RULES AND DISCRETION WITH NONCOORDINATED MONETARY AND FISCAL POLICIES

ALBERTO ALESINA and GUIDO TABELLINI*

The time inconsistency of optimal monetary policy is due to the effects of tax distortions. Thus the issue of how to improve upon the time-consistent suboptimal monetary policy is related to that of the coordination of monetary and fiscal policy. We present a model with three players (the central bank, the fiscal authority, and wage setters) in which distortionary taxes are explicitly modelled. We show that binding commitments to monetary rules are not necessarily welfare improving if monetary and fiscal policy are not coordinated. We also examine the effects of different degrees of independence of the central bank.

I. INTRODUCTION

Since the influential paper of Kydland and Prescott [1977], several authors have addressed the issue of the time inconsistency of optimal monetary policy. The underlying assumption of this line of research is that the unemployment rate determined by the market without policy intervention is above the rate that would be optimal for the central bank. As a consequence, the central bank faces an incentive to generate unexpected monetary shocks so as to reduce unemployment. This incentive is the source of the time inconsistency problem. The optimal monetary policy of low inflation is not credible in the absence of binding commitments; and the time consistent but suboptimal monetary policy leaves unemployment unaffected and generates an excessively high rate of inflation.

The key element of this argument is the hypothesis that the unemployment rate targeted by the central bank is below the rate that would be determined by the market without policy intervention. Two reasons have been suggested in the literature to justify this hypothesis: 1) labor market imperfections which force the equilibrium real wage above the level compatible with full employment,[1] and 2) the existence of tax distortions that reduce the level of activity below its "natural" level.[2]

The second reason is in fact the more general. Even if some market im-

* Carnegie Mellon University and NBER, and University of California in Los Angeles, respectively. We would like to thank Olivier Blanchard, Matthew Canzoneri, Benjamin Friedman, Ross Levine, Tosten Persson, Kenneth Rogoff, Richard Sweeney and a referee of this journal for very useful comments. Earlier versions of this paper were presented at the Bellagio Conference on "Economic Policy in Closed and Open Economics," Tel Aviv University and NBER; we thank the participants in these workshops for their comments. The usual disclaimer applies.

1. These market imperfections can be due to a monopolistic trade union, as in Canzoneri [1985], Rogoff [1985], and Tabellini [forthcoming]; or to some "efficiency wage" problem as in Katz [1986].

2. This point is emphasized, for example, in Barro and Gordon [1983].

perfections forced wages above the socially optimum level, firms could be subsidized to reche desired level of employment and these subsidies could be financed wnondistortionary tax, if it existed. Thus, it is the lack of a nondistortionaral instrument which generates the time inconsistency problem of monetalicy. Although this point has been acknowledged in the literature, the ections between the existence of tax distortions and the problem of time concy of monetary policy has not been modelled explicitly with respecthe inflation-unemployment tradeoff.[3] These connections are particularlyortant because, in most industrial countries, monetary and fiscal policies at by two authorities which are, in general, at least partially independed may face different incentives and have different objectives. Thus, the of the time consistency of monetary policy overlaps with those of the coation of monetary and fiscal policies and of the degree of independence of entral bank.

This paper analyzse issues in a game theoretic model with three players: the central bank, thal authority, and wage setters. Public expenditures have to be financed:r by means of a distortionary tax controlled by the fiscal authority, or bns of money creation controlled by the central bank. The two authorities or may not have the same preferences and may or may not act in a coated way.

When monetary scal policies are not coordinated, a monetary regime with commitments dot necessarily improve welfare over the discretionary regime. In fact, the of output and public spending in the two regimes are different: they ath higher with discretion than with commitments. Given that fiscal pos endogenous, the level of tax distortions and, as a consequence, the levoutput and public expenditures are not invariant to the regime change. Ta movement from a discretionary regime to a regime with commitments ierally not a Pareto improvement; at least one of the players is in generale worse off, and for some parameter values all the players are worse offe that this result does not rely upon the existence of stochastic shocks in tonomy. Thus, the choice between "rules or discretion" cannot be takdependently of the decision about the degree of coordination of moneand fiscal policy. In more general terms the intuition of this result is as follBy allowing the central bank to follow binding rules, two of the players (thge setters and the central bank) cooperate to achieve the "low inflation" eorium. In general, the cooperation of a subset of the players does not necily improve upon the noncooperative equilibrium. Rogoff [1985b] and JSachs [1985] provide two different examples of an analogous result in a country model.

