt is positively related to taxes, reducing the impact on output. The same argument holds for public spending. The impact of higher nominal debts on inflation is ambiguous but has a likely negative sign.¹⁹ This implies that the negative inflation response to the supply shock should be smaller. The economics behind this result is that unanticipated inflation is valuable for decreasing the real value of the nominal debt, which has to be repaid. As a positive shock reduces inflation, however, higher nominal debts imply that this response should be smaller.

III. The Impact of Central Bank Independence on Public Finances

This section investigates an institutional arrangement in which the central bank is independent of the government. The underlying assumption here is that the monetary and the fiscal authorities move simultaneously; hence, they act in a (noncooperative) Nash fashion. The aim of this section is to investigate the possible advantages of inflation targets in improving society's welfare.

¹⁸More precisely, the tax variance is decreasing in the inflation weight if $\mu_S(k + d) > 1$.

¹⁹That is, the effect is negative if $(1 + k + d)^2/\xi_S > 1 + 1/\mu_S$.

Monetary Commitment: No Inflation Target

Many authors have argued that the inflation bias story is overdone. Why should an independent central bank have an incentive to fool the private sector if doing so does not help anyone?²⁰ In this vein, the central bank is assumed to commit to sticking to the ex ante optimal policy. Thus, its optimization problem is characterized by minimizing the loss function (equation 4), subject to the rational expectations constraint (equation 7) and the supply function (equation 1). The Lagrangian is hence given by

$$L = \min_{\pi, \pi^e, \delta} \frac{1}{2} \left[\xi_M \pi^2 + (\pi - \pi^e - \tau + \varepsilon - y^*)^2 + \mu_M (g - g^*)^2 \right] + \delta [E_{t-1}(\pi_t) - \pi_t^e], \quad (20)$$

where π is the central bank's instrument and δ is the Lagrange multiplier associated with the rational expectations constraint. Minimizing equation (20) with respect to π , π^e , and δ , we obtain the following first-order conditions:

$$\xi_M \pi + (\pi - \pi^e - \tau + \varepsilon - y^*) + E(\delta) = 0 \quad (21)$$

$$-(\pi - \pi^e - \tau + \varepsilon - y^*) - \delta = 0 \quad (22)$$

$$E_{t-1}(\pi_t) - \pi_t^e = 0. \quad (23)$$

Note that the above first-order conditions show that it makes no difference whether the central bank cares about spending or not, that is, it does not matter whether $\mu_M = 0$ or not. The government's optimization problem is given by minimizing the loss function (equation 3), subject to the budget constraint (equation 6) and the supply function (equation 1).²¹ Thus the Lagrangian is

$$L = \min_{\pi, g, \lambda} \frac{1}{2} \left[\xi_F \pi^2 + (\pi - \pi^e - \tau + \varepsilon - y^*)^2 + \mu_F (g - g^*)^2 \right] + \lambda [F - (\tau + y^*) - k\pi - (g^* - g) - (\pi - \pi^e)d]. \quad (24)$$

By minimizing equation (24) with respect to τ , g , and λ , we obtain the following first-order conditions:

$$-(\pi - \pi^e - \tau + \varepsilon - y^*) - \lambda = 0 \quad (25)$$

$$\mu_F (g - g^*) + \lambda = 0 \quad (26)$$

$$F - (\tau + y^*) - k\pi - (g^* - g) - (\pi - \pi^e)d = 0. \quad (27)$$

²⁰See, for example, McCallum (1995); Clark, Goodhart, and Huang (1996); and Blinder (1997) on this issue.

²¹Note that the government does not choose inflation. Thus it cannot take account of the private sector's rational expectations.

The equivalent of equation (15) in Section II is obtained by combining equations (22), (25), and (26) with equation (27), taking rational expectations into account (note that $E_{t-1}(\pi_t) = \pi_t^e$; see equation 23) and using equation (21):

$$E(\delta) = (F - k\pi^e) \left[\frac{\mu_F}{1 + \mu_F} \right] = F \frac{\mu_F}{1 + \mu_F}, \quad (28)$$

where equation (28) is the (average) marginal cost of expected inflation. Note that central bank independence implies that the central bank does not internalize the government's budget constraint and thus does not have any temptation to devalue the nonindexed debt d . Technically, the term $(1 + d)$ in equation (15) does not appear in equation (28). Substituting equation (28) into equation (21), using equations (25) through (27), and assuming that $\mu_F = \mu_S$, one can solve for the policy outcomes:

$$k\pi = - \frac{\mu_S k}{\xi_M + \xi_M \mu_S + \mu_S (1 + k + d)} \varepsilon \quad (29)$$

$$\tau + y^* = \frac{\mu_S F}{1 + \mu_S} + \frac{\xi_M + \mu_S (k + d)}{\xi_M + \xi_M \mu_S + \mu_S (1 + k + d)} \varepsilon \quad (30)$$

$$g^* - g = \frac{F}{1 + \mu_S} - \frac{\xi_M}{\xi_M + \xi_M \mu_S + \mu_S (1 + k + d)} \varepsilon \quad (31)$$

$$y^* - y = \frac{\mu_S F}{1 + \mu_S} - \frac{\mu_S \xi_M}{\xi_M + \xi_M \mu_S + \mu_S (1 + k + d)} \varepsilon. \quad (32)$$

Decentralization here has obvious effects. The central bank does not internalize the budget constraint of the government and hence ignores the social value of seigniorage as a source of finance.²² As is easily seen from equation (29), inflation—and thus seigniorage—merely fluctuates around a zero mean. Hence, the zero inflation rules, as, for example, studied by Rogoff (1985) and Lohmann (1992), fail to consider that, as long as base money holdings are positive, inflation has some social value as a source of taxation. As a result, the entire burden of meeting the government's financing requirement rests on distortionary taxes, leading to a greater output shortfall, caused by insufficient subsidies, and the spending shortfall.

