WELFARE IMPROVING NOMINAL CONTRACTS

by

Henning Bohn
Gary Gorton

(2-89)

RODNEY L. WHITE CENTER FOR FINANCIAL RESEARCH
The Wharton School
University of Pennsylvania
Philadelphia, PA 19104-6367

WELFARE IMPROVING NOMINAL CONTRACTS

Henning Bohn and Gary Gorton

Department of Finance
The Wharton School
University of Pennsylvania
Philadelphia, PA 19104

January 1989

Abstract

The existence of nominal wage and debt contracts is a puzzle. In a model with strategic complementarities, where imperfectly competitive firms inefficiently underinvest, nominal wage or debt contracts are shown to be preferred to indexed contracts. Nominal contracts are an optimal arrangement between firms and workers because such contracts can improve on the underinvestment equilibrium by implementing Pareto-improving transfers between agents. Moreover, we show that if there are multiple underinvestment equilibria, then monetary policy can have real effects because the monetary authority can choose a money supply rule to coordinate beliefs and, thereby, select the best equilibrium.

The comments and suggestions of members of the University of Pennsylvania Macro Lunch Group were greatly appreciated. The second author thanks the National Science Foundation for research support through grant #SES86-18130.

I. Introduction

The existence of nominal wage and debt contracts remains a puzzle. Economic theory suggests that indexed contracts often dominate nonindexed contracts, e.g., Barro (1977), Fischer (1975). Yet, wage contracts contingent on the price level are not widespread, and privately issued indexed debt is basically nonexistent. As Fischer (1986), has written: "The problem of explaining the types of contingent contracts that are used is basic to understanding the operation of monetary policy." In this essay we show that nominal contracts are the preferred arrangement among agents, and that monetary policy has desirable real effects.

The existence of nominal wage contracts has remained paradoxical though there is a large literature on real wage contracts starting from Azariadis (1975), and there is a large literature in macroeconomics which assumes the existence of nominal wage contracts, e.g., Fischer (1977). The main result in the wage indexing literature, due to Gray (1977) and Fischer (1978), is that wages indexed to the price level stabilizes output when shocks are nominal, and destabilizes output when shocks are real. While this literature has grown (e.g., Blanchard (1979), Fethke and Policano (1984)), the form of the contract, i.e., the degree of indexation, continues to be taken as exogenous. This is problematical since Barro (1977) showed that often both parties to the contract face incentives to renegotiate the contract ex post. In addition, as Fischer (1986) points out, there remains the problem of why contingent contracts are not more widespread.

The nonexistence of indexed private debt has also been difficult for researchers to explain. Fischer (1975) finds virtually no conditions under which nominal bonds would dominate indexed debt. In later work Fischer (1978) argues that the decision of firms to issue nominal or indexed debt should turn on the correlation between profits and unexpected inflation. But, examining a sample of firms where the correlation is postive, he notes that none issued indexed debt.

We study a model which displays strategic complementarities. An important recent literature in macroeconomics has shown that strategic complementarities in agents' payoff functions can result in model economies displaying Keynesian features. A strategic complementarity arises when the optimal strategy of one agent depends on the strategies of other agents. The equilibria of such models display the Keynesian feature that the economy has a low level of activity because there is no way for agents to coordinate their actions. When such externalities are present there may exist a multiplicity of such inefficient equilibria. Cooper and John (1988) have recently surveyed this large and growing literature.

In the most common of these models there is imperfect competition or price rigidities leading to a demand externality. The externality is due to the fact that aggregate income rises when firms' profits rise. An increase in a firm's profits raises aggregate income by a multiple since other firms' profits are also increased as a result, a phenomenon called an "aggregate demand spillover". But such "multipliers" are ignored by privately optimizing firms. Consequently, there can be mutual gains to all firms raising output, but no incentive for an individual firm to deviate from the initial low output. Prices do not effectively coordinate decision-making because they do not capture the multiplier effects. The inefficient outcome is thus described as a "coordination failure." The resulting inefficiency can potentially be very bad because of a multiplicity of equilibria.[1] Examples of this type of model include, among others, Blanchard and Kiyotaki (1987), Hart (1982), Heller (1986), Kiyotaki (1988), Roberts (1984, 1986), Shleifer (1986), Startz (1986), Shleifer and Vishny (1988), and Weitzman (1982).

To date these models have been real models. There is no role for monetary policy or nominal contracts. Also, while the main result of such models is that the resulting equilibria are inefficient, there is no discussion of why government or privately arranged transfer schemes cannot eliminate the inefficiency. Such a transfer scheme would be a Pareto-improvement. The main result of this paper is to show that such transfer schemes can be implemented, eliminating, or at least reducing, the inefficiency. In particular, we show that money and nominal contracts are, in fact, such a transfer scheme.

The introduction of nominal magnitudes eliminates the way in which the strategy of one agent affects the strategy of another agent. The externality is internalized. The intuition is as follows. With nominal contracts and money, if other firms choose inefficient strategies, say low outputs, then the price level will be high (because output is low), reducing the wage costs or real value of indebtedness of the remaining firm. The remaining firm thus finds it profitable to raise output, regardless of what the other firms choose. In this way the externality is removed and the equilibrium is improved since more investment occurs.

The introduction of money and nominal wage contracts improves on the set of equilibria. This improvement results even if the money supply is fixed. The introduction of money <u>per</u> <u>se</u> has a real effect since it allows for nominal contracts which lead to different equilibria. We show that underinvestment is reduced, and that nominal contracting can eliminate the externalities. In a multiple equilibrium setting, an activist monetary authority, by choosing a money rule, can select the best equilibrium and, in this sense, monetary policy has a real effect on the economy.

The paper proceeds as follows. In Section II we explain the model and analyze a simple numerical example when there is no money in the economy. The example displays the inefficient underinvestment discussed above. Section III introduces money and nominal wage contracts. In the example with money, there is a unique equilibrium and it is the social optimum. Section IV analyzes the general setting with nominal wage contracts. First, we consider the outcomes when there is a fixed amount of money introduced into the economy. Then we allow the monetary authority to choose state contingent money supplies, that is, there is an activist monetary policy. The monetary authority, by choosing the right money supply rule can select an equilibrium which improves upon any of the previously attainable equilibria. To this point we will have only compared the equilibrium outcomes when there are nominal contracts to outcomes when there are no nominal contracts. Section V offers the agents in the economy the choice of contracts. We show the conditions under which agents will prefer to sign nominal contracts. Section VI briefly discusses nominal debt contracts, other transfer schemes, and partial indexation. Section VII concludes.

II. The Economy Without Money

The basic model we will study was proposed by Shleifer and Vishny (1988). Theirs is a model of imperfect competition in which there are aggregate demand spillovers. Like the other studies in this literature there is a divergence between the private investment decisions of the firms and the socially optimal investment decisions because the individual firm does not take into account that its spending increases aggregate demand and thus the profits of all firms. Consequently, there is underinvestment. In this section we introduce the basic model. Then we study a numerical example in which there are multiple equilibria, all with inefficient underinvestment. This sets the stage for our subsequent analysis.

A. The Basic Model

The economy has one period and a representative consumer who has Cobb-Douglas preferences defined over a unit interval of goods. All goods have the same expenditure shares. Thus, the consumer, with income of y, can be thought of as spending y on every commodity. The consumer is endowed with L units of labor, which he supplies inelastically, and he owns all the profits, Π, of this economy. Let a unit of labor be the numeraire. Then the budget constraint of the representative consumer is:

$$y = \Pi + L \tag{1}$$

Each good is produced in a different sector of the economy where each sector contains two kinds of firms: a competitive fringe of firms which can convert one unit of labor input into one unit of output with a constant returns to scale production technology, and a single other firm which has access to an increasing returns to scale production technology. We refer to this latter firm as "the monopolist".