A second set of reconcerns the consequences of changing the degree of coordination of mary and fiscal policy in a discretionary regime. The more independent iscentral bank (i.e., the less it is willing to finance public spending withney creation), the lower are output, inflation and

3. An exception is Cukiand Drazen [1986].

public spending, and the higher is the tax rate. Despite the loss in output and public spending, the fiscal authority is made better off by having a more independent central bank. In this sense, this result extends in a different context a previous similar finding of Rogoff [1985a]. However, this result is subject to some qualifications.

Section II of the paper outlines the model. Section III characterizes the discretionary-Nash equilibrium; section IV derives the equilibrium with commitments. The conclusions and main results are briefly summarized in section V.

II. THE MODEL

The economy is specified so that unexpected monetary policy affects only aggregate demand and fiscal policy affects only aggregate supply.[4] The supply function is given by

$$x_t = \alpha(p_t - w_t - \tau_t), \qquad \alpha > 0 \tag{1}$$

where x = log of real output; p = log of the price level; w = log of the nominal wage; τ = tax rate on the total revenue of firms. The appendix derives equation (1) from the optimization problem of a competitive firm using only one input (labor), and subject to a revenue tax. The distortionary tax rate τ provides the fiscal authority's only revenue. Results analogous to those presented in this paper can be obtained in a model with alternative forms of distortionary taxation (for instance an income tax, in a model with a positively sloped labor supply).

Nominal wages are set in a labor market that can be thought of either as populated by a centralized trade union (TU) (as, for instance, in Tabellini [forthcoming]) or by uncoordinated small agents (as, for instance, in Barro-Gordon [1983]). In the former case we can assume that the TU has the following loss function:

$$V^{TU} = (1/2)\sum_{t=0}^{T} \rho^t(w_t - p_t - v)^2, \qquad 1 > \rho > 0. \tag{2}$$

Thus, the TU wishes to minimize the deviations of the real wage from a target v.[5] The TU first order condition yields immediately

$$w_t = p_t^e + v \tag{3}$$

4. This paper abstracts from issues of short-run stabilization policies; thus the model is deterministic and disregards possible sources of nonneutrality of expected monetary policy such as long-term labor contracts or short-run output price stickiness. Monetary and fiscal stabilization policies are not the focus of this paper. Rogoff [1985a] has addressed the issue of stabilization policies in the context of a similar model, although without an explicit consideration of fiscal policy.

5. A previous version of the paper assigned to the TU a more general loss function, quadratic in both real wages and output. The qualitative features of the results were identical to those presented here, but the algebra and the notation were unnecessarily complicated. This more general specification of preferences for the TU can be derived from primitive hypotheses about the TU incentives and constraints; see Oswald [1985].

where the e superscript denotes expected values. Hence the supply function, equation (1), can be rewritten as

$$x_t = \alpha(\pi_t - \pi_t^e - \tau_t - v) \tag{4}$$

where π and π^e are the actual and expected inflation rates respectively, with $\pi_t = p_t - p_{t-1}$. Equation (3) implies a horizontal labor supply; the union members are willing to supply any amount of labor at the targeted real wage.

If $v = 0$, equation (3) represents a competitive labor market with nominal contracts of one period length and with a horizontal labor supply. Thus, the contract fixes a nominal wage and the workers are willing to supply any amount of labor at that wage. All the qualitative results of the paper hold for any nonnegative value of v, including zero. As it will be shown below, with $v > 0$ the real wage targeted by the TU forces output to be lower than the level desired by the policymakers.

Inflation and taxes are set respectively by the central bank (CB) and by the fiscal authority (FA). Within the framework of this model, the hypothesis that the CB directly controls inflation amounts to assuming that money demand is not affected by fiscal policy.[6] This in turn insures that fiscal policy is not subject to time inconsistencies. We will explain how the results reported below would change if this assumption were dropped.

This paper neglects the intertemporal dimension of the government budget constraint, by assuming that public expenditures cannot be financed by issuing public debt. Under this assumption, public expenditures are residually determined from the government accounting identity once tax rates and money seignorage have been set. The assumption that there is no public debt considerably simplifies the analysis. Its major drawback, naturally, is that the absence of an explicit role for public debt forces us to neglect the issue of the intertemporal allocation of tax distortions and of inflation.

