91-F-7

SUPPLY SHOCKS AND GOVERNMENT POLICIES IN A MONOPOLISTICALLY COMPETITIVE ECONOMY

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July 1991 (May 1991)

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ABSTRACT

Suppose that the policy maker gets information about an economy-wide supply shock causing a temporary decline in the economy's productivity, but that the information is not yet known to the general public. If the economy is monopolistically competitive, the policy to conceal its information about the supply shock improves social welfare, provided that households are sufficiently risk-averse, The policy maker can further improve social welfare through a monetary policy based on its informational superiority. Moreover, even if the representative household is risk-neutral, the optimal monetary policy may be better than simple information provision. The result stems from inefficiency due to the Nash behavior of monopolistically competitive firms, and sub-optimality of rational expectations under monopolistic competition.

* I am indebted to Yuji Genda, Akiomi Kitagawa, and seminar participants at the University of Tokyo and the Institute of Social and Economic Research, Osaka University, for their comments and suggestions.

I. INTRODUCTION

Suppose that the policy maker gets information about an economy-wide supply shock causing a temporary decline in the economy's productivity, but that the information is not yet known to the general public. Should the policy maker announce his information immediately to the public? Or, should the policy maker keep it secret and use his informational superiority to improve social welfare though a suitable monetary policy?

If the economy is perfectly competitive, the answer to the first question is positive and that to the second is negative under an oft-made macroeconomic assumption of a representative household, a representative firm, no cost of price adjustment, no distortionary tax, and perfect information about the policy maker's policy rule. Because perfect-information equilibrium dominates imperfect-information equilibrium in this case, the policy maker cannot improve social welfare (the representative household's utility) by keeping his information secret. For the same reason, monetary policy is at best equal to simple information provision, and in many case it reduces, rather than increases, social welfare. There is no room for a welfare-improving monetary policy.

The purpose of this paper is to show that these conclusions of a perfectly competitive economy are no longer true in a monopolistically competitive economy. Even under the macroeconomic assumption described above, we show that if the representative household is sufficiently risk-averse, a policy to conceal information about the supply shock improves social welfare. In this case, the policy maker can further improve social welfare through a monetary policy based on his informational superiority. Moreover, even if the representative household is risk-neutral, monetary policy may be better than simple information provision.

We obtain effectiveness and desirability of monetary policy in the monopolistically competitive economy because of inefficiency due to the Nash behavior of monopolistically competitive firms, which can be called the Nash inefficiency (see Nishimura (1991)), and sub-optimality of rational expectations under monopolistic (imperfect) competition (see Benassy (1990)). Monopolistically competitive firms set their price so as to maximize their objective function, taking other firms' prices as given. Because of strategic dependence among monopolistically competitive firms and resulting externality, monopolistically competitive firms' prices deviate from the socially optimal prices. Response of a monopolistically competitive economy to a supply shock is generally different from the socially desirable one. This suggests a possibility that rational expectations using all available information may be Pareto-dominated by other irrational expectations (Benassy (1990)). Consequently, to inform the productivity-shock information may be welfare-reducing in a monopolistically competitive economy.

In this paper, we construct an example economy in which simple information provision actually reduces social welfare and it is dominated by monetary policy. Section 2 presents the model, and characterizes equilibrium prices and equilibrium social welfare. Sections 3 and 4 contain main results of this paper. In Section 3 we show that there is a critical degree of risk aversion such that if the household's risk aversion exceeds this, then no information is better than perfect information about the supply shock. In Section 4 we characterize desirable monetary policy, and compare social welfare under monetary policy with that under simple information provision. Section 5 explores an alternative assumption about true. Section 6 concludes the paper.

2. A MONOPOLISTICALLY COMPETITIVE ECONOMY WITH PRODUCTIVITY SHOCKS

In order to clarify the Nash inefficiency of the imperfectly competitive economy described in Section 1 in the simplest way, we make two assumptions. First, product markets are monopolistically competitive because of product differentiation. Second, however, labor markets are in bilateral-monopoly relationship in which prices, wages, and employment are determined by firms so as to maximize the joint-benefit of their stockholders and their workers. The second assumption is unconventional, but it reduces the complexity of the model as shown below.

Although the bilateral-monopoly assumption greatly reduces the complexity of the model, the main result of this paper does not depend on this particular assumption. In Section 5, we relax the assumption and show that the same result is obtained even if labor markets are monopolistically competitive rather than in a bilateral monopoly.

The model we investigate in this paper is a version of monopolistically competitive macroeconomic models extensively investigated in the last decade (by, for example, Weitzman (1985), and Blanchard and Kiyotaki (1987)). The economy consists of one representative consumer[1] and n firms. Each firm produces a specific good that is an imperfect substitute for the other goods, employing labor specific to the firm. The household derives utility from the consumption of goods, liquidity services of real money balances, and leisure. The household gets initial money balances through transfer payments from the government. The household supplies labor to firms and receives wages and dividends from them.

Note that the representative household is the sole owner of the firm and the sole supplier of labor to the firm. Thus, the bilateral monopoly-relationship implies that the price of the firm's products and its production level (and thus work hours) are determined by the firm in such a way as to maximize the household's utility, by taking the price of the other firms' products as given. The resulting equilibrium is in general different from the "social optimum", in which a "social planner" simultaneously determines all prices and production levels of firms in order to maximize the household's utility. The resulting inefficiency is the Nash inefficiency described earlier, and it is the basis of the results obtained in this paper.

The Sequence of Events

Before presenting the detail of the model, it is worthwhile to specify its sequence of events. There are two stages: the first is the price-decision stage, and the second is the consumption-decision stage.

At the beginning of the first (price-decision) stage, nature chooses a particular realization of a productivity disturbance common to all firms. The policy maker then allocates money to the household through transfer payments.

There is an informational agency[2] in this economy, which announces the magnitude of the productivity disturbance and the level of the money supply. The announcement is made public, so that all agents in this economy can obtain it without incurring any costs. However, the announcement of the productivity disturbance and that of the money supply contain non-negligible errors.

Firms are assumed to know the public announcement of the productivity disturbance and the money supply. However, firms do not observe their actual demand and cost conditions before they determine their prices (the pre-determined price assumption). Firms form rational expectations about their demand and cost conditions based on available information. Firms simultaneously choose their prices based on this imperfect information.[3]

In the second (consumption-decision) stage, after all prices have been determined, the household decides how much to buy from each firm and places its orders. The household observes all disturbances and prices. It determines consumption and the end-of-period real money holdings, taking prices, wages, dividends, and initial money holdings as given. All firms are obliged to satisfy the demand that their price offers create, and thus there are no rations.[4] Firms employ labor and produce the demanded quantities. Then, the household actually purchases goods from firms and consumes them, and firms pay wages and dividends to the household.

Firms are assumed to be symmetric in that they have the same demand and production functions. We are hereafter concerned with symmetric equilibrium. The assumption of symmetry allows us to simplify our welfare analysis.

In the model described below, we put normalization factors in the utility function and the production function so that equilibrium prices are equal to unity when there is no disturbance in the economy. This no-disturbance case serves as a frame of reference in the following analysis.