The competitive fringe will always set its product price equal to the wage. The monopolist's production technology has a fixed cost of F units of labor and then yields $\alpha > 1$ units of output for each additional unit of labor input. Therefore, the monopolist cannot set product price higher than the wage and will not set product price lower because of the unit elasticity of demand. Each monopolist's profit is given by:

$$\pi(F) = y - L = (1 - 1/\alpha) \cdot y - F \tag{2}$$

The monopolist makes a profit if y satisfies $y \geq F/a$, where $a = (\alpha - 1)/\alpha$.

There is uncertainty about the fixed cost F. In particular, there are two states of the world characterized by different distributions of fixed costs across sectors. In the good state, the distribution is G(F), and in the bad state it is B(F). Assume that the likelihood ratio b(F)/g(F) is increasing in F, i.e., the relative likelihood of a higher fixed cost is higher in the bad state. Each firm only observes the realization of its own fixed cost, but not other firms' fixed cost realizations. Therefore, a firm can update its beliefs about the state of the world, but cannot determine the state of the world with certainty. The firm's posterior probability of the good state, g, given a realization F, is:

$$q(F) = \frac{p \cdot g(F)}{p \cdot g(F) + (1-p) \cdot b(F)} \tag{3}$$

where p is the prior probability of the good state occurring. The expected profit of a firm with fixed cost F is:

$$\pi^e(F) = q(F) \cdot \pi_g(F) + (1-q(F)) \cdot \pi_b(F) \tag{4}$$

where the subscript indicates the state of the world, g or b.

Notice from (2) that the firm's profit depends on aggregate output. In turn, aggregate output depends on firms' investment behavior. From (4) it is clear that if a firm with fixed cost F* invests, then all firms with $F < F^*$ will invest because profits are declining in the fixed cost. Therefore, we can characterize the equilibrium by finding the appropriate cut-off level of fixed costs. Suppose all firms with fixed cost $F < F^*$ choose to invest in equilibrium. Then aggregating profits in state i, i = b or g, of those firms which are investing yields:

$$\Pi_i(F^*) = \int_{F_{min}}^{F^*} [ay_i(F^*) - F]dI(F) = ay_i(F^*) \cdot I(F^*) - L_i(F^*) \quad (5)$$

where: $L_i(F^*) = \int_{F_{min}}^{F^*} FdI(F),$ (6)

and where I(F) is either B(F) or G(F). Substituting (5) into (1) we obtain aggregate output:

$$y_i(F^*) = \left(\frac{1}{1 - aI(F^*)}\right)\left(L - L_i(F^*)\right), \quad (7)$$

As explained in detail by Shleifer and Vishny (1988), the first term in (7) can be interpreted as a multiplier. The second term is the amount of labor used in production, i.e., excluding the labor used for the fixed cost. The multiplier reflects the fact that an increase in labor for production raises income by more than one for one if some of it is used by monopolists. In that case, there is a spillover because it raises the profits of all other operating monopolists.[2]

A Non-Contract or Real Contract Equilibrium in this economy is a Nash equilibrium in the game between monopolists which is characterized by a critical level of fixed cost, F*, such that expected profits of all firms with $F < F^*$ are positive, and the expected profits of all firms with $F > F^*$ are nonpositive, where expected profits are evaluated at the output level $y_i(F^*)$, where i = b or g.

B. An Example

We now turn to studying a particular example. Suppose there are four levels of fixed cost, $F_1 = 9$, $F_2 = 108$, $F_3 = 110$, and $F_4 = 200$. Also, suppose $L = 100$ and $\alpha = 4$ so that $a = .75$. Table 1 gives the relative numbers of firms with different fixed cost levels in the two states of the world.

In the world described by Table 1 there are two Nash equilibria, both of which are inefficient. In one equilibrium only type F_1 firms produce. We refer to this as the F_1-equilibrium. In the other equilibrium F_1 and F_2 firms invest. We refer to this equilibrium as the F_2-equilibrium. To compute the equilibria, note that F_1 firms always invest, that F_4 firms never invest, and that F_2 and F_3 firms' updated posteriors about the state coincide with their priors because the probability of drawing that particular F as a realization is the same in the two states.

It is straightforward to compute that aggregate demand in the F_1-equilibrium is 172.0 in the good state, and 115.53 in the bad state. The expected profits of each firm type are computed in Table 2. The equilibrium in which only F_1 firms invest is a Nash equilibrium because F_2 and F_3 firms will not make positive expected profits if the other F_2 and F_3 firms do not invest. On the other hand, an F_2 firm will be profitable if other F_2 firms invest because if other F_2 firms invest aggregate demand will be high enough. By examination of the outputs, it can be seen that the F_2-equilibrium Pareto-dominates the F_1-equilibrium.

The problem with these outcomes is that expected output would be highest, if the F_3 firms produced in addition to the F_1 and F_2 firms. However, as shown in Table 2, F_3 firms would have an expected loss of 0.82 if they invested. The negative expected profit of an F_3 firm, in a proposed F_3-equilibrium is the result of averaging profits of 26.50 in the good state and -28.14 in the bad state.

The reason why the private and social optima do not coincide is the presence of the spillovers. For society, any profits or losses spillover into other sectors because they raise or lower the profits of other operating monopolists. Since more monopolists are operating in the good state than in the bad state, the spillovers are higher in the good state than in the bad state. In the example, the profit of 26.50 in the good state is multiplied by 1/(0.4) = 2.5 while the loss of 28.14 in the bad state is only multiplied by 1/(0.7) = 1.43. The social optimum is not achieved because the F_3 firms do not internalize the spillovers. Thus, there is a net benefit to society if an F_3 firm invests. The F_3 firm does not internalize the social benefit.

III. Money and Nominal Contracts

In this section we will introduce money. Money allows for the possibility of nominal wage contracts. We will show that, in the example, nominal wage contracts eliminate the F_1- and F_2-equilibria and implement the proposed F_3-equilibrium, i.e., the social optimum. As we discuss subsequently, the nominal wage contracts could easily be reinterpreted as nominal debt contracts.

A. The Basic Model With Money

We assume that the representative consumer must use money to buy goods. The government transfers M units of newly printed money to the consumer initially. At the end of the world consumers must pay a tax of M units of money to the government. Now let money units be the numeraire. Once output, y, is realized the price of any good is M/y which we will refer to as the price level P. We refer to the fixed cost as "a plant."

The sequence of events is as follows:

Stage I: Nominal wage contracts between monopolists and workers (the representative individual) are signed for construction of the plant.

Stage II: Monopolists learn their fixed cost. Monopolists decide to operate or not. If they decide not to operate they must release the workers with which they have contracted to build the plant.

Outcomes: Competitive firms employ all remaining available workers. Production and consumption occur. Workers are paid; profits are paid out; taxes are paid.

In this section we assume that monopolists contract with workers to build the plant, but operation of the plant uses noncontract labor. In Appendix 1 we consider the case where all labor is contract labor. The results are similar. In Section VI we provide another interpretation of the model where the monopolists borrow using nominal debt contracts, rather than hiring workers under nominal wage contracts. That interpretation is consistent with the analysis here.

In stage I a nominal wage, w, is agreed to by workers and monopolists. In stage II, when monopolists decide to operate or not, they know w. To find out whether a firm makes a profit or not the firm has to conjecture about which other monopolists will invest. We will show below that the set of firms that invests can be characterized by a cut-off fixed cost level F* such that all firms with fixed costs $F < F^*$ will invest. So, a monopolist has to form a conjecture about F*.

