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by
John J. Seater

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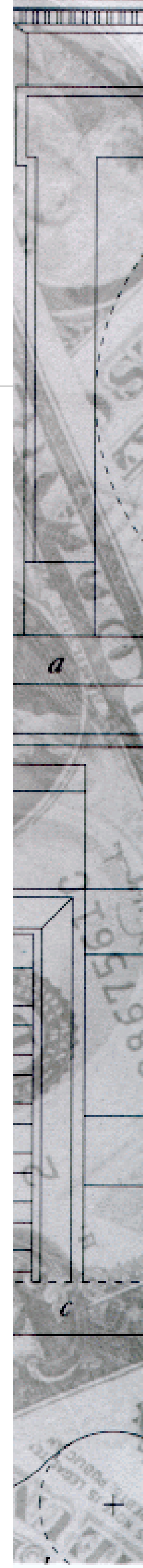

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Abstract

A unified model of monetary policy and bank regulation is presented. In accordance with modern banking theory, banks not only intermediate loans and deposits but also provide a financial service affecting aggregate output. Optimal parameter settings for monetary and regulatory policy are derived. New results are that monetary policy affects the expected level as well as the variance of output, bank regulation should change continually in response to the state of the economy, and bank regulation and monetary policy should be tightly coordinated. This last result has important implications for the institutional arrangements for conducting regulatory and monetary policy.

I. Introduction

What is the proper relation between the conduct of monetary policy and the regulation of the financial system? That question is an important one and currently of special interest in the European Community, which is wrestling with the issue of whether or not responsibility for the regulation of European financial institutions should be delegated to the new European Central Bank. On the one hand, financial institutions constitute the "channels of monetary policy" so often discussed in the literature on monetary policy. It would seem natural for the central bank of a country to have responsibility for regulation both to ensure that the structure of the financial institutions was sound and to provide useful information for the conduct of monetary policy.[1] On the other hand, there is concern that if the central bank has the responsibility for regulation, the regulation will be carried out too much for the benefit of monetary policy and not enough for the benefit of the financial system itself. A difficulty in evaluating the competing arguments in this debate is that there is no theoretical treatment that simultaneously analyzes both regulation and monetary policy. The large literature on the optimal choice of monetary policy instruments, starting with Poole (1970), does not include regulatory policy in the analysis. The even larger literature on optimal regulation of financial institutions has the symmetric problem of not including monetary policy in the analysis.

The present paper presents a unified analysis of optimal bank regulation and optimal money stock control. The approach is a generalization of Poole's (1970) original study of the optimal conduct of monetary policy, in which the central bank must decide how to respond to shocks to the economy while having only limited information on the current state of the

[1]See Ferguson (2000) for a recent argument along these lines.

economy. The model extends that line of analysis to include bank regulation as well as monetary policy.

There are two innovations in the model. One is the introduction of a financial service provided by the banking system. The financial service is tied to but not the same as the volume of bank lending, and it directly affects the productivity of the output sector of the economy. An example of such a service is bank monitoring of its borrowers (Fama, 1985; Holmstrom and Tirole, 1997). The financial service provides a crucial link between real economic activity and the financial sector that heretofore has been missing from most aggregate models. The work of Bernanke (1981, 1983) and Bernanke and Gertler (1989, 1990) suggests that such a link is important for understanding the effects of money on the real economy. The other innovation is inclusion of a bank regulatory requirement, such as a reserve requirement or required bank capital ratio, imposed on the banks by a bank regulator. This requirement affects the money multiplier; through that, it affects both the level and stability of the financial service and therefore the level and stability of real output. The trade-off facing the regulator is that a stricter regulatory requirement reduces both the mean and variance of output. The latter is desirable, but the former is not. The optimal choice of the regulatory requirement reflects these competing effects.

Several interesting results emerge from the analysis. Contrary to the usual rational expectations result, monetary policy affects the expected level ("natural rate") of real output. Bank regulatory policy should be reactive, that is, it should change continually to reflect current economic conditions. Optimal regulation therefore should not be a passive activity, setting the regulatory requirement only infrequently. The sign and magnitude of the reaction parameter depends on all the structural parameters of the system, including the variances and covariances among the random disturbances. Optimal monetary policy and bank regulation are simultaneously determined, implying that there must be tight coordination between the central bank and the regulator. The obvious institutional arrangement for achieving this coordination is to have a single agency conduct both monetary and regulatory policy.

II. The Model

The analysis is conducted in the framework of a log-linear, rational expectations IS-LM model. The model includes a supply side for aggregate output and a governmentally regulated banking system that generates inside money through a standard money multiplier mechanism.

1. *Aggregate Demand for Output.*

Aggregate output demand has no special importance in the analysis, so we confine attention to the simplest possible model:

$$Y_t^D = d_0 - d_1 R_t + \delta_t \tag{1}$$

where Y is the log of output, R is the real interest rate, δ is a random disturbance term, and the d_i are positive constants. Equation (1) is the IS equation. All effects of consumption and investment not arising from the interest rate, such as expectations of future income or of the marginal productivity of capital, are included in the term d_0. To keep the analysis tractable, we shall treat d_0 as a constant, thus suppressing all dynamic elements of the economy's behavior that would arise from changes in household or firm expectations of the future. In principle, the model can be extended in a straightforward way to include these influences, but the analysis is difficult.

2. *Aggregate Supply of Output.*

The aggregate output is given by the indirect production function:

$$\tilde{Y}_t^S = \tilde{s}_0 \left(\frac{\tilde{P}_t}{\tilde{P}_t^e} \right)^{s_1} \tilde{F}_t^{s_2} \tilde{\theta}_t$$

where $\tilde{P}$ is the price level, $\tilde{P}^e$ is the expected price level, $\tilde{F}$ is a the quantity of the financial service provided by banks, $\tilde{\theta}$ is a random term, and the s_i are positive constants. The term $\tilde{s}_0\tilde{F}^{s_2}\tilde{\theta}$ captures, among other things, the level of technical progress (i.e., total factor productivity). Taking logs of the production function gives a standard rational expectations supply function augmented to include the effect of the financial service:

(2) $$Y_t^S = s_0 + s_1(P_t - P_t^e) + s_2 F_t + \theta_t$$

where variables without tildes are the logarithms those with tildes.

The novel aspect of this aggregate production function and its corresponding aggregate supply function is the presence of the financial service F. Modern theories of financial intermediation argue that banks and other financial intermediaries provide services beyond simply intermediating deposits and loans (an activity that is nonetheless still important and discussed momentarily). Examples of such services include liquidity insurance (Bryant, 1980; Diamond and Dybvig, 1983), information sharing to overcome adverse selection (Leland and Pyle, 1977), monitoring (Diamond, 1984; Holmstrom and Tirole, 1997), facilitation of risk transfer (Allen and Santomero, 1997), and reduction of participation costs (Allen and Santomero, 1997). To expand on one specific example, we could suppose that the only element of F is monitoring, which Fama (1985) has argued is the essence of what banks really do. Monitoring prevents opportunistic behavior of the borrower during realization of the investment project funded by the loan. The possibility for opportunistic behavior arises because borrowing means that the entrepreneur has only a partial financial interest in the project and so has an incentive to devote some of his energies to other things, thus reducing the expected profitability of the project that has been financed. Monitoring prevents or at least reduces such behavior and thus increases the efficiency of the economy. See Holmstrom and Tirole (1997). This increase in efficiency can be captured by letting total factor productivity depend on the amount of monitoring, as done above. We thus have a simple model of aggregate production (and so of aggregate supply) that corresponds to the view of Bernanke (1981, 1983) and Bernanke and Gertler (1989, 1990) that financial intermediaries affect the aggregate economy through channels other than the traditional one of creating inside money.

3. *Money Market.*

Nominal money is defined as M1, the sum of private demand deposits and currency in the hands of the non-bank public. Consideration of broader aggregates is unnecessary, but attention cannot be restricted solely to high powered (outside) money because the non-monetary services intimately associated with the presence of inside money is essential to the analysis.[2] Real money demand is the usual

(3) $$M_t^D = a_0 + a_1 Y_t^D - a_2 R_t + \alpha_t$$

where M is the log of real M1, α is a random disturbance, and the a_i are positive constants. Real money supply is determined by real high powered money and the money multiplier:

(4) $$M_t^S = m_t + H_t - P_t$$

where m is the log of the money multiplier and H is the log of nominal high powered money. High powered money is determined by the central bank according to its monetary policy function

[2]McCallum (2000) has argued that omitting monetary aggregates from models of monetary economics is harmless. The analysis of this paper suggests otherwise, at least for some kinds of questions.