This result can also be looked at in a more technical manner. The model is dealing with a constrained optimization problem, in which the government

²²Also, see Beetsma and Bovenberg (1997) and Beddies (1997).

chooses its policies subject to a budget constraint. In contrast to this view, some other authors, such as Alesina and Tabellini (1987), Jensen (1994), Debelle and Fischer (1994), and Huang and Padilla (1995), transform the constrained optimization problem into an unconstrained one by substituting the budget constraint into the loss function (via spending). As a result, a central bank has to internalize the government's budget constraint if it cares about public spending ($\mu_M > 0$), that is, if it has the same preferences as society or the government.²³ However, in practice, why would the independent central bank optimize subject to the government's budget constraint? Therefore, this paper's definition ensures that there is no need to justify why preferences among society, the government, and the central bank should be different—as opposed to, for example, Debelle and Fischer (1994), who merely assume different preferences.²⁴

Assuming that $\xi_M = \xi_S$, the paper finds that stabilization also differs from the second best. With an independent central bank, the variance of inflation/seigniorage is lower, while the output and spending variances are higher [compare equations (16), (18), and (19) with equations (29), (31), and (32)]. The intuition behind this result is as follows. As the central bank does not internalize the government's budget constraint, it fails to account for the effect of unanticipated inflation on the value of repayable nominal debt. For that reason, inflation responds to a lower extent to the supply shock, producing a higher variability of output and spending. Furthermore, the variance of implicit and explicit taxes ($\tau + y^*$) is only lower with the independent central bank if $\mu_S(k + d) > 1$ (see equations 17 and 30). Thus, it appears that low-debt countries can lower the variability of their tax system by centralizing policies. High-debt countries, however, are better off in terms of the tax variability by decentralizing policies, given that k is equally low.

The impact of a change in the structural parameters of the economy, k and d , and the political parameters, ξ_S and μ_S , on the means and the variances of seigniorage, taxes, the spending shortfall, and the output shortfall are the same as discussed in Section II, except for two important differences. First, the mean sources of finance in the decentralized setting do not depend upon k . However, at the limit, if k tends to zero, that is, seigniorage is of insignificant importance, decentralization “seems” to be attractive. The means of the sources of finance (seigniorage, taxes, and the spending shortfall) coincide with those under centralized commitment (compare equations 16–19 with equations 29–32 for $k \rightarrow 0$). Second, the variance of inflation/seigniorage is strictly decreasing in d , no matter how important society views public spending and output relative to inflation. The reason for this result is that the central bank does not balance the impact of unanticipated inflation on repayable nominal debt against the preferences of society.

Regarding the welfare of the society, within this setup benevolent policymaking is preferable to central bank independence (see Appendix II for technical details).

²³This argument necessarily disappears in the centralized setting.

²⁴Thus, in their model, with respect to discretionary policy, fiscal parameters enter the inflation output via the tax effect on output and not through revenue considerations.

Monetary Commitment: An Optimal Inflation Target

In practice, most central banks, at least in the industrialized countries, are more or less independent of the government. Some governments, however, still have the power to set the targets for their national monetary policy. We will use this observation to examine whether the finance dilemma analyzed above can be solved by the use of an inflation target. Suppose the central bank would choose its policy subject to the following objective function:

$$L_F = \frac{1}{2} \left[\xi_M (\pi - \pi^T)^2 + (y - y^*)^2 + \mu_M (g - g^*)^2 \right], \xi_M, \mu_M > 0, \quad (33)$$

where the only difference from equation (4) (and equation 2 if assuming equal weights) is the target inflation rate π^T . Since we have shown in the previous section that the central bank does not internalize the government's budget constraint and thus ignores the social value of seigniorage, we examine now whether π^T can be chosen in such a way that the central bank provides the optimal level of seigniorage. Going through the same steps as earlier, we can show that by setting π^T equal to $k\mu_S F / (\xi_S + \xi_S \mu_S + \mu_S k^2)$ and assuming that $\mu_F = \mu_S$ and $\xi_M = \xi_S$, the optimal mean inflation rate resulting from benevolent policymaking (Section II) can be obtained:

$$k\pi = \frac{k^2 \mu_S F}{\xi_S + \xi_S \mu_S + \mu_S k^2} - \frac{\mu_S k}{\xi_S + \xi_S \mu_S + \mu_S (1+k+d)} \varepsilon \quad (34)$$

