Comment on Iovino, La'O and Mascarenhas, "Optimal Monetary Policy and Disclosure with an Informationally-Constrained Central Banker"*

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Abstract

Iovino, La'O and Mascarenhas (forthcoming) ask two important questions regarding the optimal conduct of monetary policy: Should the central bank's policy depend on information the central bank has that is not available to markets? And should the central bank disclose information that it has but market participants do not? Iovino, La'O and Mascarenhas answer these questions using a simple, stylized model with one-period price stickiness. They show that efficient equilibria can be sustained regardless of whether policy depends on the central bank's information and regardless of its disclosure policy. We explain the logic behind their irrelevance result and show that if restrictions are imposed on equilibria, then monetary policy should in general depend on the central bank's information. Finally, we offer some speculative answers to their questions and discuss the sense in which policy is converging towards theory.

*The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

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1 Introduction

In their paper, Iovino, La'O and Mascarenhas ask two questions regarding optimal monetary policy. The first question is, Should the central bank's policy depend on information the central bank has that is not available to markets? The second question is, Should the central bank disclose information that it has but market participants do not?

Iovino, La'O and Mascarenhas answer these questions using a simple, stylized sticky-price model. In their model, prices are sticky for only one period. They show that the efficient allocation is an equilibrium outcome regardless of whether the central bank's policy depends on its information and regardless of the information the central bank chooses to disclose. In this sense, their model is silent about whether the central bank's policy should depend on its information and also about whether information disclosure is desirable. Nevertheless, their setup is a very useful starting point to answer the two important questions they pose.

In this comment, we explain the logic behind Iovino, La'O and Mascarenhas's irrelevance result. We go on to show that seemingly desirable policy rules can also be associated with inefficient equilibrium outcomes. The central reason for these findings is that Iovino, La'O and Mascarenhas's environment is plagued by nominal indeterminacy. This indeterminacy implies that any given real equilibrium allocation has many nominal interest-rate paths and inflation rates associated with it. Thus, efficient allocations can be implemented by many different interest-rate rules, provided inflation rates adjust appropriately, and also by many different inflation-rate paths, as long as nominal interest rates adjust appropriately. Furthermore, specifying a nominal interest-rate rule does not by itself suffice to implement efficient outcomes. For any given interest-rate rule, there are many associated inflation paths and real allocations that are consistent with equilibrium. We show that if restrictions are imposed on inflation-rate paths, then monetary policy should in general depend on the central bank's information.

After explaining the logic behind Iovino, La'O and Mascarenhas's irrelevance result, we offer some speculations regarding their questions. In terms of what policy should depend on, we argue that a sensible benchmark is to examine optimal policy rules under commitment. The nature of the dependence of the rules that should govern monetary policy is then given by the nature of dependence of optimal policy rules under commitment.

We also offer speculations on optimal information disclosure. The conventional wisdom is that policy makers should disclose all the information that they possess. We discuss a recent literature that offers caveats to this idea. We argue that while these caveats should be explored more intensively, at this time, the weight of theory and evidence continues to support the conventional wisdom.

2 The Logic behind Iovino, La'O and Mascarenhas's Irrelevance Result

Iovino, La'O and Mascarenhas's model is a relatively standard general-equilibrium model with nominal rigidities. A representative household consumes, saves, and supplies labor. Production is conducted by a unit mass of differentiated intermediate-good firms that face a common aggregate productivity shock—the only real shock in the economy. Firms make nominal pricing decisions under incomplete information about the aggregate state. This approach is now a standard way of introducing nominal rigidities (see Angeletos and La'O, 2020; Mackowiak and Wiederholt, 2009; Mankiw and Reis, 2002; Woodford, 2001). A consolidated (fiscal and monetary) authority with full commitment has three policy tools: a constant revenue tax/subsidy, the nominal interest rate, and lump-sum transfers. The monetary authority is subject to an informational constraint: it has incomplete information about the current state of the economy, about which it receives a noisy signal. The nominal interest rate can be contingent only on the central banker's incomplete information set at that point in time. Households make their decisions under complete information.

We begin by describing a deterministic version of Iovino, La'O and Mascarenhas's environment and then extend it to a stochastic model. Consider a discrete-time infinite horizon model with a unit mass of intermediate-good firms, indexed by i, which operate the same linear technology to produce output y_{it}. This technology is given by

$$y_{it} = A_t \ell_{it}, \qquad \forall i \in I \equiv [0,1], \tag{1}$$

where $A_t > 0$ is the (common) aggregate productivity level and ℓ_{it} is the amount of labor demanded by firm i at time t.

