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THE OPTIMALITY OF NOMINAL INCOME TARGETING WHEN WAGES ARE INDEXED TO PRICE

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ABSTRACT

In this paper we analyze nominal income targeting when wages can be indexed to the price level. This combination of a contemporaneous nominal income targeting policy rule with optimal wage indexing provides the optimal monetary response to both demand and supply shocks, and achieves the full information output level in each period regardless of the elasticity of labor supply. Thus earlier results on the desirable features of nominal income targeting are extended and strengthened when nominal wages are indexed to the price level. We also demonstrate that nominal income targeting dominates money targeting in a overlapping contract model in which all agents condition on lagged information if the elasticity of labor supply is less than unity.

In the last decade there has been renewed interest in alternative monetary regimes, institutions, and policy procedures. One policy proposal that has received increased attention is nominal income targeting. This proposal has been suggested, for instance, by Feldstein (1984), Gordon (1983), Hall (1983), Meade (1978), and Tobin (1980, 1983). Taylor (1985) discusses this proposal in some detail, and McCallum (1987) presents a statistical analysis of a particular nominal income targeting rule in a variety of contexts. Bean (1983) presents a theoretical analysis of nominal income targeting, examining the properties of such a policy in a stochastic macro model in which rational agents sign nominal wage contracts. Given that the monetary authority's objective is to minimize the divergence of output from its full information level, nominal income targeting is the optimal policy _if_ labor supply is perfectly inelastic. With an elastic labor supply, however, nominal income targeting provides the optimal response to demand side shocks but not to supply side shocks.

The problem of designing optimal policy in the face of both demand and supply side shocks is not new. Authors such as Benavie and Froyen (1983), Parkin (1978), and Turnovsky (1980) have stressed that pure policy rules such as a strict money rule or an interest rate peg are generally not the optimal policy response to both demand and supply shocks. Thus Bean's result, that nominal income targeting provides the optimal policy response to all shocks (as long as labor supply is perfectly inelastic), is rather impressive.

One avenue of research that attempts to provide a partial solution to the problem of suboptimal policy rules in the face of demand and supply shocks is the investigation of wage indexing. Work by Gray (1976, 1978) drew attention to the properties of nominal wage contracts indexed to the price level. The relation between the monetary authority's choice of policy rule and the degree of indexing in the labor market has been investigated by Fethke and Policano (1981), Fethke and Jackman (1984), and Bradley and Jansen (1988 b), among others. This line of work demonstrates that the choice between alternate pure policy rules (e.g. strict money rule, interest rate peg) influences the degree of indexing, but the combination of one of the above policy rules with optimal indexing of wages to the price level will not in general provide the optimal response to both demand and supply shocks. This result is independent of the elasticity of labor supply.

Recent work by Turnovsky (1987) and by Aizenman and Frenkel (1985, 1986) demonstrates a type of duality relationship between monetary policy and wage indexation: given optimal monetary response to contemporaneous variables, wage indexing is redundant. Moreover, in one case Turnovsky (1987) demonstrates that wage indexing is unable to achieve the stabilization result realized by monetary policy, even when both wage indexing and monetary policy respond to the same vector of variables. Thus a general policy rule can accomplish all that wage indexing can accomplish, and more.

In spite of these results, we look again at nominal income targeting in a model that allows wage indexation to the price level. The combination of nominal income targeting and optimal wage indexing provides the optimal monetary response to both demand and supply shocks, regardless of the elasticity of labor supply. Thus earlier results on the desirable features of nominal income targeting, cited above, are substantially strengthened when wages are optimally indexed to the price level. We note here that Aizenman and Frenkel (1986) explicitly consider nominal income targeting, but they do so in a context of no wage indexation. They compare wage indexing to nominal income with the monetary policy of nominal income targeting, and they demonstrate a duality between these two policies. In contrast, our purpose is to demonstrate, for a specific monetary rule, i.e. nominal income targeting, that optimal wage indexing to price is perfectly stabilizing.

Our results are an extension of the results of Bean (1983) and Turnovsky (1987). We allow the monetary authority the ability to set monetary policy conditioned on nominal GNP, a policy rule not allowed by Turnovsky. We find, as Turnovsky finds for a wide class of other monetary rules, that perfect stabilization is possible with nominal GNP targeting, as long as productivity shocks are observable by private agents and wages are optimally indexed to price.[1] Thus a simply specified money rule not considered by Turnovsky, nominal GNP targeting, combined with optimal wage indexing to price, is perfectly stabilizing.

