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MACROECONOMIC STABILIZATION THROUGH TAXATION AND INDEXATION: THE USE OF FIRM-SPECIFIC INFORMATION

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ABSTRACT

This paper considers two alternative approaches to stabilizing an economy with firm-specific productivity disturbances. The first uses wage contracts tying wages in each firm to these disturbances as well as the price level. The second uses a tax on firms which modifies their supply behavior together with a simple wage indexation rule tying wages to prices alone. Both these schemes are viable as long as the firm-specific disturbance is known to all agents. If the firm alone observes the productivity disturbance, under either scheme it has an incentive to misrepresent current conditions. However, a combination of these two schemes is both welfare maximizing and incentive compatible.

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1. INTRODUCTION

Wage indexation offers one solution to stabilizing an economy with labor contracts which fix wages on the basis of lagged information. Beginning with the contributions of Gray (1976) and Fischer (1977), a number of studies have examined how wages might be adjusted to current information in such a way as to replicate a full information, frictionless economy--one without wage contracts. The objective of the indexation scheme, in effect, is to undo the rigidities due to the contracts. One of the main conclusions of this literature is that indexation of wages to prices is in general incapable of replicating a frictionless economy. Full wage indexation to the domestic price level will stabilize the economy against monetary disturbances, but may accentuate the destabilizing effects of real disturbances. The optimal degree of indexation, which depends upon the relative importance of real and monetary disturbances, can at best minimize but not eliminate undesirable variations of output.

Recent studies, however, have shown how it is possible for more complex forms of wage indexation to replicate exactly a frictionless economy. Karni (1983), for example, demonstrates that if the wage is indexed not only to current prices, but also to current aggregate output, then it is indeed possible to stabilize the economy perfectly relative to the frictionless economy.[1] The scheme, however, requires that information on aggregate output, the crucial variable to be stabilized, be available virtually instantaneously, or at least within the time interval envisaged by the model. Such an assumption may be reasonable if every firm in the economy is subject to the same productivity disturbances, since then each firm would be able to infer the size of the aggregate disturbances from those occurring at the individual firm level. But if the productivity disturbances are at least partially <u>firm-</u>

specific, then the observations of any one firm give only partial information about the aggregate disturbances. Moreover, if labor is less than perfectly mobile between firms during the current period, then information about firm-specific disturbances, rather than just aggregate disturbances, must be incorporated in the indexation rule since wages in a competitive economy will vary from one firm to another.

In this paper we offer two alternative approaches to stabilizing an economy subject to firm-specific disturbances. One approach relies on privately-negotiated wage contracts which tie wages in each firm to firm-specific variables, as well as to the price level. This indexation rule is analogous to Karni's rule, except that the wage rate is tied to the output of the individual firm, or equivalently, to firm-specific disturbances, rather than to the aggregate output level.

As an alternative, we propose a taxation scheme to accompany a wage indexation rule tying wages to prices alone. Like the more complex indexation scheme, this combination of taxation and indexation enables the contract economy to replicate output in the competitive, full information economy. The tax is a levy on the net revenue of the firm with a corresponding tax credit for the employment of labor. It is designed to reduce the response of the firm's demand for labor to changes in prices or productivity disturbances, thereby mimicking the firm's output behavior in a competitive benchmark economy. The essential feature of the tax is that it makes use of firm-specific information, by inducing firms to modify their labor use in response to a productivity disturbance, but does not require that wages be tied to any firm-specific information.

Both of these schemes are viable as long as the firm-specific disturbance is known to all agents, including labor and the government, as well as firms. There is no particular need for the tax scheme in this case of symmetric information since the privately-negotiated wage contract described above is able to replicate the competitive, full information economy. If the firm alone observes the productivity disturbance, however, then the tax scheme plays a role in making the privately-negotiated contract incentive-compatible. With asymmetric information, the firm has an incentive to misrepresent current economic conditions. By doing so, it can reduce its wage bill in the case of the indexation scheme or reduce its tax liability in the case of the tax scheme. But, as we show below, a combination of the tax scheme with the privately-negotiated contract not only succeeds in replicating output in the competitive, full information economy, but also eliminates the incentive on the part of firms to misrepresent. This incentive-compatible scheme involves wage indexation to both the price level and the firm-specific disturbance coupled with an appropriate taxation scheme on the firm's revenue.

In the case where the productivity disturbance is known only to firms, departures from Pareto optimality can occur due to the incompleteness of private markets. It is this which creates the potential for welfare-improving government intervention. While our analysis shows that a tax scheme can improve welfare relative to an initial (incomplete) market situation, it sheds no light on why markets are incomplete. Nor does our analysis explain why the government has any advantage in improving welfare, since it does not explore purely private contract schemes which might also restore the competitive solution.[2]

The remainder of the paper is structured as follows. Section 2 describes a benchmark competitive economy, paying particular attention to the underlying microeconomic structure. The contract economy is discussed in Section 3. The two partial schemes are discussed in Section 4, while the incentive-compatible scheme is derived and discussed in Section 5. Our conclusions are given in Section 6. The analysis can be thought of as applying either to a closed economy or to a small open economy operating in a world in which domestic and foreign goods are perfect substitutes. Only a modest modification is required to extend the results to an open economy in which domestic and foreign goods are imperfect substitutes.