Firms set nominal prices p_{it}, taking as given nominal wages W_t and a constant revenue tax τ. As usual, their objective is to maximize profits: $\pi_{it} = (1-\tau)p_{it}y_{it} - W_t \ell_{it}$.

A perfectly competitive final goods producer combines intermediate inputs y_{it} to produce the final good, Y_t, using the CES aggregator:

$$Y_t = \left(\int_i y_{it}^{\frac{\theta-1}{\theta}} \, di \right)^{\frac{\theta}{\theta-1}}, \tag{2}$$

where $\theta > 1$ is the elasticity of substitution across intermediate goods.

The economy has a representative household with preferences:

$$\sum_{t=0}^{\infty} \beta^t \big[U(C_t) - V(L_t)\big], \tag{3}$$

where $\beta \in (0,1)$ is the discount factor; $U : \mathbb{R}_+ \to \mathbb{R}_+$ and $V : \mathbb{R}_+ \to \mathbb{R}_+$ satisfy standard regularity conditions; and

$$L_t = \int_i \ell_{it}\, di, \quad \forall t \tag{4}$$

and

$$C_t \leqslant Y_t, \quad \forall t, \tag{5}$$

where L_t denotes aggregate labor supply and C_t denotes aggregate consumption.

The household's budget constraint at time t, expressed in nominal terms, is

$$P_t C_t + B_{t+1} \leqslant W_t L_t + (1+\iota_t)B_t + \int_i \pi_{it}\, di + T_t, \tag{6}$$

where P_t is the nominal price of the final consumption good, W_t is the nominal wage, B_{t+1} is risk-free nominal bonds that pay $(1+\iota_t)B_{t+1}$ one period later, π_{it} is firm profits, and T_t is lump-sum taxes/transfers from the government.

The economy has a consolidated (fiscal and monetary) authority which has full commitment and three policy tools: the nominal interest rate, ι_t, a constant revenue tax/subsidy, τ, and lump-sum transfers, T_t. The government's budget constraint is

$$\int_i \tau p_{it} y_{it}\, di + B^g_{t+1} = T_t + (1+\iota_t)B^g_t. \tag{7}$$

2.1 Shocks and Information

We now introduce shocks and describe the information structure of the economy. In each period t, nature draws from a finite set S a random variable s_t, the fundamental state. This state follows a Markov process given by the probability distribution $\mu(s_t|s_{t-1})$. Importantly, s_t determines aggregate productivity via $A : S \to \mathbb{R}_+$, where $A_t = A(s_t)$. Productivity shocks are the only real shocks in this economy.

The central banker lacks perfect information about the fundamental state. Before choosing the nominal interest rate, the central banker observes a noisy, private signal, ω_{pt}, about the current fundamental state. This signal is drawn from the finite set Ω_p according to the conditional probability distribution $\varphi_p(\cdot|s_t)$.

Firms also lack perfect information of the current fundamental state. Similar to the central banker, they observe noisy, private signals $\{\omega_{it}\}$ about s_t and also about the information possessed by the central authority ω_{pt}. Signals ω_{it} are i.i.d. across firms and drawn from the conditional probability distribution $\varphi(\cdot|s_t, \omega_{pt})$.

Although the random variable s_t captures the fundamental state of the economy, private signals have the potential to affect equilibrium outcomes. For this reason, it is convenient to augment the fundamental state. Iovino, La'O and Mascarenhas use $\bar{s}_t \in \overline{S}$ to denote the augmented fundamental state and refer to it as the "true, full aggregate state." In what follows, we adopt this convention. The true, full aggregate state $\bar{s}_t \in \bar{S}$ is given by

$$\bar{s}_t = \left\{ s_t, \omega_{pt}, \varphi(\omega_{it}|s_t, \omega_{pt}) \right\}, \tag{8}$$

where ω_{pt} is the private signal of the central banker about s_t and $\varphi(\omega_{it}|\cdot,\cdot)$ is the conditional cross-sectional distribution of firm signals.

The information structure of the economy is succinctly summarized by the information sets of the central banker and the firms; these are $\{\omega_{pt}, \bar{s}^{t-1}\}$ and $\{\omega_{it}, \bar{s}^{t-1}\}$, respectively.