With no public debt, denoting by g the ratio of public expenditures over output, and after some simplifications and approximations, the government budget constraint can be written as[7]

$$g_t = \tau_t + \pi_t. \tag{5}$$

6. For instance, if money demand is specified according to a simplified quantity theory equation,

$$m_t = p_t + \bar{x} \tag{F.1}$$

where m_t = log of money supply and $\bar{x}$ is some measure of output, independent of τ, then it follows immediately that $\pi_t = m_t - m_{t-1}$. Canzoneri [1985] adopts an identical simplification.

7. Equation (5) has been obtained as follows (upper case letters denote antilogs). Write the government budget constraint in nominal terms, with G_t = public spending:

$$G_t = \tau_t P_t X_t + M_t - M_{t-1}. \tag{F.2}$$

Then divide both sides by nominal income, $P_t X_t$:

$$g_t = \tau_t + (M_t - M_{t-1})/P_t X_t. \tag{F.3}$$

The loss functions of the CB and the FA are, respectively,

$$V^{CB} = (1/2) \sum_{t=0}^{T} \beta^t[\pi_t^2 + \mu_1 x_t^2 + \mu_2(g_t - \bar{g})^2],$$
$$\mu_1 > 0, \quad \mu_2 \geq 0, \quad 0 < \beta < 1, \quad \bar{g} > 0; \tag{6}$$

$$V^{FA} = (1/2) \sum_{t=0}^{T} \theta^t(\pi_t^2 + \delta_1 x_t^2 + \delta_2(g_t - \bar{g})^2],$$
$$\delta_1 > 0, \quad \delta_2 \geq 0, \quad 1 > \theta > 0. \tag{7}$$

As in the related literature, the policymakers wish to minimize the deviations of inflation and output from some targets, for convenience normalized at zero. In particular, zero is the level of the log of output generated by a competitive labor market with no tax distortion and no monetary surprises (see appendix). In addition, we assume that both policymakers wish to minimize the deviations of public expenditures from the same positive target, $\bar{g}$. The hypothesis that either $\bar{g}$ or v is positive is crucial for the results that follow. In particular, if $\bar{g}$ is positive, the policymakers wish to tolerate some inflation and some tax distortions in exchange for a positive amount of public expenditures.[8]

In this model the only benefit of money creation arises from seignorage, as emphasized by (5). In a more general model, a positive rate of money growth (and of inflation) may also be beneficial if it lowers the real interest rate, via a Tobin-Mundell effect.[9] Different views between the FA and the CB about interest rates may thus generate different views about monetary policy and the optimal policy mix.

Even though the two policymakers are assumed to have the same ultimate goals, throughout the paper we will allow them to differ in the relative weights μ_i and δ_i attributed to output and public expenditures relative to inflation. This disagreement may reflect the different political incentives and constraints faced by the two authorities; the CB is not elected and, in most industrial countries, it enjoys various degrees of independence from the FA. On the contrary, the FA is generally directly responsible for its actions to the electorate and to various political constituencies. Specifically, we assume that $\delta_i \geq \mu_i$, $i = 1, 2$, so that the FA does not assign a greater weight to inflation relative to output and public expenditures than the CB.

Using (F.1) in footnote 6, the last term on the right hand side of (F.3) can be rewritten as

$$(M_t - M_{t-1})/M_t \cdot \bar{X}/X_t,$$

which we approximate by $\pi_t = (M_t - M_{t-1})/M_{t-1}$.

8. The hypothesis that there is no public debt can alternatively be stated as saying that in every period the two policymakers wish to raise the same constant amount of total revenues, $\bar{g}$, in the form of either taxes or money seignorage.

9. However, Stockman [1981] and Sweeney [1987] have shown that the Tobin-Mundell effect could have the reverse sign in plausible models.

The strategic interaction between the three players is as follows. If $v > 0$ and/or $\bar{g} > 0$, both authorities would like to create unexpected inflation so as to raise output to the desired level and finance part of the public expenditures. The two authorities disagree, however, about the optimal mix of financing. The remaining sections of the paper investigate how these different incentives interact to determine output, inflation, taxation, and public expenditures under alternative institutional regimes.

II. THE DISCRETIONARY REGIME

In this regime no commitments can be made by any policymaker. The three agents act like Nashers, taking everybody else's current actions as given. Since the game is stated is repeated only a finite number of times, the only subgame perfect (hence time-consistent) Nash equilibrium of the repeated game coincides with the unique Nash equilibrium of the one-shot game. If the game were infinitely repeated, the one-shot Nash would still be an equilibrium of the game. In general there would be other equilibria sustainable by means of reputational mechanisms. However, these issues are not considered in the present paper.