2. A BENCHMARK COMPETITIVE ECONOMY

We consider an economy consisting of K firms, each of which produces an identical good by means of a Cobb-Douglas production function of the form

$$Y_t^i = (L_t^i)^{1-\theta} e^{v_t^i} . \tag{1}$$

Y_t^i and L_t^i represent the output and labor used by each firm, while v_t^i is a productivity disturbance, which is assumed to be firm specific. We assume that the firm can observe its own current output and can therefore observe the value of the disturbance v_t^i when it occurs. Throughout Sections 2-4, v_t^i is also assumed to be known to the labor employed by the firm and the government. In Section 5 we assume that it is known only to the firm and discuss the moral hazard problems this raises. In the absence of disturbances, the output of the representative firm is

$$Y_o^i = (L_o^i)^{1-\theta} , \tag{1'}$$

where the subscript o denotes the stationary equilibrium. Linearizing the production function (1) about the stationary level (1') we obtain an expression for the percentage change in output as a function of the percentage change in labor and the productivity disturbance[3]

$$y_t^i = (1 - \theta)\ell_t^i + v_t^i , \tag{2}$$

where $y_t^i \equiv (Y_t^i - Y_o^i)/Y_o^i$, $\ell_t^i \equiv (L_t^i - L_o^i)/L_o^i$, denote percentage changes.

We assume that workers are mobile between firms from one period to another, so the wage paid in the stationary equilibrium (where disturbances are absent) is the same across firms. We assume, however, that because of the significant costs of moving between firms, workers are immobile within the period, so wages can vary from firm to firm ex post once the supply disturbances are revealed to the firm. We believe this assumption is preferable to the usual one of perfect mobility between firms, which in the presence of firm-specific disturbances requires an unrealistic degree of interfirm mobility within every period.[4]

In an economy with spot labor markets, but with labor tied in the current period to individual firms, each firm has an incentive to exercise monopsony power over its labor. So the equilibrium attained by such an economy will not, in general, be Pareto optimal. The benchmark equilibrium to be used for welfare comparisons, however, should be that of an economy where both firms and labor behave competitively. So the equilibrium we describe below is one in which each firm behaves as if it were competitive in the labor market.[5] Later we shall describe indexation-cum-taxation schemes which achieve this same Pareto optimal equilibrium.

Assuming that the representative firm behaves competitively, profit maximization yields the following labor demand function expressed in terms of percentage changes:

$$\ell_t^i = \frac{1}{\theta}(p_t - w_t^i) + \frac{1}{\theta} v_t^i , \tag{3}$$

where p_t, w_t^i denote the percentage changes in the price of output and the firm-specific wage, respectively. The supply of labor, which is tied to the firm within the period, is given by

$$\ell_t^i = n(w_t^i - p_t) \ , \quad n > 0 \ . \tag{4}$$

Equating (3) and (4) yields the reduced form expressions for the employment of labor, output, and the real wage in the benchmark economy

$$\ell_t^{i*} = \left(\frac{n}{1 + n\theta}\right) v_t^i \ , \tag{5a}$$

$$y_t^{i*} = \left(\frac{1 + n}{1 + n\theta}\right) v_t^i \ , \tag{5b}$$

$$w_t^{i*} - p_t^* = \left(\frac{1}{1 + n\theta}\right) v_t^i \tag{5c}$$

where * denotes the benchmark economy. The percentage change in these real variables is a function of the firm-specific productivity disturbance, but is independent of any demand disturbance, insofar as these operate through the nominal price level.

Total output in the economy is

$$Y_t = \sum_{i=1}^{K} Y_t^i \ . \tag{6}$$

In stationary equilibrium, all firms produce the same output using the same amount of labor and paying the same wage:

$$Y_o^i = Y_o/K, \ L_o^i = L_o/K, \ W_o^i = W_o \ .$$

In an economy with supply disturbances, however, total output is a function of the aggregate supply disturbance. In percentage terms, the aggregate supply disturbance can be expressed as an average of the firm-specific disturbances, $v_t = \frac{1}{K} \sum_{i=1}^{K} v_t^i$. Each firm-specific disturbance, in turn, can be decomposed into the common aggregate disturbance and a firm-specific component, e_t^i:

$$v_t^i = v_t + e_t^i \ , \ \sum_{i=1}^{K} e_t^i = 0 \ . \tag{7}$$

Both v_t and e_t^i have means of zero and are serially uncorrelated, as well as uncorrelated with one another. Aggregate employment, aggregate output, and the average wage are obtained by summing the corresponding expressions for the firm (5a-5c) over the K firms. Each of the variables is expressed below as a percentage change from its stationary level:

$$\ell_t^* = \left(\frac{n}{1 + n\theta}\right) v_t \ , \tag{8a}$$

$$y_t^* = \frac{1 + n}{1 + \theta n} \ v_t \ , \tag{8b}$$

$$w_t^* - p_t^* = v_t/(1 + \theta n) \ , \tag{8c}$$

where $\ell_t \equiv \frac{1}{K} \sum_{i=1}^{K} \ell_t^i$, $y_t \equiv \frac{1}{K} \sum_{i=1}^{K} y_t^i$, and $w_t \equiv \frac{1}{K} \sum_{i=1}^{K} w_t^i$.

The behavior of the real and nominal variables in this economy will be used as a benchmark for the comparison with the contract economy to be introduced below. Before turning to the latter, however, we shall illustrate the adjustment of real wages and employment to a productivity shock in the benchmark economy. Figure 1 illustrates the case of a positive shock, $v_t^i > 0$. The labor supply curve is unaffected by this shock, while the labor demand curve shifts up in proportion to the disturbance (to $L_t^{d'}$). As a result, the <u>level</u> of employment and the <u>level</u> of the real wage both rise as follows

$$L_t^{i*} = L_o^i[1 + (nv_t^i)/(1 + n\theta)] \ , \tag{9}$$

$$W_t^{i*}/P_t^* = (W_o^i/P_o)[1 + v_t^i/(1 + n\theta)] \ . \tag{10}$$

These equations are obtained by substituting the values of ℓ_t^{i*} and $w_t^{i*} - p_t^*$ derived above into equations of the form

$$L_t^{i*} = L_o^i(1 + \ell_t^{i*}) ,$$

$$W_t^{i*}/P_t^* = (W_o^i/P_o)(1 + w_t^{i*} - p_t^*) .$$

For the contract economy described below, we shall specify wage indexation and taxation systems which will replicate the employment behavior of this economy. The wage rate will behave differently in the contract economy under the taxation scheme. However, an appropriate redistribution of the tax revenues will ensure that the behavior of total wage income in the two economies is identical.

