Money and Contracts

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This paper presents a novel interpretation of the fact that high nominal interest rates accompany low levels of real GNP. It constructs a model in which money and bonds are both held as a result of legal restrictions on the banking system. Open market operations may increase the equilibrium rate of interest and raise the cost of credit. This increase in the cost of credit causes firms to write labour contracts in which layoffs occur more frequently. The nature of optimal labour contracts is derived explicitly from assumptions about the information that is available to firms and to workers.

1. INTRODUCTION

This paper offers an explanation of some familiar facts that concern the relationships between money, real income and interest rates. Roughly speaking, I shall claim that money is a productive asset and that its cost is measured by the nominal rate of interest. When the interest rate is high, businesses hold a smaller proportion of their wealth in the form of liquid assets. Because of imperfections in credit markets, money plays an important role in guaranteeing the solvency of a business to its creditors and, if a firm is less liquid, there is a higher probability that it may be forced to meet temporary fluctuations in revenues by cutting back on production. This idea may be summarized by arguing that money affects the economy not only through its effect on aggregate demand but also on aggregate supply.1

The idea that imperfect financial markets may play a major role in explaining business fluctuations has recently been explored in papers by Bernanke (1983) and Bernanke and Gertler (1986). In my own previous work, Farmer (1984, 1985), I have suggested that contractionary fiscal policy may reduce output permanently by raising the real rate of interest and increasing the equilibrium frequency of bankruptcies, but I was unable to explain the effects of monetary policy because of the difficulties of incorporating both money and bonds into a tight theoretical model. In the current paper I build a model of a monetary economy that is based on legal restrictions theory. Using this model, I analyse the effects of open market operations on output in a framework in which the monetary transmission mechanism operates through effects that are associated with imperfect financial intermediation.2

Much of the paper is devoted to making the idea of liquidity more precise and in explaining how informational asymmetries may limit the ability of price flexibility to absorb demand fluctuations. The reader who is interested in understanding the macroeconomic properties of the analysis could easily skip to Section 5 and return on second reading to the micro-foundations which are laid out in Sections 3 and 4. Section 2 contains some evidence concerning the behaviour of interest rates in the U.S. and Section 6 contains a short conclusion.
2. SOME EVIDENCE CONCERNING THE BEHAVIOUR OF INTEREST RATES IN THE UNITED STATES

In this section I document the relationship between the rate of interest on prime business loans and the rate of interest on treasury bills in the post-war United States. The evidence that I present is important to my theoretical arguments because I shall suggest that monetary policy operates by increasing the spread between these two rates. It is well known that contractionary open market operations by the central bank can lead to an increase in the rate of interest on treasury bills, but it is perhaps less well documented that high nominal interest rates are also associated with a high spread between lending and borrowing rates. Some evidence concerning this spread is presented in Figure 1 which plots the interest rate on prime business loans against the interest rate on treasury bills for the period 1955–1984 in the United States. A simple regression of the prime rate on the treasury bill rate for this period yields a coefficient of 1.25 with a standard error of less than 0.05. This relationship implies that the spread between the loan rate and the deposit rate was equal to approximately one quarter of the treasury bill rate, which at some times over this period reached very high levels. For example, in 1981 the prime rate on business loans was almost 19% at a time when the treasury bill rate was only 14%. In spite of this substantial opportunity cost, U.S. corporations held $135 billion in cash and bank accounts and $17 billion in the form of government securities. Together, these two components of business liquid assets represented 11% of total assets. During the same year commercial bank loans totalled $327 billion. American businesses were, therefore, paying a high cost to retain liquidity from which one might infer that liquid
assets play a non-trivial role in the productive process. In the remainder of this paper, I shall suggest one possible way that this role may be captured theoretically.

A second thread of my theoretical argument concerns the link between nominal interest rates and GNP in the post-war U.S. This link, which has been documented by Sims (1980) and by Litterman and Weiss (1985), is illustrated by Figure 2 which graphs unemployment and the treasury bill rate against time for the period from 1964 to 1984. Notice that periods of low interest rates precede low unemployment by approximately nine months. Litterman and Weiss present evidence from vector autoregressions in which they control for the effects of anticipated inflation. This evidence suggests that the nominal rate of interest exerts an independent influence on economic activity and that a high nominal interest rate precedes a low level of economic activity with a lag.4

3. THE THEORETICAL FRAMEWORK

In this section I discuss two related aspects of the structure of the model which distinguish it from more familiar examples of overlapping generations economies. The first of these aspects concerns the financial structure which rests on the premise that money and government bonds are distinguished by legal restrictions. The second aspect, which will be taken up shortly, concerns the detailed assumptions about production and the timing of markets that are necessary to make the general equilibrium structure internally consistent.