(5) $$H_t = h_0 + h_1 R_t + \eta_t$$

where η is a random disturbance and the h_i are constants chosen by the central bank. The money multiplier m is

(6) $$m_t = m_0 - m_1 B_t + m_2 R_t + \mu_t$$

where B is the log of a regulatory variable constraining bank lending, μ is a random disturbance, and the m_i are positive constants. The interest rate R affects the multiplier through the opportunity cost of holding excess reserves.[3] An increase in R induces banks to hold less excess reserves and thus raises m.

The variable B can represent many kinds of constraints; two straightforward possibilities are a required reserve ratio or a required bank capital ratio. The precise channel through which B affects bank lending depends on what B represents, but the net effect is the same and is captured by (6). Consider the case where B is a required capital ratio. A bank's capital ratio is the ratio of the bank's capital (sources of funds obtained from the owners of the bank) to its total assets (loans plus cash). Regulators impose on banks a minimum value of the capital ratio.[4] Banks whose ratios fall below the required ratio are subject to disciplinary action, including being forced into receivership. The higher the required bank capital ratio, the less lending a bank can undertake for any given amount of capital that it has. To see this, suppose the required capital ratio is set at its upper limit of one. The banks then cannot lend any deposited funds; they can lend only their own capital. In this case, the banks cease to be banks in the usual sense of the

[3]As usual, it is the unlogged value of the interest rate that enters (6) because what really enters is log(1+R) which is approximately equal to R for small values of R.

[4]There actually are several capital/asset ratios varying in the assets considered and the risk adjustment applied to them. That complication is ignored here.

term because they stop intermediating deposits and loans.[5] Inside money will be zero, and the money multiplier equals one. As the required capital ratio is reduced below one, the banks can and will start lending some fraction of their deposits. This increase in loans raises the amount of inside money from zero to a positive amount, and the value of the money multiplier rises above one.[6] We thus have a negative relation between the money multiplier and the value of the required bank capital ratio. Exactly the same analysis applies if B is a required reserve ratio.

We suppose that B is determined by the bank regulatory authority according to the following regulatory policy function

$$B_t \ = \ b_0 + b_1 R_t + \beta_t \tag{7}$$

where β is a random disturbance and the b_i are constants chosen by the regulator. This function is unusual in that it allows the regulatory requirement B to be flexible, responding to the state of the economy through a feedback rule. One does not normally think of bank regulations as being

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[5]It is assumed for simplicity that the banks have no sources of funds other than their own capital and their deposits. They thus cannot offset the constraining effect of the capital requirement. Other sources of funds could be introduced with no substantive change in results as long as banks could not use them to fully offset the capital ratio's negative effect on the volume of bank lending and therefore on the money multiplier. Furlong (1992) presents evidence that bank lending in the United States is indeed negatively related to the required capital/asset ratio, so the simplification of ignoring the existence of non-deposit sources of funds is qualitatively harmless.

[6]Note that this discussion implies that (6) is not exact but rather is an approximation. If the required capital ratio were set to its maximum possible value of 1, then as just noted the banks could not lend any of their deposits. The banks would have no need of free reserves and so would not hold any. Also, the shocks u_t could not affect the money multiplier, which would be constant at a value of one. Consequently, an exact representation of the multiplier would have m_0 and m_2 dependent on B and also would have an exponent on u_t equal to zero whenever B equaled 1. An exact form of this nature is analytically intractable. For a critical discussion of bank capital ratios and their impact on bank behavior, see Santomero (1991).

flexible in this manner because they typically are not.[7] Nothing is lost by using the general functional form in (7); the standard inflexible requirement is obtained as a special case simply by setting the coefficient b_1 and the disturbance term β to zero. However, one of the main results of the subsequent analysis is that an inflexible B generally is suboptimal.

A random term is included in (7) for two reasons. First, the regulator responsible for the day-to-day administration of regulatory policy may not be the sole institution setting regulatory policy. In the US, for example, federal regulation of financial institutions is administered by the Federal Reserve, the FDIC, and the Comptroller of the Currency, among others. The US Congress, however, can pass laws changing regulations at any time. In addition, state governments institute regulations independently of the federal government. Second, equation (7) is a simplification of the complicated real world of bank regulation. Risk-adjusted bank capital requirements, for example, are fixed numbers. However, the impact they have on bank lending depends on the risk structure of the financial assets in existence. A change in the way risk is distributed across different borrowers will change the mix of assets banks wish to hold. The existing bank capital requirements may be viewed as more or less stringent after the change than before. The random term in (7) picks up such effects. In any case, one always can eliminate the effects of the random term in (7) simply by setting β and its variance to zero in all that follows. None of the conclusions of the analysis is altered by doing so.

An issue that has been skirted in the foregoing specifications is the role of expected inflation in determining the demand for money and the money multiplier. The opportunity cost

[7]However, before central banks learned to use open market operations to control the money supply, they did often changed reserve requirements in response to economic or financial conditions. The notion of a flexible B thus is not completely novel.

of holding currency is the spread between the real rates of return on the interest-earning asset and currency, $R\text{-}R_C$. This spread can be written in terms of nominal interest rates:

$$
\begin{aligned}
R - R_C &= (r - \pi^e) - (r_C - \pi^e) \\
&= (r - r_C) \\
&= r \\
&= R + \pi^e
\end{aligned}
$$

where r is the nominal interest rate on the interest-earning asset and r_C is the nominal interest rate on currency, which is fixed at zero. Consequently, both real money demand and the money multiplier should depend on either both R and π^e, not just R. Inclusion of π^e is analytically difficult because it introduces expectations of future values of the system's variables into the expressions for the current values. We therefore will use the expressions for money demand and the money multiplier given above and treat them as approximations to the true functions.

4. *Financial Services.*

The financial service F is intimately tied to bank lending. Banks provide the service only their own borrowers; if there are no loans, there is no service, either. The quantity of financial services F therefore is a function of the quantity of real loans:

(8) $$F_t = f_0 + f_1 L_t + \phi_t$$

where L is the log of the quantity of real loans, ϕ is a random disturbance, and the f_i are positive constants. All loans are associated with an equal value of inside money; that is, the quantity of loans is that part of the money supply that is not high-powered money:

$$\tilde{L}_t \equiv \frac{(\tilde{m}_t - 1)\tilde{H}_t}{\tilde{P}_t}$$

or, in log terms,

(9) $$L_t = \log(\tilde{m}_t - 1) + H_t - P_t$$

Unfortunately, this expression is hopelessly nonlinear because it involves the log of a difference. We need to linearize (9) to make the subsequent analysis feasible. Our goal is to study the optimal relation between bank regulation and monetary policy. In this regard, (9) has an important characteristic that permits an easy resolution of our difficulty. As the required bank capital ratio B rises, $m^{\sim}$ falls. The lowest that $m^{\sim}$ can go is 1, at which point the "loan multiplier" ($m^{\sim}$-1) equals zero and no loans are made. Thus the loan multiplier reaches zero before the money multiplier does. Another way to say this is that the percentage change in loans induced by a given change in the money multiplier is larger than the percentage change induced in the money supply. We therefore can replace the intractable (9) with the tractable approximation

(10) $$L_t = km_t + H_t - P_t$$

where k>1. This formulation captures the property that a given change in the log money multiplier m_t has a larger effect on loans than on money while remaining analytically tractable.

5. *Random Disturbances.*

Up to now, nothing has been said about the properties of the various random disturbances appearing in the model. It is sufficient for our purposes to impose the simplest possible time series structure on the disturbances, so we assume they are white noise. Nothing important is changed by allowing a general ARIMA structure, but the analysis quickly becomes tedious at best once serial correlation in the disturbances is introduced. Contemporaneous correlation of disturbances is permitted throughout the analysis.

6. *Expectations.*

We assume rational expectations, so that the expected price level P^e is just the usual mathematical expectation of the solution of the model's solution for P:

(11) $$P_t^e = E(P_t \mid I_t)$$

where I_t is the information set at time t.

III. Solution of the Model

Equations (1)-(8), (10), and (11) constitute the model. The model is conceptually simple and, having only linear equations, mathematically trivial. In this section, we derive the model's solution and then examine a graphical interpretation.

