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Central Bank Forward Guidance and the Signal Value of Market Prices

By STEPHEN MORRIS AND HYUN SONG SHIN*

Monetary policy works through financial markets, where the central bank uses its influence over market prices to steer the economy. At the same time, market prices inform the central bank on *where* to steer the economy. Monetary policy relies on market prices, and yet monetary policy influences market prices. This two-way flow introduces a potential channel of circularity whereby market outcomes reflect central bank actions, which in turn reflect market outcomes. Paul Samuelson (1994) famously compared this potential circularity with the reactions of a monkey seeing its reflection in the mirror for the first time. The monkey reacts to its own reflection in the mirror, unaware that it is seeing its own reflection.

In deference to Samuelson, we dub the two-way flow between the market prices and monetary policy the "reflection problem". The reflection problem is of central importance to debates about central bank communication and forward guidance. Alan Blinder (1998, pp59-62) highlighted this concern in connection with policy frameworks that place communication at the center of the monetary policy framework. This concern has become more salient as policy rates have become constrained by the effective lower bound after the crisis.

We study the reflection problem in a simple model of forward guidance and compare it with our earlier work on central bank communication (Morris and Shin (2002, 2005)). In our earlier work, we examined a setting where economic agents have an exogenously given coordination motive and where the central bank faces a disclosure choice on how much public information is released. Here, we examine a model better suited to central bank communication. It addresses forward guidance — in particular, the so-called *Odyssean forward guidance*, coined by Jeffrey Campbell, Charles Evans, Jonas Fisher and Alejandro Justiano (2012), where the central bank commits to a state-contingent policy that maps outcomes to monetary policy actions. In our model, the central bank's choice is how much weight to place on market signals and how much to other information in its state-contingent policy. The speech by Benoit Cœuré (2017) is a recent restatement of how Odyssean forward guidance may be employed when policy rates are at their effective lower bound, and Andy Haldane (2017) lays out the broader context for the importance of central bank communication.

In our model, market participants each have private information about economic fundamentals, as well as a noisy public signal. The central bank chooses a reaction function for its monetary policy, where its action is a function both of a market signal that arises from the average action of market participants, and other information such as its survey data. The central bank chooses its action appropriate to the economic fundamentals. Market participants, for their part, give large weight to matching the central bank's action.

The imperative of market participants to match the central bank's action gives rise to the reflection problem. The reflection problem renders the signal value of the market signal endogenous. In particular, a greater reliance on the market signal by the central bank renders the market signal less informative of the underlying economic fundamentals. When the weight on market signals is excessive, reliance on market signals in the central bank's policy rule becomes self-defeating. In general, we find that an interior value of the weight on market signals is optimal, where the optimal weight depends on the underlying parameters of the problem.

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The broader backdrop to these questions is the information value of market prices in a decentralized setting. Market participants ought to aggregate diverse and relevant information on the economy in the classic way laid out by Friedrich Hayek (1945). However, if market participants place large weight on correctly guessing the actions of the central bank, they may underplay their own judgment and overweight their assessment of what the central bank is likely to do. If, for its part, the central bank places faith in the ability of market participants to guide its monetary policy actions, it may unwittingly complete the information loop between itself and market participants, rendering market prices uninformative.

The reflection problem arises in formal models in a number of contexts. In particular, it arises in the monetary policy model of Ben Bernanke and Michael Woodford (1997). Bond and Goldstein (2015) provide a general analysis of the reflection problem and discuss a wide variety of contexts where it may be important. We return to discuss the points of contact with the literature in our concluding discussion.

I. Model

Economic fundamentals are given by the state θ, uniformly distributed on the real line.[1] There is a continuum of market participants. Individual i observes a private signal x_i of θ distributed normally with mean θ and precision β. There is also a public signal y, normally distributed with mean θ and precision α. We interpret y as a conventional wisdom or fashionable market narrative that takes hold among market paritipants,. We assume that y is not part of the central bank's policy rule because, for instance, the conventional wisdom takes hold in a fleeting way compared to the time scale of the monetary policy process.

The central bank has access to a signal z, distributed normally around θ with precision γ. We can interpret z as survey evidence available to the central bank which has not yet been publicly disclosed. The central bank chooses an action r so as to maximize:

$$-(r-\theta)^2 \tag{1}$$

Market participant i chooses action a_i to maximize

$$-w\,(a_i-r)^2-(1-w)\,(a_i-\theta)^2 \tag{2}$$

where $w \in (0,1)$. We will be interested in the case where $w \approx 1$, so that market participants place large weight in matching the central bank's action r, but they also place some weight on matching fundamentals θ.

