Central Bank Transparency  
and the Signal Value of Prices\textsuperscript{1}

Stephen Morris  
Princeton University

Hyun Song Shin  
London School of Economics

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A central bank must be accountable for its actions, and its decision making procedures should meet the highest standards of probity and technical competence. In light of the considerable discretion enjoyed by independent central banks, the standards of accountability that such central banks must meet are perhaps even higher than most other public institutions. Central banks must be transparent in this broad sense, and few would question such a proposition.

There is a narrower debate on central bank transparency that revolves around whether a central bank should publish its forecasts and whether it should have a publicly announced numerical target for inflation, and it is this narrower debate that is the topic of our essay. The narrower notion of transparency impinges on issues of accountability and legitimacy also, but its main focus has been on the effectiveness of monetary policy.

Proponents of transparency in this narrower sense point to the importance of the management of expectations in conducting monetary policy. A central bank generally controls directly only the overnight interest rate, “an interest rate that is relevant to virtually no economically interesting transactions”, as Alan Blinder (1998, p.70) puts it. The links from the overnight rate - the direct lever of monetary policy - to the prices that matter such as long-term interest rates depend almost entirely upon market expectations, and monetary policy is effective only to the extent that the central bank can shape the beliefs of the market participants. Long-term interest rates are influenced in large part by the market’s expectation of the future course of short-term rates. By charting a path for future short rates, and communicating this path clearly to the market, the central bank can influence market expectations, thereby affecting mortgage rates, corporate lending rates and other prices that have a direct impact on the economy. Having thus gained
a lever of control over long-term rates, monetary policy works through the IS curve - through quantities such as consumption and investment.

Indeed, it would not be an exaggeration to say that the management of expectations is seen by many leading monetary economists as the task of monetary policy. For Svensson (2004, p.1), “monetary policy is to a large extent the management of expectations”, or as Woodford (2005, p. 3) puts it, “not only do expectations about policy matter, but, at least under current conditions, very little else matters.”

The reasons for the pre-eminent role of expectations in monetary policy as emphasized by Svensson, Woodford and others are explained particularly well for a general audience in a policy speech by Ben Bernanke (2004b) entitled “The Logic of Monetary Policy”. Here, Bernanke explores the analogy between driving a car and steering the economy through monetary policy. The economy is a car and the Federal Open Markets Committee (FOMC) is the driver, and monetary policy actions are akin to taps on the accelerator or the brake in order to stimulate or cool the economy as appropriate given the current state of the economy. Bernanke notes that while this analogy is superficially attractive, the analogy breaks down due to the importance of the expectations of future actions by the central bank. If the economy is like a car, then it is a car whose speed at a particular moment depends not on the pressure on the accelerator at that moment, but rather on the expected average pressure on the accelerator over the rest of the trip. Woodford (2005, p.2) employs a similar transport metaphor: “central banking is not like steering an oil tanker, or even guiding a spacecraft, which follows a trajectory that depends on constantly changing factors, but that does not depend on the vehicle’s own expectations about where it is heading.” Instead, optimal policy is history dependent in that the central bank commits itself
to a rule that takes into account past conditions - even some that no longer matter for an evaluation of what is possible to achieve from now on. This is because it was the anticipation of such a rule that determined the market’s expectations today (see Blinder (1998), Woodford (2003b, ch. 7), Svensson and Woodford (2005)).

The pivotal role of market expectations puts the central bank’s communication policy at center stage, and the principles have been adopted to some extent by all central banks, but embraced most enthusiastically by central banks that have adopted explicit inflation-targeting monetary regimes. By common consent, the implementation of monetary policy based on these principles has played a key role in bringing the benefits of low and stable inflation, without the need to generate additional output instability in the process. If anything, the output cycle has become smoother, as described by Mervyn King (2005).

Although it may appear churlish to raise questions with a policy framework that has delivered such impressive results, one issue seems to have received less attention that it deserves - namely, the consequences of central bank transparency for the informativeness of prices. In order for the central bank to know how it should manage expectations, it must obtain its cues from signals emanating from the economy, which themselves are the product of market expectations. On the face of it, there is an apparent tension between managing market expectations and learning from market expectations. For instance, the central bank cannot manipulate prices and, at the same time, hope that prices yield informative signals. A recent speech by

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1See Kuttner (2004) and Battini, Kuttner and Laxton (2005) for an overview of the varieties of ways in which inflation-targeting has been implemented. The early contributions include Leiderman and Svensson (1995), Bernanke and Mishkin (1997), Bernanke, Laubach, Mishkin and Posen (1999).
Fed Governor Don Kohn (2005) identifies limits to transparency for these reasons.

The tension between managing expectations and learning from expectations reflects the dual role of a central bank in the conduct of monetary policy. As well as its role as the active *shaper* of events, the central bank must also play the role of a vigilant *observer* of events, in order to obtain its cues for future actions. The roles are complementary, since it is only by being a vigilant observer of events that it can be effective in its role as the active shaper of outcomes. On the surface at least, there is a worry that the emphasis on the active shaping of events detracts from the central bank’s role as a vigilant observer of events. The central bank holds a mirror up to the economy for cues for its future actions, but the more effective it has been in manipulating the beliefs of the market, the more the central bank will see merely its own reflection.

The dilemma between managing market prices and learning from market prices would disappear if the central bank were omniscient, so that it does not have to rely on the information flowing from market prices. Then, the only task it faces would be to convey its knowledge to the rest of the economy, thereby aligning market expectations to its own (correct) view. Even if the central bank were far from omniscient, one could argue that the central bank is so much better informed than any other individual agent in the economy that it would be incumbent on the central bank to convey what it knows forcefully so as to educate the myriad actors in the economy. In this sense, the tension between *managing* market expectations and *learning from* market expectations would be resolved in favor of the former.

This way of resolving the tension is implicit in the following argument in a speech by Ben Bernanke (2004a), entitled “Central Bank Talk and Monetary
when the monetary policy committee regularly provides information about its objectives, economic outlook, and policy plans, two benefits result. First, with more complete information available, markets will price financial assets more efficiently. Second, the policymakers will usually find that they have achieved a closer alignment between market participants’ expectations about the course of future short-term rates and their own views. [Bernanke (2004a)]

In the above passage, Bernanke makes two claims.

- When the central bank conveys its own views clearly, market prices will be more informationally efficient.

- When the central bank conveys its own views clearly, the market’s expectations will be closer to the central bank’s own expectations.

We will argue in this essay that there are strong reasons for believing that the second assertion holds true. However, we will argue that the first assertion is more open to question. In particular, the stronger are the reasons for believing the second assertion, the more doubtful is the first assertion. In short, the first assertion may be false because the second assertion is true.

It is perhaps no coincidence that many of the policy debates preoccupying central bankers today - such as the overheating residential property market and the potential fallout if the boom turns to bust - are taking place in an otherwise tranquil economic climate when measured against the conventional yardsticks of inflation and output. The suspicion is that the warning signals (such as a pick-up in inflation) that would have started flashing red in an
earlier era are no longer in operation due in large part to the success of central banks in anchoring inflation expectations, and any imbalances that lurk beneath the surface find expression through other channels such as a residential property bubble, fuelled by rapid increases in private credit.\(^2\)

The flattening of the Phillips curve in the 1990s in many countries is perhaps one indication that the signal value of aggregate prices has deteriorated as an indication of how close the economy is to capacity.

Brayton, Roberts and Williams (1999) note how the main feature of the Phillips curve - that inflation rises when labor markets tighten - was turned on its head during the U.S. economic expansion in the 1990s when the unemployment rate fell below its long-run average of around 6 percent and then fell below 5 percent, even as inflation fell (the figures below are taken from Bean (2003)). Replacing unemployment with capacity utilization does little better to rescue the Phillips curve. While the flattening of the Phillips curve could be interpreted as shifts in the NAIRU itself, the authors conclude that the explanation that fits best with the evidence is that the price-cost margin has taken the brunt of the adjustment, rather than the prices themselves. To the extent that costs are part of the fundamentals of the economy, and prices are expected to serve as a signal of the cost conditions, the fact that price-cost margins take the brunt of the adjustment is an indication that the signal value of aggregate prices has changed in recent years for the worse.

\(^2\)These concerns have been aired by Cecchetti, Genberg, Lipsky and Wadhwani (2000), and especially by economists of the BIS School (Borio and Lowe (2002) and Borio, English and Filardo (2003).
There is also some anecdotal evidence for the erosion of signal values that comes from the recent deterioration in the performance of central bank forecasts, as well as in the forecasts of their private sector counterparts. The recent drop in forecast accuracy is particularly noteworthy given the good track record of central bank forecasts in the past. For the United States, the Federal Reserve’s “Greenbook” forecasts have, until recently, had an impressive track record (see Romer and Romer (2000), Sims (2002)).