2.1. The Second Stage: Consumption Decision and Monetary Equilibrium

It is convenient to analyze the economy backwards, from the second stage to the first. In the second stage, there is no uncertainty for the household.

The Representative household

The representative household's utility function Ψ is

$$(1) \quad \Psi = \Psi(U) \equiv \frac{1}{1-z} U^{1-z},$$

where U is a total-consumption index, and z is the degree of (relative) risk aversion with respect to the total-consumption index U. The term z satisfies $z \geqq 0$.[5]

The total-consumption index U consists of utility from consumption of goods, consumption of liquidity services, and leisure. We assume

$$(2) \quad U = U(Y, \frac{\tilde{M}}{\bar{P}}, L_1, \cdots, L_n) \equiv D(n\bar{Y})^{\zeta} (\frac{\tilde{M}}{\bar{P}})^{1-\zeta} - \Sigma_{i=1}^{n} L_i^{\mu},$$

where D is a normalization factor such that $D = \zeta^{-\zeta}(1 - \zeta)^{-(1-\zeta)}$; n is the number of goods (and the number of firms); $\bar{Y}$ is the average goods-consumption index defined below; $\tilde{M}$ represents the end-of-period nominal money holdings; and $\bar{P}$ is the price index associated with $\bar{Y}$, which is defined below. ζ is a parameter which satisfies $0 < \zeta < 1$. $\tilde{M}/\bar{P}$ are the end-of-period real balances. They are included in the total-consumption index as a proxy of liquidity services that the real balances yield. L_i is the labor input specific to the i-th firm, and L_i^{μ} represents the disutility that comes from it. Thus, $\Sigma_{i=1}^{n} L_i^{\mu}$ is the total disutility of labor.[6] We assume that $1 < \mu$, which implies increasing marginal disutility of labor.

The average goods-consumption index $\bar{Y}$ is defined as follows:

$$(3)\quad \bar{Y} = \bar{Y}(\{Q_i\}:_{i = 1,\dots,n}) \equiv \{(\Sigma_{i=1}^{n} Q_i^{(k-1)/k})/n\}^{k/(k-1)},$$

where Q_i is the consumption of the i-th product. The parameter k satisfies $1 < k$. This assumption is necessary for profit maximization, which will be specified later in this section.

$\bar{P}$ is the price index associated with the average goods-consumption index $\bar{Y}$:

$$(4)\quad \bar{P} = \bar{P}(\{P_i\}:_{i = 1,\dots,n}) \equiv \{(\Sigma_{i=1}^{n} P_i^{1-k})/n\}^{1/(1-k)},$$

where P_i is the price of the i-th product.

The household's demand for each product and the demand for real balances are both derived from the maximization of Ψ with respect to Q_i and $\tilde{M}/\bar{P}$, subject to the following budget constraint:

$$(5)\quad \Sigma_{i=1}^{n} P_i Q_i + \tilde{M} = B,$$

where B is the beginning-of-period asset of the household.

Let us now consider B. The household obtains money from the government in the form of transfer payments, and wage payments and dividends from firms. Then,

$$(6)\quad B = \Sigma_{i=1}^{n} (\bar{P}\Lambda_i + \bar{P}\Pi_i) + M,$$

where Λ_i is the real wage payment, and Π_i the real dividend from the i-th firm. The beginning-of-period money holdings are equal to the money supply, M.

Demand Functions and Monetary Equilibrium

Using the properties of the CES and Cobb-Douglas functions, we can derive the demand Q_i for the i-th product and the demand for real balances $\tilde{M}/\bar{P}$. They are

$$(7)\ Q_i = \left(\frac{P_i}{\bar{P}}\right)^{-k} \bar{Y}, \text{ where } n\bar{Y} = \zeta\frac{B}{\bar{P}}, \text{ and } \frac{\tilde{M}}{\bar{P}} = (1 - \zeta)\frac{B}{\bar{P}}.$$

In order for the economy to be in monetary equilibrium at the second stage, the money demand should be equal to the money supply. Thus, the end-of-period money holdings should equal the beginning-of-period money holdings. That is,

$$(8)\ \tilde{M} = M$$

should be satisfied. Because of (7) and (8), we obtain from the monetary equilibrium condition

$$(9)\ \bar{Y} = H \frac{M}{\bar{P}}, \text{ where } H = \frac{\zeta}{1-\zeta}\frac{1}{n}.$$

Thus, in equilibrium, the average demand is proportional to the initial real money holdings.

The household's Utility in the Second-Stage Equilibrium

Substituting demand functions (7) and (9) into (1), and using (6), we obtain the household's utility in the second-stage equilibrium, such that

$$(10)\quad \Psi \equiv \frac{1}{1-z}\left[\left(\frac{B}{\bar{P}}\right) - \Sigma_i L_i^{\mu}\right]^{1-z} = \frac{1}{1-z}\left[\frac{1}{\bar{P}}\{\Sigma_{i=1}^{n}\ (\bar{P}\Lambda_i + \bar{P}\Pi_i) + M\} - (\Sigma_i L_i^{\mu})\right]^{1-z},$$

where L_i is determined by firms in the first stage.

2.2. The First Stage: Price Decision

Because firms have perfect knowledge about the economy except for the particular realization of the money supply and the productivity disturbance, firms know the household's consumption functions (7) and its indirect utility function (10).

Firms' Objective Function

Firms are indexed by i, i = 1, ..., n. The demand for the i-th firm's product, Q_i, is, from (7) and (9),

$$(11)\qquad Q_i = \left(\frac{P_i}{\bar{P}}\right)^{-k} \bar{Y}_i = H\left(\frac{P_i}{\bar{P}}\right)^{-k}\left(\frac{M}{\bar{P}}\right).$$

In order to produce output Q_i, the n-th firm needs labor inputs. We assume

$$(12)\qquad Q_i = \left(\omega\cdot\frac{1}{S}\cdot L_i\right)^{\phi},$$

where L_i is labor input, and ϕ satisfies $0 < \phi < \mu$.[7]

S is the productivity disturbance common to all firms. An increase in S implies productivity decline, and a decrease in S means productivity improvement. ω is a normalization factor such that

(13) $$\omega = \left[\frac{k-1}{(\mu/\phi)k} H^{1-(\mu/\phi)}\right]^{-1/\mu}.$$

The i-th firm's nominal profit $\bar{P}\Pi_i$ is given by

(14) $$\bar{P}\Pi_i = P_i Q_i - \bar{P}\Lambda_i,$$

where Λ_i is the real wage payment.

The i-th firm maximizes the joint benefit of its stockholders and its workers. Because the representative household is the stockholder of the firm and at the same time its worker, the firm maximizes the representative household's utility (10) with respect to its price.