$$\tau + y^* = \frac{\mu_S \xi_S F}{\xi_S + \xi_S \mu_S + \mu_S k^2} + \frac{\xi_S + \mu_S (k+d)}{\xi_S + \xi_S \mu_S + \mu_S (1+k+d)} \varepsilon \quad (35)$$

$$g^* - g = \frac{\xi_S F}{\xi_S + \xi_S \mu_S + \mu_S k^2} - \frac{\xi_S}{\xi_S + \xi_S \mu_S + \mu_S (1+k+d)} \varepsilon \quad (36)$$

$$y^* - y = \frac{\mu_S \xi_S F}{\xi_S + \xi_S \mu_S + \mu_S k^2} - \frac{\mu_S \xi_S}{\xi_S + \xi_S \mu_S + \mu_S (1+k+d)} \varepsilon. \quad (37)$$

The major drawback of this analysis is that the implementation of a positive inflation target results in the optimal mean shares of finance, as if a benevolent policymaker had chosen monetary and fiscal policies. Thus, compared with the centralized case, an independent central bank can be induced to deliver the optimal level of mean seigniorage merely by implementing an optimal inflation target.²⁵ The mechanism behind this result is as follows. With the inflation target, the

²⁵Note that this is different from the Svensson (1995) inflation target that is imposed to remove the inflationary bias that arises from discretionary policymaking.

central bank provides the optimal level of financing to the government. Since, as a result, government taxes can be lower than in the case without the inflation target, the output shortfall, as well as the spending shortfall, is smaller. It is important to note here that positive mean inflation does not derive from an incentive to boost output via surprise inflation, since it was assumed that the central bank is committed for the reasons explained above, but from optimal revenue share considerations imposed by the inflation target.

The fact that this paper's inflation target is optimal, in the sense that it ensures the optimal share of finances, is best seen by looking at the parameter k . If $k = 0$, the equations in Section II show that the optimal inflation rate—and, thus, seigniorage—is zero. The above analysis easily verifies that, in this scenario, the optimal inflation target becomes zero, resulting in mean shares of finance, as if the benevolent policymaker had been in charge. Since the inflation target is non-state-contingent, stabilization is still suboptimal compared with the benevolent case.

Regarding society's welfare, the targeting regime of this section is still inferior to that of the social planner. However, a comparison between the losses resulting from pure central bank independence and central bank independence with the optimal inflation target shows that the targeting regime is preferable to the regime without the inflation target (see Appendix II for formal details).

IV. Inflation as the Sole Objective of Monetary Policy

The desire of some European countries to establish a European Central Bank (ECB) that is especially concerned with inflation—that is, concerned about low and stable prices—is the motivation for this section.²⁶ On a national level, the monetary requirement for participating in the Economic and Monetary Union (EMU) is the establishment of an independent central bank whose main concern is seen to be inflation. Following along these lines, this section considers an extreme central bank that is only concerned with inflation.²⁷ This case is represented by the specification in equation (38) below.²⁸ Technically, this coincides with the assumption of an infinitely conservative central banker.

A General Inflation Target

Let the modified objective function of the (conservative) central bank take the following form:²⁹

²⁶To achieve the ultimate goal of price stability, the ECB targets money growth like the Bundesbank, for which authors such as Bernanke and Mihov (1996) and Clarida and Gertler (1996) find evidence that it would be better characterized as an inflation targeter, rather than a monetary targeter.

²⁷Nevertheless, in terms of the loss function, Alesina and Grilli (1992), when examining the ECB, follow Kydland and Prescott (1977), Barro and Gordon (1983), and Rogoff (1985).

²⁸Note that an arrangement such as EMU coincides with one of centralized monetary policy and decentralized fiscal policy. See, for example, Sibert (1994).

²⁹Rankin (1998) also captures the idea of (extreme) conservatism in this way. However, he does not consider the possibility of having a positive inflation target or shocks.

$$L_M^C = \frac{1}{2}[\pi - \pi^T]^2, \quad (38)$$

where π^T denotes the central bank's inflation target. Given equation (38), one can immediately establish the solution to the central bank's problem:

$$\pi = \pi^T, \quad (39)$$

which implies that inflation is always at its target. The government still faces the optimization problem of the previous section. Thus, its first-order conditions are still given by the equations (25)–(27). Solving equation (39) and equations (25)–(27) jointly and imposing the condition of rational expectations, equation (7), one arrives at (assuming that $\mu_F = \mu_S$) the following:

$$k\pi = k\pi^T = k\pi^e, \quad (40)$$

$$\tau + y^* = \frac{\mu_S k \pi^T}{1 + \mu_S} + \frac{\mu_S F}{1 + \mu_S} + \frac{1}{1 + \mu_S} \varepsilon \quad (41)$$

$$g^* - g = -\frac{k\pi^T}{1 + \mu_S} + \frac{F}{1 + \mu_S} - \frac{1}{1 + \mu_S} \varepsilon \quad (42)$$

$$y^* - y = -\frac{\mu_S \pi^T}{1 + \mu_S} + \frac{\mu_S F}{1 + \mu_S} - \frac{\mu_S}{1 + \mu_S} \varepsilon. \quad (43)$$

These results, characterized in equations (40)–(43), have some interesting implications. Whatever target inflation rate the central bank has in mind, inspection of equation (41) immediately shows that any positive rate of inflation reduces the necessity for distortionary taxes, as long as k is positive. Furthermore, output and public spending are closer to their respective targets, equations (42) and (43). The above-derived solution, however, also reveals that the entire burden of stabilizing the aggregate supply shock lies on fiscal policy and output. The reason for this is that unanticipated inflation is not available. The central bank does not care about output, given the specified loss function (equation 38). Necessarily, a government concerned about meeting fiscal criteria such as those defined in the Maastricht Treaty faces trade-offs among higher taxes, lower expenditures, and lower output subsidies.