A closely related issue is the revisions to official data. A tell-tale sign of the deterioration of the information value of signals would be large revisions to past data. The larger are the revisions, the larger were (in retrospect) the uncertainty about the economic conditions at the time. We discuss the Bank of England’s experience this year, whose forecasts have been hampered by large GDP growth revisions.

The theme explored in this essay is the tension between managing expectations and the impaired signal value of such managed expectations. We
argue that the quality of the central bank’s information is endogenous, and
a central bank that attempts to steer the market’s beliefs more vigorously
will suffer a greater deterioration in the information value of its signals.

We begin this essay by first outlining some technical considerations in
developing our argument. We begin by revisiting a much older debate in
economics between Hayek and his socialist contemporaries on the informa-
tional role of prices, and the role of the market mechanism in aggregating
the distributed information of economic agents.

Hayek Revisited

Hayek’s 1945 essay “On the Use of Knowledge in Society” has remarkable
resonance for the debates on the informational role of prices. Hayek was, of
course, arguing against his socialist contemporaries and other advocates of
Soviet central planning. However, his comments are equally relevant for the
debate on central bank transparency. He poses the problem in the following
terms.

The peculiar character of the problem of rational economic or-
der is determined precisely by the fact that the knowledge of the
circumstances of which we must make use never exists in con-
centrated or integrated form, but solely as the dispersed bits of
incomplete and frequently contradictory knowledge which all the
separate individuals possess. The economic problem of society
is thus not merely a problem of how to allocate “given” resources
- if “given” is taken to mean given to a single mind which de-
liberately solves the problem set by these “data”. It is rather
a problem of how to secure the best use of resources known to
any of the members of society, for ends whose relative importance only these individuals know. Or, to put it briefly, it is a problem of the utilization of knowledge not given to anyone in its totality” [Hayek 1945, pp. 519-520.]

Hayek was directing his argument against his contemporaries who argued for the superiority of a centrally planned economy based on the Paretian optimality principles. Chief among this group was Oskar Lange, who developed his arguments in his paper “On the Economic Theory of Socialism” published in two parts in the fledgling Review of Economic Studies in 1936 and 1937 (Lange (1936, 1937)). Lange was an economist in the Paretian tradition who, together with contemporaries such as Abba Lerner and John Hicks, provided the formal apparatus for the development of modern welfare economics. Lange provided one of the first formal arguments for what economists now know as the “two fundamental theorems” of welfare economics. But rather than seeing these results as buttressing the case for the market system, Lange saw them as compelling arguments in favor of central planning and socialism.

For Lange, following Pareto’s lead, prices are merely rates of exchange of one good for another, and it is immaterial whether they are set by the central planner or are determined in the market by supply and demand. The central planner, however, has the advantage that he can act “as if” the Walrasian auctioneer were setting prices, thereby overcoming the distortions of the market economy resulting from imperfect competition, transactions costs and externalities, and thereby achieve a superior allocation of resources.

It was into this debate that Hayek weighed in with his essay. Prices are not merely the rates of exchange between goods. Hayek points to a second role for prices - their informational role. Prices also convey information
on the fundamentals of the economy, and the shocks that constantly buffet
the economy. In more modern parlance, Hayek observes that price systems
are mappings from the states of the world to observed market prices, and
as such, convey information on the shifting fundamentals of the economy
that is not available to any agent or subset of agents in particular. Hayek’s
argument for the superiority of the market mechanism rests on the premise
that the information revealed in prices is likely to be far more illuminating
and timely than the information that any central planner could possibly
hope to amass, let alone maintain and update in a timely manner in line
with shifting fundamentals and continuing shocks to the economy.

Hayek’s emphasis on the informational role of prices anticipates the mod-
ern microeconomics literature on rational expectations equilibria (Grossman
(1976) and Radner (1979)). Hayek’s argument is also relevant for the issue
of central bank transparency and monetary policy. If the central bank aims
to manipulate market expectations in its own image, it cannot at the same
time expect the market outcome to play the role of the aggregator of the
“dispersed bits of incomplete and frequently contradictory knowledge which
all the separate individuals possess”. The more important is the informa-
tional role of prices, the greater is the tension between managing market
expectations and learning from market expectations.

Note that Hayek was not disputing that the central planner may be rel-
atively better informed than any particular agent out there in the economy.
Indeed, the central planner could have an absolute advantage over any par-
ticular agent, or some subset of agents. But that is not the point. It is
the fact that prices reveal information that is the collective wisdom of all
the agents in the economy, aggregating the diverse information of individual
agents. Thus, Romer and Romer’s (2000) finding that central bank fore-
casters are better informed than their private sector counterparts is not, by itself, a knock-down argument that the central bank does not face such a dilemma (although, as we will see later, any formal calculus of the effects must consider the relative informational prowess of the central bank over the individual agents). The corner shopkeeper who serves his small clientele would be hard-pressed to match the insights of the central bank forecasting department. However, the shopkeeper would be best placed to observe the economic fundamentals ruling in his small sliver of the real world. These small slivers, across geographical regions and sectors of the economy, when pieced together mosaic-fashion may reveal a far clearer picture than any central planner can hope to achieve through its information sources.

To be sure, the modern central bank has an awesome array of expertise and technical resources at its disposal. Sims (2002) gives a vivid description of the way in which central bank forecasts are arrived at. Forecasts are the culmination of a major logistical effort in drawing together the results of formal modelling from an array of models as well as the unquantifiable insights of experts on individual sectors of the economy. In this respect, central bank forecasting departments bear some resemblance to the economic planning ministries that Hayek has in his sights.

We cannot expect that this problem will be solved by first communicating all this knowledge to a central board which, after integrating all knowledge, issues its orders. [p. 524]

The central bank’s resources and expertise, as formidable as they are, may fail to match the collective wisdom of the economic population as a whole.
Double-Edged Nature of Public Information

The fundamental debates on the relative superiority of the market mechanism over central planning that raged in Hayek’s time reminds us that the stakes in economic debate were once much higher than they are today. However, there are lessons from the Hayek-Lange debate that are applicable even in the more modest arena of central bank transparency and monetary policy. Rather than being exhibited in the stark choice between socialism and the market economy, the issues arise in the role of public information in an economy with distributed knowledge - where each agent has a “window” on the world, each with a slightly different perspective, and each with a possible relative advantage in ascertaining some smaller sliver of the real world.

In general, a decision maker facing a choice under uncertainty will benefit from gaining greater access to information that reduces the uncertainty, since better information permits actions that are better suited to the circumstances. Also, to the extent that one decision maker’s choice is made in isolation from others, more information is generally beneficial. This conclusion is unaffected by whether the incremental information is public (in the sense of being shared by everyone) or private (available only to the relevant individual).

This simple conclusion does not always extend to contexts where decision makers’ interests are intertwined in such a way that a decision maker is an interested party in the actions taken by others. Public information in such contexts has attributes that make it a double-edged instrument. On the one hand, public information conveys information concerning the underlying fundamentals, as before. However, it also serves as a focal point for the beliefs of the group as a whole, and serves a powerful coordination role. The sunspots literature has emphasized how even signals that are “extrinsic” and so has
no direct bearing on the underlying fundamentals may, nevertheless, serve to coordinate the actions of the individual agents due to their very public nature. To the extent that public information allows coordination on good outcomes, greater precision of public information may be beneficial. But equally, coordination could be on less desirable outcomes. With sunspots, some indeterminacy would always rule.

In most cases of interest, public information is not merely a sunspot, however. Public information would convey important information concerning the fundamentals of the economy. Questions concerning transparency and monetary policy would certainly fall under this general classification. The question then is how the coordination effect of public information will affect the inferences drawn by individual economic agents, and how their intertwined interests will affect their individual incentives and the collective outcome that results from these incentives.

When there is the potential for a strong consensus to prevail or the potential for a conventional wisdom to take hold, individual incentives may become distorted in such a way as to reduce the informational value of economic outcomes. Central bank pronouncements may serve as a lightening rod to reinforce the conventional wisdom or consensus, acting to suppress the expressions of dissent from those individuals whose own private signals tell them that the conventional wisdom is flawed. When individual incentives are thus eroded, the signals that would otherwise emerge from dissenting voices to undermine the flawed consensus may be muted, serving to perpetuate the flawed consensus.

In an earlier paper\(^3\), we explored the tradeoffs that result in such a setting by examining the outcome of a collective decision problem reminiscent of

\(^3\)Morris and Shin (2002)
Keynes’s celebrated metaphor of the “beauty contest”. Keynes (1936) draws a parallel between financial markets and the sorts of newspaper competition of his day that invited readers to pick the six prettiest faces from 100 photographs. Readers won by picking the faces that “most nearly corresponds to the average preferences of the competitors as a whole”. Financial markets, Keynes argued, work in much the same way. An investor wins by anticipating which asset will become the popular choice. Provided that individual readers voted on the basis of their own sincerely held judgements, the aggregate outcome in terms of the number of votes obtained would reveal much in terms of the collective judgement of the contestants as a whole. However, the more the contestants vote on the basis of “anticipating what average opinion expects average opinion to be”, the aggregate vote will reflect increasingly the outcome of the second-guessing game between the contestants.