(a) Financial structure

The model contains three financial instruments. These are interest bearing liabilities of the government (government bonds), non-interest bearing liabilities of the government (high-powered-money), and interest bearing liabilities of private banks (deposits). Private
banks are assumed to perform a (costless) monitoring function. Private lenders are unable to observe the creditworthiness of private borrowers and they must, therefore, lend either to private banks or to the government. Private banks are able to observer the creditworthiness of private borrowers and they act as zero profit competitive intermediaries that channel the funds of private lenders to private borrowers. In the absence of government intervention, competition would force the loan rate of interest to equal the deposit rate. However, it is assumed that government imposes a reserve requirement on the private banking system that requires a bank to hold at least a fraction $\theta$ of its assets in the form of non-interest-bearing-loans to the central bank (high-powered-money). As a consequence of this assumption a competitive equilibrium will generally exhibit the property that the loan rate of interest exceeds the deposit rate in order to compensate the private bank for the loss of revenue to the central bank. In this model, all high-powered-money is held by the private banking system to satisfy reserve requirements. The consolidated balance sheet of the private banking system as a whole is described below.

<table>
<thead>
<tr>
<th>Private bank</th>
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<tbody>
<tr>
<td>Assets</td>
</tr>
<tr>
<td>$M$</td>
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<tr>
<td>$L$</td>
</tr>
<tr>
<td>Liabilities</td>
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<tr>
<td>$D$</td>
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$M$ represents the reserves of the banking system which are assumed to equal the total stock of high powered money, $L$ represents the quantity of private loans and $D$ represents bank deposits. Legal restrictions require that

$$M \geq \theta D, \quad 0 < \theta < 1$$

(1)

and optimization will require (1) to hold with equality if the nominal interest rate on loans is strictly positive. Similarly, competition requires zero profits in the banking industry which implies that

$$r^D = (1 - \theta) r^L,$$

(2)

where $r^D$ is the nominal interest rate on deposits and $r^L$ is the nominal interest rate on loans.

The following two additional implications of this structure are worth noting. First, the rate of interest on government bonds must equal the rate of interest on bank deposits in any equilibrium in which these two assets co-exist. This implication follows from the assumption that these two assets are perfect substitutes in the portfolios of lenders. Second, private banks will not choose to hold government debt since they may earn a higher rate of return by lending to private borrowers.

(b) Real structure

I assume that time proceeds in a sequence of periods, each of which is divided into two parts by the revelation of information. There are two types of agents—workers and entrepreneurs—each of which lives for two periods. Workers are endowed with a unit of labour in their youth and entrepreneurs are endowed with a unit of capital, $K$. Capital may be combined with labour in a stochastic production technology that takes the form

$$\begin{cases} y_i(s_t) = s_t - \alpha & \text{if } l_t = 1 \\ y_i(s_t) = 0 & \text{otherwise.} \end{cases}$$

(3)

The term $y_i(s_t)$ represents the output of a firm that receives productivity shock $s_t$, $l_t$ represents labour input which is restricted to take the values zero or one, and $\alpha \in (0, 1)$
is a fixed startup cost which is incurred only if production takes place. The random productivity shock is assumed to be independently and identically distributed across firms with distribution function \(H(s)\) and support \([0, 1]\). I also assume that the density function \(h(s)\) is strictly positive on the support of \(s\) and that the hazard rate of \(s\) is increasing. These assumptions simplify the exposition of the optimal contract.

The timing of events is as follows (see Figure 3). Prior to the revelation of information, workers and entrepreneurs combine into firms. Once a firm has been created, the productivity of the firm is revealed to the entrepreneur. At this stage the firm produces output and the entrepreneur pays a wage to the worker. The amount of output that is produced, and the compensation received by the worker, is determined according to the terms of a contract that is written prior to the revelation of information. Although workers and entrepreneurs are free to combine with whomsoever they choose before the revelation of information, ex post they are assumed to be immobile. Different firms receive different productivity shocks and so output will be different in different locations. But since there is a continuum of firms, and all uncertainty is idiosyncratic, aggregate output for this economy will be non-stochastic.

Money enters into this analysis through the assumption that workers cannot be paid with the liabilities of the firm—such liabilities simply are not acceptable in exchange. It may therefore be in the interests of the firm to take out a loan in order to make payments to the worker in some states of nature. The precise way in which money enters into the contractual structure is examined in the next section.