Given a conjectured F*, monopolists know that output will be determined as in equation (5) and they know the money supply rule, which we denote by $M_i(F^*)$ where i is the state of the world, i = b, g, and firms with fixed cost $F < F^*$ are investing. Therefore, the price level is:

$$P_i(F^*) = \frac{M_i(F^*)}{y_i(F^*)} \qquad (8)$$

At stage II the firm does not know what the state of the world is, but it knows the realization of its own fixed cost. The firm's posterior probabilities and its expected profit are computed as in Section II except that the profit in state i is given by:

$$\pi_i(F) = y_i(F^*) - \frac{w \cdot F}{P_i(F^*)} - \frac{1}{\alpha} \cdot y_i(F^*) \tag{9}$$

The first term in (9) is the real revenue the firm earns in state i. The second term is the real wage cost of the firm's fixed cost. The final term is the variable cost. The firm will invest if its expected profits are positive. Thus, an equilibrium value of F* must have the property that $\pi^e(F) \geq 0$, for all $F < F^*$, and $\pi^e(F) \leq 0$, for all $F > F^*$.

In stage I the nominal wage, w, must satify the condition that the expected real wage is one, that is:

$$1 = l_g \cdot \frac{w}{P_g} + (1 - l_g) \cdot \frac{w}{P_b} \tag{10}$$

where $l_g = \dfrac{p \cdot L_g}{p \cdot L_g + (1 - p) \cdot L_b}$, and L_g and L_b are as in (6). The ratio l_g can be interpreted as the probability that contract labor will be demanded in the good state of the world. Equilibrium in the labor market requires that (10) be satisfied, which implies:

$$w = \frac{1}{l_g / P_g + (1 - l_g) / P_b} \tag{11}$$

where the fact that labor supply and output depend on F* has been suppressed.

To summarize, a Nominal Contract Equilibrium in this two stage game is a sequential equilibrium which is characterized by: (1) a nominal wage, w, that is agreed upon at stage I of the game and which satisfies (10); and (2), a set of conjectures about which monopolists invest at state II of the game for each wage such that $\pi^e(F) \geq 0$, for all $F < F^*$, and $\pi^e(F) \leq 0$, for all $F > F^*$.

B. The Example With Money

Returning to the example, we will show that there exists a unique equilibrium with nominal wage contracts which implements the social optimum which was not achievable before.

Table 3 computes the expected profits for each firm type in each equilibrium and each state using M = 100. Looking at Table 3 it can be seen that the F_1- and F_2-equilibria are eliminated. First, consider the expected profits of an F_2 firm in a proposed F_1-equilibrium. Table 3 shows that an F_2 firm expects to make 9.48. Since the expected profits of the F_2 firm are positive in the proposed F_1-equilibrium, the F_1-equilibrium is eliminated. Next, consider the expected profits of an F_3 firm in a proposed F_2-equilibrium. These expected profits, 1.39, are positive. Therefore, F_2 is broken as an equilibrium. Finally, note that the expected profits of all three firm types are positive in the proposed F_3-equilibrium. Therefore, F_3 is supported as an equilibrium.

Previously we saw that the expected profits of an F_3 firm were negative in both the F_1- and F_2-equilibria. Therefore, even if an F_3 firm believed that other F_3 firms were going to invest it calculated that its expected profits would be negative, eliminating any proposed F_3-equilbrium and supporting the other two. But in Table 3 we see, in the monetary model, that even if an F_3 firm believes that other F_3 firms are not going to invest it expects positive profits. Therefore, beliefs that the F_1 or F_2 equilibrium are going to occur do not support an equilibrium when nominal contracts have been signed. The social optimum is the unique equilibrium.

To see the reason this happens notice that real wages are above one in the good state and below one in the bad state. Since there are many F_1 firms in the good state, the fraction of high wages paid by F_1 firms in the good state is higher than the fraction of the low wages paid in the bad state. On the other hand, F_2 and F_3 firms benefit because they use a smaller share of contract labor in the good state than in the bad state. This explains how a redistribution between firm types occurs across states in any equilibrium. The example shows that this redistribution can be large enough to eliminate multiplicity, i.e., makes an F_3 firm profitable even if it believes that other F_3 firms won't invest.

IV. Money Supply Rules in the General Case

The above example illustrates the effects of introducing money. In particular, even with a fixed money supply it was possible that underinvestment and the multiplicity of equilibria could be eliminated. In this section we analyze the generality of this result. Throughout we assume that the money supply rule is common knowledge.

A. Preliminaries

First we want to identify the channel through which monetary policy can effect the economy. Money works through changing the relative price level between states of the world. Define the relative price differential $\psi = P_b/P_g - 1$. Since $w/P_i = wy_i/M_i$ is the real wage in state i, the choice of M_b relative to M_g determines the real wage differential between the two states. Therefore, ψ can also be interpreted as the relative real wage differential:

$$\psi \equiv \left(\frac{wy_g}{M_g}\right) / \left(\frac{wy_b}{M_b}\right) - 1 \tag{12}$$

which we will consider to be the choice variable of the monetary authority.

To see the effect of monetary policy on a firm's decision note that the expected profits of an F-firm in an F* equilibrium are:

$$\pi^e(F|F^*) = ay^e(F|F^*) - F \cdot \left(\frac{wy_g}{M_g} \cdot q(F) + \frac{wy_b}{M_b} \cdot (1-q(F))\right) \tag{13}$$

Substituting (12) into (13) we obtain:

$$\pi^e(F|F^*) = ay^e(F|F^*) - F \cdot b_\psi(F) \tag{14}$$

where $b_\psi \equiv \dfrac{1 + \psi q(F)}{1 + \psi l_g}$, and $l_g \equiv \dfrac{p\, L_g}{p\, L_g + (1 - p)\, L_b}$.

The intuition for why money can alleviate the underinvestment problem is as follows. First note that one could replicate the outcomes of the nonmonetary economy by setting ψ equal to zero so that b_ψ would equal one. Now suppose the monetary authority sets ψ to be positive. Looking at the definition of b_ψ one can see that b_ψ is less than one whenever the posterior probability of a good state, $q(F)$, is low relative to l_g. In other words, monetary policy may be able to reduce the real value of the fixed costs, and thereby, encourage investment. Since $q(F)$ is declining in F, $q(F) < l_g$ is likely satisfied for the firms with relatively high F that were just on the margin between investing and not investing in the nonmonetary economy. The following lemma shows that this is certainly true for the marginal firm, i.e., the F* firm.

Lemma 1: $q(F^*) < l_g$.

Proof: See Appendix 2.

Next we must find values of F* that are equilibrium conjectures in the stage II game. Recalling the definition of a Nominal Contract Equilibrium, note that the second stage decisions must form a Nash equilibrium. If expected profits are decreasing in F then for any proposed F* there is a value F** such that all firms with $F < F^{**}$ invest, and none with higher F's invest. F* cannot be a rational conjecture unless $F^* = F^{**}$, where F** depends on F* and w. Thus, equilibria in the game between firms must be fixed points of this mapping (if any exist). In what follows we find sufficient conditions for existence and uniqueness of such equilibria.

The problem is tractable for two interesting classes of money supply rules, namely, a fixed money supply, and a money supply rule designed to implement a desired F*. We will first consider the fixed money supply rule. In subsection C we consider more general money supply rules that may depend on the state and on firms' investment decisions.