This paper is organized as follows. In section I we present a model which allows wage indexing to the price level. We demonstrate the desirable features of wage indexing with optimal nominal income targeting. Then in section II we analyze a "feasible" nominal income targeting procedure. We analyze a model with two period overlapping wage contracts, wage indexing to last period's unexpected price change, and information available to all agents (including the government) with a one period lag. We show that nominal income targeting is preferred to a strict money rule when labor supply is inelastic.

I <u>Supply Behavior</u>

We adopt the following model and notation. The production technology is Cobb-Douglas. Together with derived labor demand and labor supply, the model is given by:

$$y_t = (1-a)l_t + u_t, \qquad (0<a<1) \qquad (1)$$

$$w_t - p_t = b - a\, l^d_t + u_t, \qquad b=\ln(1-a) \qquad (2)$$

$$w_t - p_t = c + d\, l^s_t, \qquad (d\geq 0) \qquad (3)$$

where lower case represents logarithms, y_t is output, l_t is employment, w_t is the nominal wage, p_t the price level and u_t the productivity disturbance. Here equation (1) is a log linear aggregate production function, equation (2) is the labor demand equation implicit in (1) and the ancillary assumption of perfectly competitive profit maximizing firms, and equation (3) is the inverse labor supply function. We assume that labor supply is a monotonic function of the real wage.

Full information output, y_t^*, is the output level that would occur if the nominal wage in period t could adjust fully to contemporaneous labor market conditions. This wage, w_t^*, equates l_t^d and l_t^s. Full information output is given by:

$$y_t^* = \beta(b-\phi_o) + [1+\beta(1-\phi)]u_t. \tag{6}$$

The monetary authority is assumed to minimize the deviations of output from its full information level[3], with the deviation given by:

$$y_t-y_t^* = \beta(1-\theta)(p_t-p_{t/t-1}) + (\phi\beta)(u_t-u_{t/t-1}). \tag{7}$$

Define X_t to be nominal income, so that $x_t = p_t + y_t$. From (5) we have that

$$y_t-y_{t/t-1} = \beta(1-\theta)(p_t-p_{t/t-1}) + (1+\beta)(u_t-u_{t/t-1}). \tag{8}$$

Using (8) in (7), we have

$$y_t-y_t^*=\beta a\phi(x_t-x_{t/t-1})+ (1-a)\{[1+\beta(1-\phi)](1-\theta)-\phi\}(p_t-p_{t/t-1}). \tag{9}$$

This equation can be used to demonstrate that a combination of nominal income targeting and optimal wage indexing can eliminate the divergence of current output from full information output. In the non-indexing case (θ=0) achieving full information output requires that ϕ=1; labor supply must be completely inelastic (i.e. d=>∞). In the wage indexing case, this condition on labor supply is not required; equation (9) shows that a value for θ can be chosen to set the coefficient on unexpected price movements equal to zero. Because nominal income targeting sets the value of $x_t - x_{t/t-1}$ to zero, the deviation of output from its full employment level is eliminated. Examination of equation (9) provides the value for the optimal indexing parameter θ:

$$\theta^* = [(1+\beta)(1-\phi)]/[1+\beta(1-\phi)] \tag{10}$$

By inspection, this expression is bounded by zero and one. The optimal degree of indexing, therefore, depends on the elasticity of labor supply. When labor supply is completely inelastic (ϕ=1) no indexing is required, and when labor supply is completely elastic (ϕ=0) indexing must be complete. In addition, as a=>0, labor's share of output rises to unity, β=>∞, and it becomes optimal to fully index wages (θ^*=>1). Under the usual assumptions concerning labor's share of output, wage indexing provides a method for maintaining output at its full information level when the monetary authority is successfully targeting nominal income.