3. CONTRACT ECONOMY

The economy we wish to analyze differs from the benchmark economy described in the previous section in one crucial respect. The wage is set in a contract at the beginning of the period, before any disturbances are known. As in other contract models, this contract wage is chosen so as to clear the market at the price expected at the beginning of period t, on the basis of previous information.

Because of the existence of contract lags, the nominal wage rate is assumed to be indexed to variables known currently. To reduce (and perhaps eliminate) variations in real wages, nominal wages are indexed to the price level, p_t. Since wages are firm-specific, however, they may be indexed to firm-specific variables as well as economy-wide variables. For the wage paid to workers in firm i, the obvious candidate is the output of firm i or, equivalently, the productivity disturbance of firm i, v_t^i, which is observable to firm i. So the indexation rule will take the form:

$$w_t^i = w_t^c + b_1(p_t - E_{t-1}p_t) + b_2 v_t^i \, , \tag{11}$$

where w_t^c denotes the (economy-wide) contract wage determined at the beginning of period t and $E_{t-1}p_t$ denotes the expected price level based on information available in the previous period, t-1. The parameters b_1, b_2 describe the proportional degree of indexation.

As an alternative to this indexation rule, we offer a tax on the firm which makes use of firm-specific information. Our choice of such a taxation scheme is governed by the need to affect supply behavior directly so as to modify the individual firm's response to productivity disturbances. Each firm in the economy is subject to a marginal tax on its gross revenues $p_t + y_t^i$, at a rate β, with a corresponding tax credit for the labor employed by the firm. If T_t^i is the total tax collected from firm i, then the deviation in the tax about that in the initial equilibrium can be expressed as a percentage of the gross revenue of the firm in stationary equilibrium as follows:

$$\frac{T_t^i - T_o^i}{P_o Y_o^i} = \beta[p_t + y_t^i - (1 - \theta)\ell_t^i] \, . \tag{12}$$

Equation (12) provides the most convenient specification of the tax. Its statement in level form is given in the Appendix. With this tax, the change in the net profit of the firm, R_t^i, is given (in deviation form) by

$$\frac{R_t^i - R_o^i}{P_o Y_o^i} = (1 - \beta)(p_t + y_t^i) + \beta(1 - \theta)\ell_t^i - (1 - \theta)(w_t^i + \ell_t^i) \, . \tag{13}$$

If $\beta = 0$, the net profit function is the same as in the benchmark economy. But with β non-zero, the tax provides a lever for modifying the output behavior of the firm in response to a current disturbance.[6]

The tax modifies the response of labor demand to a productivity increase. As shown in the Appendix, maximizing net profit yields the labor demand function

$$\ell_t^i = (1 - \beta)p_t/\theta - w_t^i/\theta + (1 - \beta)v_t^i/\theta \ , \tag{14}$$

which implies the corresponding aggregate labor demand function

$$\ell_t = (1 - \beta)p_t/\theta - w_t/\theta + (1 - \beta)v_t/\theta \ . \tag{15}$$

A rise in productivity in firm i ($v_t^i > 0$) increases the demand for labor, the magnitude of the response depending upon the marginal tax rate β. When $\beta = 0$, the demand for labor shifts just as much in the contract economy as in the benchmark economy; cf (3) and (14). Employment must rise more in the contract economy than in the benchmark economy. This is because wages are fixed in the former, whereas they respond to the increase in labor demand in the latter (as long as labor supply is positively sloped). When $\beta > 0$ the demand for labor responds less to a productivity increase than in the benchmark economy. With the correct marginal tax rate, in fact, the demand for labor shifts just enough to achieve the <u>same</u> employment level as in the benchmark economy.

To obtain the contract wage, we equate aggregate labor demand (equation (15)) with an aggregate version of the labor supply equation (4), to express w_t as a function of p_t and v_t. The contract wage is then equal to the expected value of w_t, based on the information available at the beginning of the period

$$w_t^c = \left(\frac{1 - \beta + n\theta}{1 + n\theta}\right) E_{t-1} p_t \ . \tag{16}$$

The conditional expectation of the price level depends upon the nature of the underlying stochastic disturbances which current price movements reflect. We shall assume that these disturbances are white noise, in which case $E_{t-1}p_t$, and hence w_t^c, are both zero. As a result, the wage indexation rule (11) takes the simple form,

$$w_t^i = b_1 p_t + b_2 v_t^i \, , \tag{11'}$$

which ties the wage to the price (both expressed as percentage changes) and the supply disturbance.

Output of the i-th firm in the contract economy can be obtained by solving (2), (14) and (11') to express output y_t as a function of p_t and the productivity disturbance:

$$y_t^i = \left(\frac{1 - \theta}{\theta}\right)(1 - \beta - b_1)p_t + \left[\frac{1 - (\beta + b_2)(1 - \theta)}{\theta}\right]v_t^i \, . \tag{17}$$

According to this expression, output is a function of current prices as well as the productivity disturbance, with the coefficients of p_t and v_t^i being functions of the indexation and tax parameters. To determine the optimal indexation and taxation parameters, we shall compare the output in this economy with that in the benchmark economy. More specifically, we shall choose values of those parameters which minimize the value of Z:

$$Z = E(y_t^i - y_t^{i*})^2 \, . \tag{18}$$

4. OPTIMAL STABILIZATION

Substituting (17) and (5b) into (18), we obtain

$$Z = \left(\frac{1 - \theta}{\theta}\right)^2 E\left[(1 - \beta - b_1)p_t + \left[\frac{1}{1 + n\theta} - (\beta + b_2)\right]v_t^i\right]^2 \, . \tag{19}$$

Appropriate choices of the policy parameters b_1, b_2, and β will ensure that the coefficients of p_t and v_t^i are equal to zero, so that the output for each firm in the contract economy matches that in the benchmark economy. (As a result, aggregate output must be identical in the two economies.) The appropriate values satisfy the relationships

$$b_1 + \beta = 1 \ , \tag{20a}$$

$$b_2 + \beta = \frac{1}{1 + n\theta} \ . \tag{20b}$$

It is an immediate consequence of these equations that there is an extra degree of freedom with respect to the choice of the optimal policy parameters. One of them can be set arbitrarily; the other two are then determined uniquely by these two relationships. The two most natural cases to consider are where (i) wage indexation alone is available to stabilize the economy ($\beta = 0$) and (ii) taxation is used to supplement wage indexation to prices alone ($b_2 = 0$). We shall discuss these in turn.