The two key assumptions in Iovino, La'O and Mascarenhas's model are as follows:

Assumption 1. *The nominal price of any intermediate-good firm is allowed to depend only on its private information and the past history of the true, full aggregate state. That is,* $p_{it}(\omega_{it}, \bar{s}^{t-1})$ *for all* $i, t, \omega_{it}, \bar{s}^{t-1}$.

Assumption 2. *The nominal interest rate set by the central banker is allowed to depend only on the central banker's private information and the past history of the true, full aggregate state. That is,* $\iota_t(\omega_{pt}, \bar{s}^{t-1})$ *for all* $t, \omega_{pt}, \bar{s}^{t-1}$.

Assumption 1 imposes that intermediate-good producers make nominal pricing decisions based only on their incomplete, private information about the true aggregate state. Assumption 2 is similar in spirit. It imposes that the central banker sets nominal interest rates based on his or her incomplete, private information about the aggregate state.

Assumptions 1 and 2 can be jointly understood as a timing assumption. At the beginning of each period, nature draws the true, full aggregate state, $\bar{s}_t \in \overline{S}$. Then, the central banker and the firms observe their private signals and make their respective decisions under incomplete information—that is, they set the nominal interest rate and nominal intermediate-good prices, respectively. Once these objects have been determined, the aggregate state is revealed economy-wide, and households make their decisions.

2.2 Efficient Allocations

An allocation $\{c_{it}(\bar{s}^t), \ell_{it}(\bar{s}^t), y_{it}(\bar{s}^t), C_t(\bar{s}^t), L_t(\bar{s}^t), Y(\bar{s}^t)\}$ is efficient if it solves

$$\max \quad \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[U(C_t(\bar{s}^t)) - V(L_t(\bar{s}^t))\right]$$

subject to the analogs of (1), (2), (4), and (5).

2.3 Equilibrium with Complete Information and Flexible Prices

Suppose all parties have complete information about the fundamental state of the economy, s_t. In this case, the timing is as follows. At the beginning of the period, s_t is realized. All allocations and prices are functions of the history s^t. Then, intermediate-good producers choose nominal prices $p_{it}(s^t)$ and the monetary authority chooses the nominal interest rate $\iota(s^t)$. Finally, the household chooses its allocations, and $W_t(s^t), P_t(s^t)$ are determined.

An allocation is given by

$$\xi = \left\{ \{\ell_{it}(s^t), y_{it}(s^t)\}_{i \in I}, Y_t(s^t), C_t(s^t), L_t(s^t), B_{t+1}(s^t) \right\}_{s^t \in S^t},$$

a price system by

$$\rho = \left\{ \{p_{it}(s^t)\}_{i \in I}, P_t(s^t), W_t(s^t) \right\}_{s^t \in S^t},$$

and a policy by

$$\vartheta = \left\{ \tau, \iota_t(s^t), T_t(s^t), B^g_{t+1}(s^t) \right\}_{s^t \in S^t}.$$

Definition 1. *A flexible-price equilibrium is a triplet (ξ, ρ, ϑ) of allocations, prices, and policies such that households and firms maximize and markets clear.*

The conditions that a flexible-price equilibrium must satisfy at all $t, s^t \in S^t$ are then

$$\frac{V'(L_t(s^t))}{U'(C_t(s^t))} = \frac{W(s^t)}{P(s^t)}, \tag{9}$$

$$\frac{U'(C_t(s^t))}{P_t(s^t)} = \beta\left[1 + \iota(s^t)\right] \mathbb{E}\left[\frac{U'(C_{t+1}(s^{t+1}))}{P_{t+1}(s^{t+1})} \middle| s^t \right], \tag{10}$$

$$p_{it}(s^t) = \left(\frac{\theta}{\theta - 1}\right) \frac{1}{1 - \tau} \frac{W_t(s^t)}{A_t(s_t)}, \tag{11}$$

$$P_t(s^t) = \left[\int_0^1 p_{it}(s^t)^{\theta - 1}\, di \right]^{\frac{1}{\theta - 1}}, \tag{12}$$

together with equations (1), (2), (4), (5) with equality, and (7), where $B^g_{t+1} = B_{t+1} = 0$ for all t, s^t.

Equation (9) equates the marginal rate of substitution between consumption and labor to the real wage rate. Equation (10) is the standard inter-temporal Euler equation. Equation (11) describes optimal price-setting behavior by intermediate-good producers, and equation (12) determines the price of the final good. The remaining equations are identities and other conditions that ensure market clearing.