Fig. 1 illustrates the working of this result. The economy starts at point A in full equilibrium. Output equals the full information output level y^*_A. A positive productivity shock shifts full information output and short run aggregate supply (SRAS) rightward, and if labor supply is perfectly inelastic the new y^* and SRAS intersect at point B on the unit elastic aggregate demand (AD) curve that passes through A. This is Bean's result with perfectly inelastic labor supply. When labor supply is not perfectly inelastic, the increase in labor demand due to the productivity shock leads to a greater full-information employment level, leading y^* to shift to output level y^*_C. In this case SRAS for wage $\bar{w}_A$ still intersects AD at point B, but this is not the full information output level. Instead LRAS occurs at y^*_C, leading to Bean's conclusion that nominal income targeting is suboptimal when labor supply is not perfectly inelastic. We show above that indexing $\bar{w}_t$ to the price level can restore the optimality of nominal income targeting. In Fig. 1

this is shown by a decrease in $\bar{w}_t$ (and hence an increase in SRAS) in response to the decline in p_t after the productivity shock. Optimal indexing will decrease $\bar{w}_t$ enough so that SRAS ($\bar{w}_t$) intersects y^* and AD at point C. Thus we find that nominal income targeting augmented to allow for wage indexing to price has the potential for solving the vexing macroeconomic policy question of the correct policy to pursue in the face of demand and supply shocks.[4]

II A Feasible Nominal Income Targeting Procedure

The above analysis demonstrates that nominal income targeting in an economy with wage indexing is desirable. Such an analysis does not address the issue of the feasibility of nominal income targeting. In order to address this later question, we modify our analysis to allow wage indexing in a multiple-period overlapping contract setting. A proportion ($1-2\lambda$) of wages are set for one period, and the remaining proportion 2λ are set for two periods, with λ contracts negotiated on even time periods and λ contracts negotiated on odd time periods. Workers and firms continue to set the nominal wage, whether one or two periods ahead, so as to equal the expected market-clearing wage rate. Workers, firms, and the monetary authority observe variables with a lag of one period. As is well known from the work of Fischer (1977), two-period labor contracts will provide a role for feedback monetary policy to reduce deviations of output from full information output if shocks are serially correlated. In order to clarify the following exposition we assume that all disturbances follow random walks. This is certainly sufficient for policy effectiveness in models of the class discussed by Fischer.

Aggregate demand will be represented by

$$y_t = \gamma(m_t - p_t) + v_t, \tag{11}$$

where m_t is the (log) nominal money stock, controlled by the monetary authority, and v_t is a stochastic demand shock.

Aggregate supply is derived by combining the Cobb-Douglas production function (1) with equations describing wage setting behavior. At any time t there exist two nominal wages in the labor market. The proportion $1-2\lambda$ sets the wage at the beginning of each period. Hence, they set the wage for period t at the beginning of t, based on information from time t-1. We denote this wage as $w_t(I_{t-1})$. This wage is described in (4) above, and is reproduced here for convenience:

$$w_t(I_{t-1}) = p_{t/t-1} + \phi_o + \phi u_{t/t-1}. \tag{12}$$

Also at time t, there is a proportion λ of workers who negotiated a multiple period contract at the beginning of t for wages in t and t+1. The wage this group negotiates for period t is based on information available in t-1 and is also given by (12). Notice that indexing this wage is unnecessary because the latest information (i.e., knowledge of variables dated t-1) is used to set $w_t(I_{t-1})$; indexing to variables dated t-1 is redundant.

Finally, at time t there is a proportion λ of workers who negotiated a multiple period contract for t-1 and t at the beginning of t-1, based on information dated t-2.[5] This proportion of contracts, λ, set the period t wage based on information available in t-2. We denote this wage $w_t(I_{t-2})$. Wage $w_t(I_{t-2})$ is set by forecasting price and productivity shocks two periods ahead, so that

$$w_t(I_{t-2}) = p_{t/t-2} + \phi_o + \phi u_{t/t-2}. \tag{13}$$

We modify (13) to allow for wage indexing of $w_t(I_{t-2})$ to p_{t-1}. At time t, variables dated t-1 are observable, including p_{t-1}, and workers can use the new information embodied in p_{t-1}. Thus we modify (13) as:

$$w_t(I_{t-2}) = p_{t/t-2} + \phi_o + \phi u_{t/t-2} + \theta(p_{t-1}-p_{t-1/t-2}). \tag{13'}$$