From (10) and the above relations, we have

$$\Psi \equiv \frac{1}{1-z}\left[\left(\frac{B}{\bar{P}}\right) - \Sigma_i L_i^{\mu}\right]^{1-z} = \frac{1}{1-z}\left[\Sigma_{i=1}^{n}\left\{\frac{1}{\bar{P}}P_i Q_i - \omega' S' Q_i^{1+c_1}\right\} + \frac{M}{\bar{P}}\right]^{1-z},$$

Here $\omega' = \omega^{-\mu}$, $S' = S^{\mu}$, and c_1 is a parameter depending on the degree of increasing marginal disutility of labor, μ, and the degree of returns to scale, ϕ, such that

$$c_1 = (\mu/\phi) - 1 > 0.$$

Consequently, we have

$$(15) \qquad \Psi(P_1, \cdots, P_n, \bar{P}, M, S') \equiv \frac{1}{1-z}\left[\Sigma_{i=1}^{n}\Theta(P_i, \bar{P}, M, S') + \frac{M}{\bar{P}} \right]^{1-z},$$

where Θ is a function of the i-th firm's price such that

$$(16) \qquad \Theta(P_i, \bar{P}, M, S') = H(\frac{P_i}{\bar{P}})^{1-k} \frac{M}{\bar{P}} - \omega' S' \{H(\frac{P_i}{\bar{P}})^{-k} \frac{M}{\bar{P}}\}^{1+c_1}.$$

Thus, the objective function of the i-th firm firm is (15).

Throughout this paper, we assume that the number of firms n, is so large that the dependence of the price index $\bar{P}$ on a particular P_i is negligible. Thus, the firm takes $\bar{P}$ as given under this monopolistically competitive assumption.

Imperfect Information about Demand and Cost Conditions

Firms are assumed to be unable to observe their demand and cost conditions: M and S'. However, they know the characteristics of the distribution of S': that is, the distribution of S' is normal with E(S') = 1 and Var(S') = σ_s^2.[8] They also know the policy maker's monetary policy rule. Thus, if the policy maker adopts an active monetary policy so that the money supply is determined by, for example, $M - 1 = \lambda(S' - 1)$, then firms come to know the rule and the value of λ. However, firms cannot infer M correctly because S' is unobservable.

In this economy, an information agency announces M and S', but its announcement contains substantial errors. Thus, firms can observe A and B such that

$$(17) \qquad A = M + V$$

and

(18) $B = S' + W,$

where V and W are normal random variables independent of each other, M and S'. They satisfy $E(V) = E(W) = 0$, $Var(V) = \sigma_V^2$, and $Var(W) = \sigma_W^2$.

<u>First-Stage Equilibrium</u>

Symmetric equilibrium in the first stage is (P_i: $i=1,\cdots,n$) such that (1) P_i maximizes $E\{\Psi(P_1, \cdots, P_n, \bar{P}, M, S')|A, B\}$ and (2) $P_i = \bar{P}$, where $E\{\Psi|A, B\}$ is the expectation of Ψ conditional on A and B. Because demand and cost conditions are symmetric and information about M and S' are homogeneous, all firms charge the same price in symmetric equilibrium.

If $M = S' = 1$, and if both M and S' are known to all firms, then it is straightforward to show that $P_i = 1$ for all i and $\bar{P} = 1$ are equilibrium prices. Specifically, we have $\Psi_{P_i} = 0$, where Ψ_{P_i} represents the first derivative of Ψ with respect to P_i evaluated at $P_i = \bar{P} = M = S' = 1$. However, if M and S' are unknown, then M and S' should be rationally inferred from available information. To make rational expectation formation tractable, we employ a quadratic approximation (the second-order Taylor expansion) of (15) around $P_i = \bar{P} = M = S' = 1$ (see The APPENDIX).

The i-th firm's optimal price is obtained from the first-order condition of optimality based on the second-order Taylor expansion of (15) around $P_i = \bar{P} = M = S' = 1$. It is

$$P_i - 1 = \frac{\Psi_{P_i\bar{P}}\cdot E(\bar{P} - 1|A, B) + \Psi_{P_iM}\cdot E(M - 1|A, B) + \Psi_{P_iM}\cdot E(S' - 1|A, B)}{- \Psi_{P_iP_i}},$$

where Ψ_{P_iX} is the second derivative of Ψ with respect to P_i and X evaluated at $P_i = \bar{P} = M = S' = 1$. It should be noted that because we have $\Psi_{P_i} = 0$, we obtain $\Psi_{P_iX} / \Psi_{P_iP_i} = \Theta_{P_iX} / \Theta_{P_iP_i}$ for $X = \bar{P}$, M and S'. This implies that P_i is independent of z, the degree of the household's relative risk aversion with respect to the total-consumption index U. Thus, the household's risk aversion does not influence the firm's price decision.[9]

Since information (A, B) is homogeneous among firms, expectations about M and S' are also homogeneous. Consequently, under the the symmetric assumption, we have $P_i = \bar{P}$ in equilibrium and firms also know it. Thus, we obtain the equilibrium average price such that

$$(19)\quad \bar{P} - 1 = E(M - 1|A, B) + \frac{1}{c_1}E(S' - 1|A, B)\}.$$

Social Welfare in Equilibrium

Let us consider social welfare in this economy. Because there is a representative household, the total utility of the household is the natural measure of social welfare. Thus, social welfare in equilibrium, Ψ^S, is from (13), $\omega' = \omega^{-\mu}$, $1 + c_1 = \mu/\phi$, $P_i = \bar{P}$ and (15),

$$(20)\qquad \Psi^S = \Psi^S(\bar{P}, M, S') = \frac{1}{1-z}\left[\frac{1}{\zeta}H^{*}\frac{M}{\bar{P}} - \frac{k-1}{(1+c_1)k}S'H^{*}\left(\frac{M}{\bar{P}}\right)^{1+c_1}\right]^{1-z},$$

where $H^* = nH = \{\zeta/(1 - \zeta)\}$. A quadratic approximation of (20) around $\bar{P} = M = S' = 1$ is given in the APPENDIX. The result in the APPENDIX shows that we have $\Psi^S_{\bar{P}}$ (evaluated at $\bar{P} = M = S' = 1$) < 0, so that the average price is higher than the social optimum because of imperfect competition, as expected. Moreover, Ψ^{S}_{XX} (evaluated at $\bar{P} = M = S' = 1$) where $X = \bar{P}$, M, and S' is determined by z, which is the degree of the household's risk aversion.

We have shown above that market-equilibrium prices do not depend on the household's risk aversion. On the other hand, we know here that the household's risk aversion is a principal determinant of social welfare. This is another manifestation of the Nash inefficiency described in Section 1 due to the discrepancy of the private optimum from the social optimum. In Sections 3 and 4, we look at how this characteristic of the imperfectly competitive economy influences desirability of particular government policies.

3. IS INFORMATION PROVISION ALWAYS WELFARE-IMPROVING?

Suppose that the policy maker has information about S' before firms determine their prices. Does the policy maker increase social welfare by revealing his information to the public? Or, does the policy maker improve social welfare by concealing his information from the public? This section takes up this issue.