It is important to note that if $\left(\frac{\theta}{\theta-1}\right)\frac{1}{1-\tau} = 1$, then the equilibrium is efficient in that

$$C_t(s^t) = C^*(s_t),$$
$$L_t(s^t) = L^*(s_t),$$

but many interest rates and price level paths $\{\iota_t, P_t\}$ can be chosen to satisfy the inter-temporal Euler equation (10) and thus support efficient outcomes. In this formulation, the implicit assumption is that lump-sum taxes are adjusted in the background across different nominal equilibria. That is, equilibrium in this economy is in what Woodford (2003) refers to as a "Ricardian regime." The nominal indeterminacy that is pervasive in such economies plays a critical role in Iovino, La'O and Mascarenhas's irrelevance result.

In all that follows, we assume that the constant revenue tax, τ, is set so as to exactly offset monopolistic distortions.

2.4 Equilibrium with Complete Information and Sticky Prices

Next, consider an economy with no private information, but it has sticky prices in that intermediate-good producers in period t choose prices before the realization of the period-t shock. Specifically, consider the following timing. First, the intermediate-good producers choose nominal prices $p_{it}(s^{t-1})$. Then, the monetary authority chooses the nominal interest rate $\iota_t = \iota^*(s^{t-1})$. Finally, s_t is realized, and households make their decisions.

In what follows, we adopt the following notation. We use subscripts to denote time periods in which actions are taken and arguments to denote information on which decisions are based. With this convention, $P_t(s^{t-1})$ should be interpreted as the price of the final consumption good in period t, which is determined based only on information about the fundamental economic state up to period $t-1$.

The definitions of the allocation, price system, and policy are suitably modified versions of those used in the flexible-price economy.

Definition 2. *A sticky-price equilibrium is a triplet* (ξ, ρ, ϑ) *of allocations, prices, and policies, in which nominal prices and interest rates at time* t *depend only on* s^{t-1}*, wages depend on* s^t*, and* (ξ, ρ, ϑ) *are such that firms and households maximize and markets clear.*

We can now establish the following result.

Proposition 1. *The efficient outcome is an equilibrium allocation of the sticky-price economy.*

Proof. We prove the proposition by constructing prices and policies, and we show that together with the efficient allocation, this construction satisfies the equilibrium conditions. Let $P_t^*(\cdot)$ be defined by the recursion

$$P_{t+1}^*(s^t) = P_t^*(s^{t-1})\beta\left[1 + \iota_t^*(s^{t-1})\right]\mathbb{E}\left[\frac{U'(C^*(s_{t+1}))}{U'(C^*(s_t))}\middle| s^t\right], \tag{13}$$

which starts from $P_0^*(s^{-1}) = 1$, and let $W_t(s^t) = P_t^*(s^{t-1})A(s_t)$. Thus, the marginal rate of substitution between consumption and leisure equals $1/A(s_t)$, as required by efficiency. Inspecting (13), we can see that the inter-temporal Euler equation (10) is satisfied.

Next, we check the price-setting equation given by

$$p_{it}(s^{t-1}) = \mathbb{E}\left[q_{it}(s^t)\frac{W_t(s^t)}{A_t(s_t)}\middle| s^{t-1}\right], \quad \text{where} \quad q_{it}(s^t) = \frac{\Lambda(s^t)y_{it}(s^t)}{\mathbb{E}\left[\Lambda(s^t)y_{it}(s^t)|s^{t-1}\right]}, \tag{14}$$

where $\Lambda(s^t)$ is the marginal utility of wealth (i.e., the Lagrange multiplier associated with the household's budget constraint).

Substituting for $W_t(s^t)$ gives

$$p_{it}(s^{t-1}) = P_t^*(s^{t-1})\underbrace{\mathbb{E}\left[\frac{\Lambda(s^t)y_{it}(s^t)}{\mathbb{E}\left[\Lambda(s^t)y_{it}(s^t)|s^{t-1}\right]}\middle| s^{t-1}\right]}_{=1} = P_t^*(s^{t-1}). \tag{15}$$

□

Notice that this is an equilibrium with arbitrary $\iota^*(\cdot)$, in which prices do all the work.

2.5 Equilibrium with Incomplete Information and Sticky Prices

Now, we introduce private information about the fundamental state of the economy.