This formulation of the wage setting equation allows workers to set a contract for time t based on information dated t-2 but including a provision for wage increases (or decreases) when the price level in t-1 is above (below) its expected value. This formulation of the wage setting equation captures the essential aspects of real-world "cost of living adjustment" (COLA) clauses in contracts. First, it explicitly models the fact that information is available only with a lag. Second it is consistent with actual COLA clauses which index wages in the second or later period of a multiple period contract. Finally, it allows for contracts that index partially (i.e. $\theta < 1$), as well as those which include some form of "trigger level" of price change. Contracts which contain this trigger mechanism invoke the COLA clause only after the trigger value for the price level has been reached. In our equation (13') we model the trigger level as the price level predicted at t-2 to occur in t-1, or $p_{t-1/t-2}$.

A less realistic aspect of (13′) is our specification that time t wages can increase or decrease as p_{t-1} exceeds or falls short of $p_{t/t-1}$. Many real world COLA contracts disallow wage cuts when the price level is below the "trigger" level, although historical examples of such contracts are available.

Using (12) and (13′) in conjunction with (1) and (2), we have the aggregate supply curve:

$$y_t = \beta(b-\phi_o) + \beta(1-\lambda)(p_t-p_{t/t-1}-\phi u_{t/t-1}) + \beta\lambda(p_t-p_{t/t-2}-\phi u_{t/t-2}- \theta(p_{t-1}-p_{t-1/t-2})) + (1+\beta)u_t. \tag{14}$$

Full information output is given in (6) above, so that deviations of output from full information output are given by

$$y_t-y_t^* = \beta(p_t-p_{t/t-1}) + \beta\lambda(p_{t/t-1}-p_{t/t-2}) - \beta\lambda\theta(p_{t-1}-p_{t-1/t-2}) + \beta\phi(u_t-u_{t/t-1}) + \beta\lambda\phi(u_{t/t-1}-u_{t/t-2}). \tag{15}$$

The stochastic shocks are strictly permanent, so

$$u_t = u_{t-1} + \epsilon_t \tag{16}$$

$$v_t = v_{t-1} + \eta_t, \tag{17}$$

where ϵ_t, η_t are mutually uncorrelated white noise disturbances with variances σ_ϵ, σ_η respectively,

The optimal feedback monetary policy is obtained as follows. From the demand curve (11) and supply curve (14) we obtain

$$y_t-y_{t/t-1} = -\gamma(p_t-p_{t/t-1}) + \eta_t, \tag{18a}$$

$$y_{t/t-1}-y_{t/t-2} = \gamma(m_{t/t-1}-m_{t/t-2}) - \gamma(p_{t/t-1}-p_{t/t-2}) + \eta_{t-1}, \tag{18b}$$

and

$$y_t-y_{t/t-1} = \beta(p_t-p_{t/t-1}) + (1+\beta)\epsilon_t, \tag{19a}$$

$$y_{t/t-1}-y_{t/t-2} = \beta\lambda(p_{t/t-1}-p_{t/t-2}) - \beta\theta\lambda(p_{t-1}-p_{t-1/t-2}) + [1+\beta(1-(1-\lambda)\phi)]\epsilon_{t-1}. \quad (19b)$$

Equations (18) and (19) can be solved for the price expectational errors as:

$$p_t-p_{t/t-1} = (\gamma+\beta)^{-1}[\eta_t-(1+\beta)\epsilon_t] \quad (20a)$$

$$p_{t-1}-p_{t-1/t-2} = (\gamma+\beta)^{-1}[\eta_{t-1}-(1+\beta)\epsilon_{t-1}] \quad (20b)$$

$$p_{t/t-1}-p_{t/t-2} = (\gamma+\beta\lambda)^{-1}\{\gamma(m_{t/t-1}-m_{t/t-2})+\eta_{t-1}-[1+\beta(1-(1-\lambda)\phi)]\epsilon_{t-1} + \beta\lambda\theta(\gamma+\beta)^{-1}[\eta_{t-1}-(1+\beta)\epsilon_{t-1}]\} \quad (20c)$$

Substituting equations (20) into (15) we can solve for the optimal feedback rule as

$$m_t = m_{t/t-1} = m_{t/t-2} - \gamma^{-1}(\psi_3\epsilon_{t-1}+\eta_{t-1}), \quad (21)$$

where $\psi_3=[(\beta+\gamma)\phi-(1+\beta)]$.