We assume that the policy maker must choose between a policy of announcing his information and that of concealing it before he observes the productivity shock. Thus, we exclude a conditional information provision in which, for example, the policy maker announces his information if the magnitude of the productivity shock exceeds a certain value.[10]

In the previous section, we have shown that the market equilibrium does not depend on the representative household's risk aversion with respect to the total-consumption index U, whereas the household's risk aversion is the principal determinant of social welfare. In the market equilibrium, the larger the productivity shock is, the larger the adjustment in output and work hours is, which is translated into a larger variance of output and work hours. This implies a larger variance of the total-consumption index U. On the other hand, imperfect information about demand and cost conditions generally reduces the sensitivity of output and work hours to the productivity shock, and thus reduces the variance of the total-consumption index. Because strong risk aversion implies that a smaller variance of the total-consumption index is preferred, no information (imperfect information) may be better than perfect information if risk aversion is strong. This section formalizes this intuition.

<u>Market Equilibrium</u>

In order to simplify notations, let the lower-case-letter variable represent the deviation of the corresponding upper-case-letter variable from unity, so that $p_i = P_i - 1$, $\bar{p} = \bar{P} - 1$, $m = M - 1$, and $s = S' - 1$ (we omit ' in s for simplicity). Then, the market-equilibrium-price equation (19) is now

$$\bar{p} = E(m|A, B) + \frac{1}{c_1}E(s|A, B). \tag{21}$$

Let us first consider the case where the policy maker makes public his perfect information about s, and do nothing other than that. Specifically, it does not change the money supply, so that m is equal to zero. In this case, we have $E(m|A, B) = m = 0$ and $E(s|A, B) = s$. Substituting these into (21), we obtain the equilibrium price under perfect information,

$$\bar{p}_{PI} = (1/c_1)s, \tag{22}$$

where $_{PI}$ denotes perfect information.

Next consider the case in which the policy maker decides not to reveal the information. However, we assume that it still keeps m equal to zero. In this case, $E(m|A, B) = m = 0$, but s should be inferred from available information (A, B). Note that from (21) $\bar{p}$ is solely dependent on $E(s|A, B)$. It is evident that A does not contain any information about s. Consequently, $E(s|A, B)$ depends only on B. Using the technique of the linear least squares regression, the APPENDIX shows that $E(s|\bar{p}, A, B) = \theta B$ where $\theta = \sigma_s^2/(\sigma_s^2 + \sigma_w^2)$. Then, it is straightforward to show that the equilibrium price in this case is

(23) $\bar{p}_{II} = (1/c_1)\theta B = (1/c_1)\theta(s + W)$,

where $_{II}$ denotes imperfect information.

From the above result, we know that imperfect-information-equilibrium price is less sensitive to the change in the productivity shock than the perfect-information-equilibrium price, because of the existence of forecast errors in B. The unconditional variance of the imperfect-information-equilibrium price is $E(\bar{p}_{II})^2 = (1/c_1)^2\{(\sigma_s^2\sigma_w^2)/(\sigma_s^2 + \sigma_w^2)\}$, which is smaller than that of the perfect-information equilibrium price, $E(\bar{p}_{PI})^2 = (1/c_1)^2\sigma_s^2$.

Social Welfare

The above result shows that the price is more rigid under imperfect information than under perfect information. Because the nominal demand is kept constant, this implies that real balances (and thus output) are more stable under imperfect information. Because of the concavity of the social welfare function with respect to real balances (see (20)), the stability of real balances (and thus output) is desirable, so that imperfect information is better than perfect information in this respect. However, price rigidity here implies that the adjustment of the price to the productivity change is less complete. This is clearly undesirable. These two conflicting forces are present in this model.

The APPENDIX shows that the unconditional expectation of the second-order Taylor expansion of the social welfare function (20) is

(24) $$E(\Psi^S) = (\text{constant})\cdot\left[-\frac{1}{2}\left[\frac{c_1(k - 1)}{k} + zF_{yy}\right]E\{(m - \bar{p})^2\}\right.$$

$$- \{\frac{k - 1}{k} - zF_{ys}\}E\{(m - \bar{p})s\} - F_y E\{(m - \bar{p})\bar{p}\} + (\text{constant})\Big],$$

where

$$F_y = \frac{1}{\zeta} - \frac{k - 1}{k} > 0, \; F_s = \frac{k - 1}{(1 + c_1)k} > 0, \; F_{yy} = (\text{constant})\cdot(F_y)^2 > 0,$$

$$F_{ss} = (\text{constant})\cdot(F_s)^2 > 0, \text{ and } F_{ys} = (\text{constant})\cdot F_y F_s > 0.$$

The first term in (24) represents the concavity of the social welfare function with respect to real balances. Stability of real balances improves social welfare through this term. The second and third terms depict the effect of adjustment of real balances (and thus output) to the productivity shock itself (second term) and to the induced price change (third term). Rigidity of the price is not desirable because it reduces possible improvement of social welfare through these terms.

The following proposition shows that if $z = 0$, that is, the household is risk-neutral with respect to the total-consumption index, the second- and third-term effects dominates the first-term effect, so that information provision is better than no information. (See the APPENDIX for the proof of the proposition.)

PROPOSITION 1

If $z = 0$, then perfect-information equilibrium always dominates imperfect-information equilibrium, in the sense that social welfare in perfect-information equilibrium is greater than that in imperfect-information equilibrium.

Then, is it always beneficial to inform the public, regardless of the value of the household's risk aversion? The next proposition, which is the main result of this section, shows that this is not the case.

PROPOSITION 2

For any combination of (c_1, k, ζ), there exists z^+ such that imperfect-information equilibrium dominates perfect-information equilibrium for $z > z^+$.

The exact formula of z^+ is quite complicated (see the APPENDIX), but intuition behind the proposition is simple. If z is large, the household does not want the total-consumption index U to fluctuate. Note that from (20) we have

$$(25) \qquad U = \frac{1}{\zeta}H^*\frac{M}{\bar{P}} - \frac{k-1}{(1+c_1)k}S'H^*\left(\frac{M}{\bar{P}}\right)^{1+c_1}.$$

If c_1 is small, then (21) tells us that $\bar{P}$ will fluctuate a lot, and so does $(M/\bar{P})$, because M = 1 (m = 0). Consequently, rigidity induced by imperfect information is beneficial in this case. This implies that if z is large relative to c_1, imperfect-information equilibrium dominates perfect-information equilibrium.

TABLE 1 presents numerical examples of z^+ for various values of ζ, c_1 and k. It shows that if c_1 is small, then z^+ is small, and thus confirms the intuition described above.

The effect of k and ζ is more subtle than that of c_1. The parameter k, the degree of substitution between goods, can also be considered as the degree of competitiveness in product markets. Consequently, an increase in k generally puts upward pressure on the price level, and reduces the equilibrium welfare.[11] Because the concavity is stronger ($|\partial^2\Psi/\partial U^2|$ is larger) when U is smaller, an increase in k implies that the household dislikes the fluctuation of U more than ever. Consequently, it is more likely that imperfect-information-induced stability is beneficial to social welfare.

The parameter ζ represents the importance of liquidity services in the total-consumption index U. The household allocates $(1 - \zeta)$ of its real budget to real balances (see (7)). An increase in ζ implies that real balances' weight on the total-consumption index is smaller. From (25), this implies a decrease in the concavity of the total-consumption index with respect to real balances. Thus, an increase in ζ makes imperfect-information-induced stability less desirable.