2.5.1 Central Bank's Private Information

The central banker receives a noisy, private signal ω_{pt} about s_t. We assume that firms have no private information—that is, intermediate-good producers receive no signal about s_t. At the beginning of next period, the central banker's private signal ω_{pt} becomes public information.

The timing is the same as in section 2.4 except for the following modifications: intermediate-good producers set nominal prices, $p_{it}(\bar{s}^{t-1})$, and the monetary authority sets the nominal interest rate, $\iota_t(\bar{s}^{t-1}, \omega_p^t)$.

The definitions of allocation, price system, and policy are, once again, suitably modified versions of the definitions used in the flexible-price economy.

Definition 3. *A sticky-price equilibrium is a triplet (ξ, ρ, ϑ) of allocations, prices, and policies, in which nominal prices at t depend only on $\bar{s}^{t-1}$, the nominal interest rate at t depends on $(\bar{s}^{t-1}, \omega_p^t)$, wages W_t depend on $\bar{s}^t$, and (ξ, ρ, ϑ) are such that firms and households maximize and markets clear.*

Proposition 2. *Let $\iota_t^* : \bar{S} \times \Omega_p^t \to \mathbb{R}_+$ be some arbitrary function. Then, the environment with sticky prices and central bank private information has an equilibrium that coincides with the efficient outcome.*

Proof. Let $P_0^*(\bar{s}^{-1}) = 1$, and define $P_t^*(\cdot)$, for $t \geqslant 1$, by the following recursion:

$$P_{t+1}^*(\bar{s}^t) = P_t^*(\bar{s}^{t-1})\beta\left[1 + \iota_t^*(\bar{s}^{t-1}, \omega_p^t)\right]\mathbb{E}\left[\frac{U'\big(C^*(\bar{s}_{t+1})\big)}{U'\big(C^*(\bar{s}_t)\big)}\middle|\bar{s}^t\right]. \tag{16}$$

Then, let $W_t(\bar{s}^t) = P_t^*(\bar{s}^{t-1})A(s_t)$. Clearly, the inter-temporal Euler equation (10) holds by construction. Then, notice that W_t has been chosen, given P_t^*, to satisfy (9) given C_t^* and L_t^*. Since $\left(\frac{\theta}{\theta-1}\right)\frac{1}{1-\tau} = 1$ by assumption, we need only to verify that the sticky-price pricing equation holds. We do so by following the same steps as in the proof of Proposition 1. □

We now provide two examples to clarify our discussion.

Example I. Suppose that the nominal interest rate ι_t is independent of the central banker's private information ω_p^t. For instance, suppose that $\iota_t^* = \iota$ for all $t, \bar{s}^{t-1}$, and ω_p^t. In this case, even though the monetary authority does not pay attention to its private information, we still get efficiency.

Example II. Suppose that prices are such that $P_{t+1}^*(\bar{s}^t) = \bar{P}$ for all $t, \bar{s}^t$. If we suppose further that the signal received by the monetary authority ω_{pt} reveals all information about the fundamental state s_t, the efficient outcome can still be supported. The reason for this result is that nominal interest rates ι_t can vary with s^t. Thus, we have shown that the monetary authority can sustain efficiency if it can tailor its policy to its private information.

The proposition and the examples illustrate that the efficient equilibrium can be implemented in a variety of ways. One has the central bank ignoring its private information and setting monetary policy but prices adjusting in such a way as to ensure that the inter-temporal Euler equation continues to be satisfied at the efficient allocations. The fundamental reason that such an implementation is possible is that the economy has nominal indeterminacy. Any value of the initial price level is consistent with equilibrium as long as all future prices are adjusted appropriately. This feature also means that it is possible to adjust the price level from period $t+1$ onwards and simply change the nominal interest rate from period t to period $t+1$ to implement any given equilibrium. Another implementation has prices in, say, period $t+1$ not responding to the history of policies and shocks. In such a case, the interest rate in period t must respond to the period-t shock to implement efficient outcomes.

Finally, we note that the assumption that the central bank's private information in period t is observed at the beginning of period $t+1$ is a mild one. If the central bank's policy rule is strictly monotone in its private information, then this private information can be recovered from the setting of the interest rate.

2.5.2 Central Bank's and Firms' Private Information

Consider the same timing assumptions as in section 2.5.1, except that we now reinstate firms' private information. In particular, we assume that like the monetary authority, firms also receive private, noisy signals $\{\omega_{it}\}$ about the current state of productivity, and that these signals are i.i.d. across firms.