4. THE STRUCTURE OF INDIVIDUAL DECISION PROBLEMS

In this section I examine the decision problems of each agent. In the first part I outline the nature of the information that is available to the worker and to the firm and I define
the properties of a feasible labour contract. In the second part I discuss the intertemporal problem that must be solved by a worker and by an entrepreneur once they have written a labour contract and the state of nature at their firm has been realized. Finally in the third part I solve the problem of designing an optimal labour contract and I discuss the properties of the solution.

Informational Assumptions

By definition, a contract is a pair \((l_t(s_t), \omega_t(s_t))\) that represents the level of employment and the real compensation that will be received by a worker. The variable \(s_t\) represents a firm specific productivity shock that is observed by the entrepreneur, but not by the worker. In fact, the information that is available to the worker is assumed to consist only of the observation of the employment level \(l_t(s_t)\). Since this employment level is restricted by technology to take only the values \(\{0, 1\}\) the worker is effectively able to distinguish between only two sets of states of nature.\(^7\) This restriction implies that the set of contracts that are incentive compatible is limited to the class:

\[
\omega_t(s_t) = \omega_t^0 \quad \text{if} \quad l_t(s_t) = 0
\]

\[
\omega_t(s_t) = \omega_t^0 + \Delta_t \quad \text{if} \quad l_t(s_t) = 1.
\]

That is, incentive compatible contracts make one payment to the worker if he is employed and a (possibly) different payment if he is laid off. The term \(\Delta_t\) represents the marginal increment in compensation that must be paid to the worker by the entrepreneur if the firm actually operates. Since the marginal product of the firm is represented by the productivity shock \(s_t\) the \textit{ex post} decision of the firm will be to operate if and only if

\[
s_t \geq \alpha + \Delta_t. \tag{4}
\]

One further important restriction on the set of feasible contracts arises from the assumption that the liabilities of the firm are not acceptable in exchange. This restriction implies that:

\[
\omega_t(s_t) \leq (s_t - \alpha) + \frac{L_t}{P_t} \tag{5}
\]

where \(L_t\) represents the value of the monetary assets held by the entrepreneur and \(P_t\) is the price of commodities in terms of money. In view of inequality (4) this constraint may also be written in the form,

\[
\omega_t^0 \leq \frac{L_t}{P_t}. \tag{6}
\]

The liquidity constraint that is represented by inequality (6) implies that the firm must take out a bank loan if it wishes to pick a positive value for \(\omega_t^0\), since the entrepreneur has no marketable wealth of his own with which to make payments to the worker in low states. I will demonstrate below that the entrepreneur will choose to take out a loan even though it is costly to do so, because the ability to make payments to the worker in low states of nature allows the firm to make more efficient employment decisions.

The Demand for Assets

This section provides a brief description of the utility functions of agents and it derives the aggregate demands for assets that arise from optimal portfolio allocations. Both the entrepreneur and the worker are assumed to maximize the expected utility of functions
that are linear in second period consumption. Using the superscripts \(w\) and \(e\) to refer to workers and entrepreneurs these utility functions are represented as:

\[
U^w = C^w_{t+1} \\
U^e = C^e_{t+1}.
\]

This choice of utility functions is made for two reasons. First, the linearity in consumption makes the optimal contract easy to solve since both agents are risk neutral. Second, the absence of first period consumption from either utility function keeps the demand side of the model very simple and allows one to focus on supply side effects of rates of return. Since neither agent consumes in youth, the total wealth of each agent will be stored as bonds or as interest bearing bank deposits. I directly impose the equilibrium condition that these two assets both pay the same rate of interest \(r^D_t\) although it should be noted that the model could conceivably support equilibria in which one or the other of these assets is not valued. Using the superscript \(w\) to refer to the worker and \(e\) to refer to the entrepreneur one may describe the first period budget constraints of each agent as follows:  

\[
\frac{(B^w_t + D^w_t)}{P_t} = \omega_t(s_t)
\]

\[
K + \frac{(B^e_t + D^e_t)}{P_t} = y_t(s_t) - \omega_t(s_t) + \frac{L_t}{P_t} + K.
\]

If one defines aggregate output \(Y_t\) by the equation

\[
Y_t = \int_{x=0}^{1} y_t(s_t) dH(s_t)
\]  

these constraints imply that aggregate assets and aggregate output obey the identity:

\[
\frac{(B_t + D_t)}{P_t} = Y_t + \frac{L_t}{P_t}
\]

or since deposits equal loans plus high-powered-money (from the balance sheet of the private banking system) one may rewrite equation (8) as:

\[
\frac{(B_t + M_t)}{P_t} = Y_t.
\]