Given this optimal feedback money rule, the variance of output deviations from full information is given by:

$$E_{t-1}[(y_t-y_t^*)^2] = \psi_1^2\ \psi_3^2\ \sigma_\epsilon + \psi_1^2\ \sigma_\eta \equiv \sigma^* \quad (22)$$

where $\psi_1 = \beta/(\beta+\gamma)$.

When the monetary authority is pursuing the optimal feedback policy (21), there is no need for wage indexation, so $\theta\equiv0$ and the optimal feedback rule is the same as that reported by Bean. This result changes considerably, however, when we look at money targets and nominal income targets.

If the authorities decide to target the nominal money stock so that $m_{t/t-i}=\bar{m}$, for all $i>0$, then the variance of output about its full information level can be found by substituting equations (20) into (15):

$$E_{t-1}(y_t-y_t^*)^2 = \sigma^* + [\psi_2+\lambda\theta\psi_1(\psi_2-1)]^2\ \sigma_\eta$$
$$+ [\psi_2\psi_3+\psi_1\psi_2\theta\gamma(1+\beta)/\beta]^2\ \sigma_\epsilon. \tag{23}$$

where $\psi_2 = \beta\lambda/(\beta\lambda+\gamma)$.

Assuming that θ is set so as to minimize the expected output deviations in (23), we can derive the optimal value of θ, θ^*, as:

$$\theta^* = -\psi_2\{[(\psi_2-1)\lambda\sigma_\eta+\psi_2\psi_3\gamma((1+\beta)/\beta)\sigma_\epsilon]\}/$$
$$\{\psi_1[(\psi_2-1)^2\lambda^2\sigma_\eta+\psi_2^2\gamma^2((1+\beta)/\beta)^2\sigma_\epsilon]\} \tag{24}$$

As expected, $\theta^*>0$ for reasonable parameter values. More precisely, $\gamma<1$ is sufficient for $\theta^*>0$, i.e. for wages to respond positively to lagged price surprise.

When agents index optimally, output variance under a money supply target is found by substituting (24) into (23), yielding:

$$E_{t-1}(y_t-y_t^*)^2 = \sigma^* + \{\psi_2^2[\psi_2\gamma((1+\beta)/\beta)-\psi_3(\psi_2-1)\lambda]^2\sigma_\epsilon\sigma_\eta\}/$$
$$\{(\psi_2-1)^2\lambda^2\sigma_\eta+\psi_2^2\gamma^2((1+\beta)/\beta)^2\sigma_\epsilon\} \tag{25}$$

If the authorities instead pursue a nominal income target, then they set the money stock so that $x_{t/t-1} = x_t^*$, where x_t^* is the target level of nominal income. The feedback rule consistent with this policy is found by adding $(p_{t/t-1}-p_{t/t-2})$ to each side of equations (18b) and (19b), and setting the resultant expression for $(x_{t/t-1}-x_{t/t-2})$ equal to zero. This allows one to solve for $m_t = m_{t/t-1}$ as

$$m_t \equiv m_{t/t-1} = m_{t/t-2} - (1/\gamma)\{\psi_4+[\lambda(\gamma-1)\theta(1+\beta)]/[1+\beta\lambda]\}\epsilon_{t-1}$$
$$- (1/\gamma)\{1-\psi_1[\lambda(\gamma-1)\theta]/[1+\beta\lambda]\}\eta_{t-1} \tag{26}$$

where $\psi_4 = (\gamma-1)\{1+\beta[1-(1-\lambda)\phi]\}/(1+\beta\lambda)$

Substituting this money rule into the expression for output variance, we have that the variance of output about the natural rate under nominal income targeting:

$$E_{t-1}(y_t-y_t^*)^2 = \sigma^* + \lambda^2\psi_1^2(\psi_5-1)^2\theta^2\sigma_\eta + [\psi_2(\psi_3-\psi_4)+\psi_1\psi_5((1+\beta)/\beta)\theta]^2\sigma_\epsilon \qquad (27)$$

where $\psi_5 = (\beta\lambda)/(1+\beta\lambda)$.