B. Fixed Money Supply

With a fixed money supply the firm's decision problem simplifies because prices are inversely related to output in each state. Using (13) and the fixed money supply M expected profits are simply:

$$\pi^e(F) = \left[q(F) \cdot y_g(F^*) + (1 - q(F)) \cdot y_b(F^*)\right] \cdot (a - \frac{w}{M} F) \qquad (15)$$

which is positive if and only if $F < aM/w$. Thus, for every w there is a unique cut-off level of fixed costs: $F^*(w) = aM/w$. Consequently, any F* can be implemented by setting the wage equal to $w = aM/F^*$. However, not all pairs of w and F* satisfy (10). Using (3) and (6), one can show that w and F* satisfy (10) if and only if:

$$0 = C(F^*) \equiv \int_{F_{min}}^{F^*} \left[q(F)(ay_g(F^*) - F^*) + (1 - q(F))(ay_b(F^*) - F^*)\right] \cdot$$

$$\left[p_g g(F) + p_b b(F)\right] F dF \qquad (16)$$

The expression in square brackets in the first line looks very similar to the expected profits of a firm in the noncontract case where there are no labor contracts. The expression in the second line is positive. These facts can be exploited to obtain the following result.

Proposition 1: Consider the set of equilibria attainable without nominal contracts. Let F_1^* be the equilibrium in this set with the lowest investment. If there are equilibria with nominal wage contracts, then all of them have strictly higher investment than F_1^*.

Proof: See Appendix 2.

Corollary: If the nonmonetary economy has a unique equilibrium, then the monetary economy has a unique equilibrium with higher investment.

Proposition 1 shows that some underinvestment is eliminated. In other words, nominal contracts can change the outcome in the right direction, but there is no guarantee that the social optimum can be reached.

C. Activist Monetary Policies

In this section we consider money supply rules which are activist in the sense that they may be contingent on the state of nature and, possibly, on the level of investment. We provide conditions under which such rules can alleviate the underinvestment problem and improve welfare. Finally, we show when the social optimum can be achieved.

Consider money supply rules of the following form:

$$M_i(F^{**}) = \begin{cases} \infty & \text{if } F^{**} < F^* \\ 0 & \text{if } F^{**} > F^* \\ M_g & \text{if } F^{**} = F^* \text{ and } i = g \\ M_b & \text{if } F^{**} = F^* \text{ and } i = b \end{cases} \qquad (17)$$

In Appendix 3 we show how rule (17) can be derived as the limit of a rule with finite and nonzero levels of money. With this rule no F^{**} other than F^* can be an equilibrium. The reasoning is as follows. If firms deviate by investing less, $F^{**} < F^*$, then the real wage bill would be zero so that more investment would be profitable. If firms deviate by investing more, $F^{**} > F^*$, then the real wage bill is infinity so that investing less would be profitable. Therefore, F^* is the only candidate equilibrium. The following proposition provides a sufficient condition for implementation of F* as an equilibrium and shows how the monetary authority should choose M_b and M_g.

<u>Proposition 2</u> (Implementation): F* can be implemented as an equilibrium by appropriate choice of the money rule provided: $\frac{\partial \pi^e(F|F^*)}{\partial F} < 0$.

Specifically, the choice of M_b and M_g must satisfy:

$$\psi(F^*) = \frac{F^* - ay^e(F^*)}{ay^e(F^*)\, l_g(F^*) - q(F^*)F^*} \qquad (18)$$

<u>Proof:</u> Substituting (18) into (14) it is obvious that $\pi^e(F^*) = 0$. That is, the marginal firm has zero profits. To show that all firms with fixed costs above F* won't invest, and that all firms with fixed costs below F* will invest it is sufficient to show that expected profits decline with F. ‖

The proposition describes the set of equilibria which can be implemented. Because of the underinvestment problem we are mainly interested in $F^* > F_{nc}$. As shown above in subsection A, investment of the marginal firm can be encouraged by monetary policy. The difficulty in establishing an equilibrium with higher investment is that some firms with low F, i.e., firms that were infra-marginal in the nonmonetary economy, may have $q(F) > l_g$ so that their profits are reduced by monetary policy.

Figure 1 illustrates the problem. In the noncontract equilibrium the expected profits of a firm with fixed cost F is a declining function of the fixed cost which intersects the horizontal axis at F_{nc}. The function declines for two reasons. First, a higher fixed cost reduces expected profits. Secondly, a higher fixed costs results in a revision of beliefs in favor of the bad state. The introduction of money modifies the expected profits function such that it intersects the horizontal axis at F*. This modification is accomplished through the resource transfer from low cost to high cost firms effected when the price level changes. The transfer scheme shifts the expected profits function up for all firms with F larger than some level $\hat{F}$, and down for all firms with F less than $\hat{F}$. A side-effect of this transfer scheme is that the revision of beliefs accompanying a higher fixed cost now results in a lower expected real wage. If this effect is too strong, the profit function may become positively sloped. Then the expected profits of very low F firms may become negative destroying the proposed equilibrium. If the expected profits function is negatively sloped, for the proposed F^*-equilibrium, then the problem does not occur. This is why we need the condition in Proposition 2.

We now want to isolate conditions under which the equilibrium F^* will, first of all, be an improvement over the nonmonetary outcome, and secondly, under which the social optimum can be achieved. Figure 1 and the above discussion suggest that there are two ways to proceed. First, the "side-effect" will be small if the revision of beliefs is small. Second, since the expected profit function in the nonmonetary case is strictly decreasing, a sufficiently small transfer should leave the expected profit function negatively sloped. Therefore, there is hope for achieving the social optimum if it is not too far away from the nonmonetary equilibrium, F_{nc}, so that the expected profit function does not have to be rotated too much. The first approach is formalized in Proposition 3. It is preceded by Lemma 2 which states the restrictions necessary to maintain the negative slope. The second approach is formalized in Proposition 4.

Lemma 2: The monetary authority can implement any F^* that satisfies one of the following two sets of conditions:

(1): (i) $ay^e/F^* \leq 1$; (ii) $q(F^*)/l_g < ay^e/F^*$; (iii) the elasticity of $q(F)$ with respect to F is less than one in absolute value.

(2) (i), and (iv) q' is sufficiently small.

Proof: See Appendix 2.

Proposition 3: (1) Under the assumption of Lemma 2(1), the monetary authority can implement an equilibrium with somewhat higher investment than occurs in the best nonmonetary equilibrium. The monetary equilibrium is a Pareto-improvement over the nonmonetary equilibrium.

(2) Under the assumption of Lemma 2(2), the monetary authority can implement the social optimum.

Proof: See Appendix 2.

Assumption (i) of the lemma is innocuous for our purposes since it essentially limits F^* to be at or above F_{nc}. But because of the underinvestment problem, we are only interested in those values of F^*. Assumption (ii) excludes very high values of F^* for which ay^e/F^* would be very low. The first part of Proposition 3 provides a local, i.e., marginal, improvement because the social otimum may not satisfy this assumption. The critical assumptions for the lemma are (iii) and (iv). These assumptions limit how firms update their beliefs about the state of the world when they observe their type. If belief revision is well-behaved, in the sense of these conditions, then the expected profit function will be negatively sloped.

Alternative conditions for implementation of the social optimum do not require that belief revision be restricted. The other conditions require that the social optimum be close to the nonmonetary equilibrium in a sense provided below.

Proposition 4: The social optimum can be implemented if one of the two following conditions hold:

(1) $\frac{b(F^*)}{g(F^*)} > \frac{L_b}{L_g} \cdot \frac{(1 - aB(F^*))}{(1 - aG(F^*))}$, where F* is the social optimum.

(2) The parameter a is sufficiently small.

Proof: See Appendix 2.