This equation will play an important role in the general equilibrium analysis of Section 5. Turning our attention back to the problems of individuals, it follows that the consumption of each agent is simply the real value of his assets in period \(t+1\). For the worker this quantity is given by the formula:

\[
C^w_{t+1} = \omega_t(s_t)(1 + r^D_t) \frac{P_t}{P_{t+1}}
\]

and for the entrepreneur:

\[
C^e_{t+1} = [y_t(s_t) + K - \omega_t(s_t)](1 + r^D_t) \frac{P_t}{P_{t+1}} - L_t(r^D_t - r^D_t) \frac{P_t}{P_{t+1}}.
\]
In the following subsection I shall use the feasibility constraints described above and the definitions of consumption given by equations (10) and (11) to derive the structure of an optimal contract.

The Optimal Contract

One may conceive of the market for contracts as a large hiring hall in which workers and entrepreneurs meet and are free to combine into pairs. Each pair will write a contract which maximizes the expected return to the firm and which divides this expected return between the worker and the entrepreneur. The way in which the surplus is to be divided will depend on the bargaining power of each agent, in particular one would expect that the division would depend on the *ex ante* alternative opportunities of each agent. In the following problem I directly impose the assumption that the entire surplus is captured by the worker which implies that an optimal contract will maximize the expected utility of the worker subject to a non-zero expected profit constraint. Making use of the incentive compatibility condition (4) one may state this problem in the following way:  

\[ \text{Max}_{\omega^0, \Delta_t, L_t, \Delta, \omega^0_t} \int_{s_t = \Delta_t + \alpha}^{1} \Delta_t dH(s_t) \]  

such that:

\[ \int_{s_t = \Delta_t + \alpha}^{1} (s_t - \Delta_t - \alpha) dH(s_t) - \omega^0_t \left( \frac{L_t (r^L_t - r^D_t)}{P_t (1 + r^D_t)} \right) \equiv 0, \]  

\[ \frac{L_t}{P_t} \equiv \omega^0_t. \]  

Expression (12) represents the expected value of the worker’s consumption at date \( t + 1 \), discounted to date \( t \) by the deposit rate. This is simply the expected value of his compensation. Similarly, the lefthand side of inequality (13) represents the expected value of the entrepreneur’s profits. Finally, inequality (14) represents the constraint that the liabilities of the entrepreneur are not acceptable in exchange.

I now turn to an analysis of the properties of the solution to this problem. Note first that, since this is a concave programming problem, the first order conditions are both necessary and sufficient. Note also, that the inequality constraint (13) will always be binding at an optimum and that the constraint (14) will be binding if the opportunity cost of liquidity is positive. These observations allow one to write the first order conditions in the following way:

\[ 1 - \lambda - \psi = 0 \]  

\[ \psi - \lambda \left( \frac{r^L_t - r^D_t}{1 + r^D_t} \right) = 0 \]  

\[ \Delta_t Z(\Delta_t + \alpha) - (1 - \lambda) = 0. \]  

The terms \( \lambda \) and \( \psi \) are multipliers associated with constraints (13) and (14) and \( Z = (h/1 - H) \) is the hazard rate of \( s_t \).

Substituting equation (16) into (15) it follows that:

\[ \lambda = \frac{(1 + r^D_t)}{(1 + r^L_t)} \]
and:

\[ \psi = (1 - \lambda) = \frac{(r_i^L - r_i^D)}{(1 + r_i^L)} \]

If one defines the opportunity cost of borrowing liquid assets as \( i_i \):

\[ i_i = \frac{(r_i^L - r_i^D)}{(1 + r_i^L)} \]  \hspace{1cm} (18)

then these equations imply that the marginal compensation payment, \( \Delta_i \), is a continuous increasing function of the opportunity cost of liquid funds. This function \( g(\cdot) \) maps \( \mathbb{R}_+ \) onto \([0, 1 - \alpha]\) and its existence follows from the application of the implicit function theorem to equation (17), making use of the assumptions that \( Z(\cdot) \) is increasing and that \( h(\cdot) \) is everywhere positive on the interval \([0, 1]\). The properties of this function are listed below:

\[
\begin{align*}
\Delta_i = g(i_i) \\
g(0) &= 0 \\
g(x) &\rightarrow 1 - \alpha \text{ as } x \rightarrow \infty \\
\frac{\partial g}{\partial i} &> 0.
\end{align*}
\]  \hspace{1cm} (19)

The fact that \( g(0) = 0 \) implies that, if the opportunity cost of liquidity is zero, then the firm will hold enough liquid assets to guarantee efficient employment in each state. In this situation, the marginal increment in compensation \( \Delta_i \) will be set equal to zero and employment in each state will be determined by comparing the worker’s marginal product, \( s_i \), to the marginal startup cost, \( \alpha \). However, if \( i_i \) is positive then the marginal product must be greater than \( \alpha \) in order for the firm to employ the worker. In this case the employment rule is given by employing the worker only in states for which \( s_i \geq \alpha + \Delta_i \). Since \( \Delta_i \) is strictly positive, for positive \( i_i \), this employment rule leads to a strictly lower probability of employment than one would observe in a world of symmetric information.