Now, imagine how much worse the distortion would be if a widely watched authority figure were to weigh in, and offer his public judgment on the faces in the photographs, telling readers whom he deemed the prettiest. His judgment may or may not be sound. What counts is that his pronouncements reach a wide audience, and everyone knows that his pronouncements reach a wide audience. For this reason alone, his public judgment would serve as a powerful rallying point around which average opinion could coalesce. Once the public pronouncement has been issued, it would be a futile act on the part of any reader to expend effort in scouring the faces in the photographs himself, to form his own independent opinion of their fundamental attributes. Knowing that others would regard this as a futile act, and that others will not gainsay the authority figure, an individual reader would have little incentive himself to expend effort in reaching an independent judgement. The aggregate outcome of such a vote would reveal little in terms of the genuine
overall judgements of the individual contestants, and would be dominated by the public pronouncement. The signal value of the aggregate vote would thus be severely impaired.

Arguably, central bank transparency raises similar issues. When the central bank issues regular pronouncements on the economic outlook, publishes its forecasts of the output gap and the path of its policy rate, such pronouncements provide a powerful rallying point around which market expectations can coalesce. The more market participants are concerned with the beliefs of other market participants, the greater will be the impact of the central bank’s pronouncements in determining the aggregate market outcome.

The dilemma for monetary policy transparency is that such pronouncements by the central bank will, invariably, also offer genuine insight on the current and future state of the economy that has great value. But however sound as a guide to the underlying fundamentals, the central bank’s pronouncements are even better as guides to what average opinion will be. As a result, traders give the opinions of central bankers undue weight, and place less weight on their own independent assessments of the economy. Public pronouncements could thus crowd out private opinions, and the market ceases to function as a way of aggregating and revealing diverse, private judgments of the world in the way that Hayek envisaged.

Most interestingly (and most disturbingly), consider how the problem is altered when the central bank becomes even better informed. Suppose that the central bank, in light of the disappointing performance of its forecasts, decides to beef up its forecasting effort by recruiting yet more experts and pour in yet more resources. Paradoxically, the problem may become worse, not better, when the central bank’s competence in reading the economy improves. There are two countervailing effects. On the one hand,
the improved ability of the central bank to read the economy will provide better quality information to the economic agents. However, the better is the central bank at reading the economy, the more authority it gains in the eyes of the economic agents. As the central bank’s pronouncements become more authoritative, the stronger is its ability to serve as the rallying point for coordinating market expectations, suppressing further the channel through which dissenting agents can express their views. The net effect of improved central bank transparency is thus ambiguous. This is one aspect of the “paradox of transparency”. We will return to this issue in a later section when we can do the countervailing effects some justice in terms of a formal framework. Before we do so, we review some evidence that central bank transparency has reduced the signal value of prices.

**Reviewing the Evidence**

Much evidence has been accumulating recently that greater central bank transparency has been associated with the anchoring of inflation expectations, and that such anchoring has been far more effective in those countries that have put in place formal inflation-targeting monetary regimes. The evidence is seen as buttressing the case for central bank transparency, since formal inflation targeting represents the epitome of central bank transparency in terms of the degree to which the central bank communicates with the market.\(^4\)

By squeezing out the corrosive and insidious effects of inflation expectations from the economy, the anchoring of inflation expectations brings large welfare gains. But the flip-side of “well-anchored” is “uninformative”. Price signals that are well-anchored are also price signals that have little signal

\[^4\text{Kuttner (2004), Ball and Sheridan (2003).}\]
value. They reveal very little to observers who look to them for signs of underlying shifts or trends in the economy. When the effects highlighted in Hayek (1945) are important, well-anchored expectations cease to be unambiguously desirable.

Data Revisions

A tell-tale sign of the deterioration of the information value of signals would be large revisions to past data. The greater is the uncertainty over where the economy is right now, the greater will be known subsequently. Hence, the larger are the revisions to official data, the larger were (in retrospect) the uncertainty about the economic conditions at the time.

The Bank of England’s experience with data revisions in 2005 is revealing in terms of the difficulties of trying to steer the economy without good information about where the economy is at the moment. Shown below are the two “fan charts” for GDP growth as published in two consecutive issues of the BoE’s Inflation Report (Bank of England (2005)). The left panel is from the May 2005 report and the right hand panel is from the August 2005 report.
It is immediately evident that there was a large downward revision to GDP growth in early 2005, with the result that the realized outcome in the first quarter of 2005 fell in the outer tail of the projected distribution of outcomes as given by the left hand panel, leading to some scrutiny and comment from the press.\(^5\)

Another difference that is apparent is the rather exaggerated shape of the fan chart for the August 2005 report where short-range forecasts are given much larger dispersion. The change was introduced to emphasize the uncertainties surrounding current economic conditions. The large range of outcomes permissible in the short run is to anticipate data revisions.

Greater uncertainty about current conditions would be a tell-tale sign of the deterioration of signal values, and the new convention of drawing a fan chart with a “fatter” base could be seen as an indication of the greater awareness of such uncertainty. Strictly speaking, the base of the fan ought to start in the distant past - after all, there is great uncertainty even about

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\(^5\)See the opinion piece in the *Financial Times* on August 10th 2005 “Bank of England needs to re-examine its forecasts” by Geoffrey Dicks.
the past. The fatter base is a nod to the convention of drawing the fan chart as if the current conditions are known. The more the information value of central bank signals deteriorates, the wider will be the base of the fan. Thus, one of the key questions addressed in our paper will be how the central bank’s information precision changes as it shifts from one disclosure regime to another.

**Forecasts**

To the extent that uncertainty about current conditions makes forecasting the future more difficult, another tell-tale sign of a drop in signal values would be a deterioration in forecasting performance. Of course, a drop in forecasting performance cannot be seen as a clinching argument for a drop in signal values (there may be other culprits), but as we will argue later, changes in the disclosure regime are associated with changes in the time series properties of aggregate outcomes, as well as changes in the signal value of those outcomes. When poor signal values conspire with structural change, forecasting will be extremely difficult. Thus, forecasting failures would certainly be consistent with a drop in signal values.


At the Federal Reserve, the staff of the Board of Governors prepares a detailed forecast before each scheduled meeting of the Federal Open Market Committee (FOMC), known as the “Greenbook”. The purpose of the Greenbook is to serve as the background to deliberations in the FOMC, and
are the views of the staff rather than individual committee members. Sims (2002) provides a detailed description of the process by which the Greenbook forecasts are arrived at. The Greenbook forecasts are posted on the website of the Federal Reserve Bank of Philadelphia, except for the most recent five year window which remains confidential. Tulip’s (2005) study, therefore, uses the publicly disclosed data that includes forecasts of outcomes up to the end of 2001.

Tulip finds that, even as output fluctuations have moderated substantially in recent years\(^6\), the forecast errors have not. In particular, the picture for longer term forecasts (up to eight quarters) is far from encouraging. If anything, the trend in forecast accuracy has been down, rather than up. Since the late 1980s, the mean squared prediction errors have been similar to, and sometimes greater than, the variance itself. In other words, the simple sample mean (the most naive forecast) has provided a more accurate guide to GDP growth than the actual forecasts, which is to say that the forecasts have had negative predictive value.

One way to picture this is to consider a regression of the two-year change in GDP on a constant and the corresponding forecast. This regression has a negative coefficient when estimated on the last ten years of the sample (1992 to 2001).


\(^6\)as has been documented by McConnell and Perez-Quiros (2000), Kim and Nelson (1999) and Blanchard and Simon (2001).
Survey Evidence

It is natural that the flip-side of the fall in the signal value of prices is the “well-anchored” nature of market expectations. There are several recent studies of this issue. Levin, Natalucci and Piger (2004) investigate how well inflation expectations have been anchored, as revealed in the inflation forecasts in survey data. They examine data on inflation forecasts from Consensus Forecasts, Inc., who poll market forecasters twice a year on their forecasts of inflation from one to ten years ahead. Levin, Natalucci and Piger conclude that long-term inflation expectations (6 to 10 years in the future) for a group of inflation-targeting countries (Australia, Canada, New Zealand, Sweden and the United Kingdom) have become delinked from actual inflation outcomes, while there is evidence that they still respond to actual outcomes in the United States and the Euro area. They reach their conclusions by running regressions of the form:

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\Delta \pi_{it}^q = \lambda_i + \beta \Delta \pi_{it} + \varepsilon_{it}
\]  

(1)

where \( \pi_{it}^q \) is the expectation (formed at date \( t \)) of inflation \( q \) years ahead in country \( i \). \( \pi_{it} \) is a three-year moving average of inflation in country \( i \) ending at date \( t \). The coefficient \( \beta \) is the focus of the investigation, since it measures the extent to which expectations of future inflation is influenced by the experience of recent inflation. The authors report results that indicate that the \( \beta \) coefficient is small and insignificant in the formal inflation-targeting countries, but is positive, large and significant for the non-inflation targeting countries.

