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Imperfect Capital Markets and Nominal Wage Rigidities

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Should monetary policy respond to asset prices? This paper analyzes a general equilibrium model with imperfect capital markets and rigid nominal wages. Within the context of this model, there is a natural role for the benevolent central bank to dampen the real effects of asset price movements.

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1. Introduction.

Should monetary policy respond to asset prices? This is a classic question in monetary policy. This paper addresses this issue in the context of a general equilibrium model with imperfect capital markets and nominal wage rigidities. The former assumption is what makes the analysis interesting. If markets are perfect and the Modigliani-Miller theorem holds, then asset prices reflect current economic conditions but otherwise have no independent effect on real activity. A central bank response to asset prices would be appropriate only if these prices helped predict the behavior of other variables of interest.

But if markets are not perfect, so that balances-sheet effects are relevant, then matters may be quite different. If movements in asset prices affect a firm's ability to obtain financing, then asset prices have a direct and causal effect on real activity. Further, if asset price fluctuations induce real activity fluctuations that are harmful to welfare, then there may be a role for monetary policy to counter the asset price movements with changes in policy.

In the theoretical model presented below there are two types of infinitely-lived agents, entrepreneurs and households. Entrepreneurs produce output with the use of a technology that is subject to exogenous productivity shocks. Entrepreneurs are in need of financing from households, but these loans are subject to a collateral constraint. The entrepreneurs' collateral consists of previously acquired "trees". Trees generate an exogenous stream of dividends so that the price of trees is exogenous. Fluctuations in the price of trees will alter the ability of the entrepreneur to finance activity. These fluctuations are typically inefficient as the tree price need not be correlated with the entrepreneurial productivity shocks. Hence, it is welfare-improving for the central bank to counter these tree price fluctuations with changes in policy.

The theoretical literature that links capital market imperfections with a business cycle model dates to the seminal work of Bernanke and Gertler (1989). More recently, this model has been extended to a standard real business cycle environment by Carlstrom and Fuerst (1997,1998,2001) and Bernanke, Gertler and Gilchrist (2000).[1] These models share the feature that capital market imperfections are modeled with the use of Townsend's (1979) costly-state-verification environment. In contrast, Kiyotaki and Moore (1997) outline a model of inalienable human capital that generates a rigid collateral constraint. In this paper we adopt an environment similar to Kiyotaki and Moore (1997).

Bernanke and Gertler (1999,2001) address the efficacy of a central bank response to asset prices in the model outlined in Bernanke, Gertler and Gilchrist (2000). They conclude that there is no need for a direct central bank response to asset prices. We reach a different conclusion.

There are three basic reasons for the differing results. First, we conduct a standard utility-based welfare analysis while Bernanke and Gertler (1999,2001) consider policies that minimize output and/or inflation variability. Second, Bernanke and Gertler (1999,2001) analyze a sticky price model, while we consider a model with sticky nominal wages. Third this paper conducts a first-best analysis while Bernanke and Gertler starts with a Taylor-rule and asks whether a Taylor-rule that also responds to asset prices is welfare improving. In a model with sticky prices a standard result is that stabilizing the price level is the optimal policy. In Bernanke and Gertler (1999, 2001), a shock to asset prices increases aggregate demand and thus drives up the price level. Hence, a central bank that is responding to general price inflation is already responding to asset price movements so that there is no need for a

[1] See also Cooley and Nam (1998), Cooley and Quadrini (1999), and Fisher (1999).

direct response to asset prices. Instead of responding to asset prices the central bank can simply respond to price inflation but with a larger coefficient. In our model with sticky nominal wages, the appropriate policy is to respond to wage inflation. But since the first-best analysis requires stabilizing wage-inflation one has to respond to asset prices since the coefficient on wage-inflation cannot be increased.

The next section develops the basic model. Section 3 provides the main results on optimal policy. Section 4 concludes.