1. *Mathematical Solution.*

Solution begins by substituting (5), (6), (7), (8), and (10) into (2) and (4). Then (3) and (4) are solved to obtain R as a function of P. This solution is substituted into (1) and (2), giving the semi-reduced forms

(12) $$Y_t^D = d_0 - \frac{d_1 X_0}{X_1} - \frac{d_1}{X_1} P_t + \delta_t - \frac{d_1(\alpha_t + a_1\delta_t - \mu_t + m_1\beta_t - \eta_t)}{X_1}$$

(13) $$Y_t^S = X_3 + X_2\frac{X_0}{X_1} + \frac{X_2 - s_2 f_1 X_1}{X_1} P_t + s_1(P_t - P_t^e) + \theta_t + s_2\phi_t + s_2 f_1 \eta_t$$
$$- s_2 f_1 k m_1 \beta_t + \frac{X_2}{X_1}(\alpha_t + a_1\delta_t - m_1\beta_t - \eta_t)$$

where

(14)
$$X_0 = a_0 + a_1 d_0 - m_0 - h_0 + m_1 b_0$$
$$X_1 = m_2 - m_1 b_1 + h_1 + a_1 d_1 + a_2$$
$$X_2 = s_2 f_1 [k(m_2 - m_1 b_1) + h_1]$$
$$X_3 = s_0 + s_2 f_0 + s_2 f_1 k(m_0 - m_1 b_0) + s_2 f_1 h_0$$

Notice that aggregate supply Y^S depends not only on P-P^e but also on P independently. The term P-P^e represents the usual influence of expectation errors in a rational expectations model. The independent term P reflects the influence of the financial service F in (2) and the dependence of F on real loans. A change in P, given the money multiplier m_t and high powered money H_t, changes real loans, thus also changing F and Y^S. This independent influence of P on Y^S is the source of several interesting conclusions derived below.

We use the semi-reduced forms for Y^D and Y^S to solve for P in terms of P^e, obtaining:

(15)
$$P = \frac{X_1 X_3 + X_0 X_2 - d_0 X_1 + d_1 X_0}{s_2 f_1 X_1 - X_2 - d_1} + \frac{s_1 X_1}{s_2 f_1 X_1 - X_2 - d_1}(P_t - P_t^e)$$
$$+ \frac{X_1}{s_2 f_1 X_1 - X_2 - d_1}\theta_t + \frac{s_2 X_1}{s_2 f_1 X_1 - X_2 - d_1}\phi_t + \frac{s_2 f_1 X_1}{s_2 f_1 X_1 - X_2 - d_1}\eta_t$$
$$+ \frac{s_2 f_1 k X_1}{s_2 f_1 X_1 - X_2 - d_1}\mu_t - \frac{s_2 f_1 k m_1 X_1}{s_2 f_1 X_1 - X_2 - d_1}\beta_t - \frac{X_1}{s_2 f_1 X_1 - X_2 - d_1}\delta_t$$
$$+ \frac{X_1 + d}{s_2 f_1 X_1 - X_2 - d_1}(\alpha_t + a_1 \delta_t - \mu_t + m_1 \beta_t - \eta_t)$$

We then find the solution for P^e by taking the expectation of (15), which gives

(16)
$$P_t^e = \frac{X_1 X_3 + X_0 X_2 - d_0 X_1 + d_1 X_0}{s_2 f_1 X_1 - X_2 - d_1}$$

Substituting this expression back into (15) gives the reduced form solution for P:

(17) $$P_t = P_t^e + [s_1X_1 + s_2f_1X_1 - X_2 - d_1]^{-1} \cdot [X_1\theta_t + s_2X_1\phi_t + s_2f_1X_1\eta_t + s_2f_1kX_1\mu_t - s_2f_1km_1X_1\beta_t - X_1\delta_t + (X_2 + d_1)(\alpha_t + a_1\delta_t - \mu_t + m_1\beta_t - \eta_t)]$$

The expected supply of output is the mathematical expectation of (13):

(18) $$EY_t^S = \frac{X_1X_3 + X_2X_0}{X_1} + \frac{X_2 - s_2f_1X_1}{X_1}P_t^e$$

$$= \frac{-d_1X_3 - s_2f_1d_1X_0 - d_0X_2 + s_2f_1d_0X_1}{s_2f_1X_1 - X_2 - d_1}$$

The first line of (18) shows that expected *real* output depends on the expected price level, a *nominal* variable. This is a striking result, quite unlike the usual rational expectations solution in which expected nominal variables have no effects on real variables. It reflects the previously noted influence of the financial service on aggregate supply. The intuition is that, for any given amount of high powered money H and money multiplier m, an increase in the price level reduces there real quantity of loans, which also reduces the quantity of financial services. Note that in this argument, the value of H was held fixed. Changes in the price level brought about by changes in H just cancel, leaving both L and F unaffected; see equation (10). As we will see below, when we expand the X_i parameters in the second line of (18), some of the determinants of P^e drop out. In particular, the only policy parameters that will remain are b_0 and b_1 from the regulatory policy rule (7); the two parameters h_0 and h_1 from the monetary policy rule (5) disappear, so that the standard expectational neutrality of money holds.

Finally, the fully-reduced form solution for current output is

(19) $$Y_t^S = EY_t^S + [(2x_1X_2 - d_1)X_2(s_1X_1 + s_2f_1X_1 - X_2 - d_1)$$

$$+ d_1(X_2 - s_2f_1X_1 + s_1X_1)][X_1(s_1X_1 + s_2f_1X_1 - X_2 - d_1)]^{-1}\alpha_t$$

$$+ [(2x_1X_2 - d_1)(m_1X_2 - s_2f_1km_1X_1)(s_1X_1 + s_2f_1X_1 - X_2 - d_1)$$

$$+ d_1m_1(X_2 - s_2f_1X_1 + s_1X_1)][X_1(s_1X_1 + s_2f_1X_1 - X_2 - d_1)]^{-1}\beta_t$$

$$+ [(2x_1X_2 - d_1)(a_1X_2 - X_1)(s_1X_1 + s_2f_1X_1 - X_2 - d_1)$$

$$+ d_1a_1(X_2 - s_2f_1X_1 + s_1X_1)][X_1(s_1X_1 + s_2f_1X_1 - X_2 - d_1)]^{-1}\delta_t$$

$$+ [(2x_1X_2 - d_1)(s_2f_1X_1 - X_2)(s_1X_1 + s_2f_1X_1 - X_2 - d_1)$$

$$+ d_1(X_2 - s_2f_1X_1 + s_1X_1)][X_1(s_1X_1 + s_2f_1X_1 - X_2 - d_1)]^{-1}\eta_t$$

$$+ [(2x_1X_2 - d_1)(s_2f_1kX_1 - X_2)(s_1X_1 + s_2f_1X_1 - X_2 - d_1)$$

$$+ d_1(X_2 - s_2f_1X_1 + s_1X_1)][X_1(s_1X_1 + s_2f_1X_1 - X_2 - d_1)]^{-1}\mu_t$$

$$+ (2s_1X_2 - d_1)s_2\phi_t$$

$$+ (2s_1X_2 - d_1)\theta_t$$

This expression is not quite as horrendous as it seems. The first term on the right side is the expected ("natural rate of") output; all the other terms are disturbance terms multiplied by coefficients and represent temporary deviations from the expected level.