Mankiw, Reis and Wolfers (2004) examine the dispersion of inflation expectations and find a similar picture. Inflation expectations have become more concentrated around the mean - exactly the type of observation that
Keynes might have put forward as evidence of a beauty contest.

Evidence from Market Prices

A very similar picture emerges from studies that examine expectations that are embedded in financial market prices. Gurkaynak, Levin and Swanson (2005) use daily data to examine the forward inflation compensation as revealed in the difference between forward rates on nominal government bonds and inflation-indexed bonds. The authors use the forward inflation compensation to extract estimates of long-run inflation expectations, and conduct their measurements on the market for U.S., Swedish and U.K. government bonds. Sweden and the U.K. are classified as inflation-targeting countries but the U.S. is not.

For all three countries, the authors find stable long-run inflation expectations, but there are revealing differences. For the United States, long term inflation expectations appear to be influenced by recent experiences of inflation, while there is no such dependence for the U.K. and Sweden. These results echo the results obtained by Levin, Natalucci and Piger (2004) reported above. The implication is that there is such “excessive” dependence in the forward inflation premium in the United States because the Fed does not have a numerical objective for inflation to help tie down long-term inflation expectations. In addition, Gurkaynak et al. (2005) show that long-term forward yield differences in the United States respond excessively to economic news, including surprises in the Fed funds rate, which the authors attribute to shifts in market participants’ views of the Fed’s long-term inflation objectives (a result elaborated in another paper, Gurkaynak, Sack and Swanson (2005)). To contrast their results for the U.S. with the inflation-targeting countries, the authors show that such excess sensitivity in long-term infla-
tion expectations does not exist in the United Kingdom after May 1997 when the Bank of England gained operational independence and monetary policy moved to a formal inflation-targeting regime.

**Evidence from Overreactions**

There is also considerable supporting evidence from an earlier era for the coordination role for the central bank. The evidence comes from the apparent *overreaction* to announcements of money stock aggregates during the period after 1979 when Federal Reserve began to place emphasis on the growth of the money stock as an indicator of the monetary stance.

Although there is a superficial difference between the *overreaction* to central bank announcements versus the *well-anchored* nature of long-term inflation expectations, the underlying principle that unites the two is the excessive weight placed on an authoritative source of public information when individual agents face decisions that impinge on each other’s interests.

The evidence for the heightened reaction to money stock announcements in the early 1980s is documented in Roley (1983), Cornell (1983) and Roley and Walsh (1985)). Although the Federal Reserve has published weekly estimates for monetary aggregates for some time (and continues to do so today), the announcements in the early 80s were particularly significant due to the importance placed at the time on monetary aggregates as indicators of the stance of monetary policy. These money stock announcements became one of the focal events in financial markets if for no other reason than the fact that significant movements in interest rates were associated with sizeable unanticipated changes in the money stock. The market’s reaction to such announcements were noticeably larger during the period following the shift in the monetary regime in 1979 than in the previous regime of the 1970s.
Roley (1983) shows that over the 1\(\frac{1}{2}\) hour intervals spanning the weekly announcements, the variance of the change in three month Treasury bill rates in the three years since October 1979 were more than thirty times larger than that of the previous two-year period. In particular, variance of the change in the three-month Treasury bill rate from 3:30 p.m. to 5 p.m. on the announcement day (the announcement being at 4:10 p.m. on Friday) was 0.0016 for the period between 1977 up to September 1979, but then jumps to 0.0536 between October 1979 to October 1982.

When the market understands that the central bank itself watches the money stock for its policy stance, the strategic interactions between the market participants will take center stage. The actual magnitudes will matter less as compared to the fact that the announcements makes the numbers public, and hence renders them common knowledge. The forces at work are similar to the forces that move markets after breaking news stories. The news itself may not be a surprise to some market participants, but the fact that it becomes *commonly known* is news. It is this news that serves as the lightening rod that moves markets.

Both the evidence that long-term inflation expectations are well-anchored, and the exaggerated price reactions following public announcements suggest that the coordinating role of central bank transparency is alive and well, and has far-reaching effects in influencing the signal value of prices. We outline the elements of a formal framework that will be developed to address how signal values change to shifts in the disclosure regime.

**Elements of a Theory**

The simplest way to motivate the problem is in terms of a decision problem akin to the Keynes beauty contest, although it will be important to show how
real world economic decisions can be understood within a similar framework. We will return to the economic applications after seeing how the key effects enter in a simpler, abstract decision.

There are many small agents who face the problem of tailoring their action to the underlying state $\theta$, but also try to second guess the decisions of other individuals in the economy. Suppose that each agent $i$ follows the decision rule:

$$a_i = (1 - r) E_i(\theta) + r E_i(\bar{a})$$

(2)

where $\bar{a}$ is the average action in the population, $r$ is a parameter that lies between zero and one, and $E_i(\cdot)$ is the expectation operator for player $i$. Each agent puts positive weight on the expected fundamental state $\theta$ and the expected actions of others, and chooses a weighted average of the two. The parameter $r$ indicates the extent to which agent $i$ is motivated by the concern to second-guess the actions of others. If $r$ is large (close to 1), decisions are influenced predominantly by anticipation of what others do, rather than what the fundamentals are.

**Public Information Benchmark**

In the simplest case, if $\theta$ is commonly known, the equilibrium entails $a_i = \theta$ for all $i$. When agents face uncertainty concerning $\theta$, but they have access to a common source of information shared by all, their actions approximate $\theta$ most closely when uncertainty is small. Suppose $\theta$ is drawn from an (improper) uniform prior over the real line, but the agents observe the single public signal

$$y = \theta + \eta$$

(3)

where $\eta$ is normally distributed, independent of $\theta$, with mean zero and variance $\sigma^2_\eta$. The signal $y$ is ‘public’ in the sense that the actual realization of
$y$ is common knowledge among all agents. They choose their actions after observing the realization of $y$. Conditional on $y$, all agents believe that $\theta$ is distributed normally with mean $y$ and variance $\sigma^2_y$. Hence, $i$’s optimal action is

$$a_i(y) = (1 - r) E(\theta|y) + r \int_0^1 E(a_j|y) \, dj$$

(4)

where $a_i(y)$ denotes the action taken by agent $i$ as a function of $y$. Since $E(\theta|y) = y$ and since everyone can condition on $y$, we have $E(a_j|y) = a_j(y)$, so that

$$a_i(y) = y$$

(5)

for all $i$. The distance between $a_i$ and $\theta$ is

$$E[(y - \theta)^2|\theta] = \sigma^2_y$$

Thus, the smaller is the noise in the public signal, the closer is the action to the fundamentals. We will now contrast this with the Hayekian case in which agents have their own “window on the world”.

**Hayekian Case**

Consider now the case where, in addition to the public signal $y$, agent $i$ observes the realization of a *private signal*:

$$x_i = \theta + \varepsilon_i$$

(6)

where noise terms $\varepsilon_i$ are normally distributed with zero mean and variance $\sigma^2_{\varepsilon}$, independent of $\theta$ and $\eta$, so that $E(\varepsilon_i\varepsilon_j) = 0$ for $i \neq j$. The private signal of one agent is not observable by the others. Each agent has a privileged view of their own small “sliver” of the world.
As before, the agents’ decisions are made after observing their signals. Denote by $\alpha$ the precision of the public information, and denote by $\beta$ the precision of the private information, where

$\begin{align*}
\alpha &= \frac{1}{\sigma^2_{\eta}} \\
\beta &= \frac{1}{\sigma^2_{\xi}}
\end{align*}$

(7)

Then, based on both private and public information, agent $i$’s expected value of $\theta$ is:

$$E_i(\theta) = \frac{\alpha y + \beta x_i}{\alpha + \beta}$$

(8)

One simple way to solve for the equilibrium is to posit that actions are linear function of signals. We will follow this with a demonstration that this linear equilibrium is the unique equilibrium, which also gives important insights on the double-edged nature of public information. Thus, as the first step, suppose everyone follows a linear rule

$$a_j = \kappa x_j + (1 - \kappa) y.$$  

(9)

for some constant $\kappa$. Then agent $i$’s conditional estimate of the average expected action across all agents is:

$$E_i(\bar{\pi}) = \kappa \left( \frac{\alpha y + \beta x_i}{\alpha + \beta} \right) + (1 - \kappa) y$$

$$= \left( \frac{\kappa \beta}{\alpha + \beta} \right) x_i + \left( 1 - \frac{\kappa \beta}{\alpha + \beta} \right) y$$