A. Stabilization Through Wage Indexation Alone

Setting $\beta = 0$ in (20a), (20b), we immediately obtain

$$b_1 = 1 \ , \tag{20a'}$$

$$b_2 = 1/(1 + n\theta) \ , \tag{20b'}$$

so that

$$w_t^i = p_t + \frac{v_t^i}{1 + n\theta} \ . \tag{21}$$

That is, the wage rate should be fully indexed to the price level, but only partially to the productivity disturbance. It is easy to understand why this rule replicates the behavior of the frictionless economy. It keeps the indexed wage equal to the wage found in the benchmark economy; c.f. (21) and (5c).

By making use of both price and production information, (21) is analogous to the rule recently proposed by Karni (1983) for a closed economy. In a model with economy-wide disturbances, Karni proposed indexing the (economy-wide) wage to the level of aggregate output, which is assumed to be publicly known, as well as the price level. In his model, such an indexation rule eliminates all variations of aggregate output relative to that of the benchmark economy because it duplicates the wage in such an economy. The same argument applies here, except that we must tie the firm-specific wage to the firm-specific output, or equivalently, to the firm-specific disturbance as in (21).[7]

B. Stabilization Through Indexation and Taxation

The indexation rule (21) gives rise to wage rates which are firm-specific. Yet in many economies where wage indexation is practiced, the wage is tied to some common price index, so that the indexation is uniform across industries. This is the case, for example, in Australia. Thus as an alternative to indexation based on firm-specific disturbances, in this section we consider a tax scheme which, when combined with indexation of wages to prices alone, induces firms to produce at the same levels as in the benchmark economy. The tax specified in Section 3 is levied on the individual firm. Each firm makes its production decision based on the tax rate and the wage rate which is tied through indexation to the price level alone. The indexation parameter, b_2, is therefore set to zero, so that the wage rate is identical for all firms.

The optimal taxation and indexation parameters are obtained from (20a) and (20b) for the case where $b_2 = 0$:

$$b_1 = 1 - \beta = n\theta/[1 + n\theta] \;, \qquad (20a'')$$

$$\beta = 1/[1 + n\theta] \;. \qquad (20b'')$$

Choosing those values of the parameters, the coefficients of p_t and v_t^i in (19) are both equal to zero and so output in the contract economy must replicate that in the benchmark, Pareto optimal economy.

The expressions for the optimal pair of taxation and indexation parameters are simple, depending upon only the supply elasticity of labor, n, and the elasticity of labor in the production function, and being independent of the stochastic structure of the economy. Notice that the taxation parameter ranges from one to zero as the labor supply elasticity varies from zero to infinity. The wage indexation parameter in turn varies from zero to one. In general, partial wage indexation is optimal. Full indexation is optimal only in the limiting case where labor supply is infinitely elastic.

Given the optimal tax and indexation parameters, the values of the other endogenous parameters can be derived. Substituting for the optimal β into (17), output is given by

$$y_t^i = \left(\frac{1 + n}{1 + n\theta}\right) v_t^i \ . \tag{22}$$

Also, with $w_t^c = E_{t-1}p_t = 0$, the money wage (identical for all firms) corresponding to the optimal indexation scheme is

$$w_t^i = \left(\frac{n\theta}{1 + n\theta}\right) p_t \ , \tag{23}$$

and substituting this expression into (14), employment is determined by

$$\ell_t^i = \left(\frac{n}{1 + n\theta}\right) v_t^i \ . \tag{24}$$

Notice that both (22) and (24) are identical to their counterparts in the benchmark economy (equations (5b) and (5a), respectively). By contrast, the money wage, being tied directly to the price level, does not replicate that of the benchmark economy.

To explain how the combined system of indexation and taxation modifies behavior in this economy, we focus on the wage and labor demand equations. Below we express both equations in terms of the level of the real wage by substituting the expressions for $w_t^i - p_t$ found in (11') and (14), respectively (with $b_2 = 0$), into

$$(W_t^i/P_t) = (W_o^i/P_o)(1 + w_t^i - p_t)$$

to yield

$$W_t^i/P_t = (W_o^i/P_o)\left[1 - (1 - b_1)p_t\right] , \tag{25}$$

and

$$(W_t^i/P_t) = (W_o^i/P_o)\left[1 - \beta p_t - \theta \ell_t^i + (1 - \beta)v_t^i\right] . \tag{26}$$

It is evident from the form of these two equations that as long as $\beta = 1 - b_1$, a rise in the price level has no effect on employment since the real wage rises or falls by the same amount in both equations. Thus a monetary disturbance, which affects the labor market only through prices, leaves employment, and therefore output, unchanged. Observe that the real wage <u>is</u> affected, a point to which we shall return below.