The central bank's forward guidance rule is given by the policy rule:

$$r=\lambda\overline{a}+(1-\lambda)\,z \tag{3}$$

where $\overline{a}$ is the average action of market participants, interpreted as the central bank's market-based signal, and λ is the weight placed by the central bank on the average action. The central bank places weight $1-\lambda$ on its private signal z. Our benchmark solution is when the central bank can commit to its policy rule.

A. The "reflection problem"

Market participant i's optimal strategy is

$$\begin{aligned} a_i &= wE_i\,(r)+(1-w)\,E_i\,(\theta) \\ &= w\lambda E_i\,(\overline{a})+(1-w\lambda)\,E_i\,(\theta) \end{aligned} \tag{4}$$

Note that the best reply (4) puts weight on the average action $\bar{a}$ as in the coordination games in Morris and Shin (2002, 2005). The weight on the average action arises endogenously due to market participants' concern to match the central bank's choice of r, and the reciprocal concern of the central bank to match the average action. We will look for a linear equilibrium of the form:

$$a_i=\xi x_i+(1-\xi)y \tag{5}$$

where ξ is the choice of "informativeness" by the market participant, to be determined through matching of coefficients. The average action from (5) is then $\overline{a}=\xi\theta+(1-\xi)y$. Substituting

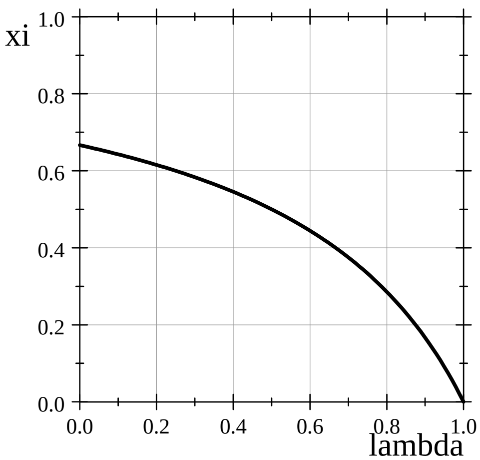
[1] In an online appendix, we solve the model with a proper normal prior on the real line. Abstracting from the dependence of the policy on the prior mean greatly simplifies the analysis.

into (4), we have

$$\begin{aligned} a_i &= w\lambda E_i(\xi\theta + (1-\xi)y) + (1-w\lambda)\, E_i\,(\theta) \\ &= (w\lambda\xi + 1 - w\lambda)\,\tfrac{\alpha y + \beta x_i}{\alpha+\beta} + w\lambda\,(1-\xi)\,y \\ &= \tfrac{\beta}{\alpha+\beta}\,(w\lambda\xi + 1 - w\lambda)\,x_i \\ &\quad + \left(1 - \tfrac{\beta}{\alpha+\beta}\,(w\lambda\xi + 1 - w\lambda)\right) y \end{aligned}$$

Matching coefficients with (5) we have:

$$\xi = \frac{\beta\,(1-w\lambda)}{\alpha + \beta\,(1-w\lambda)} \tag{6}$$



Here, we plot ξ as a function of λ for $w = \alpha = \gamma = 1$ and $\beta = 2$. The information value of the average action $\bar{a}$ is decreasing in ξ, the choice of "informativeness" by market participants. In turn, ξ is decreasing in the weight λ that the central bank places on market information. The more the central bank relies on the market signal, the less informative the market signal becomes. In this sense, reliance on the market signal can become self-defeating, and it is especially so when w is close to 1 when market participants are eager to guess correctly the actions of the central bank.

B. *Optimal weight on market signal*

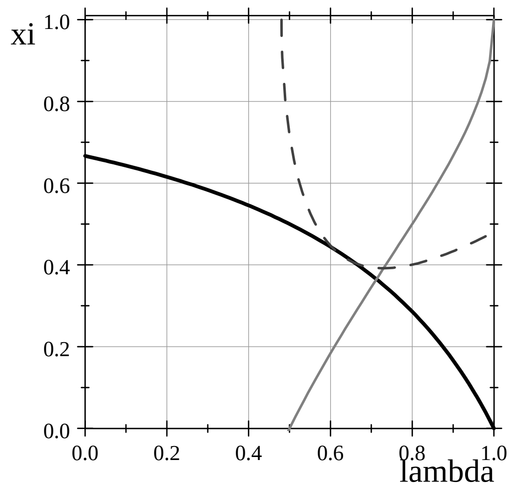
The central bank's loss function is $(r-\theta)^2$, where $r-\theta$ can be written as $\lambda\,(1-\xi)\,(y-\theta) + (1-\lambda)\,(z-\theta)$. Hence, the expected loss is