Note that one can easily show that $b(F^*)/g(F^*) > L_b/L_g$ (see the proof of Lemma 1). The other term in the formula is the ratio of the multipliers in the good and bad states. Recall that the problem of underinvestment is due to the fact that the multiplier in the good state is larger than the multiplier in the bad state. The larger the ratio of these multipliers the further away is the noncontract equilibrium from the social optimum. Thus, condition (1) holds if the ratio of the multipliers is close to one. That is, the social optimum must not be "too far" (in the multipler metric) away from the nonmonetary equilibrium.

V. The Choice of Contracts

So far we have considered the equilibrium outcomes from two games. The first was the nonmonetary economy, or indexed contracts; the second was characterized by nominal contracts. We concluded that society would be better off if it played the game with nominal contracts. But in a larger context agents must choose between indexed or nonindexed contracts. In this section we consider this choice in a repeated game context.

Suppose we consider the game discussed above as taking place in a single time period. The two stages of the game described in Section III describe the events in each period, but do not include a decision about whether the contracts are to be nominal or real. At the start of the period firms and workers must decide whether to sign nominal contracts. If all sign nominal contracts, then the outcome of the period game is the monetary equilibrium. If nobody signs nominal contracts, the outcome of the period game is the nonomonetary equilibrium.

The problem is that when firms and workers decide to sign nominal contracts or not some agents may have an incentive to deviate from the proposed equilibrium. In particular, firms may want to deviate from the nominal contract equilibrium that is desired. The following lemma shows that this is a significant problem.

Lemma 3: If a firm believes that the nominal contract equilibrium will obtain, then it can increase its one period expected profits by signing a real contract.

Proof: See Appendix 2.

Lemma 3 should not be surprising in view of the spillover problem. Nominal contracts implement a transfer scheme which encourages more firms to invest, thereby raising output. Each firm privately realizes that it can free ride on the transfer scheme knowing that its decision not to sign nominal contracts will not change the decisions of the other firms.

Lemma 3 implies that the nominal contract equilibrium cannot be the outcome of a single period game. As usual this conclusion does not extend to infinitely repeated games. The nominal contract equilibrium can be implemented in a repeated context as follows. We know that each firm would like all other firms to sign nominal contracts. A natural way to encourage other firms to sign those contracts is by threatening to sign real contracts in all future periods as soon as it sees any other firm signing real contracts. If all firms behave in this way, then the threat is effective because each firm believes that it would trigger a switch to the nonmonetary equilibrium if it did not sign nominal contracts. This logic is the intuition behind trigger strategies in game theory. Since trigger strategies are well-known we do not formalize the ideas here. The Folk Theorem shows that trigger strategies can establish the preferred nominal contract equilibrium provided individuals do not discount the future too much. (See Aumann (1981) and Rubinstein (1979).)

An alternative way to think about how the nominal contract equilibrium could be sustained involves a legal system. The presence of an exogenous agent, namely, the government, could effectively remove the choice of contracts from private consideration and implement the nominal contract equilibrium. Since the nominal contract equilibrium is preferred to the real contract equilibrium, all agents in the economy would unanimously agree that the government should enforce prohibitions of indexed contracts. There are numerous historical and current examples of government enforced prohibitions of indexed contracts. In the United States, for example, in June 1933, Congress abrogated the gold clause. The gold clause, dating from the 1860s, required debt contracts to be paid in either specified amounts of gold or the nominal equivalent of that gold weight. (See Friedman and Schwartz (1963).) When Congress outlawed the gold clause it effectively forced agents to use nominal debt contracts. There are similar examples with respect to wage contracts. While many countries permit escalator clauses, some do not. In Germany, for example, indexed wages are effectively outlawed. (See Giersch (1974) for a survey.)

VI. Alternative Transfer Schemes and Indexing

In this section the generality of the model is briefly discussed. The above model was couched in terms of wage contracts, but the results can also be interpreted as applying to nominal debt contracts. In fact, there are a number of transfer schemes which would be Pareto-improving in the same way as the nominal wage contracts. The model is also consistent with partial indexing, as discussed below.

To see the interpretation of the above model in terms of debt contracts suppose that monopolists must borrow to finance the fixed cost. Interpret the representative agents as lenders. Monopolists will hire workers under real contracts once the fixed plant has been purchased, and if they decide to operate. Thus, in Stage I firms and lenders sign debt contracts. In Stage II, as before, monopolists learn their fixed cost and decide to operate or not. If they decide not to operate, then they are allowed to prepay their debt. Otherwise they pay back their debt after outcomes have been realized. It should be clear that this is the same the transfer scheme discussed above, and therefore, is welfare-improving.

There are also other possible transfer schemes which can achieve the same results. An example of another transfer scheme is an investment tax credit that encourages investment. (See Kiyotaki (1988).) The point is not that nominal contracts are a unique way of implementing the desired transfer scheme, but rather that they can be seen as transfer schemes. With this interpretation the existence of nominal contracts is not paradoxical. Moreover, it seems that a natural way to implement such a system of transfers would be through this channel since it is easily implementable. Other transfer schemes, such as an investment tax credit scheme require much more government involvement, and hence, are likely more costly.

Finally, notice that the above model is consistent with partial indexation which is sometimes observed. The monetary authority, in the above model, sets the relative price differential across the two states of the world. If it is set correctly, then the relative real wage differential is just such that the appropriate transfers are implemented. If there were other factors effecting optimal monetary policy so that the relative prices across the two states had to be set in some different way, then clearly there exists a partial indexing scheme which can recover the appropriate real wage differential. In this case, the transfer scheme would still operate, but wages (or debts) would be partially indexed. Our model is abbreviated in that we have no other such role for monetary policy.

VII. Concluding Remarks

In this essay we have shown that nominal contracts implement transfers which can result in Pareto improvements in an economy with strategic complementarities. If prices depend on the state of nature, then nominal contracts vary in value across states, thereby changing agents' incentives. By choice of state-contingent money supplies, an activist monetary authority can (under certain conditions) achieve the social optimum. If there are multiple equilibria, then the monetary authority can, in any case, select the best outcome. In these senses, monetary policy has real effects.

Appendix 1

The analysis in Section III remains largely unchanged when all labor is contract labor. In that case the contract labor inputs in equation (10) and (11) should refer to total labor input by monopolists. For the example, we compute the equilibrium profits of F_1, F_2, and F_3 firms in Table 1A, for each of the three possible equilibria. (Table 1A corresponds to Table 3 of the main text.) The table demonstrates that with nominal contracts F_3 firms will earn positive expected profits regardless of whether other type F_3 firms invest or not. Therefore, they will invest and there is a unique equilibrium.

Appendix 2

Proof of Lemma 1: Substituting the definitions of $q(F^*)$ and l_g, one obtains:

$$\frac{p \cdot L_g}{p \cdot L_g + (1-p) \cdot L_b} > \frac{p \cdot g(F^*)}{p \cdot g(F^*) + (1-p) \cdot b(F^*)}$$

which can be written as:

$$\frac{L_b}{L_g} < \frac{b(F^*)}{g(F^*)} , \quad \text{or}$$

$$b(F^*)L_g - g(F^*)L_b > 0 .$$

Substituting in the definition of L_i, from (4), one obtains:

$$0 < \int_{F_{min}}^{F^*} F\left[b(F^*)g(F) - g(F^*)b(F^*)\right]dF$$

$$= \int_{F_{min}}^{F^*} Fg(F)g(F^*) \left[\frac{b(F^*)}{g(F^*)} - \frac{b(F)}{g(F)}\right]dF$$

The term in square brackets is positive because the likelihood ratio is increasing. ‖