4. MONETARY POLICY

In Section 3, we have shown that for a sufficiently large z, a simple imperfect-information policy, in which the policy maker conceals his information and does nothing other than that, is better than the perfect-information policy, in which the policy maker announces his information. This result suggests possibility that the policy maker may increase social welfare by a discrete monetary policy based on his informational superiority. This section characterizes desirable monetary policy. Specifically, we explore whether a discrete monetary policy dominates an information-provision policy <u>even in the case of risk neutrality</u> of the representative household with respect to the total-consumption index, where an information-provision policy has been shown to dominate a no-information policy in Section 3. We then analyze the condition under which desirable monetary policy is accommodating, in which the policy maker increases the money supply (and thus increases aggregate demand) when the economy suffers from productivity decline (and thus cost increase) due to a supply shock.

The policy maker can make the money supply m (= M - 1) responsive to the productivity shock s (= S' - 1). Suppose that the policy is to set m such that $m = \lambda s$. If λ is positive, the policy maker increases nominal aggregate demand when productivity goes down. This can be called an accommodating policy rule, because the policy maker accommodates the upward cost pressure on prices due to the productivity decline. If λ is negative, the policy maker's policy rule can be called as counter-acting, because the policy maker reduces nominal aggregate demand when there is a upward pressure on prices. In the following, we consider the case that λ is constant, and not contingent on s. Thus, we are concerned with the linear-monetary-policy rule. In the following analysis we call the optimum linear monetary policy the best monetary policy.[12]

Although to compute the optimal λ is possible in the general case, resulting formula is quite complicated without no economic insight. Taking this into account, in the remainder of this section, we concentrate on the case in which σ_v^2 is large compared with $\sigma_s^2 \cdot \sigma_w^2$. This implies that the monetary announcement contains a much larger error than the cost announcement. (Because a large error is often observed in the actual monetary announcement, this may not be an unreasonable assumption.[13])

Because the monetary announcement contains a large error, the monetary announcement A has little information about s even though m is equal to λs. Thus, we have $E(s|A, B) = \theta B$ and $E(m|A, B) = \lambda E(s|A, B) = \lambda\theta B$, under our maintained assumption that $\sigma_v^2 > \sigma_s^2 \cdot \sigma_w^2$, where $\theta = \sigma_s^2/(\sigma_s^2 + \sigma_w^2)$ as in Section 3 (see the APPENDIX for detail). Consequently, taking $m = \lambda s$ into account, we have from (21)

$$\bar{p} = (\lambda + \frac{1}{c_1})\theta(s + W), \tag{26}$$

and

$$m - \bar{p} = \{\lambda(1 - \theta) - \frac{1}{c_1}\theta\}s - (\lambda + \frac{1}{c_1})\theta W. \tag{27}$$

These two equations, (26) and (27), show us that an increase in λ from zero decreases the effect of the productivity shock (s) on real balances $(m - \bar{p})$, and at the same time it increases the sensitivity of $\bar{p}$ to s. These two effects are beneficial to social welfare, as explained in Section 3.

However, to keep information about s secret introduces an additional disturbance, W, to the economy, which is undesirable. This suggests that if the variance of W, σ_W^2, is small, then social welfare under the best monetary policy is greater than that in perfect-information equilibrium, and at the same time the best policy is accommodating ($\lambda > 0$).

TABLE 2 confirms this intuition. This table shows the optimal λ and the deviation in social welfare from the perfect-information case, in the case that $\zeta = .7$, $k = 2.7$, and $c_1 = .24$.[14] If $z = 0$, the table shows that the no-information-policy social welfare is unambiguously smaller than the perfect-information social welfare (PROPOSITION 1). However, if the variance of the forecast error in the supply-disturbance announcement (σ_W^2) is small, then the best-monetary-policy social welfare is greater than the perfect-information social welfare.

Next, consider the condition under which the best policy is accommodating. The APPENDIX proves the following proposition.

<u>PROPOSITION 3</u>

If

$$(28)\ \frac{1}{c_1}\{\frac{1}{\zeta} - \frac{k-1}{k}\}(\frac{\sigma_s^2}{\sigma_W^2}) - \left[\frac{k-1}{k} - z\{\frac{1}{\zeta} - \frac{k-1}{(1+c_1)k}\}^{-1}\{\frac{1}{\zeta} - \frac{k-1}{k}\}\frac{k-1}{(1+c_1)k}\right] > 0,$$

then the optimal λ is positive.

It is evident that if σ_W^2 is small then (28) is satisfied, as the foregoing discussion suggested. Similarly, if at lease one of z and σ_s^2 is large, (28) is satisfied so that the best policy is accommodating. If the variance of the productivity shock is large and/or the household's degree of risk aversion is large, a desirable policy is to reduce the fluctuation of the total-consumption index (the term in the bracket of (20)). This implies that the policy maker should increase the money supply (m) when the price ($\bar{p}$) is increased due to a decline in productivity (s).

5. MONOPOLISTICALLY COMPETITIVE UNIONS

In the previous sections, we have maintained that labor markets are characterized by bilateral-monopoly relationship between the firm and its work force. In this section, we show that the result obtained in the previous sections does not depend on this particular assumption.

In this section, we assume that labor inputs are differentiated, and that each labor input is controlled by a monopolistically competitive union. Unions set their wage, and firms determine employment. We assume that labor markets open before product markets do. Unions determine their wage before they have perfect knowledge about the economy (predetermined wage assumption). Specifically, we assume that unions do not know labor demand conditions. Unions can observe the monetary and supply-disturbance announcement of the information agency (A and B), form rational expectations, and simultaneously determine their wages based on these expectations. By contrast, we now assume for simplicity that firms in product markets have perfect information when they determine their prices.

As in the model of Sections 2 through 4, we put normalization factors in the utility function and the production function so that equilibrium prices and wages are equal to unity when there is no disturbance.

The Representative Household

In order to incorporate labor-input differentiation and labor-market monopolistic competition into the model, we slightly modify the representative household's utility. We assume that there are t different labor inputs, all of which are used in the production of each differentiated product. The household's total-consumption index is now

$$(29) \qquad U = U(\bar{Y}, \frac{\tilde{M}}{\bar{P}}, L_1, \cdots, L_t) \equiv D(n\bar{Y})^{\zeta} (\frac{\tilde{M}}{\bar{P}})^{1-\zeta} - \gamma \cdot \Sigma_{j=1}^{t} L_j^{\mu},$$

where γ is a normalization factor such that

$$(30) \qquad \gamma = \frac{r-1}{\mu r}\{\frac{\phi(k-1)}{k}H\}^{1-\mu},$$

where r is a parameter defined later in this section. Otherwise, the representative household's preferences are the same as in Sections 2 through 4.