$$\lambda^2(1-\xi)^2\frac{1}{\alpha} + (1-\lambda)^2\,\frac{1}{\gamma} \tag{7}$$

Our benchmark solution is for the case when the central bank can commit to the choice of λ, anticipating the market participants' choice of ξ given in (6). Substituting (6) into the central bank's loss function (7), the central bank aims to minimize:

$$\left(\frac{\alpha\lambda}{\alpha + \beta\,(1-w\lambda)}\right)^2 \frac{1}{\alpha} + (1-\lambda)^2\,\frac{1}{\gamma} \tag{8}$$

As β becomes larger, the central bank puts higher weight on the market signal but the optimal weight λ on the market signal is obtained as an interior solution.



The solution for λ is given by the point of tangency where the ξ function is tangent to the indifference curve derived from the central bank's loss function. For the chosen parameter values of $w = \alpha = \gamma = 1$ and $\beta = 2$, the solution is $\lambda^* = 0.63$ and $\xi^* = 0.42$.

To gain further insights into the solution, it is useful also to consider the no commitment case, where the central bank's choice of λ is the best response to the market participants' choice of ξ. From (7), the central bank's best reply to ξ is

$$\lambda = \frac{\alpha}{\alpha + \gamma\,(1-\xi)^2} \tag{9}$$

The no commitment solution is the Nash equilibrium solution where (9) intersects the $\xi\,(\lambda)$ function, shown in the figure. The no commitment solution is $\lambda^{**} = 0.71 > \lambda^*$ and $\xi^{**} = 0.36 < \xi^*$. Since the central bank's indifference curves have slope of zero along its best reply function, the commitment solution obtained as a Stackelberg equilibrium always lies to the left of the Nash equilibrium solution. In other words, when the central bank can commit to its Odyssean forward guidance, it will choose to put strictly less weight on the market signal. As a result, the market signal ends up being more informative than under the Nash equilibrium solution.

The comparison of the benchmark solution with the Nash solution illustrates well the optimality of the central bank following a rule that does not to put too high a weight on the market signal, lest this becomes self-defeating and the market signal becomes uninformative.

C. Variations

For simplicity, we assumed that the state was drawn from an improper uniform prior distribution. This assumption allowed the simple closed form analysis of the model. In an online appendix, we analyze the general model where θ is has a proper prior distribution, with mean $\overline{\theta}$ and precision δ. The analysis is more complex, but the qualitative results remain largely the same. We also check that the analysis described above with the improper prior corresponds to the limit of what happens as the precision δ tends to zero.

We assumed that the CB policy rule did not depend on y. This is an important modelling assumption. In the model, the reflection effect operates because market participants overweight public information and thus private signals are not revealed. If the CB was able to condition on public information, it could correct for this bias. In particular, it could put a weight greater than 1 on the market signal, and a negative weight on the public signal. We don't think that this is a relevant scenario for policy, but to understand the model, we describe what happens in this case. Formally, consider the case where $\alpha = 0$ but θ has the proper prior distribution, so that the mean $\overline{\theta}$ serves as a public signal. In this case, there is a policy rule for the central bank that will make the expectation of $(r-\theta)^2$ arbitrarily small (although not zero).

Fix any $\varepsilon > 0$. Consider the policy rule

$$r = (1-\varepsilon)\left(\overline{a} + \frac{\delta}{\beta}\left(\overline{a}-\theta\right)\right) + \varepsilon z$$

If we set $\varepsilon = 0$, equilibrium would be be indeterminate. But for any positive ε, there will be a unique equilibrium. By putting a weight greater than 1 on the market signal $\overline{a}$, market participants can be induced to follow the strategy

$$a_i = \frac{\delta}{\beta+\delta}\overline{\theta} + \frac{\beta}{\beta+\delta}x_i$$

so that

$$\overline{a} = \frac{\delta}{\beta+\delta}\overline{\theta} + \frac{\beta}{\beta+\delta}\theta.$$

Thus, in equilibrium, we have

$$r = (1-\varepsilon)\,\theta + \varepsilon z.$$

and the expectation of $(r-\theta)^2$ is $\frac{\varepsilon^2}{\gamma}$, which can be made arbitrarily small by choosing ε sufficiently small.