2. The Model

The theoretical model consists of households and entrepreneurs. We will discuss the decision problems of each in turn. In the case of households we will consider two variants of the model: (i) a model in which nominal wages are perfectly flexible, and (ii) a model in which nominal wages are sticky and adjust across time in a Calvo-style (1983) fashion.

2.a. Households.

Households are infinitely lived, discounting the future at rate β. Their period-by-period utility function is given by

$$U(C_t) \equiv C_t - \frac{L_t^{1+\frac{1}{\eta}}}{1+\frac{1}{\eta}} \quad , \tag{1}$$

where C_t denotes consumption and L_t denotes labor. We choose this particular functional form for convenience. Each period the household chooses how much to consume, how much to work, how much cash to loan to the entrepreneur, and how many real assets to acquire. It is helpful to think of this real asset as an apple tree that produces D_t consumption goods at the end of time t. The exogenous dividend process is given by

$$D_{t+1} = (1-\rho_D)D_{ss} + \rho_D D_t + \varepsilon_{t+1}^D. \tag{2}$$

Note that we have made no assumptions regarding the nature of this stochastic process. It may or may not be correlated with the productivity level in the production process as defined later. Tree shares trade at a share price of q_t at the beginning of the period (before the time-t dividend is paid). Hence, the household's intertemporal budget constraint is given by

$$P_t C_t + P_t q_t f_t + B_t + M_{t+1} \leq M_t + R_t B_t + P_t f_t D_t + P_t q_t f_{t-1} + P_t w_t L_t, \tag{3}$$

where P_t is the price of the consumption good, f_t is the consumer's tree purchases in time t, M_t denotes cash holdings at the beginning of period t, and w_t is the real wage. The household also supplies one-period, risk-less cash loans to entrepreneurs, B_t, at gross nominal interest rate R_t.

The household's consumption purchases face the following cash-in-advance constraint:

$$B_t + P_t f_t (q_t - D_t) + P_t C_t \leq M_t + P_t q_t f_{t-1} + P_t w_t L_t + X_t, \tag{4}$$

where X_t denotes the time-t monetary injection. Notice that the household engages in financial market transactions before proceeding to the goods market so that (4) is net of these financial market transactions. For simplicity we assume that dividends are available within the period to purchase the consumption good (equivalently, dividends can be directly consumed by the household). The household's first order conditions are

$$L_t = w_t^{\eta} \tag{5}$$

$$E_t\left\{\frac{\beta P_t R_t}{P_{t+1}}\right\} = 1 \tag{6}$$

$$\beta E_t\{q_{t+1}\} = q_t - D_t \tag{7}$$

Equation (5) is the labor supply equation, where η is the labor supply elasticity. Equation (6) is the Fisherian nominal interest rate decomposition (the real rate is constant at 1/β). Equation (7) describes the equilibrium tree price and can be written as

$$q_t = E_t \sum_{j=0}^{\infty} \beta^j D_{t+j} \ . \tag{8}$$

The asset price depends only upon the exogenous dividend process. We have purposely structured the model so that the nominal rate has no direct effect on labor supply nor on tree prices.

2.b. Households with sticky nominal wages.

In contrast to the case of flexible nominal wages, suppose instead that households are monopolistic suppliers of labor and that nominal wages are adjusted in a Calvo-style (1983) fashion as in Erceg, Henderson and Levin (2000). In this case labor supply behavior is given by

$$L_t = (z_t w_t)^{\eta} \ . \tag{9}$$

The variable z_t is the monopoly distortion as it measures how far the household's marginal rate of substitution is from the real wage. In the case of perfectly flexible but monopolistic wages, $z_t = z$ is constant and less than unity. The smaller is z, the greater is the monopoly power. In the case of sticky wages, z_t is variable and moves in response to the real and nominal shocks hitting the economy. Erceg et al. (2000) demonstrate that in log deviations *nominal* wage adjustment is given by:

$$\tilde{\pi}_t^W = \lambda \tilde{z}_t + \beta E_t \tilde{\pi}_{t+1}^W \qquad (10)$$

where $\tilde{\pi}_t^W$ is time-t nominal wage growth (as a deviation from steady-state nominal wage growth).