2. *Graphical Interpretation.*

We can depict the model in an IS-LM framework augmented to include aggregate supply and rational expectations (see Branson, 1989). The IS equation is simply equation (1) with current Y replacing Y^D. The LM equation is obtained by equating money demand and supply - equations (3) and (4) - and using (5), (6), and (7) to eliminate H_t, m_t, and B_t, which gives

(20) $$Y_t = (m_2 - m_1b_1 + h_1 + a_2)R_t - P_t + (m_0 - m_1b_0 + h_0 - a_0) - \alpha_t - m_1\beta_t + \eta_t + \mu_t$$

$$= (X_1 - a_1d_1)R_t - P_t + (a_1d_0 - X_0) - \alpha_t - m_1\beta_t + \eta_t + \mu_t$$

The terms after the first two constitute the intercept, which consists of a constant and a linear combination of some of the disturbances. Finally, there is a third equation representing the output supply side of the economy; we can call it the SS equation (for Supply Side). It is obtained by using (8), (10), (5), (6), and (7) to eliminate F_t and then L_t, H_t, m_t, and B_t from (2), which gives

$$\text{(21)}\quad \begin{aligned} Y_t &= (s_2 f_1 k m_2 - s_2 f_1 k m_1 b_1 + s_2 f_1 h_1) R_t + s_1 (P_t - P_t^e) - s_2 f_1 P_t \\ &\quad + (s_0 + s_2 f_0 + s_2 f_1 k m_0 - s_2 f_1 m_1 b_0 + s_2 f_1 h_0) - s_2 f_1 m_1 \beta_t + s_2 f_1 \eta_t + s_2 f_1 k \mu_t + s_2 \phi_t \\ &= [X_2 + s_2 f_1 (k-1) m_1 b_1] R_t + s_1 (P_t - P_t^e) - s_2 f_1 P_t \\ &\quad + \left[X_3 + s_2 f_1 (k-1) m_1 b_0\right] - s_2 f_1 m_1 \beta_t + s_2 f_1 \eta_t + s_2 f_1 k \mu_t + s_2 \phi_t \end{aligned}$$

Figure 1 shows the IS, LM, and SS curves. The graph shows a situation of general equilibrium, with the three curves intersecting at a common point. Figure 1 differs from the standard augmented model in that the SS curve is positively sloped rather than vertical, reflecting the effect of the interest rate on the quantity of the financial service F, which in turn affects output. Also notice that the intercepts of the LM and SS curves depend on the policy parameters b_0 and h_0, and the slopes depend on b_1, and h_1. The policy reaction parameters b_1 and h_1 can have either sign and any magnitude, so in general the slopes of the LM and SS curves can be either positive or negative. If b_1 and h_1 are small, the slopes are positive, and the curves have been drawn that way in Figure 1. The dependence of slopes and intercepts on the policy parameters is what underlies the optimal choice of those parameters, as we see shortly. Figures 2 and 3 show two experiments that illustrate the workings of the model and that also will help understand the subsequent discussion of optimal policy parameter choice.

Consider first an unexpected decrease in the demand for money (that is, a negative realization of α). The behavior of the economy is shown in Figure 2. The shock to α has no effect on either IS or SS but does move the LM curve rightward from its initial position LM_0 to LM_1, thus disturbing general equilibrium. To restore equilibrium, the economy raises the price level P, which moves the LM curve back to the left. If price perceptions were always correct, so that P^e changed one-to-one with P, and if financial services had no effect on output supply (that is, if s_2 were zero), then P would rise until the LM curve had returned to its original position. The economy would be back at its original equilibrium in real terms, with only nominal effects of the money shock. However, two forces alter this conclusion. First, price perceptions are not always correct. In particular, for the usual rational expectations reasons, P^e lags behind P, so that $(P - P^e)$ in this case becomes positive. This perceptual error shifts the SS curve right. Second, the increase in P reduces the quantity of real loans L, which reduces the quantity of financial services F, which in turn reduces output supply. This effect shifts the SS curve left. The net shift in SS is unclear and depends on parameter magnitudes. Figure 2 shows the case where the perceptual error dominates. SS shifts right from SS_0 to SS_2, meeting the LM curve at LM_2. There is a temporary equilibrium at E_2. As time passes, P^e begins to catch up to P, shifting SS back to the left, which then requires further increases in P to shift the LM curve farther leftward. If financial services were absent from the aggregate supply equation ($s_2 = 0$), then this process would continue until both SS and LM had returned to their original positions and the economy was back in full equilibrium at E_0. Ultimately, the money demand shock would have only nominal effects. This conclusion is consistent with the analysis presented in Branson (1989). When financial services affect output supply, a different conclusion emerges. It is still true that P^e equals P once the economy has reached general equilibrium, and the perceptual error has disappeared. However, the higher value of P means that F is lower than before the money demand shock, so the value of aggregate supply also is lower in the new equilibrium than in the initial one. The LM and SS curves end up at LM_3 and SS_3, with the final equilibrium is point E_3.[8]

Consider next an unexpected decrease in aggregate demand (that is, a negative realization of δ), shown in Figure 3 as a shift from IS_0 to IS_1. The economy's response is similar in character to that in the previous case. The price level in this case must fall to shift the LM curve rightward and restore equilibrium. As P falls, P^e lags behind, causing a perceptual error and thus shifting SS leftward. The fall in P also raises F. Again assuming that the perceptual error dominates, a temporary equilibrium occurs at point E_1. As P^e catches up to P, the perceptual error closes, and SS moves back to the right. Eventually the economy reaches its full equilibrium at point E_3. In this case, the shock has a permanent effect on output, but it is unclear whether output ends up higher or lower than its initial value. On the one hand, the lower interest rate in the new general equilibrium is associated with a lower level of the financial service F; on the other hand, the lower price level is associated with a higher level of F. Figure 3 has been drawn under the assumption that the interest rate effect dominates, leaving output lower than before the shock.

The foregoing examples were chosen for illustrative purposes because of their simplicity. Nonetheless, they do lead to an important conclusion: the behavior of the financial sector affects the real economy in both the short and long run. Other kinds of shocks show the importance of the financial sector even more clearly. In particular, notice that both μ (money multiplier shock)

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[8]Money demand shocks thus are not neutral in the long run. Shocks to high powered money (non-zero realizations of η) are neutral in the long run, however. The coefficient of η in the SS equation has the same magnitude and opposite sign as the coefficient of P. Ultimately, P responds one-to-one to η, so the effects of η on aggregate supply exactly cancel. The model thus displays long run neutrality of money.

and ϕ (financial services shock) enter the SS equation, so that these purely financial shocks have *direct* effects on aggregate output supply. In terms of the IS-LM-SS graph, μ and ϕ shift the SS curve as well as the LM curve.[9] These direct effects, as well as the indirect effects of the previous two examples, are quite unlike anything seen in traditional macroeconomic analysis (save for the work of Bernanke, 1981, 1983, and Bernanke and Gertler, 1989, 1990). They reflect the effects of a financial sector that provides real services; they are the reason that the behavior of the financial sector is important for real economic activity.

Finally, as already mentioned, the slopes and intercepts of the LM and SS curves depend on the regulatory and monetary policy parameters b_0, b_1, h_0, and h_1. These parameters are at the disposal of the authorities and can be used to offset or at least reduce the impact of shocks to the economy. For example, the money demand shock analyzed in Figure 2 can be offset by an appropriate change in h_0. Also notice that the long-run effect of the money demand shock on real output can be altered by changing the slope of the SS curve through changes in b_1 and h_1. We now turn to an analysis of the optimal choice of the four policy parameters.

IV. Optimal Policy

We suppose that the policy maker has two objectives: to maximize the expected value (the "natural rate") of real output and to minimize the variance of current output around its expected value. In the usual analysis of optimal monetary policy choice under uncertainty, all interest centers on minimizing the variance of real output. No attention is paid to the level of output because monetary policy does not affect expected output EY in standard rational

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[9]The rest of the analysis of such shocks follows the same steps as those of Figures 2 and 3 and is left to the reader.

expectations models. In the present model, however, bank regulatory policy affects EY, so we need to include EY in the objective function. The formal objective function is discussed momentarily.

Policy makers would have no difficulty designing optimal policy if they could know the current state of the economy. They would observe the shifts in the IS, LM, and SS curves and would change their policy parameters (b_0, b_1, h_0, and h_1 in this case) to eliminate the temporary deviations from full equilibrium that we saw in Figures 2 and 3. Unfortunately, policy makers cannot know the current state of the economy because of data limitations and so are forced to base their policy decisions instead on various indicator variables. To keep the present discussion simple, we will suppose that the only indicator variable available to policy makers is the interest rate. The two examples discussed at the end of the previous section illustrate the problem that policy makers face. In the example of Figure 2, a shock to money demand causes (1) a short-run decrease in R and increase in Y and (2) a long-run increase in R and decrease in Y. In the example of Figure 3, a shock to commodity demand also causes a short-run decrease in R but a concurrent decrease rather than increase in Y; in the long run, R decreases even more, and output rises, possibly ending up above its pre-shock value (but drawn in Figure 3 as ultimately lower than the pre-shock value). A policy maker who wants to use policy to stabilize real output will find himself in a quandary because a given observed movement in the interest rate - the only information he has on the current state of the economy - can correspond to a positive or negative shock to output about its expected value and to a positive or negative change in the expected value itself. The policy maker thus will have difficulty deciding which way to move his policy parameters and how far to move them.[10] The analysis that follows derives the optimal policy prescription.