A Specific Inflation Target

Turning to the central bank's inflation target, π^T , if the government can impose an inflation target that provides the desired level of seigniorage, as specified in the second-best equilibrium of Section II, straightforward calculation reveals that

$$k\pi = \frac{k^2 \mu_S F}{\xi_S + \xi_S \mu_S + \mu_S k^2} \quad (44)$$

$$\tau + y^* = \frac{\mu_s \xi_s F}{\xi_s + \xi_s \mu_s + \mu_s k^2} + \frac{1}{1 + \mu_s} \varepsilon \quad (45)$$

$$g^* - g = \frac{\xi_s F}{\xi_s + \xi_s \mu_s + \mu_s k^2} - \frac{1}{1 + \mu_s} \varepsilon \quad (46)$$

$$y^* - y = \frac{\mu_s \xi_s F}{\xi_s + \xi_s \mu_s + \mu_s k^2} - \frac{\mu_s}{1 + \mu_s} \varepsilon, \quad (47)$$

which gives the same shares of the mean financing sources as in the case where the benevolent policymaker was in charge. Thus, although the central bank does not have output in its objective function, the imposed inflation target ensures that expected output is at its second best level. Implicitly, the central bank, by implementing the target, acts as if it cared about average output *and* the government's budget constraint. The intuition behind this result is as before, namely, that by providing the optimal level of seigniorage, the government has to rely to a lesser extent on taxes. The decreased reliance on taxes has a positive effect on output. Since this scenario considers a central bank that is committed to stick to the ex ante optimal policy, this result again highlights that any output effect derives from taxation, which itself depends on the level of seigniorage provided by the central bank. However, as the central bank is assumed to explicitly care only about inflation in its objective function, the inflation target cannot achieve optimal stabilization. Thus, extreme forms of central bank independence might not be optimal.³⁰ Depending on the size of k , seigniorage should be a part of finance. The above-specified target ensures that, if $k \rightarrow 0$ at the limit, the seigniorage motive, as well as inflation, vanishes.³¹ Thus, the commitment/discretion discussion is not an issue as long as the government sticks to the inflation target. If the government cares about staying in office, why should it then not try to act in the interest of the private sector? In that connection, Goodhart (1993, p. 8) states: "As Lincoln said, you cannot fool all of the people all of the time." The social loss under this arrangement, however, is higher than it would be in the case in which the bank also cares about output stabilization and faces the inflation target. Compared to the case where the central bank does care about output stabilization but does not face an inflation target, the welfare implications are ambiguous and depend on the size of the supply shock variance (again, see Appendix II for a formal derivation).

V. Conclusion

This paper has focused on the interplay between monetary and fiscal policies within a stochastic framework. Its contribution to the literature is the examination

³⁰See, for example, Goodhart (1993) for an excellent discussion of the issue of central bank independence.

³¹The reason for this result is that the optimal inflation target in this scenario is zero. Note that this has nothing to do with the Svensson (1995) approach, where a "negative" inflation target (given that society's inflation target is zero) is required in order to remove the inflationary bias. The positive inflation target here is designed to provide the government with optimal seigniorage revenues, as in the previous section.

of the explicit inclusion of issues of stabilization in a public finance framework and the implications of inflation targets for public finances. The paper concludes that unrestricted central bank independence may not be optimal from society's point of view, regardless of whether the bank cares only about inflation or about both output and inflation. In terms of society's welfare, in the absence of a benevolent policymaker, the most appealing solution is to implement an optimal inflation target for the independent central bank, given that the bank also cares about output.

Given the paper's way of specifying the preferences of society and the policymakers, neither a fully independent central bank without the above-specified optimal inflation target nor a central bank that cares only about inflation (even if given an optimal inflation target) will generate a preferable outcome from society's point of view, compared with an independent central bank mindful of all arguments in society's loss function and having an optimal inflation target.

This paper assumed that all debt has to be repaid within the current period. In light of EMU, the model could be extended to investigate the Maastricht deficit criterion by allowing for debt accumulation. It could also be extended to allow for fiscal policy interactions between sovereign fiscal authorities within the union, which together interact with the centralized monetary authority, the ECB. Thus, one could focus on the public good character of fiscal policy. Since the European Community lacks a powerful federal government, one could investigate a situation in which the decentralized fiscal authorities can build coalitions to minimize the spillover effects of their fiscal decisions into other union countries. To capture the potentially distortionary effects of the inflation tax on the demand for real money balances, one could also endogenize the real base money holdings parameter. These issues are left for future research.