Once again, the definitions of allocation, price system, and policy are suitably modified versions of the definitions used in the flexible-price economy.

Definition 4. *A sticky-price equilibrium is a triplet* (ξ, ρ, ϑ) *of allocations, prices, and policies, in which nominal prices* p_{it} *depend on* $(\bar{s}^{t-1}, \omega_i^t)$*, the aggregate price level* P_t *depends on* $(\bar{s}^{t-1})$*, the nominal interest rate at* t *depends on* $(\bar{s}^{t-1}, \omega_p^t)$*, wages* W_t *depend on* $\bar{s}^t$*, and* (ξ, ρ, ϑ) *are such that firms and households maximize and markets clear.*

Proposition 3. *Let* $\iota_t^* : \bar{S} \times \Omega_p^t \to \mathbb{R}_+$ *be some arbitrary function. Then, the environment with sticky prices and two-sided private information has an equilibrium in which the allocation is efficient.*

Proof. If each monopolistically competitive producer believes that no other producer will make nominal pricing decisions sensitive to private information, the wage rate is $W_t(\bar{s}^t) = P_t^*(\bar{s}^{t-1})A(s_t)$ so that the optimal pricing rule for any individual producer $i \in [0,1]$ is clearly $p_{it}(\bar{s}^{t-1}, \omega_i^t) = p_{it}^*(\bar{s}^{t-1})$. To show that the efficient outcome can be implemented, one can mimic the steps of the proof in Proposition 2, with ι_t^* and P_t^* now being functions of $(\bar{s}^{t-1}, \omega_p^t)$ and $(\bar{s}^{t-1})$, respectively. $\square$

Proposition 3 shows that even in the presence of two-sided informational frictions, efficiency can still be attained.

2.6 Inefficient Equilibria

We now construct an example of an economy with an inefficient equilibrium. This example illustrates that there are monetary-policy rules that can implement efficient equilibria, but the same rules can also implement inefficient equilibria. The construction here makes clear that it is easy to construct many such examples. Thus, there is no guarantee that following the "right" monetary policy ensures that efficient outcomes will result.

Consider an economy in which there is uncertainty only in the first period ($t = 0$), and only the monetary authority has private information. The timing is as follows. At the beginning of period $t = 0$, intermediate-good producers choose nominal prices p_{i0}. Then, the monetary authority receives a private signal ω_{p0} that reveals the fundamental state (i.e., $\omega_{p0} = s_0$) and then sets $\iota_0(\omega_{p0})$. At the end of the period, s_0 is realized, and households make decisions. In subsequent periods ($t \geqslant 1$), $s_t = \bar{s}$ for all t, the planner chooses $\iota_t = 1/\beta - 1$, and prices are given by $\overline{P}_1(s_0)$. (This example is closely related to that in Krugman, Dominquez and Rogoff, 1998).

Clearly, in all periods $t \geqslant 1$, the equilibrium outcome is the efficient allocation. Prices are constant over time, but the level of prices, $\overline{P}_1(s_0)$, is not uniquely pinned down.

Consider now a monetary policy that in period $t = 0$, sets $\iota_0(\omega_{p0}) = \iota_0$ for all ω_{p0}. That is, the monetary authority keeps interest rates the same in all period-0 states. In the following proposition, we show that $\overline{P}_1(s_0)$ can be chosen in such a way that the equilibrium is efficient in period 0 as well.

Proposition 4. *In the economy with uncertainty only in the first period, there exist continuation prices $\overline{P}_1(s_0)$ such that the efficient allocation is an equilibrium.*

Proof. Let $P_0 = 1$ and let $\overline{P}_1(s_0)$ be defined by

$$1 + \iota_0 = \frac{1}{\beta}\frac{\overline{P}_1(s_0)}{P_0}\frac{U'(C^*(s_0))}{U'(C^*(\bar{s}))}.$$

Let wages be given by $W_0(s_0) = A(s_0)P_0$ and $W_t(s_0) = A(\bar{s})\overline{P}_1(s_0)$ for all $t \geqslant 1$. It is easy to verify that the pricing equation is satisfied. $\square$

Thus, we have shown that an interest-rate policy that does not depend on the central bank's information implements efficient outcomes. Next, we show that the same interest-rate policy is consistent with an inefficient equilibrium. To do so, we suppose that the price level for period $t \geqslant 1$ is a constant that does not depend on the state s_0 and denote this price level by P_1.