Before we proceed to the formal analysis, we can see immediately something of the general character of the answer. Optimal choice of the four policy parameters will depend on two sets of parameters in the model: (1) the variances and covariances of all disturbance terms, and (2) the slope and intercept terms of the various demand and supply functions. The variances and covariances matter because they determine the probabilities that an observed change in the interested rate is caused by shifts in each of the IS, LM, and SS curves. The policy maker needs to know which curve is shifting to respond appropriately. The slopes and intercepts matter because they determine the impact that any policy response will have on output and therefore determine how big the policy response should be. (For example, if the LM curve were flat, then the money demand shock shown in Figure 2 would have no effect on the economy because the LM curve would simply shift rightward on top of itself.) The four policy parameters cause movements and tilts in the LM and SS curves; the effect on output of moving either of these curves depends on the initial positions and slopes of all three curves.[11]

We now proceed to a formal derivation of the optimal choice of the model's four policy parameters, b_0, b_1, h_0, and h_1.

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[10]In fact, the information problem is even more difficult for the policy maker because the economy also can experience shocks to the aggregate supply function, causing shifts in the SS curve with commensurate changes in the interest rate. Such shifts are included in the formal analysis below, though not shown in Figures 2 or 3.

[11]Readers familiar with Poole's (1970) analysis will recognize the similarities between his work and the analysis presented here.

1. *Optimality Criterion.*

Optimality is defined as the maximization of a social welfare function V that depends on both the expected level of output EY and the variance VarY of output about EY. The function is

(22) $$V(EY, VarY)$$

$$V_1 > 0 \qquad V_{11} < 0$$

$$V_2 < 0 \qquad V_{22} < 0$$

We have no intuition for the signs of the cross-derivative $V_{12} = V_{21}$. They play no role in what follows, so we leave them unspecified.

The reader will notice the absence from the welfare function of that standard goal variable of the banking literature, "banking system stability." The policy maker's goal is to maximize social welfare; banking system stability is in itself no more relevant to that goal than, say, cheese shop stability. Banking system stability does enter the welfare function indirectly, in a sense, because the banking system affects the economy in two important ways that other specific industries (including cheese shops) do not. The first is the classic monetary transmission mechanism. Inside money is created by bank lending, so disruptions to the banking system also disrupt the money supply. The second is the intermediary service, which affects the efficiency of production. Banking system instability causes instability in both the money supply and the intermediary service and therefore also cause instability in output. The money multiplier in the model captures the effect of the banking system on the money supply; the financial service variable F captures the intermediary service. Nonetheless, one must keep in mind that minimization of banking system stability in itself is not an objective of optimal policy and so is not an end in itself. It is relevant only to the extent that it leads to the optimal mix of expected output and variance of output. Indeed, as we now see, in a maximizing environment with policy trade-offs, it is as conceivable that there is not enough banking system instability as that there is too little.

Bank regulation affects the ability of both channels to transmit any instability in the banking system to real output. In the model, "banking system instability" would be interpreted as the variance of the random term μ in the money multiplier equation (6). That term captures various effects, including changes in the public's desired currency/deposit ratio (which can change dramatically as part of a bank panic) and failure of banks (such as through bankruptcy, perhaps in response to a bank panic). Increasing the required bank regulation variable B reduces the transmission of any variability in μ to aggregate output. To see this, recall that all equations in the model are in log form. Thus the money multiplier is the antilog of m_t:

$$\tilde{m}_t = e^{m_0}(1 + B_t)^{-m_1}(1 + R_t)^{-m_2}\tilde{\mu}_t$$

The variance of $m^{\sim}$ involves the product of the variance of the random term $\mu^{\sim}$ and the square of the term $(1+B)^{-m}{}_1$. A higher value of B thus reduces the variance of $m^{\sim}$. It then is clear from (2), (4), and (8) that the variances of aggregate output, the money supply, and the financial service all are reduced as well. Thus increasing the bank regulatory requirement reduces the variances of the variables of interest.

Finally, note that increasing the bank regulatory requirement not only reduces the variances of important variables but also reduces their expected levels. In particular, a higher value of B means a lower value of expected output EY, as is easily seen by taking the expected values of (6), (8), and (10) and substituting into the expected value of (2). We thus have the basis for a classic optimization problem: on the one hand, raising B is good because it reduces variance of output, but on the other hand it is bad because it reduces expected output. We now turn our attention to solving that optimization problem.

2. *The Effects of the Policy Parameters on EY and Y.*

It is convenient to consolidate the effects of the policy parameters in the expressions for EY and Y. We begin by rearranging the terms in expressions for the X_i variables, defined in (14), to obtain the following:

(23)
$$\begin{aligned} X_0 &= U_0 + U_1 h_0 + U_2 b_0 \\ X_1 &= U_3 + h_1 + U_4 b_1 \\ X_2 &= U_5 + U_6 h_1 + U_7 b_1 \\ X_3 &= U_8 + U_6 h_0 + U_7 b_0 \end{aligned}$$

where the U_i are functions of the structural parameters excluding the four policy parameters and are defined in Table 1. We can substitute these expressions for the X_i into (18) and (19) and rearrange terms to get (after an enormous amount of tedious algebra)

(24)
$$\begin{aligned} EY_t &= \frac{Z_{EY0} + Z_{EY1} b_0 + Z_{EY2} b_1}{Z_{D0} + Z_{D1} b_1} \\ &\equiv Y^e(b_0, b_1) \end{aligned}$$

(25)
$$Y_t = EY_t + \left(\frac{\sum_{i=0}^{9} Z_{\alpha Yi} q_i}{\sum_{i=0}^{5} Z_{YDj} q_j} \right) \alpha_t + \left(\frac{\sum_{i=0}^{9} Z_{\beta Yi} q_i}{\sum_{i=0}^{5} Z_{YDj} q_j} \right) \beta_t + \left(\frac{\sum_{i=0}^{9} Z_{\delta Yi} q_i}{\sum_{i=0}^{5} Z_{YDj} q_j} \right) \delta_t + \left(\frac{\sum_{i=0}^{9} Z_{\eta Yi} q_i}{\sum_{i=0}^{5} Z_{YDj} q_j} \right) \eta_t$$

$$+ \left(\frac{\sum_{i=0}^{9} Z_{\mu Yi} q_i}{\sum_{i=0}^{5} Z_{YDj} q_j} \right) \mu_t + \left(\sum_{i=0}^{2} Z_{\phi Yi} q_i \right) \phi_t + \left(\sum_{i=0}^{2} Z_{\theta Yi} q_i \right) \theta_t$$

$$= Y_t^e + K^{\alpha}(b_1, h_1)\alpha_t + K^{\beta}(b_1, h_1)\beta_t + K^{\delta}(b_1, h_1)\delta_t + K^{\eta}(b_1, h_1)\eta_t + K^{\mu}(b_1, h_1)\mu_t$$

$$+ K^{\phi}(b_1, h_1)\phi_t + K^{\theta}(b_1, h_1)\theta_t$$

where the q_i are the elements of the 10-fold vector

$$\mathbf{q} \equiv (1, h_1, b_1, h_1 b_1, h_1^2, b_1^2, h_1^2 b_1, h_1 b_1^2, h_1^3, b_1^3)$$

the Z coefficients, defined in Table 1, depend on the system parameters other than the four policy parameters, and the K^j are functions of b_1 and h_1 defined as the ratios of the sums in the first line of (25). We can make (25) more compact by defining the vector Ω of random terms:

$$\Omega_t \equiv (\alpha_t, \beta_t, \delta_t, \eta_t, \mu_t, \phi_t, \theta_t)$$

so that we can write (25) as

(26)
$$Y_t = Y^e(b_0, b_1) + \sum_{\omega \in \Omega} K_{\omega}(b_1, h_1)\omega_t$$

We then can write the variance of current output as

(27)
$$\begin{aligned} VarY_t &\equiv E(Y_t - Y^e)^2 \\ &= E\left(Y^e + \sum_{\omega \in \Omega} K^{\omega}\omega_t - Y^e \right) \\ &= E\left(\sum_{\omega \in \Omega} K^{\omega}\omega_t \right) \\ &= \sum_{\omega \in \Omega} (K^{\omega})^2 \sigma_{\omega}^2 + 2 \sum_{\omega \neq \nu \in \Omega} K^{\omega} K^{\nu} \sigma_{\omega\nu} \end{aligned}$$

There are some interesting things to notice here. Both expected income EY and current income Y depend on the bank regulation policy parameters b_0 and b_1. Bank regulation affects the amount of loans made for any given stock of high powered money and so also affects the amount of the financial service offered by banks. The financial service has real effects and so affects both EY and Y. In contrast, monetary policy has much more limited impact. EY does not depend on either h_0 or h_1; money is expectationally neutral. Current income Y also is independent of h_0, but it does depend on h_1. Independence from h_0 is another manifestation of expectational neutrality; h_0 is the mean of high powered money and affects no real variables. Dependence of Y on h_1 reflects the ability of monetary policy to amplify or reduce random disturbances through the reaction function and is typical of rational expectations models such as that used here (Walsh, 1998; Woglom, 1979).