The one-shot Nash equilibrium can be computed directly from the first-order conditions of the two policymakers, together with (4) and (5), to obtain (the superscript d stands for discretion)[11]:

$$(\bar{g} - g^d) = v + \bar{g})/[\alpha^2\delta_1(1 + \mu_2) + \delta_2(1 + \alpha^2\mu_1)] > 0 \qquad (8a)$$

$$^d = -(\delta_2/\alpha\delta_1)(\bar{g} - g^d) < 0 \qquad (8b)$$

$$[(\mu_1\delta_2 + \mu_2\delta_1)/\delta_1](\bar{g} - g^d) > 0. \qquad (8c)$$

In equilibrium output and public spending are below their targets (zero and $\bar{g}$) while inflation is above its target (zero). The higher is the need to use distortionary taxation to finance public spending (i.e., the higher is $\bar{g}$) and the higher is the real wage targeted by the TU, v, the further away are π, x and g from their respective targets. Thus, in particular, for given tax distortions, the higher is the real wage targeted by the unions, the lower is output.

If $\delta_2 = \mu_2 = 0$, that is public expenditure does not enter in the objective functions of the policymakers, then inflation and output are at their targeted level, irrespective of the level of the real wage (v). This happens for the following reason: if $\delta_2 = 0$, from (4), (5) and (8), it follows that $g = \tau = -v$. Therefore, the government subsidizes firms until the desired level of output is reached. These subsidies are proportional to the total revenue of the firm. Since there is no inflation or distortionary taxes, these subsidies are financed by means of a nondistortionary lump-sum tax (i.e., a negative g). This confirms that the time inconsistency problem of monetary policy is ultimately due to the lack of nondistortionary taxes.

By taking partial derivatives of (8) with respect to μ_1 and μ_2, some tedious algebra establishes that a reduction of μ_1 and/or μ_2 brings about lower inflation, lower output, lower expenditures and higher taxes. The intuitive explanation of this result is simple. If the CB attributes a lower weight to public expenditure relative to inflation (μ_2), it is less willing to finance public spending by means of money creation. As a consequence, the FA is induced to raise taxes, which in turn reduce output. Similarly, a reduction in the relative weight attributed to output (μ_1) reduces the time consistent rate of inflation, since it decreases the CB incentive to create unexpected inflation. But this in turn induces the FA to raise taxes, with a negative impact on output. The net effect on spending is always negative.

A reduction in the weights μ_1 and μ_2 can be interpreted as the appointment of a central banker particularly averse to inflation. It can be shown that, starting from a situation in which the FA controls both policy instruments (i.e., $\mu_i = \delta_i$), the reduction of μ_1 and μ_2 holding δ_i constant makes the FA better off. If one assumes that the FA incorporates the "true" social preferences, then this result implies that society would be made better off by having decentralized monetary and fiscal policies, with the central bank being more averse to inflation than society itself. Rogoff [1985a] derived this same conclusion in a model in which, however, fiscal policy is assumed to be invariant to any monetary regime change.

Our result can be explained as follows. In this model, monetary policy is subject to a time inconsistency problem whereas fiscal policy is not, as shown by equation (4). As a result, in the discretionary equilibrium with $\mu_i = \delta_i$, the authorities are collecting too much revenue in the form of inflation and too little revenue in the form of taxes. Hence, the reduction of μ_i has the effect of moving both inflation and taxes in the right direction. The same applies with respect to the level of public spending.

This welfare result might not necessarily apply to a model in which both monetary and fiscal policy are subject to a time inconsistency. In such a model, a reduction in μ_i would still bring about lower inflation and higher taxes. But now, whereas inflation moves in the right direction, taxes do not (since they were too high to begin with). Thus the FA could be made worse off by the reduction of μ_i.

IV. A REGIME WITH BINDING COMMITMENTS

By construction, the Nash equilibrium characterized in section III is time consistent, in the sense that no player has any incentive to deviate from this equilibrium, given the equilibrium actions of its opponents; in particular the TU sets nominal wages high enough and the FA sets taxes low enough so that the CB does not have any incentive to generate policy surprises.

By entering into a binding commitment before nominal wages are set, the CB acts as Stackelberg leader with respect to the TU, and can sustain a time inconsistent equilibrium. Maintaining the assumption that the CB and the FA

10. Hess [1986] considered a repeated game with the same three players of this paper. However, he does not focus on the trade-off between inflation and distortionary taxes.