We assumed that the central bank wanted to minimize $(r-\theta)^2$, setting their action equal to a target. The central bank cared about $\overline{a}$ only as a signal of the true state, but did not care intrinsically about what it was. This simple objective highlighted the logic of the reflection problem. However, we reach qualitatively similar conclusions if the central bank is interested in manipulating $\overline{a}$. In particular, suppose that the central bank wanted to minimize

$$(\kappa r + (1-\kappa)\,\overline{a} - \theta)^2$$

for some $0 \leq \kappa \leq 1$. If $\kappa = 1$, we have our benchmark model. If $\kappa = 0$, the central bank's action no longer matters. But for $\kappa > 0$, the central bank's problem will be to choose λ to minimize

(10)
$$(1-\kappa\,(1-\lambda))^2\,(1-\xi)^2\frac{1}{\alpha} + \kappa^2\,(1-\lambda)^2\,\frac{1}{\gamma}$$

anticipating that ξ will be given by (6) as a function of λ.

II. Points of contact with literature

We have highlighted the reflection problem: the more weight is given to informative market signals, the less informative they become. The problem can be understood in the broader context of the Lucas Critique (Robert E. Lucas (1976)) or "Goodhart's Law" given in a lecture in 1975 (Charles A. E. Goodhart (1975)) that any useful statistical measure of the economy ceases to be useful if it is adopted as a target.

The reflection problem arises in the monetary policy models of Woodford (1994) and Bernanke and Woodford (1997). If market signals were fully informative, the central bank would want to choose policies under which market signals would no longer be informative. Svensson and Woodford (2004) emphasize that policy makers will have an incentive to commit to a policy rule because of the reflection problem. Aoki (2006) examines the quantitative significance of this effect in a monetary policy model. The reflection problem arises is a wide variety of contexts. In Goldstein, Ozdenoren and Yuan (2011), the central bank's decision to defend its currency against a speculative attack will depend on how much speculation is observed, and this dependence redners the speculative activity less informative. In Bond and Goldstein (2015), the government's decision to bail out a financial institute based on market measures of firm performance will reduce the informativeness of underlying firm performance.

In our model, the central bank announces how policy actions will be chosen as a function of market and other signals. This is one component of forward guidance in practise. Another component of forward guidance is direct communication of information. We discussed this in Morris and Shin (2002) and Jeffery Amato, Morris and Shin (2002), and we can use our model to discuss this issue also. We focussed on the central bank's problem of choosing λ to minimize (7), subject to ξ being given in (6). But suppose we fixed λ and assumed that the central bank could also influence α - the precision of the public information that market participants use in selecting their action. Increasing α will have a direct and an indirect effect. For a fixed ξ, an increase in α will increase the accuracy of the CB action. But an increase in α will lower ξ and thus the informativeness of the market signal. Thus increasing α will have an ambiguous impact on the CB objective.

In the benchmark model of this paper, the bank cares only about hitting the target, not influencing private sector actions. However, we noted in section I.C that similar results would hold if the central bank cared about private sector actions. It is the incentive to target the average action that gives private sector agents an incentive to ignore private signals, creating both the reflection problem and the possibility that public signals damaged welfare. In Morris and Shin (2002), market participants were assumed to have a private value of matching others' actions even though it did not have social value. See Marios Angeletos and Chen Lian (2017a) and Goldstein and Yang (2017) for a discussion of this modelling choice and more on the welfare impact of information transparency.

We considered a static model with forward guidance captured by the conditional policy rule. In practise, there is a dynamic process in which conditioning on private sector information today reduces information revealed tomorrow. Morris and Shin (2005) and Manuel Amador and Philippe Weill (2012) discuss dynamic crowding out of private information by public information revelation.

III. The reflection problem in practice

A concrete example of the reflection problem is the information content of market-implied inflation expectations derived from inflation swaps. An inflation swap is a financial contract where a market participant facing inflation risk (such as a defined benefit pension fund) can hedge the inflation risk by promising to pay a fixed nominal amount per year in return for a floating payment that depends on realised inflation. Shin (2017) notes that the inflation swap rate began to move in lockstep with the nominal bond yield itself, especially after 2014.

One possible explanation for the comovement is that it reflects in part the impact of central bank forward guidance. If the central bank lets it be known that the inflation swap rate enters future monetary policy actions, market participants will anticipate easier monetary policy when the inflation swap rate falls and chase nominal yields down. This type of front-running may be so effective that the central bank need not follow through with any actions of its own. Signalling its contingent plan of action would be enough.

An open question is to what extent the decline in nominal yields has made the fixed payments received by inflation sellers more attractive to investors who value nominal bond-like payoffs. If so, this would be an additional element that binds the inflation swap rate with the nominal rate, and subject the swap rate to the same amplification forces that push around the nominal yield itself.

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