3. *Optimal Regulatory and Monetary Policy.*

We choose b_0, b_1, h_0, and h_1 to maximize (22). The four first order conditions are

(28)
$$\frac{\partial V}{\partial b_0} = V_1 \frac{\partial Y^e}{\partial b_0} + V_2 \frac{\partial VarY}{\partial b_0}$$
$$= V_1 \frac{\partial Y^e}{\partial b_0}$$
$$\equiv J^{b_0}(b_0, b_1)$$
$$= 0 \qquad \text{for max}$$

(29)
$$\frac{\partial V}{\partial b_1} = V_1 \frac{\partial Y^e}{\partial b_1} + V_2 \frac{\partial VarY}{\partial b_1}$$
$$\equiv J^{b_1}(b_0, b_1, h_1)$$
$$= 0 \qquad \text{for max}$$

(30)
$$\frac{\partial V}{\partial h_0} = V_1 \frac{\partial Y^e}{\partial h_0} + V_2 \frac{\partial VarY}{\partial h_0}$$
$$\equiv 0 \qquad \text{for all } h_0$$

(31)
$$\frac{\partial V}{\partial h_1} = V_1 \frac{\partial Y^e}{\partial h_1} + V_2 \frac{\partial VarY}{\partial h_1}$$
$$= V_2 \frac{\partial VarY}{\partial h_1}$$
$$\equiv J^{h_1}(b_1, h_1)$$
$$= 0 \qquad \text{for max}$$

The signs of the derivatives of the functions J^i generally are ambiguous, depending on the magnitudes of all the structural parameters of the system. The parameter h_0 does not affect anything, so its first order condition (30) is identically zero irrespective of the value chosen it. Choice of h_0 is arbitrary, and we may ignore equation (30) hereafter. The other three policy parameters are chosen to satisfy the system consisting of (28), (29), and (31). In general, the three relevant policy parameters b_0, b_1, and h_1 must be determined simultaneously. This may seem a little surprising, given that b_0 does not directly affect the variance of income VarY and h_1 does not directly affect the expected level of output EY. Indeed, b_0 is absent from the first order condition (31) for h_1, and h_1 is absent from the condition (28) for b_0. However, b_1 enters both conditions and so ties b_0 and h_1 together. Choice of b_0 affects choice of b_1; choice of b_1 affects choice of h_1; and conversely.

The system (28), (29), and (31) is highly non-linear in the three policy parameters, so an explicit solution is impossible to provide. Nonetheless, we can deduce several important conclusions quite quickly.

3.1. *Output effects of monetary policy.*

Standard rational expectations models obtain the result that monetary policy affects only the variance of current output but not the level of expected real output. Once we introduce financial services and regulation of the banking system, we get quite a different result. In such a setting, monetary policy does affect the level of expected real output. The effect is indirect, but it is there. Bank regulatory requirements alter the amount of financial service provided by the banking system and thus affect expected output directly. However, the optimal values for the bank regulation parameters depend on the value of the monetary policy reaction parameter h_1, so the choice of h_1 affects the choice of b_0 and b_1 and thereby affects not only VarY but also EY.

3.2. *The level of regulatory policy.*

Although the monetary policy intercept parameter h_0 is not relevant to anything of interest here, the regulation policy intercept parameter b_0 is. The mean level of the bank regulatory variable B is b_0+b_1ER, which depends not only on the reaction parameter b_1 but also on the intercept parameter b_0. The value of b_0 affects the amount of lending for any given quantity of high powered money and thus also affects the amount of the financial service F supplied by the banking system; that in turn affects aggregate output.

3.3. *Active bank regulatory policy.*

A very interesting result is that the optimal bank regulation reaction parameter b_1 generally is not zero. Both the sign and magnitude of b_1 depend on all the non-policy parameters of the system: the intercept and slope coefficients from the demand and supply equations for both money and output and the variances and covariances of all the random disturbances in the economy. These system parameters are impounded in the J^i functions in (28), (29), and (31). This result mirrors the well-known conclusion from the literature on optimal monetary policy, where it is shown that the monetary policy reaction parameter generally is not zero and depends on all the parameters of the system (Poole, 1970; Walsh, 1998; and Woglom, 1979). As in that literature, the parameter h_1 generally is not zero.

An important implication is that bank regulation should not be a passive activity, in which the bank regulatory requirements are set once (or once in a great while) and then left unchanged. Rather, the requirements should change in response to the shocks hitting the economy.

As in all models of this type, the effectiveness of monetary policy hinges on the monetary authority having an information advantage over private agents. If the private sector knows everything the central bank knows, it can achieve everything that reactive monetary policy can simply by adjusting the price level.[12] The same conclusion is *not* true of bank regulation.

[12]Of course, it may be not be realistic to suppose that most private agents have same information about the economy that the central bank has. Indeed, some information available to

Because both b_0 and b_1 directly affect the quantity of financial service F provided to the economy, they have real effects even if all agents in the economy have the same information as the regulators. We can see this in Figure 1, in which the slope of the SS function is not vertical, as it is in the usual treatment (Branson, 1989), but rather is positive, reflecting the effect of the financial service F. The quantity of F is determined in part by the values of b_0 and b_1.

3.4. *Institutional arrangements for optimal policy coordination.*

The simultaneity of optimal policy parameter choice in the model means that regulation of bank capital and conduct of monetary policy should be coordinated. Neither can be done properly without reference to the other. The requisite coordination is all the more demanding because, as just noted, bank capital regulation should be active rather than passive. Both the level of the bank regulatory requirement and the quantity of money should be adjusted continually in response to changing economic conditions, and the adjustments need to be coordinated with each other. The need for coordination arises from two separate sources in the model. First, random disturbances in the banking and monetary sectors may be correlated. It is quite plausible, for example, that the disturbance ϕ to the supply of financial services is correlated with the disturbance μ to the money multiplier. Second, even if the disturbance covariances are all zero, the optimal policy parameters are still related to each other through the structure of the economy. In general, each policy parameter depends on all the coefficients and variances of the system, so each policy parameter's optimal value is influenced by all sectors of

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the central bank is likely to be proprietary information that must be kept secret. This certainly is the case with the US central bank, which has access to a great deal of detailed information on individual private banks. In addition, it seems safe to say the average household knows much less than the central bank about the economy's structure and workings; this sort of information advantage, however, is very difficult to capture in a formal rational expectations model in which all agents know the true structure of the economy.

the economy. Conversely, this fact implies that bank regulatory policy both can be used to counteract disturbances in both the real and monetary sectors of the economy; indeed, the formal solution shows that the two sets of policy parameters must be varied simultaneously to achieve an optimal response to any given disturbance to the system.

These conclusions argue for a close link between the monetary and regulatory authorities. The obvious way to provide that link is to give responsibility for both types of policy to a single government agency. Indeed, the whole spirit of the foregoing analysis implies this arrangement. Choosing both the monetary and regulatory policy parameters by maximization of a single social welfare function amounts to having a central planner make all policy, and what is a central planner but a single agency?

Other considerations of the real world not included in the analysis here may call for modification of this conclusion. For example, Di Noia and Di Giorgio (1999) present evidence that countries where banking supervision is assigned monopolistically to the central bank are characterized on average by more protected and less efficient banking systems. Why this is true is unclear. Perhaps it is just another manifestation of the tendency for regulated industries to end up dominating the agencies that regulate them; it may be that powerful banks get their governments to assign supervision of themselves to a single agency that they then end up controlling one way or another. In any case, monopoly control may be as inefficient and unimaginative in the regulatory sphere as it is in the productive one. If so, there is then a tension between the theoretical ideal of a single unified monetary and regulatory agency suggested by the results presented above and the political reality that monopoly agencies are inefficient.