Proof of Proposition 1: Define:

$$\pi^e_{nc}(F^*) = q(F^*) \cdot \left[ay_g(F^*) - F^*\right] + \left[1 - q(F^*)\right] \cdot \left[ay_b(F^*) - F^*\right],$$

which is the expected profit of a firm with fixed cost F^* in the case of no contracts (indicated by the subscript "nc") if all firms with fixed cost up to F^* invest. By definition, F^*_1 is the smallest value of F^* that satisfies $\pi^e_{nc}(F^*) = 0$. Assuming $\pi^e_{nc}(F_{min}) > 0$, it follows by continuity that:

$\pi^e_{nc}(F^*) > 0$, for all $F_{min} \le F^* < F^*_1$. Since $y_g(F^*) > y_b(F^*)$ and since $q(F)$ is negatively sloped:

$$q(F) \cdot \left(ay_g(F^*) - F^*\right) + \left(1 - q(F)\right)\left(ay_b(F^*) - F^*\right) \ge \pi^e_{nc}(F^*) > 0$$

for all $F \le F^* < F^*_1$. Thus, the integrand in (16) is strictly positive for all $F \le F^* < F^*_1$ and zero for $F = F^* = F^*_1$. Hence, $C(F^*) > 0$ for all $F^* < F^*_1$. That is, no value $F^* \le F^*_1$ can satisfy condition (16). This completes the proof. ‖

Proof of Lemma 2(1): Looking at (14), note that expected output declines with F, hence it is sufficient to show that $Fb_\psi(F)$ increases in F for ψ given by (18). Note that:

$$Fb_\psi(F) = \frac{ay^e l_g - q(F^*)F^* + q(F^*)(F - ay^e)}{F^*\,(l_g - q(F^*))} \tag{A1}$$

The derivative of (A1) is:

$$\frac{\partial(Fb_\psi(F))}{\partial F} = \frac{ay^e l_g - q(F^*)F^* + (q(F) + Fq'(F))\,(F^* - ay^e)}{F^*(l_g - q(F^*))} \tag{A2}$$

The assumptions of the lemma guarantee that (A2) is positive. ‖

Proof of Lemma 2(2): Taking the derivative of (14) at the value of $\psi(F^*)$ indicated by (18), we obtain:

$$\frac{\partial\pi}{\partial F} = q'(F) \cdot \left[a(y_g - y_b) - \frac{F^* - ay^e}{l_g - q(F^*)}\right] - \frac{ay^e\, l_g - q(F^*)F^* + q(F)(F^* - ay^e)}{F^*(l_g - q(F^*))} \tag{A3}$$

By Proposition 3, we have to show that $\frac{\partial\pi}{\partial F} < 0$.

Let $\hat{F}$ be defined by $q(\hat{F}) = l_g$ (see Figure 1). For $F \ge \hat{F}$, $q(F) \le l_g$ implies that:

$$ay^e \cdot l_g - q(F^*)F^* + q(F) \cdot (F^* - ay^e)$$
$$= ay^e \cdot (l_g - q(F)) + F^*(q(F^*) - q(F)) > 0$$

since $q(F^*) > q(F)$. Thus, the second term in $\frac{\partial \pi}{\partial F}$ is positive.

For $F < \hat{F}$, $q(F) > l_g$ implies that $ay^e \cdot l_g - q(F^*)F^* + q(F)\cdot(F^* - ay^e) > ay^e \cdot l_g - q(F^*)F^* + l_g\,(F^* - ay^e) = F^*(l_g - q(F^*)) > 0$, since $F^* \geq ay^e$. Again, the second term in $\frac{\partial \pi}{\partial F}$ is positive, which proves that part (iv) of the proposition is sufficient. ‖

Proof of Propostion 3: In any noncontract equilibrium, $ay^e = F_{nc}$. Let F_{nc} be the nonmonetary equilibrium with the highest level of investment. We will show that there exists $F^* > F_{nc}$ that satisfies (i) and (ii) of Lemma 2(1). Lemma 1 implies that condition (ii) is satisfied at F_{nc}, condition (i) is obvious, and (19) reduces to one, which is bounded away from zero. Therefore, (ii) must be satisfied and the derivative of (19) is positive in a neighborhood of F_{nc}. Let F^{**} be a value of F above F_{nc} in this neighborhood. Now we must show that condition (i) is satisfied at F^{**}. Since there is underinvestment in the best nonmonetary equilibrium, the social optimum must be at a value of F higher than F_{nc}. At the social optimum we have:

$$0 = \frac{dy^e}{dF^*} = p \cdot \frac{dy_g}{dF^*} + (1-p) \cdot \frac{dy_b}{dF^*}$$

$$= p \cdot g(F^*) \cdot \frac{ay_g - F^*}{1 - aG(F^*)} + (1 - p) \cdot b(F^*) \cdot \frac{ay_b - F^*}{1 - aB(F^*)}$$

$$= \frac{p \cdot g(F^*) + (1 - p) \cdot b(F^*)}{1 - aB(F^*)} \cdot \Big(q(F^*) \cdot \frac{1 - aB(F^*)}{1 - aG(F^*)} \cdot (ay_g - F^*) + [1 - q(F^*)] \cdot (ay_b - F^*)\Big) \qquad (A4)$$

$$= \frac{p \cdot g(F^*) + (1 - p) \cdot b(F^*)}{1 - aB(F^*)} + \Big((ay\,(F^*)^e - F^*) \cdot \frac{1 - aB(F^*)}{1 - aG(F^*)} +$$

$$\frac{a\left(G(F^*) - B(F^*)\right)}{1 - aG(F^*)} \cdot [1 - q(F^*)] \cdot (ay_g - F^*))$$

This implies that:

$$ay^e - F^* = - \frac{a(1 - q(F^*)) \cdot \left[G(F^*) - B(F^*)\right]}{1 - aB(F^*)} \cdot (ay_g - F^*) ,$$

which is negative, since $G(F^*) > B(F^*)$ and $ay_g - F^* > 0$. Therefore, (ii) is satisfied at the social optimum. If we restrict F^{**} to be at or below the social optimum, condition (i) must be satisfied at F^{**}, by continuity. For part (2) notice that (i) is satisfied at the social optimum. ||

Proof of Proposition 4: Notice that the expression for $\frac{\partial \pi}{\partial F}$ in equation (A3) is also negative, if:

$$a(y_g - y_b) - \frac{F^* - ay^e}{l_g - q(F^*)} > 0 ,$$

since $q' < 0$ and since the second term in (A3) positive. Recalling the definition of y^e and lemma 1, this is equivalent to:

$$\Gamma \equiv (l_g - q(F^*) + q(F))y_g + (1 - l_g + q(F^*) - q(F)) \cdot y_b - \frac{F^*}{a} > 0 .$$

At the social optimum, we have $\frac{dy^e}{dF^*} = 0$, which implies (see (A4)):

$$\frac{q(F^*)}{1 - aG(F^*)} \cdot y_g + \frac{1 - q(F^*)}{1 - aB(F^*)} \cdot y_b - \frac{F^*}{a} \cdot \left(\frac{q(F^*)}{1 - aG(F^*)} + \frac{1 - q(F^*)}{1 - aB(F^*)}\right) = 0 .$$