Productivity disturbances have two-fold effects on the labor market facing individual firms. To the extent that an increase in productivity is economy-wide ($v_t > 0$), the wage and labor demand equations must both shift in proportion to the resulting change in the price level. (The price level falls, although the magnitude of the price adjustment cannot be determined without introducing a demand side of the economy.) To the extent that the firm itself experiences an increase in productivity ($v_t^i = e_t^i > 0$), in contrast, the labor demand curve alone is affected, shifting horizontally by

$$\ell_t^i = \frac{(1 - \beta)}{\theta} v_t^i = \frac{n}{(1 + n\theta)} v_t^i . \tag{27}$$

In Figure 1, we illustrate this adjustment to the firm-specific disturbance for the case where only this firm experiences a disturbance. An increase in productivity confined to firm i leaves the price level constant so the wage is also constant. The rise in productivity shifts L_t^d to $L_t^{d''}$, thus raising employment to L_t^{i*}.[8]

5. INCENTIVE-COMPATIBLE SCHEMES

In the previous sections we have assumed that the firm-specific productivity disturbances are observed by all the agents in the economy. Under this assumption either of the two schemes we have been discussing will succeed in replicating output in the benchmark economy perfectly. In this section we consider what happens when the firm alone observes its productivity disturbance. We first show that the firm has an incentive to misrepresent current conditions, in order to reduce its wage bill in the case of the indexation scheme,[9] or to reduce its tax liability in the case of the tax scheme. We then show how a combination of the two schemes is incentive-compatible by which we mean that there is no incentive on the part of the firm to misrepresent the true disturbance.[10]

We begin by illustrating the incentive to misrepresent a firm-specific rise in productivity in firm i ($v_t^i = e_t^i$). We do this by comparing the profits to the firm obtained by revealing the truth (which we call 'full disclosure') with those obtained by not revealing the disturbance (which we label 'cheating'). Let the firm's net (after-tax) profits be written as a percentage change from their stationary value as $\Pi_t^i = (R_t^i - R_o^i)/R_o^i$. Using the expression (A.6) for $R_t^i - R_o^i$ developed in the appendix and substituting into that expression the wage indexation rule (11'), we obtain the following expression for profit in the case of full disclosure

$$\Pi_t^i\Big|_{\text{full disclosure}} = \frac{1}{\theta}\left\{(1-\beta)(p_t + y_t^i) + \beta(1-\theta)\ell_t^i - (1-\theta)(w_t^i + \ell_t^i)\right\}$$

$$= \frac{1}{\theta}\left\{(1-\beta)(p_t + v_t^i) - (1-\theta)(b_1 p_t + b_2 v_t^i)\right\} . \tag{28}$$

If the firm announces its productivity disturbance, then it must pay a higher tax, βv_t^i, or pay its workers a higher wage, $b_2 v_t^i$, depending upon whether the tax or the firm-specific wage indexation scheme is in effect. If, on the other hand, the firm decides not to reveal the disturbance, it can avoid the higher tax or the higher wage, so that its profits are given by

$$\Pi_t^i\Big|_{\text{cheating}} = \frac{1}{\theta}\left\{(1-\beta)p_t + v_t^i - (1-\theta)b_1 p_t\right\} . \tag{29}$$

The gain in profits from cheating is therefore

$$\Pi_t^i\Big|_{\text{cheating}} - \Pi_t^i\Big|_{\text{full disclosure}} = \frac{1}{\theta}\left\{\beta + (1-\theta)b_2\right\}v_t^i . \tag{30}$$

It is clear that as long as the productivity disturbance is positive, there is an incentive not to announce productivity gains, whether the tax (at the rate β) or the firm-specific indexation scheme (with indexation parameter b_2) is in effect.[11] By the same reasoning, if the rise in productivity is economy-wide ($v_t^i = v_t$), then the firm will have an incentive to claim that the resulting fall in prices is due to disturbances elsewhere in the economy. A firm could claim, for example, that prices have fallen because of productivity disturbances confined to other firms.

Since labor should be aware of these incentives to misrepresent, it will be reluctant to enter into an indexation scheme of this type unless there is some provision for monitoring the firm's productivity. Monitoring, in fact, is sometimes found in profit-sharing schemes in the United States, where labor is allowed to bring in independent auditors to verify a firm's profit figures. Similarly, the government is unlikely to establish a tax scheme unless some monitoring of the firm is possible. In either case, even if monitoring is feasible, it is likely to be costly to the economy. Thus as an alternative to these schemes which require surveillance, we now propose a modification of the tax and indexation rules which eliminates the incentive to cheat on the part of the firm. The necessary modification is suggested by (30) above. Specifically, we need to combine the tax and indexation schemes and to convert the tax into a <u>subsidy</u> ($\beta < 0$), so that

$$\beta = -(1 - \theta)b_2 < 0 , \tag{31}$$

in which case the gain from misrepresenting current conditions is eliminated entirely.

Of course we still require the indexation and taxation parameters to replicate the benchmark economy. Thus the combination of b_1, b_2, and β, which satisfy (20a), (20b), as well as (31) will succeed <u>both</u> in achieving the stabilization objective and in inducing firms to reveal the truth. The unique set of indexation and tax parameters which satisfies all three conditions (20a), (20b), and (31) is given by

$$b_1 = 1 + \frac{1 - \theta}{\theta(1 + n\theta)} > 1 , \tag{32a}$$

$$b_2 = \frac{1}{\theta(1 + n\theta)} > 0 , \tag{32b}$$

$$\beta = - \frac{(1 - \theta)}{\theta(1 + n\theta)} < 0 . \tag{32c}$$

Since (20a) and (20b) are satisfied, all deviations of output from that in the benchmark economy are eliminated. And since (31) is satisfied, there is no incentive on the part of firms to misrepresent current conditions.