APPENDIX I

Derivation of Government Budget Constraint

As in Beetsma and Bovenberg (1997), real money balances in period t are given by $M_t/P_t = kY^*$, where Y^* is the output level in the absence of any distortions (the antilog of y^*) and $k \geq 0$ is the constant ratio of real money holdings and nondistortionary output (given by $k = M_t/(P_t Y^*)$). Hence, $(M_t - M_{t-1})/M_t = (P_t - P_{t-1})/P_t$.³² Under the assumption that the tax distortions are not too large, revenues from distortionary taxes can be approximated by $\tau_t P_t Y^*$.³³ Lump-sum taxes are given by $\theta_t P_t Y^*$. Denoting by G_t the level of government spending, by B_t the amount of indexed single-period debt, by D_t the amount of nonindexed single-period debt sold at the end of the previous period against the price P_{t-1} and interest rates r_{Bt} and r_{Dt} , respectively, and, finally, by $(M_t - M_{t-1})$, the increase in the nominal money supply, the nominal government budget constraint is given by (also, see Jensen, 1994)

$$P_t G_t + (1 + r_{Bt})P_t B_t + (1 + r_{Dt})P_{t-1} D_t = \tau_t P_t Y^* + \theta_t P_t Y^* + (M_t - M_{t-1}) + P_t (B_{t+1} + D_{t+1}). \quad (A1)$$

³²The requirement for this to hold is that nondistortionary output Y^* is independent of the tax rate τ . Alesina and Tabellini (1987) or Canzoneri (1985) use an identical simplification.

³³See, for example, Alesina and Tabellini (1987), who also use the approximation $Y \approx Y^*$.

Dividing equation (A1) by $P_t Y^*$, using the result $\pi_t = (P_t - P_{t-1})/P_t$, and approximating $(1 + r_{Dt})P_{t-1}/P_t$ by $(1 + r_{Dt} - \pi_t)$, the government budget constraint (equation A1) can be rewritten in terms of shares of nondistortionary output:

$$g_t + (1 + r_{Bt})b_t + (1 + r_{Dt} - \pi_t)d_t = \tau_t + \theta_t + k\pi_t + b_{t+1} + d_{t+1}. \quad (\text{A2})$$

To ensure that investors are willing to buy government debt, the interest rate on indexed debt should be as high as the ex ante real rate of return of an outside investment opportunity— r , say. Regarding nominal, nonindexed debt, the investor simply sets expected inflation as a markup on this ex ante real rate r to compensate for any expected inflation during the maturity of the debt. Hence, the nominal interest rate on nonindexed government debt is equal to $r + \pi^e$. Thus the government budget constraint stated in equation (A2), dropping time subscripts and assuming that *no new debt* is issued, satisfies

$$g + (1 + r)b + (1 + r + \pi^e - \pi)d = \tau + \theta + k\pi,$$

which (without lump-sum taxes) is the budget constraint stated in equation (5) in the text.

APPENDIX II

Comparison of Social Loss in Alternative Central Banking Regimes

This appendix compares the social loss (equation 2) under benevolent policymaking, BP; central bank independence, CI; central bank independence with an optimal inflation target, CIT; and central bank independence where the bank is only concerned with inflation but has an optimal inflation target, CCIT. The social loss for the alternative regimes is obtained by substituting the respective policy outcomes into the social loss function (equation 2), assuming that players share the same preferences, that is, $\xi = \xi_S = \xi_F = \xi_M$ and $\mu = \mu_S = \mu_F = \mu_M$. It is then straightforward to show that

$$\begin{aligned} L^{BP} &< L^{CIT} < L^{CI} \\ L^{BP} &< L^{CIT} < L^{CCIT} \\ L^{CI} &\cong L^{CCIT}. \end{aligned} \quad (\text{A3})$$

The proofs for these results are straightforward. The social loss for each regime can be calculated as

$$L^{BP} = \frac{1}{2} \frac{\xi_S \mu_S F^2}{\xi_S + \xi_S \mu_S + \mu_S k^2} + \frac{1}{2} \frac{\xi_S \mu_S \sigma_\epsilon^2}{\xi_S + \xi_S \mu_S + \mu_S (1 + k + d)^2} \quad (\text{A4})$$

$$L^{CI} = \frac{1}{2} \frac{\mu_S F^2}{1 + \mu_S} + \frac{1}{2} \frac{\xi_S \mu_S (\xi_S + \mu_S + \xi_S \mu_S) \sigma_\epsilon^2}{(\xi_S + \xi_S \mu_S + \mu_S (1 + k + d))^2} \quad (\text{A5})$$

$$L^{CIT} = \frac{1}{2} \frac{\xi_S \mu_S F^2}{\xi_S + \xi_S \mu_S + \mu_S k^2} + \frac{1}{2} \frac{\xi_S \mu_S (\xi_S + \mu_S + \xi_S \mu_S) \sigma_\epsilon^2}{(\xi_S + \xi_S \mu_S + \mu_S (1 + k + d))^2} \quad (\text{A6})$$

$$L^{CCIT} = \frac{1}{2} \frac{\xi_S \mu_S F^2}{\xi_S + \xi_S \mu_S + \mu_S k^2} + \frac{1}{2} \frac{\mu_S \sigma_\epsilon^2}{1 + \mu_S}. \quad (\text{A7})$$