Along with the optimal employment rule, one may also recover the demand for liquid assets from the solution to this problem. For any positive \( i_i \), holding liquid assets will be costly, which implies that inequality (14) will hold. This equality implies that the firm takes out loans in order to cover its wage bill in low states; in high states these payments may be partially met from revenues. The value of loans as a function of their opportunity cost is found by making use of the fact that inequality (13) will hold at an optimum, i.e. expected profits will be driven to zero. Making use of this observation one may define a function \( G(\cdot): \mathbb{R}_+ \rightarrow \mathbb{R} \), such that

\[ \omega_i^0 = \frac{L_i}{P_i} = G(i_i). \]  \hspace{1cm} (20)

The function \( G(\cdot) \) is given by the expression:

\[ G(i_i) = (1 - i_i) \int_{s_i = g(i_i) + \alpha}^{1} (s_i - g(i_i) - \alpha) dH(s_i). \]  \hspace{1cm} (21)

Notice that for \( i_i \in [0, 1] \) this function is strictly decreasing.

As the opportunity cost of liquidity rises, the firm will economize on its liquid assets and the worker will receive less compensation in low states of nature. To compensate the worker for this loss in low states the firm must increase its compensation in high
states. But this increase in high states will affect the probability of employment since there will now be fewer states in which the entrepreneur decides to employ the worker. The aggregate implications of this result are discussed in more detail in the next section but, roughly speaking, they can be summarized as follows. Across the whole economy, higher nominal interest rates imply that firms will choose to hold less money and, therefore, in aggregate they will be more likely to lay off workers. Since different firms receive different draws from the same distribution, in aggregate, higher interest rates will be associated with lower output.

5. GENERAL EQUILIBRIUM

This section describes the properties of an aggregate macroeconomic model that is constructed from the microeconomic foundations described above. The demand side of this model is similar to a simple textbook IS/LM model with a "real balance effect". The supply side of the model is, however, rather different since money affects production and this property allows monetary policy to have a powerful effect on output.

In the following treatment I define a fiscal policy to be a sequence of values of government expenditures \( \{g_t\}_{t=0}^{\infty} \) stretching into the infinite future and I focus on policies of the form \( g_t = g \) for all \( t \). I have chosen to set taxes to zero in all periods in order to avoid complicating the notation although the extension to allow for positive taxes is not difficult. A monetary policy is a choice of two sequences; the reserve ratio \( \{\theta_t\}_{t=0}^{\infty} \) and the stock of money \( \{M_t\}_{t=0}^{\infty} \). I consider only constant sequences of the form \( \theta_t = \theta \) for all \( t \), for the first of these two policy instruments. For the choice of the second monetary instrument, \( M_t \), a number of alternative policies are possible. For example, one might examine simple money growth rules of the form \( M_t = \lambda M_{t-1} \), or alternatively one might examine interest rate control rules of the form \( r_t^D = r \) for all \( t \). A particularly simple policy to examine within the context of the present model is a reactive policy in the class \( M_t = \mu [M_t + B_t] \). In this class of policies the central bank chooses to monetize a fraction \( \mu \) of total government liabilities in each period. The parameter \( \mu \) represents an index of the "looseness" of monetary policy. An increase in \( \mu \) corresponds to an open market purchase of debt and of a commitment to maintain a higher ratio of money to debt into the indefinite future.