The Firm

We assume that the i-th firm needs t different labor inputs in order to produce its products. That is, the firm's production function is

$$(31) \qquad Q_i = (\omega \cdot \frac{1}{S} \cdot t\bar{N}_i)^{\phi}$$

where ω is a normalization factor such that

$$\omega = \left[\frac{k}{\phi(k-1)}H^{(1/\phi)-1}\right].$$

$\bar{N}_i$ is the average-labor-input index, which is defined as

$$\bar{N}_i = \bar{N}((N_{ij}\}:j=1, \cdots, t) \equiv \{(\Sigma_{j=1}^{t} N_{ij}{}^{(r-1)/r})/t\}^{r/(r-1)}.$$

Here N_{ij} is the j-th labor input of the i-th firm. The parameters satisfy $r > 1$ and $0 < \phi < \mu$. Thus, each labor input is an imperfect substitute of one another, and r represents the degree of substitutability.

The firm's real profit is then

(32) $$\Pi_i = \frac{1}{\bar{P}}\{P_i Q_i\} - \frac{1}{\bar{P}}\Sigma_{j=1}^{t} W_j N_{ij},$$

where the second term is the total real-wage payment. Here W_j is the wage of the j-th labor input.

Let us first consider the firm's cost minimization problem by taking Q_i as given. This yields

(33) $$N_{ij} = (\frac{W_j}{\bar{W}})^{-r}(\bar{N}_i) \quad \text{and} \quad \Sigma_{j=1}^{t} W_j N_{ij} = \bar{W}t\bar{N}_i = \bar{W}\omega' S'(Q_i)^{1/\phi},$$

where $\omega' = \omega^{-1}$ and $S' = S$ (we use the notation S' in order to make clear similarity of this model to that in the previous sections). Here $\bar{W}$ is the wage index corresponding to the labor-input index $\bar{N}_i$, such that

(34) $$\bar{W} = \bar{W}(\{W_j\}:j=1,\cdots,t) = \{(\Sigma_{j=1}^{t} W_j^{(1-r)})/t\}^{1/(1-r)}.$$

Note that demand is still (11). Consequently, the i-th firm's real profit is

(35) $$\Pi_i = \Pi(P_i, \bar{P}, M, \bar{W}) \equiv H(\frac{P_i}{\bar{P}})^{1-k}(\frac{M}{\bar{P}}) - \omega'\{S'\frac{\bar{W}}{\bar{P}}\}(H(\frac{P_i}{\bar{P}})^{-k}(\frac{M}{\bar{P}}))^{1/\phi}.$$

Thus, the firm's real-profit function has a functional form similar to (16).

As in Sections 2 through 4, the firm maximizes the representative household's utility with respect to P_i. This turns out to be equal to maximize the real profit (35) with respect to P_i.

<u>The Union</u>

Let us look at labor demand. Let L_j be the demand for the j-th labor input, such that $L_j \equiv \Sigma_{i=1}^{t} N_{ij}$. Define the average-labor-demand index $\bar{L}$ such as

$$(36) \qquad \bar{L} \equiv \frac{1}{t}\Sigma_{j=1}^{t}\left(\frac{W_j}{\bar{W}}\right)L_j.$$

Then we obtain[15]

$$(37) \qquad L_j = \left(\frac{W_j}{\bar{W}}\right)^{-r}(\bar{L}) \text{ where } \bar{L} = \omega' S'\{H(\frac{M}{\bar{P}})\}^{1/\Phi}.$$

In a monopolistically competitive labor market, the supply of one type of labor is controlled by one union. The union controlling the j-th labor input sets the wage W_j in order to maximize the utility of the representative household. This turns out to be equal to maximize the following "union preference" function.

$$(38) \; \Phi_j = \Phi(W_j, \bar{W}, M, \bar{P}) \equiv \frac{W_j}{\bar{P}}\left(\frac{W_j}{\bar{W}}\right)^{-r}\omega' S'\{H(\frac{M}{\bar{P}})\}^{1/\Phi} - \gamma\left[\left(\frac{W_j}{\bar{W}}\right)^{-r}\omega' S'\{H(\frac{M}{\bar{P}})\}^{1/\Phi}\right]^{\mu},$$

Thus, the union's preference function has a functional form similar to (16).

Equilibrium

Because of the similarity between the firm's profit function, and the union's preference function, and (16), one can expect a similar result in this monopolistically-competitive-labor-market case. Following the same procedure as in Sections 2 through 4, we have the equilibrium price in product markets such that

(39) $$\bar{p} = \Phi\{\bar{w} + (\frac{1}{\Phi} - 1)m + s\},$$

where as in Sections 3 and 4, $\bar{p} = \bar{P} - 1$, $s = S' - 1$, $\bar{w} = \bar{W} - 1$, and so on. Note that under the assumption of this section, firms are perfectly informed. Similarly, we obtain the following equilibrium wage

(40) $$\bar{w} = \{1 - (\mu - 1)\frac{1}{\Phi}\}E(\bar{p}|A, B) + (\mu - 1)\frac{1}{\Phi}E(m|A, B) - (\mu - 1)E(s|A, B),$$

where $E(\cdot|A, B)$ is now the expectation of the union. Combining these two equations and taking account that unions can correctly infer $\bar{w}$ because of homogeneous information ($E(\bar{w}|A, B) = \bar{w}$), we get

(41) $$\bar{p} = E(m|A, B) + \frac{\mu}{\{(\mu/\Phi) - 1\}}E(s|A, B).$$

It is evident that (41) is qualitatively the same as (21). Thus, the result obtained in the previous sections also hold true in the case of monopolistically competitive labor markets with minor modifications.

6. CONCLUDING REMARKS

We have shown in this paper that simple information provision may not be desirable in a monopolistically competitive economy under productivity shocks. If households' risk aversion is strong enough, then there are cases in which no information is better than perfect information. Monetary policy clearly dominates simple information provision in this case. The Nash inefficiency is the principal cause of the sub-optimality of perfect information. It also provides a new rationale for monetary policy: it enables the policy maker to improve social welfare of a laissez-faire economy "trapped" in the Nash inefficiency.

NOTES

1. The assumption of only one representative household is made only for expositional simplicity. The result of the model does not change if there are many identical households.

2. This may be an information bureau of the government. For example, in the case of the money supply, the central bank itself provides the public with information about it. Or it may be a private forecaster who announces his own estimate of the money supply and the productivity shock.

3. The model presented here incorporates productivity shocks in the framework of Nishimura (1991: Chapter 2). However, this model differs from the latter in an important way. Nishimura (1991) assumes that firms know their own demand and cost conditions but that they do not know their competitors' prices. Thus, the focus is on the strategic uncertainty in which other firms' decision is not perfectly known to them. However, in this model, we assume homogeneous information, so that firms can correctly infer other firms' prices. However, they do not have perfect information about their own demand and cost conditions. Thus, we are concerned with non-strategic uncertainty in the following analysis.

4. We assume away the possibility that firms renege on their price offers and ration their products. Such behavior antagonizes customers and may be detrimental to the long-run profits. Thus, we implicitly assume that the cost of turning customers away is large. The presence of the cost of turning customers away is absolutely standard in operations research and inventories models (see Taha (1982: Chapter 12)). This cost is also incorporated into oligopoly models (see Dixon (1989)).