Therefore, it can be shown that

$$\begin{aligned}
 L^{BP} - L^{CI} &= \frac{1}{2} \frac{\xi_s \mu_s F^2}{\xi_s + \xi_s \mu_s + \mu_s k^2} + \frac{1}{2} \frac{\xi_s \mu_s \sigma_\varepsilon^2}{\xi_s + \xi_s \mu_s + \mu_s (1+k+d)^2} \\
 &\quad - \frac{1}{2} \frac{\mu_s F^2}{1 + \mu_s} - \frac{1}{2} \frac{\xi_s \mu_s (\xi_s + \mu_s + \xi_s \mu_s) \sigma_\varepsilon^2}{(\xi_s + \xi_s \mu_s + \mu_s (1+k+d))^2} < 0
 \end{aligned} \tag{A8}$$

$$\begin{aligned}
 L^{BP} - L^{CIT} &= \frac{1}{2} \frac{\xi_s \mu_s F^2}{\xi_s + \xi_s \mu_s + \mu_s k^2} + \frac{1}{2} \frac{\xi_s \mu_s \sigma_\varepsilon^2}{\xi_s + \xi_s \mu_s + \mu_s (1+k+d)^2} \\
 &\quad - \frac{1}{2} \frac{\xi_s \mu_s F^2}{\xi_s + \xi_s \mu_s + \mu_s k^2} - \frac{1}{2} \frac{\xi_s \mu_s (\xi_s + \mu_s + \xi_s \mu_s) \sigma_\varepsilon^2}{(\xi_s + \xi_s \mu_s + \mu_s (1+k+d))^2} \\
 &= -\frac{1}{2} \frac{\xi_s^2 \mu_s^2 (k+d)^2 (1+\mu) \sigma_\varepsilon^2}{(\xi_s + \xi_s \mu_s + \mu_s (1+k+d))^2 (\xi_s + \xi_s \mu_s + \mu_s (1+k+d))^2} < 0
 \end{aligned} \tag{A9}$$

$$\begin{aligned}
 L^{BP} - L^{CIT} &= \frac{1}{2} \frac{\xi_s \mu_s F^2}{\xi_s + \xi_s \mu_s + \mu_s k^2} + \frac{1}{2} \frac{\xi_s \mu_s \sigma_\varepsilon^2}{\xi_s + \xi_s \mu_s + \mu_s (1+k+d)^2} \\
 &\quad - \frac{1}{2} \frac{\xi_s \mu_s F^2}{\xi_s + \xi_s \mu_s + \mu_s k^2} - \frac{1}{2} \frac{\mu_s \sigma_\varepsilon^2}{1 + \mu_s} \\
 &= \frac{1}{2} \frac{\xi_s \mu_s \sigma_\varepsilon^2}{\xi_s + \xi_s \mu_s + \mu_s (1+k+d)^2} - \frac{1}{2} \frac{\mu_s \sigma_\varepsilon^2}{1 + \mu_s} \\
 &= -\frac{1}{2} \frac{\xi_s \mu_s (1+k+d)^2 \sigma_\varepsilon^2}{(\xi_s + \xi_s \mu_s + \mu_s (1+k+d))^2 (1 + \mu_s)} < 0
 \end{aligned} \tag{A10}$$

$$\begin{aligned}
 L^{CI} - L^{CIT} &= \frac{1}{2} \frac{\mu_s F^2}{1 + \mu_s} + \frac{1}{2} \frac{\xi_s \mu_s (\xi_s + \mu_s + \xi_s \mu_s) \sigma_\varepsilon^2}{(\xi_s + \xi_s \mu_s + \mu_s (1+k+d))^2} \\
 &\quad - \frac{1}{2} \frac{\xi_s \mu_s F^2}{\xi_s + \xi_s \mu_s + \mu_s k^2} - \frac{1}{2} \frac{\xi_s \mu_s (\xi_s + \mu_s + \xi_s \mu_s) \sigma_\varepsilon^2}{(\xi_s + \xi_s \mu_s + \mu_s (1+k+d))^2} \\
 &= \frac{1}{2} \frac{\mu_s F^2}{1 + \mu_s} - \frac{1}{2} \frac{\xi_s \mu_s F^2}{\xi_s + \xi_s \mu_s + \mu_s k^2} \\
 &= \frac{1}{2} \frac{\mu_s k^2 F^2}{(\xi_s + \xi_s \mu_s + \mu_s k^2) (1 + \mu_s)} > 0
 \end{aligned} \tag{A11}$$