Agent $i$’s optimal action is

$$a_i = (1 - r) E_i(\theta) + r E_i(\bar{\pi})$$

(10)

$$= (1 - r) \left( \frac{\alpha y + \beta x_i}{\alpha + \beta} \right) + r \left( \frac{\kappa \beta}{\alpha + \beta} \right) x_i + \left( 1 - \frac{\kappa \beta}{\alpha + \beta} \right) y$$

$$= \left( \frac{\beta (r \kappa + 1 - r)}{\alpha + \beta} \right) x_i + \left( 1 - \frac{\beta (r \kappa + 1 - r)}{\alpha + \beta} \right) y$$
Comparing coefficients in (9) and (10), we therefore have

\[ \kappa = \frac{\beta (r \kappa + 1 - r)}{\alpha + \beta} \]

from which we can solve for \( \kappa \). The equilibrium action \( a_i \) is given by

\[ a_i = \frac{\alpha y + \beta (1 - r) x_i}{\alpha + \beta (1 - r)} \quad (11) \]

Now compare equations (8) with (11). If we define welfare as the average (across \( i \)) of the distance \((a_i - \theta)\), then the socially optimal decision is for all agents to submit their best estimate of \( \theta \), as given by (8). However, what they end up doing is to over-emphasize the public signal and de-emphasize their own private information, as is evident in (11). The greater is the coordination motive (i.e. the larger is \( r \)), the greater is the over-reliance on public information.

Allen, Morris and Shin (2002) develop this theme in an asset pricing model where the price of an asset today is the average expectation of tomorrow’s price. Average expectations fail to satisfy the “law of iterated expectations”. That is to say, the average expectation today of the average expectation tomorrow of future payoffs is not the same thing as the average expectation of future payoffs. In a Hayekian environment, the failure of the law of iterated expectations follows a systematic pattern that puts too much weight on shared information - conventional wisdom or other public signals, including past prices. Past prices, in particular, receive too much weight relative to the statistically optimal weight in a frictionless world. Given the importance of the failure of the law of iterated expectations, it is illuminating to dwell briefly on how the example sketched above can be shown to be an example of such a failure.
Higher Order Beliefs

Recall that player $i$’s decision rule is

$$a_i = (1 - r) E_i (\theta) + r E_i (\pi)$$ (12)

Substituting and writing $\mathcal{E} (\theta)$ for the average expectation of $\theta$ across agents we have

$$a_i = (1 - r) E_i (\theta) + (1 - r) r E_i \left( \mathcal{E} (\theta) \right) + (1 - r) r^2 E_i \left( \mathcal{E}^2 (\theta) \right) + ...$$

$$= (1 - r) \sum_{k=0}^{\infty} r^k E_i \left( \mathcal{E}^k (\theta) \right)$$ (13)

In order to evaluate this expression, we must solve explicitly for $E_i \left( \mathcal{E}^k (\theta) \right)$.

Recall that player $i$’s expected value of $\theta$ is:

$$E_i (\theta) = \frac{\alpha y + \beta x_i}{\alpha + \beta}$$ (14)

Thus the average expectation of $\theta$ across agents is

$$\mathcal{E} (\theta) = \int_{0}^{1} E_i (\theta) \, di = \frac{\alpha y + \beta \theta}{\alpha + \beta}$$

Now player $i$’s expectation of the average expectation of $\theta$ across agents is

$$E_i \left( \mathcal{E} (\theta) \right) = E_i \left( \frac{\alpha y + \beta \theta}{\alpha + \beta} \right)$$

$$= \frac{\alpha y + \beta \left( \frac{\alpha y + \beta x_i}{\alpha + \beta} \right)}{\alpha + \beta}$$

$$= \frac{((\alpha + \beta)^2 - \beta^2) y + \beta^2 x_i}{(\alpha + \beta)^2}$$

and the average expectation of the average expectation of $\theta$ is

$$\mathcal{E}^2 (\theta) = \mathcal{E} \left( \mathcal{E} (\theta) \right)$$

$$= \frac{((\alpha + \beta)^2 - \beta^2) y + \beta^2 \theta}{(\alpha + \beta)^2}$$
Higher order expectations put more weight on the (noisy) public information at the expense of the truth. Not only does the law of iterated expectations fail, it fails in a systematic way where higher order expectations are less informative about $\theta$. By induction we have $E^k(\theta) = (1 - \mu^k)y + \mu^k\theta$ where $\mu = \beta/(\alpha + \beta)$, and

$$a_i = (1 - r) \sum_{k=0}^{\infty} r^k \left[ (1 - \mu^{k+1}) y + \mu^{k+1} x_i \right]$$

$$= \left( 1 - \frac{\mu (1 - r)}{1 - r \mu} \right) y + \left( \frac{\mu (1 - r)}{1 - r \mu} \right) x_i$$

$$= \frac{\alpha y + \beta (1 - r) x_i}{\alpha + \beta (1 - r)}$$

This is exactly the unique linear equilibrium we identified earlier.

**Economic Interpretations of Decision Rule**

The decision rule (2) that was motivated by the beauty contest can be given more familiar macroeconomic underpinnings by appealing to the ‘island economy’ model of Lucas (1972, 1973) and Phelps (1970). Thus, suppose that there is a large number of small ‘islands’, which can be interpreted either as distinct geographical regions, or different sectors of the economy. There is a single good in this economy, and the supply of this good on island $i$ is denote by $q_i^s$. The supply of the good is increasing in the difference between the price on island $i$ and the perceived average price across all islands. In particular, we take the linear supply function:

$$q_i^s = b (p_i - E_i(\bar{p}))$$

(15)

where $p_i$ is the price on island $i$, $\bar{p}$ is the average price across all islands, and $b > 0$ is a supply parameter. The expectations operator $E_i(.)$ denotes the expectation with respect to the information available to residents of island $i$. 

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The demand for the good on island $i$ is a decreasing linear function of the price on the island, but the demand also depends on the best estimate of some underlying fundamental variable $\theta$. In the original treatment of this problem by Lucas and Phelps, $\theta$ is construed as being the money supply, and is something that is under the central bank’s control. Demand on island $i$ is given by

$$q_i^d = E_i(\theta) - p_i$$

where $\theta$ is the money supply. Market clearing then implies

$$p_i = (1 - r)E_i(\theta) + rE_i(\bar{p})$$

where $r = b/(b+1)$. This is the pricing rule obtained by Phelps (1983), which extends the standard Lucas-Phelps island economy model by incorporating a role for the expectations of prices set on other islands. Thus, we retrieve the “beauty contest” decision rule.

The pricing rule given by (17) has been given a more modern motivation by Woodford (2003a) in terms of price setting by firms who have some market power due to the imperfect substitutability between goods. In this context, $\theta$ represents the underlying cost conditions for the firms. Firms care about the prices set by other firms due to price competition across firms. Woodford (2003a) considers pricing rules for firms of the form:

$$p_i = E_i p + \xi E_i \chi$$

where $p_i$ is the (log) price set by firm $i$, $p$ is the average price across firms, $\chi$ is marginal cost (in real terms) and $\xi$ is a constant between 0 and 1. The operator $E_i$ denotes the conditional expectation with respect to firm $i$’s information set. The parameter $\xi$ is related to the elasticity of substitution between goods, and becomes small as the economy becomes more competitive.
(see Woodford (2003a)). Townsend (1983) discussed similar linear rules but in the context of investment. An active literature has developed exploring the Hayekian theme in the context of an imperfectly competitive economy.\footnote{See Adam (2003), Amato and Shin (2004), Hellwig (2002, 2004) and Ui (2003). See also Kasa (2000) and Pearlman and Sargent (2002). The latter shows how the problem can sometimes be reduced to the one with common knowledge. Similar issues arise in the context of asset pricing. See Allen et al. (2002), and Bacchetta and Van Wincoop (2002, 2004).}

Rewriting (18) in terms of nominal marginal cost, defined as $\theta = \chi + p$, we have

$$p_t = (1 - \xi) E_t p + \xi E_t \theta$$

yielding another way to derive the beauty contest decision rule.

The examples above pertain to the pricing of goods, but many of the properties of beauty contests arise in the context of financial market pricing, also. Financial market prices present the additional complication that they are forward-looking (that the price today is the expected payoff at some future date). Nevertheless, the excessive impact of public information can be shown at the cost of some additional apparatus. Allen, Morris and Shin (2002) derive asset pricing formulas of the form

$$p_t = \tilde{E}_t \tilde{E}_{t+1} \cdots \tilde{E}_{t+h} \theta_{t+h}$$

where $p_t$ is the price of a financial asset at $t$, and $\theta_{t+h}$ is the fundamental payoff at date $t + h$. Thus, the price of an asset today is the average expectation today of the average expectation tomorrow, and so on, of the eventual realized fundamentals.