If θ is set to minimize the expression in (27), it will be set at θ^{**} where

$$\theta^{**} = -\{\psi_2(\psi_3-\psi_4)\psi_5((1+\beta)/\beta)\sigma_\epsilon\}/\{\lambda^2\psi_1(\psi_5-1)^2\sigma_\eta+\psi_1\psi_5^2((1+\beta)/\beta)^2\sigma_\epsilon\} \qquad (28)$$

It can be shown that $\theta^{**}>0$, so that, as under money targeting, optimal indexing makes the wage respond positively to lagged price surprises.

Given θ^{**}, output variance (27) becomes

$$E_{t-1}(y_t-y_t^*)^2 = \sigma^* + \{\psi_2^2(\psi_3-\psi_4)^2(\psi_5-1)^2\lambda^2\sigma_\epsilon\sigma_\eta\}/\{\psi_5^2((1+\beta)/\beta)^2\sigma_\epsilon+\lambda^2(\psi_5-1)^2\sigma_\eta\}. \qquad (29)$$

We are interested in comparing output variance under a money target and a nominal income target when indexing is available to and utilized by private agents. In the model without indexing (i.e $\theta=0$), nominal income targeting is preferred to money targeting if, given $\phi\leq 1$, we have $\gamma < 1$. Thus a sufficiently small effect of real money balances on real aggregate demand is sufficient to conclude that nominal income targeting is preferred to money targeting. We now turn to a comparison of money and nominal income targets when indexing is allowed.

When the wage indexing parameter θ is set optimally, the expression for output variance under a money target can be shown to be

$$E_{t-1}(y_t-y_t^*)^2 = \sigma^* + \{(\beta+\gamma)^2\phi^2\psi_2^2\sigma_\epsilon\sigma_\eta\}/\{\sigma_\eta+(1+\beta)^2\sigma_\epsilon\}, \qquad (30)$$

while the expression for output variance under a nominal income target is

$$E_{t-1}(y_t - y_t^*)^2 = \sigma^* + \{(1+\beta)^2(\beta\lambda+\gamma)^2(1-\phi)^2\psi_2^2\sigma_\epsilon\sigma_\eta\}/$$
$$\{(1+\beta\lambda)^2[\sigma_\eta + (1+\beta)^2\sigma_\epsilon\}. \tag{31}$$

Subtracting (31) from (30), we find that nominal income targeting results in smaller output variance if

$$\psi_2^2\sigma_\epsilon\sigma_\eta\{(\beta+\gamma)^2\phi^2 - [(1+\beta)^2(\beta\lambda+\gamma)^2(1-\phi)^2]/(1+\beta\lambda)^2\}/\{\sigma_\eta + (1+\beta)^2\sigma_\epsilon\} > 0. \tag{32}$$

Rearranging and simplifying, we have the condition that

$$\phi(\beta+\gamma)(1+\beta\lambda) > (1+\beta)(\gamma+\beta\lambda)(1-\phi). \tag{33}$$

A sufficient condition for this to hold is that $d \geq 1$, in other words that labor supply is inelastic. A less restrictive condition is that

$$d > a[a\gamma+(1-a)\lambda]/\{[a\gamma+1-a][a+(1-a)\lambda]\} \tag{34}$$

If $a=1$, then (34) becomes $d > 1$, or $(1/d) < 1$. If $a=0$, then (34) becomes $d > 0$, or $(1/d) < \infty$. Moreover, as long as condition (34) is satisfied, the value of γ is irrelevant. This stands in contrast to the case when wage indexing is not allowed, i.e. that nominal income targeting is preferred to money targeting when $\gamma < 1$. The value of γ is not unimportant here, however, as the right hand side of (34) is increasing in γ. But even as $\gamma \Rightarrow \infty$, $d > 1$ is sufficient for (33) to hold.

Killingsworth (1983) surveys the literature on labor supply and provides estimates of the elasticity of labor supply from a large number of studies. While findings of highly elastic labor supply are not unheard of, most investigators report inelastic labor supply. Accepting this consensus, nominal income targeting is preferred to money targeting in the context of our macroeconomic model.[6]

III Conclusion

We analyze nominal income targeting when nominal wages are indexed to the price level. In section one we pursue this analysis in a model which allows contemporaneous nominal income targeting by the monetary authorities and contemporaneous wage indexing. We find that optimal wage indexing makes nominal income targeting perfectly stabilizing regardless of the elasticity of labor supply. Note that this result does not obtain with other strict monetary policies, such as a strict money rule, an interest rate peg, or a price rule -- see Bradley and Jansen (1988 a,b). This is, however, the result that obtains with optimal response of the monetary authority to a vector of contemporaneous variables, as in Turnovsky (1987).