A concern sometimes suggested in the literature is that bank regulators and the central bank have different objectives, so that assigning regulation to the central bank could pervert regulation if the central bank were to give too much weight to monetary policy considerations in deciding what the regulations should be. The analysis presented here suggests quite the opposite. With one agency responsible for both regulation and monetary policy, that agency then acts as a social planner and gives correct weight to all considerations. Indeed, if improper weights are ever likely to be given to parameter choices, it would seem to be when the two functions are assigned to separate institutions that may well have different, parochial objective functions.

V. Conclusions

On a theoretical level, perhaps the most surprising conclusion of the foregoing analysis is that monetary policy can affect the expected level of real output even in a rational expectations model. This effect arises from the cross-effects of bank regulation and monetary policy on each other. Bank regulation affects the money supply, so it ends up being chosen simultaneously with and therefore influenced by monetary policy. However, bank regulation directly affects output, so monetary policy affects output indirectly. Optimal choice of monetary policy takes this indirect effect into consideration.

On a practical level, the most important conclusions concern the conduct of regulatory policy and the implied institutional arrangements for carrying it out. Bank regulation should be active rather than passive, continually changing in response to economic conditions. This is an important conclusion. There is no question that financial regulation can have powerful effects on aggregate economic activity.[13] To my knowledge, however, systematic activism has not characterized bank regulatory policy in any country, although there is some evidence of

[13]For example, Choi (2000) argues that strengthening of capital adequacy requirements were an important contributor to the recent sharp recession in Korea.

occasional episodes in which regulations were conditioned on economic conditions.[14] No less important is the conclusion that optimal regulatory and monetary policy should be simultaneously chosen, implying that the institutions responsible for them must at least coordinate their activities and perhaps even should be combined into one agency.

The analysis here has looked at only one aspect of bank regulation, the choice of the optimal level of the regulatory requirement. There are other important aspects. With respect to regulation of bank capital, for example, there is concern with the proper valuation and control of the riskiness of various types of capital that go into the capital ratio. Santomero and Seater (2000) suggest that controlling riskiness involves a trade-off between the stability gains from such control on the one hand and the associated reduction in aggregate output on the other hand. In other words, control of capital riskiness will have to be evaluated in the context of a macroeconomic model that properly accounts for the effects that regulation has on aggregate economic activity. In that case, the optimal control of bank portfolio riskiness will have to be determined simultaneously with the optimal choice of the level of the capital ratio as analyzed above. Similar issues may arise with other types of bank regulation.

[14]Berger, Kyle, and Scalise (2000) present evidence that U. S. bank regulators were stricter during the credit crunch period of 1989-92 than subsequently. The last recession in the U.S. occurred during 1989-92; after that, the U.S. economy enjoyed a major boom. Even if this behavior was part of a larger systematic relation between regulation and economic conditions, the direction of causality is unclear. If economic conditions drove regulatory behavior, the optimality of the latter cannot be known until the implied reaction function is compared with that suggested by the foregoing theory.

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Table 1
Definitions of Composite Parameters in Equations (23), (24), and (25)

U_0	$a_0 + a_1d_0 - m_0$
U_1	-1
U_2	m_1
U_3	$m_2 + a_1d_1 + a_2$
U_4	$- m_1$
U_5	$s_2f_1km_2$
U_6	s_2f_1
U_7	$- s_2f_1km_1$
U_8	$s_0 + s_2f_0 + s_2f_1km_0$
W_1	$[s_1 - s_2f_1(k-1)]m_2 + (s_1 + s_2f_1)(a_1d_1 + a_2) - d_1$
W_2	s_1
W_3	$[- s_1 + s_2f_1(k-1)]m_1$
W_4	$[s_2f_1(k-1) + s_1]m_2 + (s_1 - s_2f_1)(a_1d_1 + a_2)$
W_5	$[- s_2f_1(k-1) - s_1]m_1$
W_6	$- s_2f_1(k-1)m_2 + s_2f_1(a_1d_1 + a_2)$
W_7	$s_2f_1(k-1)m_1$
W_8	$s_2f_1k(a_1d_1 + a_2)$
W_9	$s_2f_1(k-1)$
W_{10}	$2s_1(m_2 + a_1d_1 + a_2) -d_1$
W_{11}	$2s_1$
W_{12}	$-2s_1m_1$
W_{13}	$a_1s_2f_1km_2 - m_2 - a_1d_1 - a_2$
W_{14}	$a_1s_2f_1 - 1$
W_{15}	$- a_1s_2f_1km_1 + m_1$

Z_{EY0}	$- d_1 s_0 - d_1 s_2 f_0 + s_2 f_1 d_0 (a_1 d_1 + a_2) - d_1 s_2 f_1 (a_0 + a_1 d_0) - d_1 s_2 f_1 (k-1) m_0 - s_2 f_1 d_0 (k-1) m_2$
Z_{EY1}	$d_1 s_2 f_1 (k-1) m_1$
Z_{EY2}	$s_2 f_1 d_0 (k-1) m_1$
Z_{D0}	$s_2 f_1 (a_1 d_1 + a_2) + s_2 f_1 (k-1) m_2 - d_1$
Z_{D1}	$s_2 f_1 (k-1) m_1$
Z_{EP0}	$(m_2 + a_1 d_1 + a_2)(s_0 + s_2 f_0 + s_2 f_1 k m_0) + (a_0 + a_1 d_0 - m_0) s_2 f_1 k m_2 - (m_2 + a_1 d_1 + a_2) d_0 + d_1 (a_0 + a_1 d_0 - m_0)$
Z_{EP1}	$(m_2 + a_1 d_1 + a_2) s_2 f_1 - d_1$
Z_{EP2}	$(s_0 + s_2 f_0 + s_2 f_1 k m_0) + (a_0 + a_1 d_0 - m_0) s_2 f_1 - s_2 f_1 k m_2 - d_0$
Z_{EP3}	$(m_2 + a_1 d_1 + a_2)(- s_2 f_1 k m_1) + m_1 + d_1 s_2 f_1 k m_2 + d_1 m_1$
Z_{EP4}	$- m_1 (s_0 + s_2 f_0 + s_2 f_1 k m_0) - s_2 f_1 k m_1 (a_0 + a_1 d_0 - m_0) + d_0 m_1$
Z_{EP5}	$s_2 f_1$
Z_{EP6}	$- s_2 f_1 m_1$
Z_{EP7}	$- s_2 f_1 k m_1$
Z_{EP8}	$s_2 f_1 m_1$
Z_{EP9}	$s_2 f_1 k m_1$
Z_{EP10}	$- s_2 f_1$
Z_{YD0}	$(s_1 + s_2 f_1)(m_2 + a_1 d_1 + a_2)^2 - s_2 f_1 (m_2 + a_1 d_1 + a_2) k m_2 - d_1 (m_2 + a_1 d_1 + a_2)$
Z_{YD1}	$2 s_1 (m_2 + a_1 d_1 + a_2) + s_2 f_1 (m_2 + a_1 d_1 + a_2) - s_2 f_1 k m_2 - d_1$
Z_{YD2}	$- 2(s_1 + s_2 f_1)(m_2 + a_1 d_1 + a_2) m_1 + s_2 f_1 (m_2 + a_1 d_1 + a_2) k m_1 - s_2 f_1 k m_1 m_2 + d_1 m_1$
Z_{YD3}	$- 2 s_1 m_1 + s_2 f_1 (k-1) m_1$
Z_{YD4}	s_1
Z_{YD5}	$s_1 m_1^2 - s_2 f_1 (k-1) m_1^2$

$Z_{\alpha Y0}$	$W_{10}W_1U_5 + d_1W_4$
$Z_{\alpha Y1}$	$W_{10}W_1U_6 + W_{11}W_1U_5 + W_{10}W_2U_5 + d_1W_2$
$Z_{\alpha Y2}$	$W_{10}W_1U_7 + W_{12}W_1U_5 + W_{10}W_3U_5 + d_1W_5$
$Z_{\alpha Y3}$	$W_{11}W_1U_7 + W_{12}W_1U_6 + W_{10}W_2U_7 + W_{12}W_2U_5 + W_{10}W_3U_6 + W_{11}W_3U_5$
$Z_{\alpha Y4}$	$W_{11}W_1U_6 + W_{10}W_2U_6 + W_{11}W_2U_5$
$Z_{\alpha Y5}$	$W_{12}W_1U_7 + W_{10}W_3U_7 + W_{12}W_3U_5$
$Z_{\alpha Y6}$	$W_{11}W_2U_7 + W_{12}W_2U_6 + W_{11}W_3U_6$
$Z_{\alpha Y7}$	$W_{12}W_2U_7 + W_{11}W_3U_7 + W_{12}W_3U_6$
$Z_{\alpha Y8}$	$W_{11}W_2U_6$
$Z_{\alpha Y9}$	$W_{12}W_3U_7$