$$\begin{aligned}
 L^{CI} - L^{CCIT} &= \frac{1}{2} \frac{\mu_s F^2}{1 + \mu_s} + \frac{1}{2} \frac{\xi_s \mu_s (\xi_s + \mu_s + \xi_s \mu_s) \sigma_\epsilon^2}{(\xi_s + \xi_s \mu_s + \mu_s (1 + k + d))^2} \\
 &\quad - \frac{1}{2} \frac{\xi_s \mu_s F^2}{\xi_s + \xi_s \mu_s + \mu_s k^2} - \frac{1}{2} \frac{\mu_s \sigma_\epsilon^2}{1 + \mu_s} \\
 &= \left[\frac{1}{2} \frac{\mu_s}{1 + \mu_s} - \frac{1}{2} \frac{\xi_s \mu_s}{\xi_s + \xi_s \mu_s + \mu_s k^2} \right] F^2 \\
 &\quad + \left[\frac{1}{2} \frac{\xi_s \mu_s (\xi_s + \mu_s + \xi_s \mu_s)}{(\xi_s + \xi_s \mu_s + \mu_s (1 + k + d))^2} - \frac{1}{2} \frac{\mu_s}{1 + \mu_s} \right] \sigma_\epsilon^2 \cong 0.
 \end{aligned} \tag{A12}$$

Note that the coefficient on F^2 is strictly positive while the coefficient on σ_ϵ^2 is strictly negative. Thus, if the supply shock variance is not too large, central bank independence when the bank has an optimal inflation target but cares only for inflation might be better than a central bank that stabilizes output but does not keep in mind the government's finances.

$$\begin{aligned}
 L^{CI} - L^{CCIT} &= \frac{1}{2} \frac{\xi_s \mu_s F^2}{\xi_s + \xi_s \mu_s + \mu_s k^2} + \frac{1}{2} \frac{\xi_s \mu_s (\xi_s + \mu_s + \xi_s \mu_s) \sigma_\epsilon^2}{(\xi_s + \xi_s \mu_s + \mu_s (1 + k + d))^2} \\
 &\quad - \frac{1}{2} \frac{\xi_s \mu_s F^2}{\xi_s + \xi_s \mu_s + \mu_s k^2} - \frac{1}{2} \frac{\mu_s \sigma_\epsilon^2}{1 + \mu_s} \\
 &= \frac{1}{2} \frac{\xi_s \mu_s (\xi_s + \mu_s + \xi_s \mu_s) \sigma_\epsilon^2}{(\xi_s + \xi_s \mu_s + \mu_s (1 + k + d))^2} - \frac{1}{2} \frac{\mu_s \sigma_\epsilon^2}{1 + \mu_s} < 0
 \end{aligned} \tag{A13}$$

References

- Alesina, Alberto, and Vittorio Grilli, 1992, "The European Central Bank. Reshaping Monetary Politics in Europe," in *Establishing a Central Bank: Issues in Europe and Lessons from the U.S.*, ed. by Matthew B. Canzoneri, Vittorio Gulli, and Paul R. Masson (Cambridge: Cambridge University Press), pp. 49–77.
- Alesina, Alberto, and Guido Tabellini, 1987, "Rules and Discretion with Noncoordinated Monetary and Fiscal Policies," *Economic Inquiry*, Vol. 25 (October), pp. 619–30.
- Andrabi, Tahir, 1997, "Seigniorage, Taxation and Weak Government," *Journal of Money, Credit, and Banking*, Vol. 29 (February), pp. 106–26.
- Ashworth, John, and Lynne Evans, 1998, "Seigniorage and Tax Smoothing in Developing Countries," *Journal of Economic Studies*, Vol. 25 (No. 6), pp. 486–95.
- Barro, Robert J., and David B. Gordon, 1983, "A Positive Theory of Monetary Policy in a Natural Rate Model," *Journal of Political Economy*, Vol. 91 (August), pp. 589–610.
- Beddies, Christian H., 1997, "The Interaction of Fiscal and Monetary Policies in a World with Uncertainty," Queen Mary and Westfield College Discussion Paper No. 372 (London: Department of Economics, Queen Mary and Westfield College, University of London).