The law of iterated expectations fail also in this context, and the direction of the failure is toward excessive influence of public information. Asset pricing applications present some technical difficulties, such as the fact that past (and even current) prices constitute public signals that enter into the
information sets of traders. Thus, the innocuous looking notation “\( \bar{E}_t \)” actually conceals much subtlety.

However, the broad conclusions are the same as for the static beauty contest game. Public information has a disproportionate impact on financial market prices. The precise sense in which public information has a disproportionate impact is that the market price deviates systematically from the average expectation of the fundamental value, and the bias is always toward commonly shared information, including past prices. More formally,

\[
 p_t = \bar{E}_t \bar{E}_{t+1} \cdots \bar{E}_{t+h} \theta_{t+h} \\
 \neq \bar{E}_t \theta_{t+h} 
\]

and the distance between \( p_t \) and the expectation of \( \theta_{t+h} \) based purely on public information is smaller than the distance between \( \bar{E}_t \theta_{t+h} \) and the expectation of \( \theta_{t+h} \) based purely on public information. Thus, the key features of the overreaction to public information apply to financial markets also.

**Endogenous Information Precision**

So far, we have treated the public information precision \( \alpha \) as given. But the information available to central banks derive from outcomes in the economy itself, and hence is the result of actions taken by individual economic agents. To the extent that individuals’ decisions are affected by public information, we can expect the signal values of the resulting outcomes to be sensitive to the disclosure regime.

We show that this is indeed the case. The information precision of a central bank that issues regular forecasts is lower than that of a central bank that simply tracks the evolution of the fundamentals through its signals. Let us postpone a discussion of the potential welfare effects of such impaired
signal precision until the next section, and concentrate here on why the information value deteriorates when a central bank discloses more.

Time is discrete and indexed by \( t \in \{ \cdots -2,-1,0,1,2,\cdots \} \). The fundamentals \( \{ \theta_t \} \) evolve as a Gaussian random walk:

\[
\theta_t = \theta_{t-1} + \phi_t
\]  

(22)

where \( \{ \phi_t \} \) are independent standard normal innovations.

At each date there is a new generation of private sector actors who observe a noisy signal of the fundamentals at that date, together with present and past disclosures by the central bank (if any). Individual \( i \)'s noisy signal in generation \( t \) is given by

\[
x_{it} = \theta_t + \varepsilon_{it}
\]

where \( \varepsilon_{it} \) are i.i.d. normal across individuals and across generations, with precision \( \beta \).

We are assuming a sparse information set for the individual at date \( t \) (for instance, there is no access to the private information of previous generations). But we do this as a way of setting the basic level of information on which the central bank can add by disclosing its own estimates and forecasts, if it chose to. Extending the model to encompass richer setting would be worthwhile for specific applications.

The private sector agents play a beauty contest game, and follow the decision rule:

\[
a_{it} = (1 - r) E_{it}(\theta_t) + r E_{it}(\bar{a}_t)
\]

(23)

where \( \bar{a}_t \) is the average action across individuals at date \( t \).

The central bank observes a noisy signal about what the private sector individuals did in the previous period. At date \( t \), the central bank observes
the signal:

\[ z_t = a_{t-1} + \psi_t \]  

where \{\psi_t\} are i.i.d. Gaussian noise terms independent of all other random variables, and with variance \(1/\gamma\).

The central bank’s information set at date \(t\) is the collection of all past signals \(\cdots z_{t-2}, z_{t-1}, z_t\). We are interested in the central bank’s information precision at date \(t\) as measured by

\[ \text{Var}(\theta_t|z_t, z_{t-1}, \cdots) \]

Compare two regimes. In the first, the central bank makes no disclosures, and simply tracks the fundamentals through its signals. In the second, the central bank discloses its best estimates of the fundamentals. Since the fundamentals follow a random walk, the disclosure of the central bank’s estimate of \(\theta\) is tantamount to issuing forecasts of future values of \(\theta\) at all horizons.

**Case without Disclosures**

Suppose the central bank does not disclose its estimates of the fundamentals. Since there is a continuum of private sector agents, and they receive i.i.d. signals conditional on the fundamentals, the average action \(\hat{a}_t\) fully reveals the true fundamental state \(\theta_t\). Thus, the central bank’s signals are given by

\[ z_t = \theta_{t-1} + \psi_t \]

Write \(\hat{z}_t\) as the linear estimate of \(\theta_t\) based on \(\{z_t, z_{t-1}, z_{t-2}, \cdots\}\), and let \(\alpha_t\) be the precision of this estimate as measured by \(1/\text{Var}(\theta_t|z_t, z_{t-1}, \cdots)\). Then, on observing \(z_{t+1}\) at date \(t + 1\), the linear estimate of \(\theta_t\) is

\[ \frac{\alpha_t \hat{z}_t + \gamma z_{t+1}}{\alpha_t + \gamma} \]  

(25)
with precision $\alpha_t + \gamma$. Since $\theta_{t+1} = \theta_t + \phi_{t+1}$, we have a recursive formula for the central bank’s information precision over time, namely

$$
\frac{1}{\alpha_{t+1}} = \text{Var} (\theta_{t+1} | z_{t+1}, \hat{z}_t)
= 1 + \frac{1}{\alpha_t + \gamma}
$$

(26)

The steady state information precision in the non-disclosure case is thus the value $\alpha$ that solves

$$
\alpha \left(1 + \frac{1}{\alpha + \gamma}\right) = 1
$$

(27)

**Case with Disclosures**

Suppose the central bank discloses its signals to the individual agents. With disclosures, the information set of agent $i$ in generation $t$ is

$$
\{x_{it}, z_t, z_{t-1}, \ldots\}
$$

(28)

Let $\hat{z}_t$ be the linear estimate of $\theta_t$ based on just the central bank disclosures only, and let $\alpha_t$ be the precision of this estimate. Then this individual takes action:

$$
a_{it} = \frac{\alpha_t \hat{z}_t + (1 - r) \beta x_{it}}{\alpha_t + (1 - r) \beta}
$$

(29)

By taking the average across $i$ in (29), the average action is

$$
\bar{a}_t = \frac{\alpha_t \hat{z}_t + (1 - r) \beta \theta_t}{\alpha_t + (1 - r) \beta}
$$

$$
z_{t+1} - \psi_{t+1} = \frac{\alpha_t \hat{z}_t + (1 - r) \beta \theta_t}{\alpha_t + (1 - r) \beta}
$$

Solving for $\theta_t$ as a function of $\hat{z}_t, z_{t+1}$,

$$
\theta_t = \left(1 + \frac{\alpha_t}{(1 - r) \beta}\right) z_{t+1} - \frac{\alpha_t}{(1 - r) \beta} \hat{z}_t - \left(1 + \frac{\alpha_t}{(1 - r) \beta}\right) \psi_{t+1}
$$
Thus, the incremental information value to the central bank from observing 
\( z_{t+1} \) comes from the signal:

\[
\begin{align*}
  s_{t+1} &\equiv \left( 1 + \frac{\alpha_t}{(1 - r) \beta} \right) z_{t+1} - \frac{\alpha_t}{(1 - r) \beta} \hat{\varepsilon}_t \\
\end{align*}
\] (30)

which is orthogonal to \( \{z_r\}_{r \leq t} \). The precision of \( s_{t+1} \) is \( \gamma \left( 1 + \frac{\alpha_t}{(1 - r) \beta} \right)^{-2} \), which we denote by \( \hat{\gamma}_t \).

Since, \( \hat{\gamma}_t \leq \gamma \) we can conclude that the incremental information value to the central bank of observing its signal \( z_{t+1} \) is lower in the disclosure case. Moreover, this incremental information value is lower the better was its overall precision \( \alpha_t \) in the previous period. In other words, raising the central bank’s overall information precision has the effect of lowering the signal value of its subsequent signal. The intuition is that increased precision at \( t \) intensifies the beauty contest, and reduces the information value of the average action. This lowers information precision of the signal arriving at \( t + 1 \).