There are two features of this combined taxation and indexation scheme which require further discussion. First, the indexation parameter for prices

(b_1) is greater than unity so that wages are indexed more than proportionally to prices. Second, the combined scheme does not necessarily duplicate the income distribution found in the benchmark economy. However, by the appropriate choice of a lump sum tax to finance the subsidy to firms, we can ensure that <u>after-tax</u> wage income is proportional to prices, rather than being over-indexed, and that the <u>after-tax</u> income distribution is identical to that of the benchmark economy, at least at the aggregate level. The subsidy to firms must be financed by a lump sum tax on labor and firms proportional to their shares in nominal output, $(1 - \theta)$ and θ, respectively.

Consider first the change in after-tax wage income for the workers in firm i. The workers in that firm must pay $\tau_t^i - \tau_o^i = -(1 - \theta)(T_t - T_o)/K$ of lump sum taxes to finance the revenue subsidy, where $\tau_t^i - \tau_o^i$ is the tax on the workers of firm i, $T_t - T_o$ is the subsidy (the negative tax on the revenues of firms), both expressed as deviations from their levels in a stationary equilibrium, and K is the number of firms.[12] So their total after-tax income, denoted by N_t^i, can be expressed as a deviation from its level in a stationary economy, as follows

$$\begin{aligned} N_t^i - N_o^i &= (W_t^i L_t^i - W_o^i L_o^i) - (\tau_t^i - \tau_o^i) \\ &= (W_t^i L_t^i - W_o^i L_o^i) + \frac{1}{K}(1 - \theta)(T_t - T_o) \ . \end{aligned} \tag{33}$$

To obtain an expression for total lump sum taxes, we aggregate the expression for the subsidies paid to firms (12) and simplify[13]

$$T_t - T_o = \sum_{i=1}^{K} (T_t^i - T_o^i) = P_o Y_o \beta (p_t + v_t) \ . \tag{34}$$

Given the Cobb Douglas production technology, the share of labor income in the stationary economy is given by $(1 - \theta) = (W_o L_o)/(P_o Y_o)$. The tax which the labor force in firm i pays is therefore

$$\tau_t^i - \tau_o^i = -\frac{(1-\theta)(T_t - T_o)}{K} = -\frac{W_o L_o}{K}\beta(p_t + v_t) = -W_o^i L_o^i \beta(p_t + v_t) \ . \qquad (35)$$

Wage income for the workers of firm i, exclusive of the tax, is obtained by substituting the demand for labor (14) and the wage indexation rule (11') into

$$W_t^i L_t^i - W_o^i L_o^i = W_o^i L_o^i (w_t^i + \ell_t^i)$$

to yield

$$W_t^i L_t^i - W_o^i L_o^i = W_o^i L_o^i \{[\frac{(1-\beta) - b_1(1-\theta)}{\theta}]p_t + [\frac{(1-\beta) - b_2(1-\theta)}{\theta}]v_t^i\} \ . \qquad (36)$$

Total after-tax income is therefore given by

$$N_t^i - N_o^i = W_o^i L_o^i [(\frac{1-(b_1+\beta)(1-\theta)}{\theta})p_t + [\frac{1-\beta-(1-\theta)b_2}{\theta}]v_t^i + \beta v_t] \ . \qquad (37)$$

Since at the optimum $b_1 + \beta = 1$, the coefficient of p_t in (37) is equal to unity. Thus, after-tax wage income is fully indexed to the price level.[14] Wage indexation itself overcompensates workers for a rise in the price level, but the tax levied to pay for the subsidy to firms reduces net wage income so that it rises in proportion to prices.

We now show that the tax used to finance the subsidy to firms restores aggregate wage income and profits to their levels in the benchmark economy. We demonstrate this result only for wage income, since this together with profits exhausts nominal output. Aggregate after-tax wage income is obtained by aggregating $N_t^i - N_o^i$ in (37) over K firms. This yields

$$N_t - N_o = \sum_{i=1}^{K} (N_t^i - N_o^i)$$

$$= W_o L_o [(\frac{1-(b_1+\beta)(1-\theta)}{\theta})p_t + (\frac{(1-\beta)-(1-\theta)b_2}{\theta} + \beta)v_t] \ . \qquad (38)$$

At the optimum, given by (32a)-(32c), we find

$$N_t - N_o = W_o L_o \{p_t + (\frac{1 + n}{1 + n\theta}) v_t\} \quad . \tag{38'}$$

Wage income in the frictionless economy is obtained by substituting (8a) and (8c) into the following expression

$$\begin{aligned} W_t^* L_t^* - W_o L_o &= W_o L_o \{w_t^* + \ell_t^*\} \\ &= W_o L_o \{p_t^* + (\frac{1 + n}{1 + n\theta}) v_t\} \quad . \end{aligned}$$

Since $p_t^* = p_t$, as long as output is identical in the two economies, the after-tax wage income in the contract economy is identical to the tax-free wage income in the benchmark economy.

Although aggregate after-tax income matches that in the benchmark economy, the labor force in each firm does not receive the same income, inclusive of taxes, as in the benchmark economy. Likewise, the income of each owner of a firm differs in the two economies. So in order to achieve the same consumption pattern as in the benchmark economy, we must assume that total consumption by labor (or owners) is independent of the distribution of income within that class.[15] By designing the taxes in this way, the government avoids affecting the incentives of the individual firms in responding to firm-specific disturbances.

6. CONCLUSIONS

In this paper we have analyzed wage contracts in an economy with firm-specific productivity disturbances. In the case where the disturbance is known to all relevant agents we have considered two alternative schemes which achieve the same equilibrium as in the competitive frictionless economy. The first is a privately negotiated wage indexation rule which ties wages in each firm to the overall price level, as well as the firm-specific productivity disturbance. The indexation rule, which is analogous to Karni's rule for an aggregate economy, involves full indexation to prices and partial indexation to the productivity disturbance. Secondly, we have proposed a taxation scheme to accompany a simpler form of wage indexation tying wages to prices alone and have shown how this too can achieve the same objective. The tax, levied on a firm's revenue with a tax credit for labor use, modifies the firm's response to the productivity disturbance, inducing the firm to produce the same output as in the benchmark economy. The optimal indexation scheme is a partial one and depends upon just two parameters: (i) the supply elasticity of labor, and (ii) the elasticity of labor in the production function. The tax rate depends upon the same two parameters.