2.c. Entrepreneurs.

Entrepreneurs are also infinitely-lived with linear preferences over consumption. They are distinct from households in that they operate a production technology that uses labor to produce output

$$y_t = A_t H_t \qquad (11)$$

where A_t is the current level of productivity, and H_t is the amount of labor employed. The productivity level A_t is an exogenous random process given by

$$A_{t+1} = (1 - \rho_A) A_{ss} + \rho_A A_t + \varepsilon_{t+1}^A . \qquad (12)$$

The entrepreneur's wage bill is subject to a cash-in-advance constraint:

$$P_t w_t H_t \leq M_t^e \qquad (13)$$

where M_t^e denotes the firm's cash holdings. The entrepreneur begins each period with no cash and thus borrows the needed cash from households at gross nominal rate R_t. The entrepreneur is also constrained by a borrowing limit. In particular, the entrepreneur must be able to cover his entire cash loan plus interest with collateral accumulated in advance. We will denote this collateral as n_t for "net worth". The loan constraint is thus

$$R_t w_t H_t \leq n_t . \tag{14}$$

Notice that all variables are in real terms.

Why is the firm so constrained? There are many possible informational stories that would motivate such a constraint. For example, suppose that the households first supply their labor input, but that output is subsequently produced if and only if the entrepreneur provides his unique human capital to the process. We now have a classic hold-up problem in which the entrepreneur could ex post force households to accept lower wage payments, for otherwise nothing will be produced. These problems can be entirely avoided if the household requires cash up front, i.e., restriction (13). But what is to prevent the entrepreneur from playing the same game with the lenders of the cash used to finance (13)? These lenders protect themselves from a loan hold-up by requiring the collateral constraint (14).

We can easily enrich this story by assuming that there exists financial institutions that intermediate these cash loans between households and entrepreneurs. For example, suppose that these intermediaries provide within-period financing to entrepreneurs, and that this financing is used by firms to pay households. The intermediary, however, is concerned about the hold-up problem, and thus limits its' lending to the firm's net worth. Hence, we once again have the collateral constraint (14). Kiyotaki and Moore (1997) use a similar constraint. See Hart and Moore (1994) for a complete discussion of the hold-up problem.

Below we will assume that the loan constraint binds so that the demand for labor is given by

$$H_t = \left(\frac{n_t}{R_t w_t}\right) \tag{15}$$

The demand for labor varies inversely with the real wage but is positively affected by the level of net worth. Entrepreneurs that have more collateral are able to employ more labor because hold-up problems are less severe. The binding collateral constraint implies that the marginal product of labor is greater than the real wage (i.e., the firm would like to hire more labor but is collateral-constrained).

The entrepreneurs' sole source of net worth is previously acquired ownership of apple trees. If we let e_{t-1} to denote the number of tree shares acquired at the beginning of time $t-1$, then time t net worth is given by

$$n_t = e_{t-1} q_t . \tag{16}$$

The entrepreneur's budget constraint is given by

$$c_t^e + e_t q_t = e_{t-1} q_t + e_t D_t + A_t H_t - w_t R_t H_t . \tag{17}$$

Using the binding loan constraint, we can rewrite this as

$$c_t^e + e_t q_t = e_t D_t + A_t H_t \tag{18}$$

Because of these profit opportunities from net worth, the entrepreneur would like to accumulate trees until the constraint no longer binds. To prevent this from happening we assume that entrepreneurs discount the future at a higher rate than do households so that their Euler equation for tree accumulation is given by

$$q_t - D_t = (\beta \gamma) E_t \left[q_{t+1} \left(\frac{A_{t+1}}{w_{t+1} R_{t+1}} \right) \right]. \tag{19}$$