We assume that $U(C, L) = \log(C) - bL$ for $b > 0$. Fix a continuation equilibrium $(C^*(\bar{s}), P_1)$ for all $t \geqslant 1$. We show that there is an equilibrium in which consumption in period 0, C_0, is the same across all states. Let C_0 be defined by

$$C_0 = 1 \Big/ \left\{ b\mathbb{E}\left[\frac{1}{A(s_0)}\right]\right\}, \tag{17}$$

and let P_0 be defined implicitly by

$$\frac{1}{P_0 C_0} = \beta(1+\iota)\frac{1}{P_1}\frac{1}{C^*(\bar{s})}. \tag{18}$$

Proposition 5. *Consider our economy with uncertainty only in period* $t = 0$*. Fix a continuation equilibrium* $(C^*(\bar{s}), P_1)$ *for* $t \geqslant 1$*. Then, there is an equilibrium in which* (C_0, P_0) *satisfy equations (17)–(18). Furthermore, this equilibrium is inefficient.*

Proof. Let $L_0(s_0) = C_0/A(s_0)$, so that the resource constraint holds. Let the wage rate W_0 be given by bC_0P_0, so that marginal rate of substitution between consumption and leisure equals the real wage rate. Equation (18) is simply the inter-temporal Euler equation, so that this necessary condition for equilibrium is satisfied. We need only to verify that the pricing equation holds. That is, we need to verify that P_0 satisfies

$$P_0 = \mathbb{E}\left[q_0(s_0)\frac{W_0}{A_0(s_0)}\right], \quad \text{where} \quad q_0(s_0) = \frac{\Lambda(s_0)Y_0(s_0)}{\mathbb{E}\left[\Lambda(s_0)Y_0(s_0)\right]}, \tag{19}$$

where $\Lambda(s_0)$ is the marginal utility of wealth at time $t = 0$.

Since households have log utility, $\Lambda(s_0)$ is equal to $1/(P_0C_0)$, which equals $1/(P_0Y_0(s_0))$. If we use this result and equation (17), it follows that the pricing equation (19) is satisfied. Thus, we have constructed allocations and prices for period 0 that, together with continuation allocations and prices, are an equilibrium for our economy.

To show that this equilibrium is inefficient, note that it is straightforward (using our functional-form assumptions) to prove that in the efficient allocation, labor supply L_0 is constant across states, and consumption varies across states. □

Notice in this example that if we restrict attention to equilibria in which the price level from period one onwards does not depend on period-0 shocks, it is possible to implement the efficient allocations using an interest-rate policy that varies with s_0. Thus, interest-rate policies that exploit the central bank's private information can, in some cases, be associated with better outcomes than those associated with interest-rate policies that do not.

2.7 Lessons from this Analysis

We have shown that with sticky prices and central bank private information, efficient outcomes can be implemented as equilibria with policy rules that do not depend on the central bank's private information, as well as by policy rules that do depend on this information. We have also shown that if we restrict attention to equilibria in which inflation rates do not depend on the history of shocks and actions, then efficiency necessarily requires that the central bank's policy depend on its information. Of course, given the vast multiplicity of equilibria, such dependence does not guarantee that efficient outcomes will result.

The straightforward way to proceed is to solve for the Ramsey equilibrium allowing for private information on the part of the central bank. The solution to this problem yields policy rules that specifically describe the nature of the dependence of policy on private information. The Ramsey outcome can be implemented using sophisticated policy rules along the lines of Bassetto (2002) and Atkeson, Chari and Kehoe (2010).

3 Thoughts on Iovino, La'O and Mascarenhas's Two Questions

We begin by discussing the first question. One answer to this question is in the analysis of Chari, Dovis and Kehoe (2020). In their economy, it turns out that in a Ramsey equilibrium, policy should react to a class of shocks that they label *Mundellian* shocks and should not react to a class that they label *temptation* shocks. In a one-period sticky-price model, technology shocks turn out to be Mundellian, and mark-up shocks turn out to be temptation shocks. In this sense, with one-period price stickiness, policy should depend on technology shocks, but not on mark-up shocks. With multi-period price stickiness, policy should depend on both types, because mark-up shocks turn out to be partly Mundellian and partly temptation. Thus, this example illustrates that the extent to which monetary policy should respond to various shocks depends on the details of particular models. The general point remains that the best way to answer the first question is to solve the relevant Ramsey problem.