In the case where the productivity disturbance is known to the firm alone, we have shown that the firm has an incentive to misrepresent current conditions. When taxes are combined with firm-specific wage indexation, however, the incentive for the firm to cheat is eliminated. The tax must take the form of a revenue subsidy to firms financed by a lump sum tax shared by labor and firms in proportion to their contribution to total output. As stated at the outset, our analysis does not explain the absence of complete markets or why the government through this tax scheme has an advantage in making privately-negotiated contracts incentive-compatible. It may well be the case that a purely private contract can fulfill the same role. We leave such an investigation for future research.

As a final point we may note that the results we have obtained can be interpreted as applying either to a closed economy or an open economy under purchasing power parity. The results are virtually unchanged in the case of an open economy in which domestic and foreign goods are distinct. In the latter case the same degree of indexation is applied to the CPI, rather than to the domestic price level.

FOOTNOTES

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1. Aizenman (1983) and Aizenman and Frenkel (1983) follow a different course by analyzing indexation in economies where prices are currently observable, but output is not. They show that indexation can eliminate all variations in output relative to the full information competitive economy except those due to disturbances unforecastable on the basis of current information.

2 Several studies have investigated implicit labor contracts for the case where firms have an informational advantage. (See, for example, Azariadis and Stiglitz, 1983, and the papers cited there).

3. Of course (2) holds exactly, rather than as only a first order approximation, if all lower case letters are interpreted as logarithms. Working with percentage changes makes aggregation simpler.

4. It would be even more preferable to model explicitly the costs associated with short-run mobility, although this would complicate the analysis considerably.

5. A competitive equilibrium would be attainable in a frictionless economy without contract lags if the disturbances were common to a subset of firms within which labor was mobile even within the period (such as firms within a particular geographic area), as long as that subset is large enough to ensure competitive labor market behavior.

6. McCallum and Whitaker (1979) analyze the stabilizing effects of an income tax which acts as a built-in stabilizer for aggregate output. Although

our tax also acts as a built-in stabilizer, it is levied on the revenue of firms rather than on income, and therefore modifies supply rather than demand behavior. Because it affects the supply behavior of firms, it is able to undo the distorting effects of the labor contracts on the output of individual firms.

7. Indexation to the productivity disturbance can be thought of as a bonus scheme. Bonuses tied to the firm's performance are quite common practice in countries such as Japan as well as in specific industries in the United States, such as investment banking. Bonus schemes, however, are typically asymmetric in not penalizing workers in bad years.

8. The above argument establishes that the taxation-indexation scheme succeeds in replicating output in the benchmark economy. Using the same argument as that developed in Section 5 below we can show that by an appropriate lump sum rebate of the tax we are able to restore aggregate wage income and profits to their respective levels in the benchmark economy.

9. Barro (1977) and Fischer (1977) discuss problems of moral hazard arising when firms are aware of real disturbances, but labor is not.

10. For a discussion of incentive-compatibility in a general context, see Myerson (1979).

11. In the case of a negative productivity shock, (30) measures losses. In this case to minimize losses the firm will have an incentive to reveal the productivity decrease and to index wages or pay taxes accordingly.

12. Recall that since T represents a subsidy, $T_t < 0$.

13. Equation (34) is derived as follows. Combining equations (2) and (12),

$$T_t^i - T_o^i = \beta(P_o Y_o^i)(p_t + v_t^i) \text{ .}$$

Summing over the K firms, and noting that $Y_o^i = \frac{Y_o}{K}$ and $v_t = \frac{1}{K}\sum_{i=1}^{K} v_t^i$, we obtain (34).

14. The subsidy to firms is equal to zero in stationary equilibrium, $T_o^i = 0$, so $N_o^i = W_o^i L_o^i$. (To show that $T_o^i = 0$, evaluate T_t^i in (A.1) at $t = 0$, where by assumption $P_o = 1$.) If the productivity disturbances are equal to zero ($v_t^i = v_t = 0$), equation (37) simplifies to

$$(N_t^i - N_o^i)/N_o^i = p_t \ .$$

15. If indifference curves are homothetic, the total consumption of labor will be independent of the distribution among the labor forces of individual firms.

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Appendix:

In this appendix, the expressions (12)-(14) for the contract economy are derived.

Consider the following expression for the tax levied on firm i, expressed in terms of the levels of output and other variables:[a]

$$T_t^i = P_t Y_t^i - (P_t Y_t^i)^{1-\beta} (L_t^i)^{\beta(1-\theta)} \quad , \quad 0 < \beta < 1 \; . \tag{A.1}$$

As noted in the text, this is a tax on gross revenue, with a credit for the employment of labor. If we linearize this expression by taking a first-order (Taylor series) approximation, we obtain:

$$\begin{aligned} T_t^i - T_o^i = {} & P_o (L_o^i)^{1-\theta} [p_t + y_t^i] - (P_o)^{1-\beta} (L_o^i)^{1-\theta} \\ & \left[(1 - \beta)(p_t + y_t^i) + \beta(1 - \theta) \ell_t^i \right] \; . \end{aligned} \tag{A.2}$$

Assuming that by choice of units, $P_o = 1$, and noting that by (1') $Y_o^i = (L_o^i)^{1-\theta}$, we can express taxes as a percentage of gross revenue as follows:

$$\begin{aligned} \frac{T_t^i - T_o^i}{P_o Y_o^i} &= p_t + y_t^i - \left[(1 - \beta)(p_t + y_t^i) + \beta(1 - \theta) \ell_t^i \right] \\ &= \beta\left[p_t + y_t^i - (1 - \theta) \ell_t^i \right] \; . \end{aligned} \tag{A.3}$$

This is equation (12) of the text.