The left-hand side is the cost of acquiring another tree in time-t. The right-hand side is the return from that tree in time t+1. It provides a collateral value of q_{t+1} which can be used to hire labor that earns a return of $\left(\frac{A_{t+1}}{w_{t+1}R_{t+1}}\right)$ >1, where the inequality arises from the binding collateral constraint. To offset this extra return, we will choose $\gamma < 1$ so that both the household and entrepreneur hold trees in the steady-state. We can use the binding collateral constraint to rewrite (19) as

$$q_t - D_t = (\beta\gamma)E_t \frac{A_{t+1}L_{t+1}}{e_t}$$

or equivalently

$$e_t(q_t - D_t) = (\beta\gamma)E_t A_{t+1}L_{t+1} \tag{20}$$

2.d. Equilibrium.

There are four markets in this theoretical model: the labor market, the tree market, the loan market, and the money market. The labor market clears with $H_t = L_t$. The equilibrium tree price is given by (8), while the shares sum to one, $e_t + f_t = 1$. The loan market clears at $B_t = M_t^e$. Finally, the money market clears with the household holding the per capita money supply intertemporally. In what follows we assume that monetary policy is defined by a path for the gross nominal interest rate R_t. The implied path of inflation comes from the Fisher equation (6), while the passive money supply behavior (the X_t process) can be backed out of the binding cash-in-advance constraint.

2.e. Log-linearizing the model.

Because the model is relatively simple, it is convenient to express the equilibrium in terms of log-deviations. Below the ~'s represent percentage deviations from the steady-state.

$$\tilde{L}_t = \eta(\tilde{w}_t + \tilde{z}_t) \tag{21}$$

$$\tilde{\pi}_t^W = \lambda\tilde{z}_t + \beta E_t \tilde{\pi}_{t+1}^W \tag{22}$$

$$\tilde{w}_t = \tilde{w}_{t-1} + \tilde{\pi}_t^W - \tilde{\pi}_t \tag{23}$$

$$\tilde{R}_t = E_t \tilde{\pi}_{t+1} \tag{24}$$

$$\tilde{e}_t = \frac{1-\beta}{\beta}\tilde{D}_t - \frac{1}{\beta}\tilde{q}_t + E_t\left(\tilde{A}_{t+1} + \tilde{L}_{t+1}\right) \tag{25}$$

$$\tilde{q}_t + \tilde{e}_{t-1} = \tilde{w}_t + \tilde{L}_t + \tilde{R}_t \tag{26}$$

$$\tilde{A}_{t+1} = \rho_A \tilde{A}_t + \varepsilon_{t+1}^A \tag{27}$$

$$\tilde{q}_t = \tilde{D}_t\left(\frac{1-\beta}{1-\rho_D\beta}\right) \tag{28}$$

$$\tilde{D}_{t+1} = \rho_D \tilde{D}_t + \varepsilon_{t+1}^D \tag{29}$$

Equations (21)-(22) describe labor supply behavior. Equation (23) follows from the definition of the real wage. In the case of flexible wages, $\tilde{z}_t = 0$ for all t so that (22)-(23) are not relevant. Equation (24) is the Fisher equation, while (25)-(26) describe entrepreneurial behavior. Equation (25) is the log-linear version of (20). Equation (26) follows from the assumed binding collateral constraint (15). Finally the exogenous shocks are given by (27)-(29). To close the model we need only define monetary policy.

If the collateral constraint were not binding, equations (25)-(26) would be replaced with the entrepreneur's first order condition for labor. The labor demand equation in the model without agency costs is given by

$$\tilde{A}_t = \tilde{w}_t + \tilde{R}_t \tag{26b}$$

Note that the real wage is not simply the marginal productivity of labor but is distorted by the nominal interest rate, R_t. This is because there is a CIA constraint: the entrepreneur must borrow cash in order to cover the workers' wage bill (13).