At date \( t + 1 \), the central bank’s linear estimate of \( \theta_t \) is

\[
\frac{\alpha_t \hat{\varepsilon}_t + \hat{\gamma}_t s_{t+1}}{\alpha_t + \hat{\gamma}_t}
\] (31)

with precision \( \alpha_t + \hat{\gamma}_t \). Since \( \theta_{t+1} = \theta_t + \phi_{t+1} \), we have a recursive formula for the central bank’s information precision in the disclosure case.

\[
\frac{1}{\alpha_{t+1}} = 1 + \frac{1}{\alpha_t + \hat{\gamma}_t} = 1 + \frac{1}{\alpha_t + \gamma \left( \frac{(1-r)\beta}{\alpha_t + (1-r)\beta} \right)^2}
\] (32)

The steady state information precision in the disclosure case is the value of \( \alpha \) that solves

\[
\alpha \left[ 1 + \frac{1}{\alpha + \gamma \left( \frac{(1-r)\beta}{\alpha + (1-r)\beta} \right)^2} \right] = 1
\] (33)
Comparing the Regimes

Comparing the steady state information precision levels in the two regimes given by (27) and (33), we can see that steady state precision is lower under the disclosure regime since the expression in square brackets in (33) is larger than $1 + \frac{1}{\alpha + \beta}$. For parameter values $r = 0.85$ and $\beta = 1$, we can plot the steady state information precision $\alpha$ as a function of the variance $1/\gamma$ of the noise term $\psi$. This plot is given by figure 1. The central bank has higher information precision in the non-disclosure case. In both cases the information precision can be raised to the upper bound of 1 by reducing the variance of the noise, but the disclosure case requires very small noise to get close to the upper bound.

It is also apparent from the implicit formula (33) for steady state $\alpha$ that the central bank’s information precision is a function of the private sector agents’ information precision. This is very natural, since the central bank

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8 The value $r = 0.85$ is implied by $\xi = 0.15$ in the imperfect competition interpretation of the beauty contest rule. See Woodford (2003b) for a discussion of the magnitude of $\xi$.
learns by observing what the individual agents do. The reason why $\beta$ enters in this relation is because the aggregate actions $\bar{a}_t$ are revealing only to the extent that private agents put weight on their own private signals. The more informative are their private signals, the greater is the information value of the aggregate action. In this sense, the central bank’s information value is dependent on (and is derivative of) the private sector agents’ information precision.

Figure 2 plots $\alpha$ as a function of $\beta$ for varying sizes of the noise $\psi_t$ in the central bank’s signal (holding other parameter values the same as for the previous chart). The central bank’s information precision is increasing in the private sector’s information precision, but $\alpha$ can lie below $\beta$, especially when $\beta$ itself is large. One reason for this is that, whereas private sector agents have contemporaneous information about $\theta_t$ from their signals (say, by observing a signal about their current marginal cost), the central bank’s signal comes with some delay, and the innovation to $\theta_t$ increases the central bank’s uncertainty.
Finally, it is worth noting that the forecasting rule for the central bank will undergo changes if it moves from a non-disclosure regime to a disclosure regime. Since $\theta_t$ follows a random walk, the linear estimates given by (25) and (31) are also forecasts of all future values of $\theta$. Needless to say, if the central bank continues to use the old (non-disclosure) forecasting rule under the new (disclosure) regime, then its forecast will be off the mark. We could see this as a variation of the Lucas Critique as applied to central bank transparency. The time series properties of aggregate actions will change as the disclosure regime changes.

**Welfare Effects of Transparency**

The impaired signal value for the transparent central bank will impinge on any control problem that it faces, and poses greater challenges in taking decisions under uncertainty. Thus, the central bank will face a tradeoff between the welfare gains that result from being able to steer the future beliefs of economic agents, and the impaired signal value that results from disclosures of its forecasts. Evaluating the terms of such a tradeoff will be an important topic of investigation. Furthermore, the degree of transparency itself emerges as one dimension to the optimal control problem, and we may expect a debate on “optimal transparency”. We believe these issues to be the key to resolving the welfare effects of transparency in the spirit of the Hayek-Lange debate.

The debate to date, however, has concentrated on the one-shot model of beauty contests sketched earlier where $\alpha$ is taken as given. Although the current debate sheds no light on the endogenous nature of central bank information, it is nevertheless illuminating in outlining some of the other dimensions of the debate.
Welfare for the Static Problem

Retracing our steps to the equilibrium decision rule (11), we can solve for the equilibrium strategies in terms of the basic random variables \( \theta, \eta \) and \( \{ \varepsilon_i \} \).

\[
a_i = \theta + \frac{\alpha \eta + \beta (1 - r) \varepsilon_i}{\alpha + \beta (1 - r)} \quad (34)
\]

If \( r = 0 \), the two types of noise (private and public) would be given weights that are commensurate with their precision. That is, \( \eta \) would be given weight equal to its relative precision \( \alpha / (\alpha + \beta) \) while \( \varepsilon_i \) would be given weight equal to its relative precision \( \beta / (\alpha + \beta) \). However, the weights in (34) deviate from this. The noise in the public signal is given relatively more weight, and the noise in the private signal is given relatively less weight. This feature reflects the coordination motive of the agents, and reflects the disproportionate influence of the public signal in influencing the agents’ actions.

However, the welfare effect of this greater emphasis on the noise in the public signal depends very much on the welfare function chosen. The debate to date has turned on the which welfare function is the most appropriate.

Morris and Shin (2002) assumed that the beauty contest element of the individuals’ decisions is socially wasteful, and enters only as a zero sum component in the agents’ payoffs. In this case, social welfare is enhanced only to the extent that individuals’ actions approximate the fundamental state \( \theta \). In such a formulation, increased precision of public information is not guaranteed to raise welfare. Expected welfare in Morris and Shin (2002) is given by

\[
E \left[ W \mid \theta \right] = -\frac{\alpha^2 E(\eta^2) + \beta^2 (1 - r)^2 E(\varepsilon_i^2)}{(\alpha + \beta (1 - r))^2} \quad (35)
\]

\[
= -\frac{\alpha + \beta (1 - r)^2}{(\alpha + \beta (1 - r))^2}
\]
Welfare is increasing in the precision of the private signals, as we can see by differentiating (35) with respect to $\beta$.

$$\frac{\partial E(W_0)}{\partial \beta} = \frac{(1 - r)((1 + r)\alpha + (1 - r)^2 \beta)}{(\alpha + \beta (1 - r))^2} > 0$$  \hspace{1cm} (36)

However, the derivative of (35) with respect to $\alpha$ is:

$$\frac{\partial E(W_0)}{\partial \alpha} = \frac{\alpha - (2r - 1)(1 - r)\beta}{(\alpha + \beta (1 - r))^2}$$  \hspace{1cm} (37)

so that

$$\frac{\partial E(W_0)}{\partial \alpha} \geq 0 \text{ if and only if } \frac{\beta}{\alpha} \leq \frac{1}{(2r - 1)(1 - r)}$$  \hspace{1cm} (38)

When $r > 0.5$, there are ranges of the parameters where increased precision of public information is detrimental to welfare.

If $\alpha$ is restricted to some interval $[0, \bar{\alpha}]$ for technical feasibility reasons, we can expect a “bang-bang” solution to the choice of optimal $\alpha$ in which the social optimum entails either providing no public information at all (i.e. setting $\alpha = 0$), or providing the maximum feasible amount of public information (i.e. setting $\alpha = \bar{\alpha}$). The better informed is the private sector, the higher is the hurdle rate of precision of public information that would make it welfare enhancing.

However, the zero-sum nature of the coordination element in payoffs is crucial to Morris and Shin’s (2002) result. If, instead, the coordination itself has some social value, then the ambiguous effect of $\alpha$ disappears. Woodford (2005, appendix A) shows that if, instead, the beauty contest element in the payoff enters into the welfare function in its own right, then welfare is no longer given by (35) but rather by

$$-\frac{\alpha + \beta (1 - r^2)}{(\alpha + \beta (1 - r))^2}$$  \hspace{1cm} (39)
Woodford points out that this function is globally increasing in $\alpha$, and so greater precision of public information cannot be harmful.

In the same spirit, Angeletos and Pavan (2004) and Hellwig (2004) propose micro-founded models that incorporate coordination elements in the welfare function. In the case of Angeletos and Pavan (2004), the coordination element comes from an investment problem with positive spillover effects, and so an explicit coordination premium is built into the problem.

The coordination element in Hellwig (2004) is more subtle. Hellwig presents a macroeconomic model with monopolistic competition based on the Dixit-Stiglitz aggregators for consumption and price. In particular, the average price for the economy as a whole is given by the index:

$$P_t = \left[ \int_0^1 (p_i^t)^{1-\theta} \, di \right]^{\frac{1}{1-\theta}} (40)$$

where $\theta > 1$ is the elasticity of substitution between goods and $p_i^t$ is the price charged by firm $i$ at date $t$. In effect, the average price is a generalized harmonic mean of prices\(^9\). This has important consequences. Although profit is increasing in $P_t$, it is decreasing in price dispersion, reflecting the fact that the harmonic mean always lies below the arithmetic mean. Thus, a firm’s expected profit increases when price dispersion is reduced. In turn, the form of the price index reflects the preference for variety implicit in the Dixit-Stiglitz utility function.

An alternative perspective is to note that a consumer’s indirect utility (utility as a function of prices at the optimum) is a convex function of prices, reflecting the ability of consumers to switch away from expensive goods in favor of cheaper ones. Price dispersion then has a beneficial effect. Thus, the choice of models has an important (indeed, pivotal) effect on the conclusion.