Using this definition of policy, one may represent the aggregate model by the following system of equations:

\[
\frac{(M_t + B_t)}{P_t} = Y_t, \tag{22}
\]

\[
\frac{M_t}{P_t} = \frac{\theta}{1 - \theta} \frac{\frac{\theta r_t^D}{1 - \theta + r_t^D}}{1 - \theta + r_t^D}, \tag{23}
\]

\[
Y_t = f\left(\frac{\theta r_t^D}{1 - \theta + r_t^D}\right), \tag{24}
\]

\[
M_t = \mu (M_t + B_t), \tag{25}
\]

\[
\frac{(B_t + M_t)}{P_t} = g + \frac{(B_{t-1}(1 + r_{t-1}^D) + M_{t-1})}{P_t}. \tag{26}
\]

Equation (22) is the aggregate demand for assets that was derived in Section (4). It follows from the assumptions that all income is produced by the young and that all income is saved. Equation (23) represents the economy's demand for money schedule.
It is derived by aggregating the demand for loans across entrepreneurs. Since all entrepreneurs demand the same loans, and since the aggregate mass of entrepreneurs is normalized to unity, I use the symbol $L$ to refer both to aggregate and individual loan demand. The demand for high-powered money by banks is derived from the loan demand of entrepreneurs from the following expressions:

$$\frac{M_t}{P_t} = \frac{D_t}{P_t} = \frac{\theta (M_t + L_t)}{P_t} = \frac{\theta M_t}{P_t} + \theta G(i_t).$$

The first equality follows from the assumption of competitive banking and the second from the balance sheet of the private banking system.

Competition also implies:

$$r_t^L = \frac{r_t^D}{(1 - \theta)}$$

from which it follows that the opportunity cost of holding money is a continuous increasing function of the nominal rate of interest on deposits. This function is described below:

$$i_t = \frac{\theta r_t^D}{1 - \theta + r_t^D}.$$

Substituting this expression into the function $G(\cdot)$ one obtains the expression for money demand given in equation (23).

Equation (24) represents the most significant departure from more familiar models. It is an aggregate supply equation which is constructed by aggregating the quantity of output that is produced at any firm, across all of the firms that receive a favourable enough productivity shock to make production worthwhile. The function $f(\cdot)$ is defined below:

$$f(i_t) = \int_{s=g(i_t)+\alpha}^{1} (s_i - \alpha) dH(s_i).$$

Since $g(\cdot)$ is strictly increasing, it follows that $f(\cdot)$ is a decreasing function of the opportunity cost of liquid assets. Equations (22) to (24) together with the policy rule (25) may be combined to give a reduced form system that determines output and the rate of interest as functions of the monetary policy instruments $\theta$ and $\mu$. The government budget constraint, (26), then determines the rate of outside asset creation and, hence, the rate of inflation. As we shall see, in this model, inflation is a fiscal phenomenon.

Combining equations (22), (23) and (25) one may derive the following expression which I refer to as the policy locus:

$$Y_t = \frac{\theta}{(1 - \theta)\mu} G\left(\frac{\theta r_t^D}{1 - \theta + r_t^D}\right).$$

For given $\theta$ and $\mu$, equation (27) defines a downward sloping curve in output × interest rate space. This is graphed in Figure 4 as the curve $PP$. A second relationship between output and the nominal interest rate is given by the aggregate supply curve, equation (24), which is depicted in Figure 4 by the locus $AS$. Figure 4 is drawn under the assumption that policies lie in a range that admits of the existence of an equilibrium in which the nominal interest rate is positive. These restrictions may be stated as follows:

$$1 < \frac{\theta}{1 - \theta} \mu < \frac{f(\theta)}{G(\theta)}.$$  \hspace{1cm} (28)

The lefthand inequality in expression (28) guarantees that the policy locus in Figure 4
cuts the horizontal axis to the right of the AS locus. If this inequality is violated then the equilibrium rate of interest falls to zero and money and bonds become perfect substitutes: monetary policy becomes impotent and the equilibrium quantity of output that is produced is equal to the quantity that would be produced in the absence of an informational asymmetry. This quantity is given by the expression:

\[ f(0) = \int_{s_i = \alpha}^{1} (s_i - \alpha) dH(s_i). \]  

(29)

In this situation the liquidity constraint on firms becomes non-binding and the firm is willing to hold any quantity of liquid assets greater than or equal to its compensation payments in low states. Conversely, the right hand inequality of expression (28) guarantees that, as the interest rate tends to infinity, the policy locus in Figure 4 lies strictly to the left of the aggregate supply curve. This condition would be violated for particularly restrictive monetary policies, that is, reserve ratios close to one or open market operations that choose to monetize a very small fraction of total government liabilities. Monetary policies of this type are not consistent with the existence of an equilibrium.

The effects of monetary policy in this economy are summarized by movements in the position of the policy locus. A commitment to monetize a larger fraction of government liabilities, that is an increase in \( \mu \), will shift this locus down and to the left. A similar
effect will occur if the reserve requirement is decreased, that is, if $\theta$ is decreased. Both of these policies result in a higher equilibrium level of aggregate output and a lower nominal interest rate because they decrease a distortionary tax on the banking system and lower the cost of credit. Credit has a well-defined role in this economy that hinges on the ability of liquid assets to alleviate problems that originate with informational asymmetries. By lowering the cost of credit a looser monetary policy raises the equilibrium level of economic activity.