There are two distinct distortions operating in the model. The first is the monopoly distortion, z_t, which acts like a fluctuating shadow wage tax on labor supply. Since $z_t < 1$ employment will be less than is socially efficient. Faster (slower) nominal wage growth lowers (increases) the distortion serving to increase (decrease) employment. The second distortion comes from the collateral constraint. By assumption firms must have collateral outstanding to pay off the loans which are needed to acquire the cash necessary to pay workers before production starts. This distortion acts like a fluctuating shadow wage tax on entrepreneurs. Increases (decreases) in net worth decrease (increase) this implicit tax. Similarly changes in the nominal interest rate cause this distortion to fluctuate. Decreases in the interest rate decrease the distortion since entrepreneurs can make larger loans for a given amount of collateral. If net worth is ample enough so that the loan constraint is not binding then the nominal interest rate will still distort the economy due to the CIA-constraint on the wage bill (see (26b)).

3. Optimal Policy.

What is the optimal response of the nominal interest rate to productivity and dividend shocks? To answer such a question we need a welfare criterion. The most natural choice in the present context is the sum of household and entrepreneurial utility. This is given by

$$V_t \equiv c_t + c_t^e - \frac{L_t^{1+\frac{1}{\eta}}}{1+\frac{1}{\eta}} = A_t L_t + D_t - \frac{L_t^{1+\frac{1}{\eta}}}{1+\frac{1}{\eta}}, \tag{30}$$

where the equality follows from the fact that total time-t consumption must equal the total supply of time-t consumption goods. This supply comes from those goods produced using the entrepreneur's production technology, and the dividends that are produced by the apple tree. The linear preferences in consumption imply that the distribution of consumption is irrelevant so that the only choice variable in V_t is employment. Maximizing V_t with respect to L_t yields the following optimality condition

$$L_t = A_t^{\eta} \tag{31}$$

We will call this outcome the first-best as the welfare criterion cannot be made larger.

We will proceed in two steps. First, we will take as given the steady-state level of the nominal interest rate and construct the policy rule that will achieve (31) in deviations form,

$$\tilde{L}_t = \eta \tilde{A}_t .$$

We will refer to this as the "optimal deviations policy". We will assume that the steady-state level of the nominal interest rate is sufficiently large so that the zero nominal interest rate bound is never violated. But by focusing on deviations, we are ignoring the possibility that the optimal policy may be described by following a Friedman rule in which the nominal interest rate is set to zero, i.e., the steady-state nominal rate is zero. Hence, we first solve for optimal policy given that the steady state gross nominal interest rate exceeds one, $R_{ss} > 1$. As a second step we will consider the more general question of optimal policy in which the nominal interest rate may occasionally or always be set to zero.

3.a. Optimal Deviations with Flexible Wages.

In the case of flexible wages so that $\tilde{z}_t = 0$ for all t, we can easily solve for the equilibrium level of employment:

$$\tilde{L}_t = \frac{\eta}{1+\eta}(\tilde{q}_t + \tilde{e}_{t-1} - \tilde{R}_t) \tag{32}$$

Substituting (28) into (25) we have

$$\tilde{e}_t = -\rho_D \tilde{q}_t + E_t\left(\tilde{A}_{t+1} + \tilde{L}_{t+1}\right). \tag{33}$$

Scrolling (32) forward, and then using (33) yields

$$\tilde{L}_{t+1} = \frac{\eta}{1+\eta}\{[\tilde{q}_{t+1} - E_t(\tilde{q}_{t+1})] - [\tilde{R}_{t+1} - E_t(\tilde{R}_{t+1})]\} + \eta E_t(\tilde{A}_{t+1})\,. \tag{34}$$

Contemporaneous employment does not respond to shocks to productivity, A_t (see (32)). This is a manifestation of the collateral constraint. When productivity is high the firm would like to expand employment but is unable to do so because of the need to finance current activity with current collateral. Thus, the collateral constraint limits the ability of the firm to respond to shocks. But the collateral constraint causes employment to respond to tree price shocks. This is inefficient in a welfare sense as these shocks need not be correlated with aggregate productivity.