$Z_{\beta Y0}$	$m_1(- W_{10}W_1W_8 + d_1W_4)$
$Z_{\beta Y1}$	$m_1(- W_{10}W_1W_9 - W_{11}W_1W_8 - W_{10}W_2W_8 + d_1W_2)$
$Z_{\beta Y2}$	$m_1(- W_{12}W_1W_8 - W_{10}W_3W_8 + d_1W_5)$
$Z_{\beta Y3}$	$m_1(- W_{12}W_1W_9 - W_{12}W_2W_8 - W_{10}W_3W_9 - W_{11}W_3W_8)$
$Z_{\beta Y4}$	$m_1(- W_{11}W_1W_9 - W_{10}W_2W_9 - W_{11}W_2W_8)$
$Z_{\beta Y5}$	$m_1(- W_{12}W_3W_8)$
$Z_{\beta Y6}$	$m_1(- W_{12}W_2W_9 - W_{11}W_3W_9)$
$Z_{\beta Y7}$	$m_1(- W_{12}W_3W_9)$
$Z_{\beta Y8}$	$m_1(- W_{11}W_2W_9)$
$Z_{\beta Y9}$	0

$Z_{\delta Y0}$	$W_{10}W_1W_{13} + d_1a_1W_4$
$Z_{\delta Y1}$	$W_{10}W_1W_{14} + W_{11}W_1W_{13} + W_{10}W_2W_{13} + c_1a_1W_2$
$Z_{\delta Y2}$	$W_{10}W_1W_{15} + W_{12}W_1W_{13} + W_{10}W_3W_{13} + d_1a_1W_5$
$Z_{\delta Y3}$	$W_{11}W_1W_{15} + W_{12}W_1W_{14} + W_{10}W_2W_{15} + W_{12}W_2W_{13} + W_{11}W_3W_{13}$

$Z_{\delta Y4}$	$W_{11}W_1W_{14} + W_{10}W_2W_{14} + W_{11}W_2W_{13}$
$Z_{\delta Y5}$	$W_{12}W_1W_{15} + W_{10}W_3W_{15} + W_{12}W_3W_{13}$
$Z_{\delta Y6}$	$W_{11}W_2W_{15} + W_{12}W_2W_{14} + W_{11}W_3W_{14}$
$Z_{\delta Y7}$	$W_{12}W_2W_{15} + W_{11}W_3W_{15} + W_{12}W_3W_{14}$
$Z_{\delta Y8}$	$W_{11}W_2W_{14}$
$Z_{\delta Y9}$	$W_{12}W_3W_{15}$

$Z_{\eta Y0}$	$W_{10}W_1W_6 - d_1W_4$
$Z_{\eta Y1}$	$W_{11}W_1W_6 + W_{10}W_2W_6 - d_1W_2$
$Z_{\eta Y2}$	$W_{10}W_1W_7 + W_{12}W_1W_6 + W_{10}W_3W_6 - d_1W_5$
$Z_{\eta Y3}$	$W_{11}W_1W_7 + W_{10}W_2W_7 + W_{12}W_2W_6 + W_{11}W_3W_6$
$Z_{\eta Y4}$	$W_{11}W_2W_6$
$Z_{\eta Y5}$	$W_{12}W_1W_7 + W_{10}W_3W_7 + W_{12}W_3W_6$
$Z_{\eta Y6}$	$W_{11}W_2W_7$
$Z_{\eta Y7}$	$W_{11}W_2W_7 + W_{11}W_3W_7$
$Z_{\eta Y8}$	0
$Z_{\eta Y9}$	$W_{12}W_3W_7$

$Z_{\mu Y0}$	$W_{10}W_1W_8 - d_1W_4$
$Z_{\mu Y1}$	$W_{10}W_1W_9 + W_{11}W_1W_8 + W_{10}W_2W_8 - d_1W_2$
$Z_{\mu Y2}$	$W_{12}W_1W_8 + W_{10}W_3W_8 - d_1W_5$
$Z_{\mu Y3}$	$W_{12}W_1W_9 + W_{12}W_2W_8 + W_{10}W_3W_9 + W_{11}W_3W_8$
$Z_{\mu Y4}$	$W_{11}W_1W_8 + W_{10}W_2W_9 + W_{11}W_2W_8$
$Z_{\mu Y5}$	$W_{12}W_3W_8$
$Z_{\mu Y6}$	$W_{12}W_2W_9 + W_{11}W_3W_9$
$Z_{\mu Y7}$	$W_{12}W_3W9$
$Z_{\mu Y8}$	$W_{11}W_2W_9$

$Z_{\mu Y9}$	0
$Z_{\phi Y0}$	s_2W_{10}
$Z_{\phi Y1}$	s_2W_{11}
$Z_{\phi Y2}$	s_2W_{12}
$Z_{\theta Y0}$	W_{10}
$Z_{\theta Y1}$	W_{11}
$Z_{\theta Y2}$	W_{12}

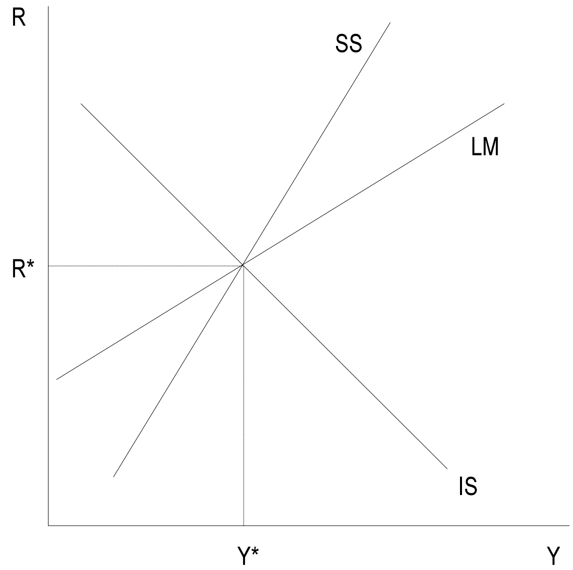

Figure 1: IS-LM-SS

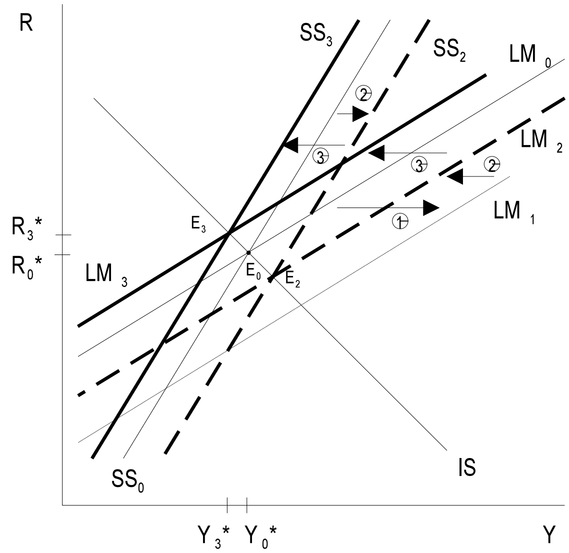

Figure 2: Negative shock to money demand

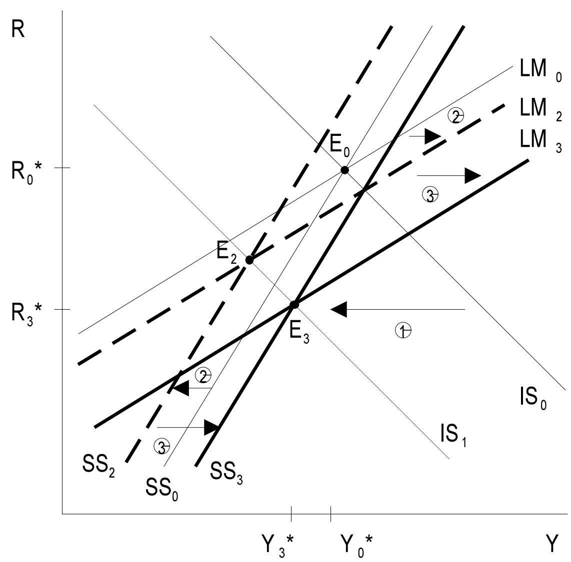

Figure 3: Negative shock to output demand