- Beetsma, Roel M., and A. Lans Bovenberg, 1997, "Designing Fiscal and Monetary Institutions in a Second-Best World," *European Journal of Political Economy*, Vol. 13 (February), pp. 53–79.
- , 1998, "Monetary Union Without Fiscal Coordination May Discipline Policymakers," *Journal of International Economics*, Vol. 45 (August), pp. 239–58.
- , 1999, "The Interaction of Fiscal and Monetary Policy in a Monetary Union: Balancing Credibility and Flexibility," in *The Economics of Globalization: Policy Perspectives from Public Economics*, ed. by Assaf Razin and Efraim Sadka (Cambridge: Cambridge University Press).
- Bernanke, Ben S., and Ilian Mihov, 1996, "What Does the Bundesbank Target?" NBER Working Paper 5764, (Cambridge, Massachusetts: National Bureau of Economic Research).
- Blinder, Alan S., 1997, "What Central Bankers Could Learn from Academics—and Vice Versa," *Journal of Economic Perspectives*, Vol. 11 (Spring), pp. 3–19.
- Cagan, Phillip, 1956, "The Monetary Dynamics of Hyperinflation," in *Studies in the Quantity Theory of Money*, ed. by Milton Friedman (Chicago: University of Chicago Press), pp. 25–117.
- Calvo, Guillermo, and Pablo E. Guidotti, 1993, "On the Flexibility of Monetary Policy: The Case of the Optimal Inflation Tax," *Review of Economic Studies*, Vol. 60 (July), pp. 667–87.
- Calvo, Guillermo, and Leonardo Leiderman, 1992, "Optimal Inflation Tax under Precommitment: Theory and Evidence," *American Economic Review*, Vol. 82 (March), pp. 179–94.
- Canzoneri, Matthew B., 1985, "Monetary Policy Games and the Role of Private Information," *American Economic Review*, Vol. 75 (December), pp. 1056–70.
- Clarida, Richard, and Mark Gertler, 1996, "How the Bundesbank Conducts Monetary Policy." NBER Working Paper 5581 (Cambridge, Massachusetts: National Bureau of Economic Research).
- Clark, Peter B., Charles A. E. Goodhart, and Haizhou Huang, 1996, "Optimal Monetary Policy Rules in a Rational Expectations Model of the Phillips Curve," LSE Financial Markets Group Discussion Paper No. 247 (London: London School of Economics and Political Science).
- Click, Reid W., 1998, "Seigniorage in a Cross-Section of Countries," *Journal of Money, Credit, and Banking*, Vol. 30 (May), pp. 154–71.
- Debelle, Guy, and Stanley Fischer, 1994, "How Independent Should a Central Bank Be?" in *Goals, Guidelines, and Constraints Facing Monetary Policymakers*, ed. by Jeffrey C. Fuhrer (Boston: Federal Reserve Bank of Boston), pp. 195–221.
- Dornbusch, Rudiger, 1996, "Debt and Monetary Policy: The Policy Issues," NBER Working Paper No. 5573 (Cambridge, Massachusetts: National Bureau of Economic Research).
- Evans, Lynne J., and Michael C. Amey, 1996, "Seigniorage and Tax Smoothing—Testing the Extended Tax-Smoothing Model," *Journal of Macroeconomics*, Vol. 18 (Winter), pp. 111–25.
- Froyen, Richard T., and Roger N. Waud, 1995, "Optimal Seigniorage versus Interest-Rate Smoothing," *Journal of Macroeconomics*, Vol. 17 (Winter), pp. 111–29.
- Fukuta, Y. and Akihisa Shibata, 1994, "A Cointegration Test of the Optimal Seigniorage Model," *Economics Letters*, Vol. 44 (April), pp. 433–37.
- Goodhart, Charles A. E., 1993, "Central Bank Independence," LSE Financial Markets Group, Special Paper Series No. 57 (London: London School of Economics and Political Science).
- Gros, Daniel, and Guy Vandille, 1995, "Seigniorage and EMU: The Fiscal Implications of Price Stability and Financial Market Integration," *Journal of Common Market Studies*, Vol. 33 (June), pp. 175–96.
- Huang, Haizhou, and A. Jorge Padilla, 1995, "Fiscal Policy and the Sub-Optimality of the Walsh Contract for Central Bankers," LSE Financial Markets Group Discussion Paper No. 223 (London: London School of Economics and Political Science).

- Jensen, Henrik, 1994, "Loss of Monetary Discretion in a Simple Dynamic Policy Game," *Journal of Economic Dynamics and Control*, Vol. 18 (May), pp. 763–79.
- Kydland, Finn E., and Edward C. Prescott, 1977, "Rules Rather than Discretion: The Inconsistency of Optimal Plans," *Journal of Political Economy*, Vol. 85 (June), pp. 473–91.
- Lohmann, Susanne, 1992, "Optimal Commitment in Monetary Policy: Credibility Versus Flexibility," *American Economic Review*, Vol. 82 (March), pp. 273–86.
- Mankiw, N. Gregory, 1987, "The Optimal Collection of Seigniorage: Theory and Evidence," *Journal of Monetary Economics*, Vol. 20 (September), pp. 327–41.
- McCallum, Bennett T., 1995, "Two Fallacies Concerning Central Bank Independence," *American Economic Review, Papers and Proceedings*, Vol. 85 (May), pp. 207–11.
- Rankin, Neil, 1998, "Is Delegating Half of Demand Management Sensible?" *International Review of Applied Economics*, Vol. 12 (September), pp. 415–22.
- Rogoff, Kenneth, 1985, "The Optimal Degree of Commitment to an Intermediate Monetary Target," *Quarterly Journal of Economics*, Vol. 100 (November), pp. 1169–89.
- Sibert, Anne, 1994, "The Allocation of Seigniorage in a Common Currency Area," *Journal of International Economics*, Vol. 37 (August), pp. 111–22.
- Svensson, Lars E. O., 1995, "Optimal Inflation Targets, 'Conservative' Central Banks, and Linear Inflation Contracts," CEPR Discussion Paper No. 1249 (London: Centre for Economic Policy Research).
- Tabellini, Guido, 1986, "Money, Debt and Deficits in a Dynamic Game," *Journal of Economic Dynamics and Control*, Vol. 10 (December), pp. 427–42.
- , 1988, "Monetary and Fiscal Policy Coordination with a High Public Debt," in *High Public Debt: The Italian Experience*, ed. by Francesco Giavazzi and Luigi Spaventa (Cambridge: Cambridge University Press), pp. 90–134.