Using this condition to eliminate y_b from Γ, one obtains:

$$\Gamma = \frac{y_g - \frac{F^*}{a}}{(1-\alpha G(F^*)) \cdot (1-q(F^*)} \cdot \Big[(1-aG(F^*)) \cdot (l_g-q(F^*) + q(F))(1-q(F^*))$$

$$- (1-aB(F^*) \cdot (1 - l_g - q(F) + q(F^*) \cdot q(F^*)\Big]$$

$$= \frac{y_g - \frac{F^*}{a}}{(1-aG(F^*)(1-q(F^*))} \left[x \cdot (1 - aG(F^*)(1 - q(F^*)) - aB(F^*)q(F^*))\right.$$

$$\left. + a(B(F^*) - G(F^*)) \cdot q(F^*) \cdot (1 - q(F^*))\right]$$

where $x = (l_g - q(F^*)) + (q(F) - q(F^*)) > 0$. Since $y_g > \frac{F^*}{a}$ and $a < 1$, x is multiplied by positive expressions. Noting that $x \geq (lg - q(F^*)) > 0$, a sufficient condition for $\Gamma > 0$ (which implies $\frac{\partial \pi}{\partial F} < 0$) is:

$$\gamma \equiv (l_g - q(F^*)) \cdot \left[1 - aG(F^*)(1 - q(F^*)) - aB(F^*)q(F^*)\right] +$$

$$a \cdot (B(F^*) - G(F^*))\, q(F^*)\, (1 - q(F^*)) > 0 \; .$$

Using the definition of l_g and some algebra, one can show that this expression is equivalent to:

$$\gamma = l_g\, q(F^*)\, \frac{(1 - p)}{p} \cdot \left[\frac{b(F^*)}{g(F^*)} - \frac{L_b(F^*)}{L_g(F^*)} \cdot \frac{(1 - aB(F^*))}{(1 - aG(F^*))}\right] ,$$

which shows that (1) is a sufficient condition. Further algebra and use of the definitions of L_b and L_g show that:

$$\gamma = \frac{l_g \cdot q(F^*)}{p \cdot g(F^*) \cdot L_g(F^*)} \cdot \int_{F_{min}}^{F^*} F \cdot \left[g(F)b(F^*)(1 - aG(F^*)) - b(F)g(F^*)\right.$$

$$\left. \cdot (1 - aB(F^*))\right] dF$$

$$= \frac{l_g \cdot q(F^*)}{p \cdot L_g(F^*)} \cdot \int_{F_{min}}^{F^*} F \cdot g(F)(1-aG(F^*)) \cdot \left[\frac{b(F^*)}{g(F^*)} - \frac{b(F)}{g(F)} \cdot \frac{(1-aB(F^*))}{(1 - aG(F^*))}\right] dF \; .$$

An increasing likelihood ratio implies $\frac{b(F^*)}{g(F^*)} > \frac{b(F)}{g(F)}$, for all $F < F^*$. Since $\frac{1 - aB(F^*)}{1 - aG(F^*)} > 1$, for all $\gamma > 0$, the sign of γ is uncertain in general. But as $a \to 0$, $\frac{1 - aB(F^*)}{1 - aG(F^*)} \to 1$, so that there is some small $\bar{a}$ such that the integral is positive for $0 < a \le \bar{a}$. Then $\gamma > 0$, $\Gamma > 0$, and $\frac{\partial \pi}{\partial F} < 0$, proving (2). ‖

Proof of Lemma 3: The firm's decision depends on a comparison between expected profits under nominal and real contracts. In stage I, the firm does not know its fixed cost F, but it knows that it will operate if F turns out to be less than some critical level. The critical level is F* with a nominal contract. Without a nominal contract, the critical level F_{nc} must satisfy the non-profit condition $\pi^e_{nc}(F_{nc}) = 0$, where:

$$\pi^e_{nc}(F) = q(F)\ (ay_g - F) + (1 - q(F))\ (ay_b - F)$$

Taking expectations over F, expected profits with the nominal contract are:

$$\int_{F_{min}}^{F^*} [p(ay_g - \frac{w \cdot F}{P_g}) \cdot g(F) + (1 - p) \cdot (ay_b - \frac{w \cdot F}{P_b}) \cdot b(F)]dF$$

$$= \int_{F_{min}}^{F^*} [p(ay_g - F) \cdot g(F) + (1 - p) \cdot (ay_b - F) \cdot b(F)]dF + \qquad \text{(A5)}$$

$$+ \int_{F_{min}}^{F^*} F[p \cdot g(F)(1 - \frac{w}{P_g}) + (1 - p)\ b(F)(1 - \frac{w}{P_b})]dF$$

Using equations (3) and (6), the second integral is equivalent to:

$$\int_{F_{min}}^{F^*} p \cdot g(F) \cdot F\ dF \cdot [1 - \frac{w}{P_g} + (1 - \frac{w}{P_b}) \cdot \frac{1 - l_g}{l_g}]$$

By equation (10), the term in square brackets is zero. Thus, expected profits with nominal contracts are equal to the first integral in equation (A5). Notice that this integral would give the expected profit without nominal contracts, if the integral were taken over the interval $[F_{min}, F_{nc}]$. Since the integrand takes a positive value if and only if F is in the interval $[F_{min}, F_{nc}]$, the integral over $[F_{min}, F^*]$ has a lower value. This shows that a firm's expected profits are higher without nominal contracts than with them. ‖

Appendix 3

In this appendix we show how to interpret the money supply rule, (17). The zero and infinity components of the rule are important to rule out equilibria with F^* not equal to F^{**}. Notice that the rule should not be interpreted as the limit of the following rule:

$$M_i(F^{**}) = \begin{cases} \varepsilon & \text{if } F^{**} > F^* \\ K & \text{if } F^{**} < F^* \\ M_g & \text{if } F^{**} = F^* \text{ and } i = g \\ M_b & \text{if } F^{**} = F^* \text{ and } i = b \end{cases}$$

The reason is that this rule may not eliminate multiple equilibria. For example, if individuals anticipate $M = \varepsilon$ with probability one, then any wage rate satisfying (11) would support an equilibrium with $M = \varepsilon$. Instead, we should interpret (17) as the limit of a rule of the following form:

$$M_i(F^{**}, w) = \begin{cases} \varepsilon \cdot w & \text{if } F^{**} > F^* \\ K \cdot w & \text{if } F^{**} < F^* \\ M_g & \text{if } F^{**} = F^* \text{ and } i = g \\ M_b & \text{if } F^{**} = F^* \text{ and } i = b \end{cases}$$

In other words, the rule depends on both F and w. Selecting ε and K appropriately, one can insure that the <u>real</u> wage is high or low enough to preclude an equilibrium with F^{**} not equal to the desired equlibrium F^* Specifically, choose $K > F^*/a > \varepsilon$. Consider any w and any candidate F^{**} for an equilibrium. If $F^{**} < F^*$, then: $\pi^e(F|F^{**}, w) > 0$, for all $F < aK$. But since $aK > F^* > F^{**}$, F^* cannot be an equilibrium. A similar argument can be made to show that $F^{**} > F^*$ cannot be an equilibrium. As explained in the text, M_g and M_b are chosen to insure that F^* is, in fact, an equilibrium.

Footnotes

[1] As explained by Cooper and John (1988) strategic complementarity is necessary, but not sufficient, for multiple equilibria.

[2] To see this note, following Shleifer and Vishny, that:

$$\frac{dy(F^*)}{dF^*} = \frac{\pi(F^*)\ dI(F^*)}{1 - aI(F^*)}$$

where $\pi(F^*)$ is the profit of the marginal firm. In other words, the effect of the marginal firm's investment on total income is more thanone for one because the profits earned by the marginal firm are spent on goods produced by other firms. The profits of these firms are then, in turn, spent of the marginal firms goods.

References

Aumann, Robert (1981), "Survey of Repeated Games," in Aumann et. al., eds., Essays in Game Theory (Bibliographisches Institut: Mannheim).

Azariadis, Costas (1975), "Implicit Contracts and Underemployment Equilibria," Journal of Political Economy 83(6) (December), 1183-202.

Barro, Robert (1977), "Long-Term Contracting, Sticky Prices, and Monetary Policy," Journal of Monetary Economics 3 (July), 305-16.