We can now easily back out the interest rate policy that allows the economy to respond to shocks efficiently. Substituting the optimal labor behavior (31) into (32) we have:

$$\tilde{R}_t = \tilde{q}_t + \tilde{e}_{t-1} - (1+\eta)\tilde{A}_t . \quad (35)$$

Similarly, we can use (34) to find

$$\tilde{R}_{t+1} = [\tilde{q}_{t+1} - E_t(\tilde{q}_{t+1})] - (1+\eta)[\tilde{A}_{t+1} - E_t(\tilde{A}_{t+1})] . \quad (36)$$

What are the properties of this optimal-deviations monetary policy? When there is a positive shock to productivity A_t, the central bank should lower the nominal interest rate so that employment can expand in an efficient manner. A constant interest rate policy does not allow this because of the collateral constraint. This procyclical interest rate policy overcomes the collateral constraint and allows the economy to respond appropriately.

In contrast, if there is a shock to share prices that drives up q_t, the central bank should increase the interest rate by enough to keep employment constant. It is inefficient for employment to respond to these dividend shocks, and the central bank can ensure no response by raising the nominal rate in response.

Notice that the optimal policy is i.i.d. Policy need only respond to innovations in the shocks. This is because the entrepreneur varies his tree accumulation decision in response to any anticipated level of productivity or tree prices (see (25)).

3.b. Optimal Deviations with Sticky Wages and no Agency Costs.

In this section we examine optimal policy in the model with sticky wages but where the collateral constraint is not binding so that labor demand is given by (26b). Combining (26b) and (30) implies $\tilde{R}_t = \tilde{z}_t$. That is, optimal policy should eliminate the net distortion (z/R). While an interest rate rule given by $R_t = -\tilde{w}_t$ will support the first-best, this policy rule rule leads to real indeterminacy and thus is subject to welfare-reducing sunspot fluctuations. But, we can achieve determinacy and optimal deviations with the following rule: $\tilde{R}_t = \tau\tilde{\pi}_t^W$ where τ = ∞. In equilibrium, wage inflation, z_t, and the nominal rate will be pegged. This is also the optimal interest rate policy in Erceg, Henderson and Levin (2000) in the case in which only nominal wages are sticky.

3.c. Optimal Deviations with Sticky Wages and Agency Costs.

Substituting this optimal labor behavior into (25) and eliminating w_t using (21) we can back out the interest rate policy that will support (30):

$$\tilde{R}_t = \tilde{q}_t + \tilde{e}_{t-1} - (1+\eta)\tilde{A}_t + \tilde{z}_t . \tag{33}$$

With flexible wages ($\tilde{z}_t = 0$) this is just (31). Similarly with constant net worth it stabilizes the net distortion R/z. Thus optimal policy in a model with both agency costs and sticky wages is simply a combination of the optimal policy with each distortion individually. Once again we can scroll (31) forward one-period to obtain

$$\tilde{R}_{t+1} = \tilde{z}_{t+1} + [\tilde{q}_{t+1} - E_t(\tilde{q}_{t+1})] - (1+\eta)[\tilde{A}_{t+1} - E_t(\tilde{A}_{t+1})] .$$

The optimal policy that is determinate and stabilizes wage inflation and z_t is

$$\tilde{R}_{t+1} = \tau\tilde{\pi}_{t+1}^w + [\tilde{q}_{t+1} - E_t(\tilde{q}_{t+1})] - (1+\eta)[\tilde{A}_{t+1} - E_t(\tilde{A}_{t+1})] . \tag{34}$$

where τ = ∞.