As a result of the role of credit in production, monetary policy may have a powerful effect on output. In order to highlight this effect, some very strong assumptions have been made about the properties of production functions and utility functions. These assumptions turn out to imply a very weak effect, on output, of fiscal policy. Some of the more important simplifying assumptions, together with their implications, are discussed below.

On the demand side of the model, agents face a trivial intertemporal allocation decision and the real rate of interest affects neither the demand for consumption goods by the young nor does it influence investment. On the supply side, the stock of capital is technologically fixed and therefore independent of the rate of return. The quantity of output that is produced cannot, therefore, be influenced by variations in the aggregate capital stock. The possibility of bankruptcy has been eliminated with the assumption that entrepreneurs are able to repay their bank loans by selling their endowment of capital. Hence, high real interest rates cannot lower output by increasing the frequency of bankruptcies as in my (1984) and (1985) papers. One is left with only one channel by which fiscal policy can affect real decisions. An increase in government spending causes the rate of asset creation to rise through the government budget constraint, equation (26). Since the nominal interest rate and the real value of assets are determined by the monetary side of the economy summarized in Figure 4, equation (26) is free to determine only the inflation rate and hence the real rate of return. Increases in government spending divert resources away from the consumption of the old by driving up prices and reducing the money value of deposits and of government bonds. In this sense inflation is a fiscal phenomenon since it is ultimately generated by the creation of government bonds to finance an expenditure program. It will necessarily be true, however, that the rate of money growth equals the rate of inflation, for any stationary policy in the class described above since such policies are associated with stationary equilibrium values of real money balances. This situation is entirely consistent with the underlying fact that inflation is ultimately fiscal in nature, since the rate of money growth is endogenously determined by the reactive policy rule, equation (25).

For any given monetary policy one may define the equilibrium values of the real value of government debt, of high powered money, and of the nominal interest rate as functions of $\theta$ and $\mu$;

\[
\begin{align*}
    b &= \frac{B_t}{P_t} = b(\theta, \mu) \\
    m &= \frac{M_t}{P_t} = m(\theta, \mu) \\
    r &= r^D_t = r(\theta, \mu).
\end{align*}
\]

(30)

Using these definitions one may write the government budget constraint as follows:

\[
b + m = g + \frac{(1 + r)}{(1 + \pi)} (b + m) - \frac{rm}{(1 + \pi)},
\]

(31)
where the term \( \pi \) represents the inflation rate. Notice that if \( g \) is equal to \( rm/(1 + \pi) \) then the equilibrium inflation rate is equal to the nominal interest rate \( r \). The critical level of government spending, \( \hat{g} \), for which this result holds can be described as a function of the monetary policy parameters \( \theta \) and \( \mu \) by solving equation (31) for \( \pi \):

\[
\pi = r + \frac{g(1 + r) - rm}{b + m - g}.
\]  

(32)

It follows that \( \hat{g} \) is given by the expression:

\[
\hat{g} = \frac{m(\theta, \mu)r(\theta, \mu)}{1 + r(\theta, \mu)}.
\]  

(33)

Values of expenditure greater than \( \hat{g} \) will generate a rate of inflation that exceeds the nominal interest rate and drives the real rate of interest below zero. Similarly, levels of expenditure that fall short of \( \hat{g} \) will cause the rate of inflation to fall below the nominal interest rate and drive up the real rate of interest.

In this economy, monetary policy determines the level of output and the nominal rate of interest and fiscal policy determines the inflation rate and the real rate of interest. This dichotomy arises in part from the rudimentary structure of preferences and, in part, from the way that open market operations have been modelled. However, the essential features of the analysis will be common to more complicated models in this class. If credit plays an important role in production then one should expect to see a long run relationship between nominal interest rates and output.

6. CONCLUSION

In traditional Keynesian analysis, demand management policies affect output and employment primarily because prices are sticky. According to this view the interest rate is an intermediate variable that transmits the effect of fiscal and monetary policies to demand. When the interest rate is high aggregate demand falls and businesses respond in the short run by cutting back on production rather than by adjusting wages and prices. But it is a central part of this theory that, if the economy were left to itself for a long enough period of time, flexible wages and prices would eventually restore a full employment equilibrium regardless of the prevailing fiscal and monetary policies.