Blanchard, Olivier (1979), "Wage Indexing Rules and the Behavior of the Economy," Journal of Political Economy 87 (August).

Blanchard, Olivier and Nobuhiro Kiyotaki (1987), "Monopolistic Competition and the Effects of Aggregate Demand," American Economic Review 77(4) (September), 647-66.

Cooper, Russell and Andrew John (1988), "Coordinating Coordination Failures in Keynesian Models," Quarterly Journal of Economics CIII(3) (August), 441-463.

Fethke, Gary and Andrew Policano (1984), "Wage Contingencies, the Pattern of Negotiation and Aggregate Implications of Alternative Contract Structures," Journal of Monetary Economics (September), 151-71.

Fischer, Stanley (1986), Indexing, Inflation, and Economic Policy (MIT Press: Cambridge, Massachusetts).

________________ (1978), "On the Nonexistence of Privately Issued Index Bonds in the U.S. Capital Market," in Erik Lundberg, ed., Inflation Theory and Anti-Inflation Policy (Macmillan Press Ltd.), 502-18.

________________ (1977), "Long-term Contracts, Rational Expectations, and the Optimal Money Supply Rule, Journal of Political Economy 85, 191-206.

________________ (1975), "The Demand for Index Bonds," Journal of Political Economy 83(3) (June), 509-34.

Friedman, Milton and Anna Schwartz (1963) A Monetary History of the United States, 1867-1960 (Princeton University Press: Princeton, New Jersey).

Giersch, Herbert (1974), "Index Clauses and the Fight Against Inflation," in Essays on Inflation and Indexation (American Enterprise Institute: Washington D.C.), 1-24.

Gray, Jo Anna (1976), "Wage Indexation: A Macroeconomic Approach," Journal of Monetary Economics 2(2) (April), 221-36.

Hart, Oliver (1982), "A Model of Imperfect Competition With Keynesian Features," Quarterly Journal of Economics XCVII, 109-38.

Heller, Walter (1986), "Coordination Failure Under Complete Markets With Applications to Effective Demand," in Equilibrium Analysis: Essays in Honor of Kenneth J. Arrow, Volume II, Walter P. Heller Ross Starr, and David Starrett, eds. (Cambridge: Cambridge University Press).

Kiyotaki, N. (1985), "Multiple Expectational Equilibria Under Monopolistic Competition," Quarterly Journal of Economics CIII(4) (November), 695-713.

Roberts, J. (1984), "General Equilibrium Analysis of Imperfect Competition: An Illustrative Example," Stanford University, mimeo.

________ (1986), "Involuntary Unemployment and Imperfect Competition: A Game Theoretic Macro Model," Stanford University, mimeo.

Rubinstein, Ariel (1979), "Equilibrium in Supergames with the Overtaking Criterion," Journal of Economic Theory 21, 1-9.

Shleifer, A. (1986), "Implementation Cycles," Journal of Political Economy, XCIV, 1163-90.

________ and Robert Vishny (1988), "The Efficiency of Investment in the Presence of Aggregate Demand Spillovers," Journal of Political Economy 96(6) (December), 1221-31.

Startz, R. (1986), "Monopolistic Competition as a Foundation for Keynesian Macroeconomic Models," University of Washington, mimeo.

Weitzman, M. (1982), "Increasing Returns and the Foundations of Unemployment Theory," Economic Journal XCII, 787-804.

FIGURE 1

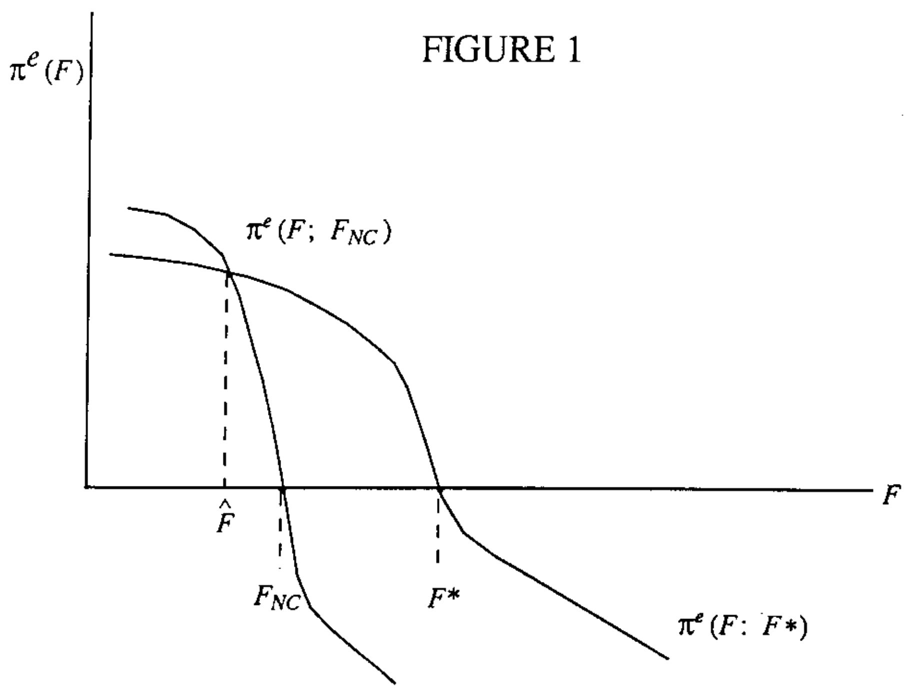

TABLE 1

Fixed Costs and Distribution of Firm Types across States

	Firm Type			
	F_1	F_2	F_3	F_4
Fixed Cost	9	108	110	200
Fraction of Firm Type if state is:				
GOOD	0.6	0.1	0.1	0.2
BAD	0.2	0.1	0.1	0.6

TABLE 2

Expected Profit by Possible Equilibrium - Noncontract

	F_1 Firms Produce	F_1 and F_2 Firms Produce	F_1, F_2 and F_3 Firms Produce
Output	143.77	144.60	145.57
F_3 Firm Profits	-2.18	-1.55	-0.82
F_2 Firm Profits	-0.18	0.45	1.18
F_1 Firm Profits	98.82	99.45	100.18

TABLE 3

Expected Profits by Possible Equilibrium - Contract

Profits Assuming Workers Expect:	F_1 Firms Produce	F_1 and F_2 Firms Produce	F_1, F_2 and F_3 Firms Produce
F_1-equilibrium			
F_2 Firm Profits	9.48	9.54	--
F_1 Firm Profits	99.63	100.21	--
F_2-equilibrium			
F_3 Firm Profits	1.39	1.39	1.40
F_2 Firm Profits	3.32	3.34	3.36
F_1 Firm Profits	99.12	99.69	100.36
F_3-equilibrium			
F_3 Firm Profits	1.08	1.09	1.10
F_2 Firm Profits	3.02	3.04	3.06
F_1 Firm Profits	99.09	99.66	100.34

TABLE 1A

Expected Profits by Possible Equilibrium When All Labor Is under Contract

Profits Assuming Workers Expect	F_1 Firms Produce	F_1 and F_2 Firms Produce	F_1, F_2 and F_3 Firms Produce
F_1-equilibrium			
F_2 Firm Profits	11.37	11.43	--
F_1 Firm Profits	99.79	100.36	--
F_2-equilibrium			
F_3 Firm Profits	6.94	6.98	7.02
F_2 Firm Profits	8.77	8.82	8.88
F_1 Firm Profits	99.57	100.15	100.82
F_3-equilibrium			
F_3 Firm Profits	6.69	6.73	6.78
F_2 Firm Profits	8.53	8.58	8.64
F_1 Firm Profits	99.55	100.13	100.80