In one sense our result should not be surprising - given two independent instruments, it is usually possible to deal with two types of shocks. We point out, however, that other strict monetary policy rules coupled with wage indexing to the price level will not be perfectly stabilizing. Here nominal income targeting and wage indexing are two independent instruments which in the cooperative game we have described yield the optimal joint response of government policymakers and private agents to supply and demand shocks. In essence, the nominal income target means that any change in the price level observed by private agents is due to supply shocks, and these are dealt with via positive indexing of nominal wages to the price level.

In section two we analyze a model with two-period overlapping labor contracts. Both private agents and the government observe variables with a one period lag. Wages are indexed to lagged (unexpected) price changes. We find that in the absence of perfectly inelastic labor supply, nominal income targeting with optimal indexing dominates a money target with optimal indexing for labor supply elasticities that are less than unity. This model explicitly models the lag in the observation and enactment of both government policy decisions and private sector decisions, and demonstrates the robustness of the results from the model of section one.

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Notes

1. We also find, as does Turnvosky for a variety of money rules, that nonobservable productivity shocks means nominal income targeting with optimal indexing is not perfectly stabilizing.

2. We justify this by assuming that workers and firms choose $\bar{w}_t$ to minimize $E_{t-1}(\bar{w}_t-w_t^*)^2$, where w_t^* is the wage that would clear the market at time t if it were a spot market. Assuming risk-neutral agents will then yield the certainty equivalence result that $\bar{w}_t$ will be set to equate $l^s_{t/t-1}$ and $l^d_{t/t-1}$.

3. For a risk neutral agent, minimizing the variance of output about full information output is equivalent to minimizing the welfare loss resulting from nominal wage contracts. See Aizenman and Frenkel (1985), and Turnovsky (1987).

4. We have also investigated the optimality of nominal income targeting in an open-economy context. In that case we employ a stochastic rational expectations version of the Fleming-Mundell model, along with the labor market and aggregate supply equations developed in the text.

(A model of this type was recently used by Turnovsky (1987) to investigate policy issues.) For this open economy model we find that the combination of nominal income targeting and optimal wage indexation to price eliminates any divergence between current output and full information output. Intuitively, because the monetary authority has the ability to offset demand side shocks (keeping nominal demand constant), it can offset exchange rate shocks just as it can offset domestic demand shocks.

Turnovsky (1987) analyzes policy rules when shocks are not observable contemporaneously by private agents. If the productivity shock u_t is not observable by the firm, then we could not derive the strong result of this section, since the combination of a nominal income target and optimal indexing would not be perfectly stabilizing. Note, however, that a firm not observing its productivity shock means the firm does not know its own output level contemporaneously. We regard this as unrealistic.

5. At the beginning of t-1 they also negotiated a contract for t-1, $w_{t-1}(I_{t-2})$, which is not indexed and is found by appropriately modifying the time subscripts in (12).

6. This result is robust over different specifications of the demand side of the economy. To assure ourselves that the dominance of nominal income targeting over money targeting did not arise from our

specification of the demand side as the quantity equation, we redid the analysis extending the demand side to include stochastic "IS" and "LM" equations of the following form:

i) $y_t = \alpha_0 + \alpha[r_t - (p_{t+1/t-1} - p_{t/t-1})] + e_t$, and

ii) $y_t = \tau(m_t - p_t) + \rho r_t + v_t$.

Despite the added complexity on the demand side, we find that d>1 is still a sufficient condition for preferring nominal income targeting to money targeting. We also investigated price targeting and interest rate targeting in this richer demand setting, and find d>1 sufficient for preferring nominal income targeting to price targeting. Comparing nominal income targeting to an interest rate target is more interesting. In a special case where the income elasticity of money demand is one and the interest elasticity of money demand is zero, a sufficient condition for preferring a nominal income target is again d>1. These results are available from the authors upon request.