Although this view is internally consistent, it has not provided a satisfactory explanation of western experience since the 1970s primarily because it has difficulty in accounting for the secular increases in unemployment rates that have occurred, to a greater or lesser extent, in all western nations. The alternative view that I have put forward in this paper attributes a direct role to interest rates through their effect on aggregate supply. My own preliminary investigations suggest that supply-side effects of interest rates can account for much of the employment variation in U.S. data although one must allow real and nominal rates of interest to work separately. It is for this reason that I have developed the ideas contained in this paper which stress the role of nominal interest rates through the use of liquid assets in the productive process. My previous work on this topic has argued that when the real rate of interest is high, output and employment will fall as the equilibrium incidence of bankruptcies and layoffs increases. In practice, both real and nominal rates may be important.

This supply-side theory of the role of interest rates has two appealing features. From a purely theoretical perspective it is parsimonious in its explanation of relative prices—one is not obliged to introduce "free parameters" in the sense of Lucas (1976) in order to
explain quantity fluctuations. But it does not follow that because one adopts an equilibrium explanation of price determination that one is also forced to accept a classical theory of resource utilization. In the supply-side theory of the role of interest rates the "natural rate" of employment cannot be defined independently of monetary and fiscal policy even in the long run. Related to this purely theoretical appeal is the potential of the theory to explain both cyclical and secular movements in resource utilization through movements in interest rates. Perhaps it is not purely coincidental that a decade of unprecedentedly high interest rates has also been a decade of unprecedentedly high unemployment, and perhaps one does not have to reject equilibrium theory to explain both sorts of phenomena.

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NOTES

1. The idea that money enters the production function is, of course, not new. See, for example, Patinkin (1965). The current analysis argues that the effect of money on production is important and it provides an explicit account of why this might be so.
2. Legal restrictions theory was originally proposed by Bryant and Wallace (1979) as a means of explaining why agents may hold assets that are dominated in rate of return and Neil Wallace (1983) argues that any explanation of the premium for holding treasury bills over money must rest on legal restrictions of one kind or another. In the current paper I have drawn heavily on the results of joint work with Costas Azariadis (1987) who has persuaded me that reserve requirements represent an elegant way of implementing a theory of legal restrictions. For other work along these lines see Romer (1985) or English (1986).
4. Litterman and Weiss use industrial production, which moves very closely with unemployment, and they analyze monthly post-war data. I have deliberately chosen the 1964–84 sample period because over this period the correlation between unemployment and the nominal interest rate is obvious without correcting for the influence of other variables by conducting vector autoregressions.
5. I make no attempt to understand why a supposedly benevolent government would impose a reserve requirement of this nature although this is clearly an interesting question and one that properly belongs in the field of the theory of optimal taxation. Bryant and Wallace (1979) have argued convincingly that without legal restrictions of some form one would never expect treasury bills to sell at a discount.
6. This assumption, which is common in the principal-agent literature, has the effect of ruling out pooling solutions of asymmetric information contracts. The hazard rate is defined by the relationship: \( Z(s) = h(s)/(1 - H(s)) \) where \( h \) is the density function and \( H \) is the distribution function of \( s \).
7. The assumption that \( l(s) \) may only take two values makes the optimal contract particularly easy to solve. A more general analysis is contained in Farmer (1988) in which it is assumed that \( l(s) \) belongs to some positive interval.
8. The term \( K \) represents the capital assets of the entrepreneur. These assets are held between periods \( t \) and \( t + 1 \) and sold in the goods market at date \( t + 1 \). Since this term appears as both a demand and a supply term, it does not alter the equilibrium conditions of the model. By making the assumption that \( K \) is positive, one is able to rule out the possibility of the bankruptcy of the entrepreneur. Even in states of zero production the firm will be able to repay its loan to the bank.
9. Since the mass of entrepreneurs is normalized to unity it follows that there is no notational confusion if one uses the same symbol \( L \) to refer to the loans of individual entrepreneur and to the aggregate loans of the entire cohort of entrepreneurs. A similar remark applies to the terms \( B^r, B^w, D^r \) and \( D^w \).
10. This is directly analogous to the technique used by Grossman and Hart (1981) who discuss a similar problem in more detail. See also Farmer (1984).
11. It is worth noting that the value of \( \hat{g} \) is found by setting the value of government spending equal to the real values of revenue from the inflation tax; that is, the government is running a zero budget deficit at this critical value of \( g \). In models with other sources of tax revenues the critical value of expenditure will be that value which just balances the budget when all sources of tax revenue are accounted for.

REFERENCES