We now turn to the second question. A vast literature has established that in a very large class of environments, more information is better. The simplest examples of these environments are in decision problems. If a decision maker uses expected utility to evaluate outcomes, then if decisions are held fixed, welfare is unaffected by new information that changes the likelihood of various states of nature. Here, more information helps if it allows decision makers to change decisions. This intuition carries through in environments with competitive, complete markets in which lump-sum redistributive policies are available. The reason is that if markets are complete, equilibrium allocations are efficient, and the equilibrium can be obtained by solving an appropriate social-planning problem. This problem is simply a decision problem.

The message of this literature is that departures from full disclosure are desirable to the extent that markets are not competitive, markets are not complete, or redistributive policies are not available.

One can construct examples in which information disclosure is inefficient. Consider the following classic example of inefficiency. This example has N individuals, one of whom has cancer. No one knows the identity of this person. The information disclosure to be considered is the immediate disclosure of the identity of the person with cancer. Suppose first that insurance markets are available and that all individuals are insured against cancer. Then, if all individuals have expected utility, they are indifferent whether the identity of the individual with cancer is revealed immediately or at a later date. Consider next an environment in which the information disclosure occurs first and then insurance markets are allowed to open. In this setting, once the identity of the person with cancer is revealed, that individual will not be able to obtain insurance from others. If all individuals are risk averse, they would strictly prefer for this information to not be disclosed.

More recent examples in game-theoretic contexts illustrate that more public information need not be better. Morris and Shin (2002) showed that in coordination problems, better public information may not lead to better outcomes. More generally, in beauty-contest problems, better public information may lead to worse outcomes, though Hellwig (2005), Svensson (2006) and Roca (2010) argued that for reasonable parameters, better public information leads to better outcomes. A useful area for further research is to examine Angeletos and Pavan (2009)'s conjecture that if equilibrium is efficient, better information is better, but if equilibrium is inefficient, better information may be worse.

One issue that has been ignored in the literature is that revealing information helps ensure accountability. If the central bank has access to information that can be verified by the legislator and the private agents if it is disclosed, then mandating central bank disclosure can help ensure that the central bank is accountable to the public. Allowing the central bank to keep this information secret may allow it to pursue actions that the public does not desire, on the grounds that it is better informed than the public.

A related issue that has received attention in the literature is transparency in the instruments that the central bank uses to make policy. Atkeson, Chari and Kehoe (2007) argue that certain kinds of instruments, like interest rates or exchange rates, are more transparent than others, like monetary aggregates, in the sense that it is easier to detect deviations from a rule. The idea is that it is more difficult for private agents to get information on monetary aggregates from sources other than the central bank. Atkeson, Chari and Kehoe also study the tightness of monetary-policy instruments. In their terminology, a monetary-policy instrument is tighter if changes in this instrument are more closely tied to the goals of monetary policy, like output or inflation. Atkeson, Chari and Kehoe argue that transparent instruments are always more desirable. In this sense, they argue that more information disclosure by the central bank is better.

Dovis and Kirpalani (2019), however, challenge the Atkeson, Chari and Kehoe view. They argue that the designers of policy rules (like legislators or the European Union) may themselves lack commitment, and be willing to overlook their rules.They argue that in such situations, opaque rules may be better to restrain their actions.

Our view is that notwithstanding the recent flurry of papers outlining circumstances under which information disclosure should be limited, the preponderance of the evidence suggests that information disclosure by central banks leads to improved economic performance.

4 Concluding Comments

An encouraging feature of recent developments in policy making is that practical policy is moving ever closer to the prescriptions of theory. Since at least Lucas and Stokey (1983), we have understood that from a theoretical perspective, it makes sense to think of policy as a function of the history of exogenous shocks. Since the contributions of Bassetto (2002) and Atkeson, Chari and Kehoe (2010), we have understood that from a theoretical perspective, it makes sense to think of policy as a function of both the history of exogenous shocks and the history of endogenous variables. As a practical matter, this formulation means that when policy makers make policy, they need to explain to the public the shocks that they have seen and why those shocks have led them to a particular course of action. Such explanations are possible only with a great deal of information disclosure.

Not too long ago, the conventional wisdom in central banks was that revealing information would serve only to unsettle markets. A sphinx-like policy was thought to be best. Today, central banks ceaselessly communicate the information they have, as well as their intentions for the future. Thus, practical policy does seem to be converging to the prescriptions of theory.

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