5. In equilibrium described below, the total consumption index is equal to the household's real wealth (in which disutility of labor is taken into

account). Portfolio theory tells us that people are likely to averse risk in their real wealth. Thus, $z > 0$ is likely.

6. The assumption that the representative consumer supplies labor to all firms is not essential in the following analysis. We have a model similar to that in the text if there are n households supplying only one type of labor inputs which is specific to a particular firm, so long as preferences over consumption of goods and liquidity services of real balances are the same as in the text.

7. Thus, we allow increasing returns to scale, as long as this is dominated by an increasing marginal disutility of labor.

8. Technically, this assumption implies that there may be negative S'. Although a negative S' causes a problem in its interpretation, we can make the possibility arbitrary small by choosing an appropriate σ_S^2.

9. This is true so long as M and S' are not far from unity (that is, the quadratic approximation of (15) remains a good approximation).

10. Conditional information provision may be better than both of simple information provision and no information provision. However, because our purpose is not to find the first-best information policy but to show that perfect information may be domintated by no informaton, we do not consider possibility of conditional information provision in this paper.

11. Note that in our model ω' is chosen so as to normalize the equilibrium price to unity under perfect information. Consequently, an increase in k reduces social welfare by increasing ω', instead of increasing the equilibrium price.

12. Clearly, this does not always coincide with the optimal monetary policy in the set of all monetary policies including non-linear monetary policy. Thus, we do not use the term the "optimum monetary policy" in this section.

13. A parallel case in which the cost announcement contains a much larger error can be also easily analyzed. However, things become quite complicated if both announcements contain forecast errors of a similar magnitude.

14. Bils (1987) estimates the marginal labor cost in manufacturing, assuming the bilateral-monopoly labor-market relationship (labor as a quasi-fixed factor) in a similar way to the present model. His estimate implies that c_1 = 0.24 if the production function exhibits constant returns. Hall (1986) investigates the mark-up in many industries. His estimate of the mark-up in durables and non-durables in manufacturing implies that k = 2.67.

15. Because by definition we have

$$t\bar{W}\bar{L} = \Sigma_{j=1}^{t} W_j L_j = \Sigma_{i=1}^{n} \Sigma_{j=1}^{t} W_j N_{ij},$$

the latter part of (33) implies

$$\bar{L} = \omega' S' \frac{1}{t} \Sigma_{i=1}^{n} (Q_i)^{1/\phi}.$$

Note that the union knows that in equilibrium $P_i = \bar{P}$ for all i. Thus, we have the formula in the text from the definition of L_j, (36) and (33).

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APPENDIX

1. A QUADRATIC APPROXIMATION OF THE FIRM'S OBJECTIVE FUNCTION

The second-order Taylor expansion of (15) is

$$\Psi\{X\} = \Psi\{(\mathbf{1})\} + \Psi_X\{X - (\mathbf{1})\} + (1/2)\{X - (\mathbf{1})\}'\Psi_{XX}\{X - (\mathbf{1})\}, \tag{A1}$$

where $X = (P_1, \cdots, P_n, \bar{P}, M, S')'$ and $(\mathbf{1}) = (1, \cdots, 1)'$. Here ' denotes the transpose, Ψ_X is the first derivative and Ψ_{XX} is the second derivative of Ψ evaluated at $X = (P_1, \cdots, P_n, \bar{P}, M, S')' = (1, \cdots, 1)$. Note that by construction we have $\Psi_{P_i} = 0$.

Let the lower-case-letter variable represent the deviation of the corresponding upper-case-letter variable from unity, so that $p_i = P_i - 1$, $\bar{p} = \bar{P} - 1$, $m = M - 1$, and $s = S' - 1$ (we omit ' in s for notational simplicity). From (A1), the i-th firm's objective function is then

$$E(\Psi|A, B) = \frac{1}{2}\Psi_{P_iP_i}\cdot p_i^2 + \Psi_{P_i\bar{P}}\cdot p_iE(\bar{p}|A, B) + \Psi_{P_iM}\cdot p_iE(m|A, B) + \Psi_{P_iS'}\cdot p_iE(s|A, B) + (\text{terms given to the i-th firm}), \tag{A2}$$

where $\Psi_{P_i} = 0$ is used. Here $\Psi_{P_iP_i}$, $\Psi_{P_i\bar{P}}$, Ψ_{P_iM}, and $\Psi_{P_iS'}$ are

$$\Psi_{P_iP_i} = -(U^*)^{-Z}(k - 1)(1 + c_1k)H;\quad \Psi_{P_i\bar{P}} = (U^*)^{-Z}(k - 1)\{1 + c_1(k - 1)\}H;$$
$$\Psi_{P_iM} = (U^*)^{-Z}c_1(k - 1)H;\quad \text{and } \Psi_{P_iS'} = (U^*)^{-Z}(k - 1)H, \tag{A3}$$

where $H = (1/n)\{\zeta/(1 - \zeta)\}$, and U^* is the total-consumption index when $P_i = \bar{P} = M = S' = 1$, which is equal to

$$\text{(A4)} \qquad U^* = \left\{\frac{1}{\zeta} - \frac{k - 1}{(1 + c_1)k}\right\}H^*,$$

where $H^* = nH = \{\zeta/(1 - \zeta)\}$.

2. A QUADRATIC APPROXIMATION OF THE SOCIAL WELFARE FUNCTION

Through straightforward but tedious calculation, we have the second-order Taylor expansion of the social welfare function Ψ^S around $P_i = \bar{P} = M = S' = 1$, which can be rearranged in terms of deviation from unity in the following way.

$$\text{(A5)} \quad \frac{(U^*)^z}{H^*}\Psi^S - \frac{(U^*)^z}{H^*}\cdot\frac{1}{1-z}\cdot\{U^*\}^{1-z}$$

$$= F_y(m - \bar{p}) - F_s s - \frac{1}{2}\left[\frac{c_1(k - 1)}{k} + zF_{yy}\right](m - \bar{p})^2$$

$$- F_y\{(m\bar{p}) - (\bar{p})^2\} - \left\{\frac{k - 1}{k} - zF_{ys}\right\}(m - \bar{p})s - \frac{1}{2}zF_{ss}s^2,$$

where

$$F_y = \frac{1}{\zeta} - \frac{k - 1}{k}; \quad F_s = \frac{k - 1}{(1 + c_1)k}; \quad F_{yy} = \frac{H^*}{U^*}\cdot(F_y)^2;$$

(A6)

$$F_{ss} = \frac{H^*}{U^*}\cdot(F_s)^2; \quad \text{and} \quad F_{ys} = \frac{H^*}{U^*}\cdot F_y F_s.$$

3. RATIONAL EXPECTATIONS

We consider the case in which the government's monetary policy has the form: $m = \lambda s$, where λ is a constant. Note that the policy of doing nothing is equal to the one setting $\lambda = 0$.