11. The first-order conditions for the CB and FA optimum in any period are respectively

$$\pi + \alpha\mu_2(g - \bar{g}) = 0, \qquad -\alpha\delta_1 x + \delta_2(g - \bar{g}) = 0.$$

Combining these with (4) yields (8).

act simultaneously, we can compute the equilibrium with commitments simply by imposing the requirement that $\pi_i = \pi_i^e$ before taking the CB first-order conditions, rather than subsequently. In other words, the CB is now allowed to take into account that in equilibrium no unexpected inflation is possible. The equilibrium can then be computed directly from the CB and FA first-order conditions[12] (the c superscript stands for commitments):

$$(\bar{g} - g^c) = \alpha^2\delta_1(v + \bar{g})/[\alpha^2\delta_1(1 + \mu_2) + \delta_2] > 0 \quad (9a)$$

$$x^c = -(\delta_2/\alpha\delta_1)(\bar{g} - g^c) < 0 \quad (9b)$$

$$\pi^c = \mu_2(\bar{g} - g^c) > 0. \quad (9c)$$

Comparing (8) and (9), the following proposition can immediately be established.

PROPOSITION 1.

$$\pi^c < \pi^d;\ x^c < x^d;\ \tau^c > \tau^d;\ g^c < g^d.$$

If $\mu_i = \delta_i$ both policymakers are better off in the regime with commitments. If $\mu_i \neq \delta_i$ both policymakers can be worse off in the regime with commitments than in the discretionary regime.

This result summarizes one of the major findings of this paper. In the previous related literature in which tax distortions were considered invariant to changes in the monetary regime, by allowing the CB to enter into binding commitments the inflation rate was reduced and output left unaffected. The conclusion was, then, that a regime with binding commitments was necessarily preferable to a discretionary regime. This result carries through to our model, if the two policymakers have the same loss function, despite the fact that the FA is forced to raise taxes in the equilibrium with commitments. However, the result that commitments are always better than discretion does not hold if the CB and the FA assign different weights to their objectives. In fact, in the regime with commitments the FA is forced to choose in a worse tradeoff between public spending and tax distortions, since money seignorage is smaller than in the discretionary equilibrium. Hence, the FA reacts to the change in monetary regime by raising taxes, thereby reducing output, to compensate for part of the loss of public spending determined by the decrease in money creation. The FA is made worse off by a committed CB, if the gain from the reduced inflation is more than compensated by the losses of output and public spending. This is likely to happen if the difference between the weights assigned by the two authorities to public expenditures, $(\delta_2 - \mu_2)$, is large. Surprisingly enough, even the CB could be worse off in the regime with commitments, if the output loss associated with the higher taxes exceeds the benefit of the lower inflation. This is likely to happen if the weight assigned by the CB to the output objective

12. The CB and FA first-order conditions in this case are respectively

$$\pi + \mu_2(g - \bar{g}) = 0, \qquad -\alpha\delta_1 x + \delta_2(g - \bar{g}) = 0.$$

Combining them with (4) and (5) yields (9).

(μ_1) is large. Finally, the TU is indifferent between the two regimes (even though it would be worse off with a committed CB if the TU cared also about employment). Thus, a committed CB can bring about a Pareto deterioration, in the sense that none of the players would be made better off and at least one of them can be made worse off.[13]

An objection to proposition 1 could be raised. The macroeconomic model assumes that the demand for money does not depend on the nominal interest rate, and thus on expected inflation. Thereby, the model assumes away a second source of time inconsistency of monetary policy, due to the incentive to generate unexpected inflation so as to increase the rate of money seignorage (on this issue, see Calvo [1978], Barro [1983], and Grossman and Van Huyck [1986]). If this second source of time inconsistency were added to the model, would the welfare implications of proposition 1 still hold? The answer is that in general they would. As Barro [1983] has shown, for a range of parameter values it would still be true that, in a regime with commitments, the CB would raise a smaller amount of revenue from money creation than in a discretionary regime. This in turn would still provide the FA with an incentive to react to the monetary regime change by raising distortionary taxes. If the loss functions of the two policymakers were sufficiently different, this reaction could still bring about a welfare deterioration for all the players in the game.