Notice that despite the fact that there are two distinct distortions – one from sticky wages and the other from binding collateral constraints – both distortions can be eliminated with one policy instrument. The reason is because the monetary policy rule that eliminates the distortion from sticky wages is in equilibrium a constant interest rate. It is not achieved, however, by pegging the interest rate, a policy rule which would be indeterminate. It is achieved by responding super aggressively to nominal wage inflation which uniquely selects out of the interest rate peg equilibria the one that eliminates the sticky wage distortion.

3.d. First-Best Monetary Policy.

Thus far we have concentrated on an economy where the steady state or average nominal interest rate is given at $R_{ss} > 1$. The question is whether the Friedman rule where the interest rate is pegged at zero might be optimal. Since nominal interest rates cannot be negative with a zero nominal interest rate the central bank cannot respond to asset-price and technology shocks so that labor cannot respond to shocks efficiently. This is the cost of persuing such a policy. But the benefit is that a lower nominal interest rate relaxes the collateral constraint and thus increases average employment. Because of the collateral constraint and the monopoly distortion (z < 1) there is too little employment in this economy. In this section we show that because a Fiedman rule expands employment it is the optimal first-best policy.

To be precise we implement the Friedman rule as follows: $R_t = \left(\frac{\pi_t^W}{\pi_{ss}^W}\right)^{\tau}$ where $\tau = \infty$ and $\bar{\pi}^w$ is the wage-inflation peg consistent with R=1.[2] In equilibrium $\pi_t^w = \bar{\pi}^w$ and $R_t = 1$.

[2] We are ignoring some serious implementational issues associated with this rule. Although in equilibrium this rule will result in an interest rate peg out of equilibrium the public must believe that any downward deviation in nominal wages will be met with an aggressive cut in the interest rate and thus they must believe that the interest rate can be negative.

The other policy we consider is $R_t = \left(\frac{\pi_t^W}{\pi_{ss}^W}\right)^{\tau}\left(\frac{n_t}{A_t^{1+\eta}}\right)\min\left[\frac{A_t^{1+\eta}}{n_t}\right]$ where again $\tau = \infty$ and $\bar{\pi}^w$ is now the wage-inflation peg consistent with R>1. With a little rearranging it is easy to see that we have the following labor supplies:

R = 1

$$L_t = A_t^{\eta}\left[\frac{\bar{z}n_t}{A_t^{1+\eta}}\right]^{\eta/1+\eta}$$

R > 1

$$L_t = A_t^{\eta}\min\left[\frac{\bar{z}n_t}{A_t^{1+\eta}}\right]^{\eta/1+\eta}.$$

Therefore employment is always greater with the Friedman rule. Welfare will also be higher because V is concave and maximized when $L_t = A_t^{\eta}$.

The conclusion that (34) defines optimal policy when R > 1 is also subject to another caveat. Although the above policy allows the economy to respond to shocks efficiently it may be optimal because of non-linear effects for $\tau < \infty$ so that z_t fluctuates. In this case employment is given by

$$L_t = A_t^{\eta}\left(\frac{z_t}{\bar{z}}\right)^{\eta/1+\eta}\min\left[\frac{\bar{z}n_t}{A_t^{1+\eta}}\right]^{\eta/1+\eta}.$$

Although movements in z_t are inefficient they allow average employment to be higher since z and A are positively correlated. Note that this occurs, however, because the average interest rate under this second policy is lower than it is with z_t constant. It would not arise in the second best analysis if the average interest rate were given instead of the steady state interest rate.

4. Conclusion.

This paper addresses the question of how monetary policy should be conducted in a world in which in which asset prices have a direct effect on real activity because of binding collateral constraints. In this environment if the average interest rate is constrained to be positive – perhaps because of fiscal considerations -- there is a welfare-improving role for a monetary policy that will actively respond to asset price and productivity shocks. This activist interest rate policy allows the economy to respond to shocks in a Pareto efficient manner. By assumption, monetary policy cannot eliminate the long run impact of the informational constraint, but it can smooth the fluctuations in this constraint. This smoothing is welfare-improving.

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