The problem is to find the conditional expectation of s based on A and B such that $A = \lambda s + V$ and $B = s + W$, where s, V, and W are independently normally distributed with $E(s) = E(V) = E(W) = 0$; $Var(s) = \sigma_s^2$; $Var(V) = \sigma_V^2$; and $Var(W) = \sigma_W^2$. The solution of this problem is found by the linear least squares regression. It is $E(s|A, B) = \delta A + \theta B$, where

$$\text{(A7)} \qquad \delta = \frac{\lambda^2(\sigma_W^2/\sigma_V^2)\sigma_s^2}{\lambda^2(\sigma_W^2/\sigma_V^2)\sigma_s^2 + \sigma_s^2 + \sigma_W^2},$$

and

$$\text{(A8)} \qquad \theta = \frac{\sigma_s^2}{\lambda^2(\sigma_W^2/\sigma_V^2)\sigma_s^2 + \sigma_s^2 + \sigma_W^2}.$$

It is evident from the above relations that if either $\lambda = 0$ (Section 3) or $\sigma_V^2 >> \sigma_W^2 \cdot \sigma_s^2$ (Section 4), then $\delta = 0$ and $\theta = \sigma_s^2/(\sigma_s^2 + \sigma_W^2)$.

4. PROOFS OF PROPOSITIONS 1 AND 2

From the results obtained in the text, we know that $\bar{p}_{PI} = (1/c_1)s$ and $\bar{p}_{II} = (1/c_1)\{\sigma_s^2/(\sigma_s^2 + \sigma_W^2)\}(s + W)$. Because $m = 0$, we have $E(\bar{p})^2 = E(m - \bar{p})^2 = - E(m - \bar{p})\bar{p}$, and $E(ms) = 0$, and $E(m - \bar{p})s = - E(\bar{p}s)$. Consequently, we obtain from (A5)

$$\text{(A9)}\left[E\left[\frac{(U^*)^z}{H^*}\psi^s\right]_{PI} - E\left[\frac{(U^*)^z}{H^*}\psi^s\right]_{II}\right]\left[(\frac{1}{c_1})^2\sigma_s^2\{1 - \frac{\sigma_s^2}{\sigma_s^2 + \sigma_w^2}\}\right]^{-1}$$

$$= -\frac{1}{2}\cdot\frac{c_1(k - 1)}{k} + (\frac{1}{\zeta} - \frac{k - 1}{k}) + \frac{k - 1}{k}c_1$$

$$- \frac{zH^*}{2U^*}\cdot\left[(\frac{1}{\zeta} - \frac{k - 1}{k})^2 + 2(\frac{1}{\zeta} - \frac{k - 1}{k})\{\frac{k - 1}{(1 + c_1)k}\}c_1\right].$$

<u>Proof of PROPOSITION 1.</u> If $z = 0$, then the sign of $E\Psi^*_{PI} - E\Psi^*_{II}$ depends on

$$(\frac{1}{\zeta} - \frac{k - 1}{k}) + \frac{1}{2}\cdot\frac{c_1(k - 1)}{k},$$

which is positive because $1 > \zeta$ and $k > 1$.

<u>Proof of PROPOSITION 2.</u> Let z^+ be z making $E\Psi^S_{PI} - E\Psi^S_{II} = 0$. From (A9), and taking the definition of H^* and U^*(see (A4)) we obtain that

$$z^+ = \left[\frac{1}{2}\cdot\frac{c_1(k - 1)}{k} + (\frac{1}{\zeta} - \frac{k - 1}{k})\right]$$

$$\cdot 2\{\frac{1}{\zeta} - \frac{k - 1}{(1 + c_1)k}\}\cdot\left[(\frac{1}{\zeta} - \frac{k - 1}{k})^2 + 2(\frac{1}{\zeta} - \frac{k - 1}{k})\{\frac{k - 1}{(1 + c_1)k}\}c_1\right]^{-1}.$$

Because $1 > \zeta$ and $k > 1$, it is evident that if $z > z^+$, then $E\Psi^S_{PI} < E\Psi^S_{II}$.

5. SOCIAL WELFARE UNDER AN ACTIVE MONETARY POLICY ($\lambda \neq 0$) AND THE PROOF OF PROPOSITION 3

Under the assumption of Section 4 ($m = \lambda s$ and $\sigma_v^2 >> \sigma_s^2\sigma_w^2$), we have $\tilde{p} = (1/c_1)\theta(s + W)$. Consequently, social welfare is from (A5)

$$E\left[\frac{(U^*)^z}{H^*}\psi s\right] = -\frac{1}{2}\left[\frac{c_1(k - 1)}{k} + zF_{yy}\right]\left[\{\lambda(1 - \theta) - \frac{1}{c_1}\theta\}^2\sigma_s^2 + (\lambda + \frac{1}{c_1})^2\theta^2\sigma_w^2\right]$$

$$- F_y\{\lambda^2 + \frac{1}{c_1}\lambda\}\theta^2\sigma_s^2 + F_y(\lambda + \frac{1}{c_1})^2\theta^2(\sigma_s^2 + \sigma_w^2)$$

$$- \{\frac{k - 1}{k} - zF_{ys}\}\{\lambda(1 - \theta) - \frac{1}{c_1}\theta\}\sigma_s^2 + \text{constant terms.}$$

Differentiating this with respect to λ, and rearranging terms of the first-order condition, we have

$$\lambda^* = \left[\frac{c_1(k - 1)}{k} + zF_{yy}\right]^{-1}\left[\frac{1}{c_1}F_y(\sigma_s^2/\sigma_w^2) - \{\frac{k - 1}{k} - zF_{ys}\}\right].$$

Because $k > 1$, $c_1 \geqq 0$, $z \geqq 0$, and $Fyy > 0$, we have PROPOSITION 3, by substituting F_y and F_{ys} with (A6).

TABLE 1

CRITICAL VALUE OF z MAKING NO INFORMAITON BETTER
THAN PERFECT INFORMATION:
NUMERICAL EXAMPLES OF z+

ζ	k	c_1	z^+
0.7	1.1	0.1	1.99
0.7	1.1	3	2.10
0.7	1.1	6	2.28
0.7	3	0.1	1.94
0.7	3	3	3.31
0.7	3	6	5.08
0.7	10	0.1	1.91
0.7	10	3	4.55
0.7	10	6	7.67
0.3	10	0.1	1.97
0.3	10	3	2.55
0.3	10	6	3.40

TABLE 2

NUMERICAL EXAMPLES OF THE OPTIMUM MONETARY POLICY

σ_s^2	σ_w^2	z	optimal λ	SOCIAL WELFARE: DEVIATION FROM PERFECT-INFORMATION CASE: no information	optimal policy
1	0.1	0	216.13	-1.380	319.470
1	0.1	2	21.81	0.0476	33.306
1	0.1	4	11.77	1.4755	19.895
1	2	0	6.85	-10.1215	-7.7593
1	2	2	1.25	0.3493	1.1452
1	2	4	0.96	10.8201	11.7120
1	10	0	-1.96	-13.8020	-13.5372
1	10	2	0.38	0.4763	0.5773
1	10	4	0.50	14.7547	15.0886

Note: Forecast errors in the monetary announcement is assumed to have much larger variance than that of forecast errors in the supply-disturbance announcement.
Other parameters are: $\zeta = 0.7$; $c_1 = 0.24$; $k = 2.7$.