Finally, note that the comparison between the discretionary equilibrium and the equilibrium with commitments involves both a monetary and a fiscal regime change, since in both equilibria it is assumed that the two policymakers move simultaneously. This hypothesis is used merely to simplify the algebra, however, and in no way affects the nature of the results. A previous version of this paper contained a section analyzing only the monetary regime change, under the assumption that in both monetary regimes the FA acted as the dominant player in a Stackelberg equilibrium (i.e., under the assumption that in each period the FA would move first and could precommit with respect to the CB and the TU). The results (available upon request) confirm those of proposition 1: if $\mu_i \neq \delta_i$, the regime with a committed CB can be Pareto inferior relative to the regime with a discretionary CB, for a range of parameter values.

V. CONCLUDING REMARKS

The time inconsistency of optimal monetary policy is due to the lack of nondistortionary fiscal instruments. However, the tax distortions have been left implicit in the existing literature on the subject. In this paper these tax distortions are explicitly modelled and endogenously determined in a game with three players: the central bank, the fiscal authority and wage setters.

This paper shows that fiscal policy (and hence the level of tax distortions) is not invariant to changes in the monetary regime; whenever the monetary

13. For instance, a range of parameter values that makes both policymakers worse off with commitments is $\alpha = 1$, $\mu_2 = 1$, $\mu_1 = \delta_1 = \delta_2 = 5$.

reform alters the revenraised through money seignorage, the fiscal authority is induced to change level of taxation and/or the level of spending. This in turn has repercussi on the level of output that were neglected in the previous literature on topic. Whether or not the monetary reform is welfare improving thus gener depends on the degree of coordination between monetary and fiscal py.

In this paper, this ral point has been illustrated with respect to two kinds of monetary ref. One endows the central bank with the possibility of making binding coitments. This is the reform most discussed in the literature. The second olves appointing a central banker particularly averse to inflation and indepent from the FA (see, for example, Rogoff [1985a]).

In both cases, altho the reform succeeds in reducing the equilibrium rate of inflation, it alsods to reductions in the equilibrium level of output and public spending, ito higher taxes. As a consequence, contrary to the existing literature, thest of these two reforms (commitments) is not unambiguously welfare roving. On the contrary, if the two policymakers differ in the relative wits assigned to their final objectives, a regime with commitments may be usirable from the point of view of both policymakers. From a descriptive poof view, this result may help to explain why there is much disagreement at monetary reforms that would enable the monetary authorities to precomm From a normative point of view, it suggests that the desirability of commituts depends on the existing degree of coordination of monetary and fiscalicy. The issue concerning the optimal degree of coordination, in turn, ends on which policy suffers from the time inconsistency. If, as in the rel of this paper, only monetary policy is subject to a time inconsistency, thn a discretionary equilibrium some decentralization of monetary and fiscal cy is desirable. In other words, the fiscal authority is made better off by hag an independent central bank which is more averse to inflation than the fiauthority is, despite the loss in the revenue from money seignorage. Hover, if both fiscal and monetary policy are subject to a time inconsistency prm (or if neither is), this result may no longer hold.

This paper can be frully extended by incorporating a richer intertemporal dimension. There two important intertemporal issues that should be addressed in this conte:irst is the introduction of public debt. This would raise the important issu how to distribute the costs of inflation and of tax distortions over time itsetting with noncoordinated monetary and fiscal policies.[14] The second esion is to consider reputational aspects associated with the time consistensues. This can be done by postulating punishment strategies for the player for instance, in Barro and Gordon [1983] and Hess [1986] for a three-playame.

14. This topic has been addd by Tabellini [1986] in a somewhat different setting.

APPENDIX

Derivation of Equation (1)

The firm's optimization problem is (upper case letters denote antilogs)

$$\text{Max } P(1 - \tau)X - WN$$

subject to $X = N^{\gamma}$, $0 < \gamma < 1$.

The firm is a price taker in the output and in the labor market and is taxed on its total revenues. The first-order condition is

$$\gamma P(1 - \tau)N^{\gamma - 1} = W.$$

Using the production function to substitute away N and then taking logs yields

$$x = [\gamma/(\gamma - 1)][w - \ln\gamma - p - \ln(1 - \tau)],$$

where lower case letters denote logs. Finally, approximating $\ln(1 - \tau)$ by $-\tau$,

$$x = \alpha(p - w - \tau) + k,$$

where

$$\alpha = \gamma/(1 - \gamma) \qquad k = [\gamma/(1 - \gamma)]\ln \gamma.$$

Equation (1) in the text sets $k = 0$, to simplify notation. Equation (1) could have been written with $k \neq 0$, with the assumption that the target level of output for all players was k rather than 0; all the results would then have been identical to those presented in the text.

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