\(^9\)More accurately, it is the power mean with a negative power. See, for instance, http://mathworld.wolfram.com/HarmonicMean.html
The sensitivity of Morris and Shin’s (2002) original result (as highlighted in the on-line appendix to the paper\textsuperscript{10}) to the inclusion of coordination elements and choice of framework suggests that the results obtained in the one-shot version of the beauty contest model should not be relied upon too much in drawing firm conclusions on the desirability of greater transparency.

Also, many of the potential costs of suppressing information are not well captured in a static symmetric agent economy. For example, suppose that we added to the static models of Morris and Shin (2002), Angeletos and Pavan (2004) and Hellwig (2004), an uninformed group of agents who learnt about the state only from public signals and by observing the average actions of the informed agents. These agents have to undertake a private investment (with no payoff consequences for other agents). The utility of such agents will be enhanced by having average actions be more informative about the state, i.e., by minimizing $(\bar{a} - \theta)^2$. This objective function gives an even greater incentive to suppress public information than the welfare function (3) employed in the analysis of Morris and Shin (2002). If there are enough such agents, transparency will reduce total welfare. We do not advocate introducing such payoffs, but we merely mention it as another instance of the myriad payoffs that could be assumed.

**Relative Precision**

Lars Svensson (2005) has written a reply to Morris and Shin (2002) that raises another issue. Svensson (2005) takes the Morris and Shin (2002) payoffs at face value, and makes two observations. First, the result that welfare is *locally decreasing* in the precision of public information holds only with restrictions on information parameters that are empirically very restrictive.

\textsuperscript{10}http://www.e-aer.org/data/dec02_app_morris.pdf
(\(\alpha\) has to be small relative to \(\beta\)). Second, even on a global analysis, when the public signal has precision no lower than the precision of the private signal, welfare is higher \textit{with} the public signal than without.

Svensson’s point can be explained by referring back to welfare as given by (35), but expressed as a function of \(\alpha\). Let us denote this by \(V(\alpha)\). Thus,

\[
V(\alpha) = -\frac{\alpha + \beta (1 - r)^2}{(\alpha + \beta (1 - r))^2}
\]

(41)

On the assumption that the withholding of the public signal is equivalent to setting \(\alpha = 0\), the ex ante welfare in the absence of the public signal is thus

\[
V(0) = -\frac{1}{\beta}
\]

(42)

There is a hurdle rate \(\bar{\alpha}\) for the precision of the public signal such that welfare \textit{with} the public signal is lower than the welfare without if and only if \(\alpha < \bar{\alpha}\). The hurdle rate is the value of \(\alpha\) that solves \(V(\alpha) = V(0)\), and is given by

\[
\bar{\alpha} = \beta (2r - 1)
\]

(43)

Since \(0 < r < 1\), the hurdle rate is lower than the precision \(\beta\) of the private information. Thus, for the benchmark case where the precision of public information is no lower than the precision of private information (i.e. where \(\alpha \geq \beta\)), welfare is higher \textit{with} the public signal than without.

Without taking fully into account the endogenous nature of \(\alpha\), it would be difficult to come to a firm conclusion on the relative size of \(\alpha\) versus \(\beta\). We can see from figure 2 of the previous section that when good public information is dependent on high precision of \textit{private} information, choosing one has implications for the other.

The evidence from Romer and Romer (2000) that the Fed’s Greenbook forecasts outperform the forecasts of the Fed’s private sector counterparts
is often cited as evidence that $\alpha$ is larger than $\beta$. However, private sector forecasters are not the typical “economic agent” as studied in most economic models. The private sector forecasters are special types of agents that try to mimic the central bank’s decision problem, but have less resources to perform the task. Rather, $\beta$ should be understood to refer to the information precision of genuine economic agents that learn about the current state of the economy from their own transactions. For instance, in the price setting game version of the beauty contest rule, the economic agent is a firm that tries to balance the competitive effects of price changes with the need to keep price above marginal cost. Here, $\beta$ is the precision of the firm’s estimate of its own marginal cost.

The stylized model in Morris and Shin (2002) also suffers from the fact that it imposes independence of the signals conditional on $\theta$. The on-line appendix to Morris and Shin (2002) dealt with a more general case that allows for correlated signals, and Morris, Shin and Tong (2005) present an example in a reply to Svensson (2005) that shows how the welfare effects can be more subtle away from the simple benchmark case.

The debates formulated in the static model have extended our understanding along several directions, but the limited nature of the static framework and the sensitivity of the results to the assumed payoffs suggest that we have come close to the limits of useful debate within the confines of such a restrictive framework. Much more important would be the endogenous nature of public information precision itself. It is this issue that lies at the heart of the debate between Hayek and his socialist contemporaries, and the largest stakes in the monetary policy transparency debate lie here.
Implications for Monetary Policy

One of the pitfalls of engaging in debate is to oversell one’s case, and to risk making untenable claims. The dangers are large especially if the issue is something as basic and desirable as the transparency of a prominent and influential public institution. Thus, it is worth drawing breath and take a larger perspective. The arguments presented in this essay do not address the question of whether any particular forecast or other information should be disclosed. Rather, the objective has been to review arguments about the tradeoffs involved in the choice of framework for communicating with the diverse economic actors. Nor do we claim that transparency (or inflation targeting, or publication of forecasts) is undesirable. Our aim is the much more modest one of drawing attention to the two-sided nature of the debate.

Transparency affords considerable leverage to central bankers in influencing the beliefs of economic agents. But there is a potential paradox of transparency. One of the inevitable fruits of the success in influencing beliefs is that the central bank has to rely on less informative signals to guide its decisions. If policy makers are to consolidate the successes achieved to date, they will have to turn their attention to how monetary policy should be conducted in an era when prices are less informative.

If the central bank does not recognize that signal values are impaired in a world of managed expectations, it may be lulled into a false sense of security when imbalances are building up elsewhere in the economy. Even as consumer goods prices are stable and the flows in the IS curve are well behaved, asset prices may be buoyed by excessively lax credit conditions that build up problems without obvious outward signs of trouble.

If inflation-targeting is practised flexibly, the output costs of financial distress could figure in the overall calculations. What would be less easy
to overcome would be the political economy hurdles facing a central bank’s monetary policy committee whose mandate is interpreted narrowly as inflation and output stabilization over a relatively short horizon. The key issue is whether a monetary policy committee that suspects that imbalances are building up under the radar feels that it can justify departing from the inflation target over the targeting horizon in order to forestall larger problems over a longer horizon.

Australia is one recent instance where the central bank acted to lean against the wind by raising interest rates and then keeping them high in the face of an overheating residential property market, even though consumer prices and output were well-behaved. The Reserve Bank of Australia came under considerable criticism that it was acting beyond its mandate - that it was looking “beyond its horizon” of two years in targeting inflation. By taking such actions, the RBA was undoubtedly taking a risk with its own reputation, since the politically more expedient path would have been to stick to its mandate interpreted more narrowly. In the event, the RBA’s pre-emptive actions proved well-based, and its reputation has been enhanced. Thus, in practice, central bankers have adapted well to the new regime, and debates are frequently conducted in broader terms. After all, the Reserve Bank of Australia is also an inflation-targeting central bank.

We do not have enough space here to broach the larger topic of central bank accountability. Transparency in this broader sense is crucial for the establishing and maintaining the political legitimacy of the central bank as a public institution. Geraats (2003) gives a taxonomy of the different types of transparency.

The idea that central bankers have a large (and perhaps disproportionate) effect on other actors is well understood by central bankers themselves, as
suggested in the following passage from the transcripts of the FOMC meeting on August 18th 1992, where Chairman Greenspan urges caution on not divulging the discussions at the meeting:\footnote{Available from www.federalreserve.gov/fomc/transcripts/1992/augmeet.pdf. We are grateful to Anil Kashyap for drawing our attention to these transcripts.}

[Chairman Greenspan] ... and I beseech you to be as careful as you can. And especially for those of us who will be in Jackson Hole in a couple of weeks or so where the press will be swarming around. The more sharply analytical press members will be there and as a result will not ask anybody direct questions but will use the usual outline of the phrases you use, the tilt of your head, or the form of your syntax in making a judgment as to what did not or did not occur.

The instincts of the central banker are on good display. In this respect, the arguments put forward in our paper touch on very familiar ground, and in some respects we have labored the obvious. There are many more issues related to transparency than we can do justice to here.\footnote{Committee decision making raises another set of interesting issues. Meade and Stasavage (2005) present one of the rare empirical studies of the effect of transparency on committee decision making.} Central bank transparency presents some of the most interesting and challenging policy issues of our time.

\section*{References}

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http://www.nuff.ox.ac.uk/users/Shin/working.htm


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