Given the tax function (A.1), the net profit of the firm is

$$R_t^i = (P_t Y_t^i)^{1-\beta} (L_t^i)^{\beta(1-\theta)} - W_t^i L_t^i \; . \tag{A.4}$$

The first-order approximation of this expression is

$$\begin{aligned} R_t^i - R_o^i = {} & (P_o)^{1-\beta} (L_o^i)^{1-\theta} \left[(1 - \beta)(p_t + y_t^i) + \beta(1 - \theta) \ell_t^i \right] \\ & - W_o^i L_o^i (\ell_t^i + w_t^i) \; . \end{aligned} \tag{A.5}$$

Given the Cobb-Douglas production function, we know that

$$\frac{W_o^i L_o^i}{P_o Y_o^i} = 1 - \theta ,$$

so dividing (A.5) by $P_o Y_o^i$ we obtain

$$\frac{R_t^i - R_o^i}{P_o Y_o^i} = (1 - \beta)(p_t + y_t^i) + \beta(1 - \theta)\ell_t^i - (1 - \theta)(w_t^i + \ell_t^i) , \tag{A.6}$$

which is equation (13) in the text.

Finally, writing (A.4) as

$$R_t^i = P_t^{1-\beta}(L_t^i)^{1-\theta} e^{(1-\beta)v_t^i} - W_t^i L_t^i , \tag{A.7}$$

and differentiating with respect to L_t^i, yields the first-order condition for the firm:

$$(1 - \theta)P_t^{1-\beta}(L_t^i)^{-\theta} e^{(1-\beta)v_t^i} = W_t . \tag{A.8}$$

The first-order approximation for this expression is

$$(1 - \beta)(p_t + v_t^i) - \theta\ell_t^i = w_t^i ,$$

which by rearrangement is just (14) in the text.

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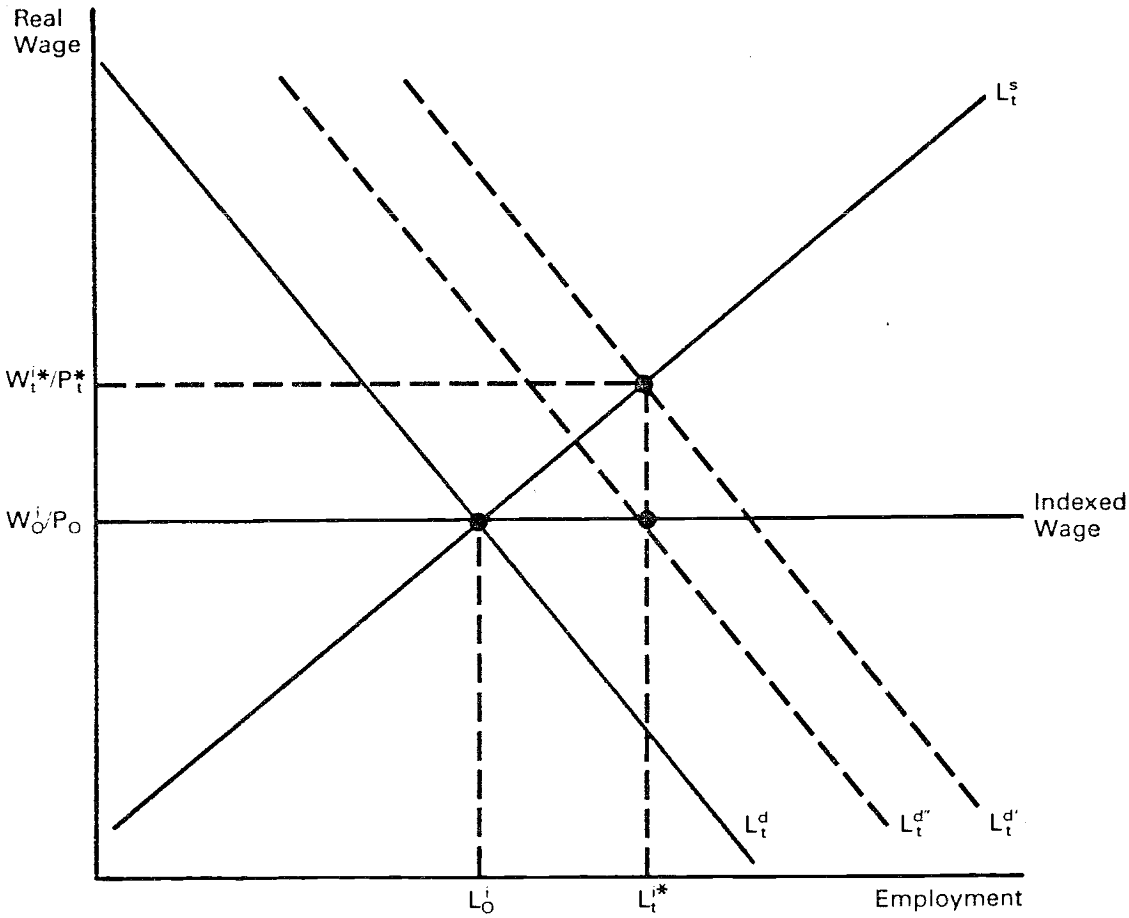
[a]The standard wage indexation scheme which we adopt in this paper has an analogous level form:

$$W_t^i = W_t^c\left(\frac{P_t}{E_{t-1}P_t}\right)^b ,$$

with the indexation parameter, b, entering as a geometric weight.



Current Equilibrium Values in Benchmark Economy:

$$L_t^{i*} = L_O^i\left(1 + \frac{nv_t^i}{1 + \theta n}\right),$$

$$\frac{W_t^{i*}}{P_t^*} = \frac{W_O^i}{P_O}\left(1 + \frac{v_t^i}{1 + \theta n}\right).$$